APPENDIX D(1)

CONSTRUCTION PHASE QUALITY ASSURANCE PROGRAM

APPENDIX D(1) (Cont'd.)

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LIST OF TABLES

1.0 QUALITY ASSURANCE PROGRAM

This Appendix contains historical information as indicated by the italicized text. USAR Section I-3.4 provides a more detailed discussion of the purpose of highlighting certain text with italics. The factual information being presented in this Appendix as historical has been preserved as it was originally submitted to the Atomic Energy Commission in the CNS FSAR, as amended, with the exception of: a) information relating to the post-construction Quality Assurance Program which is superseded by the NPPD Cooper Nuclear Station Quality Assurance Program for Operation Policy Document (USAR Appendix D), and b) information related to the classification of Systems, Structures, and Components which is contained in USAR Appendix A.

1.1 Introduction

Cooper Nuclear Station, located near Brownville, Nebraska, is owned and will be operated by the Nebraska Public Power District. The District, as owner and operator, has full responsibility and authority for the station and will take all necessary and appropriate action to insure that the station is designed, constructed, tested, and operated in accordance with sound engineering principles and safe operating practices.

It is the District's policy to ensure the highest feasible degree of functional integrity and reliability of equipment, structures and systems which are required for the safe and reliable operation of Cooper Nuclear Station. Particular emphasis is placed on quality and conformance to the design criteria and specifications for those systems, components, and structures which are required to maintain the integrity of the primary system pressure boundary and engineered safeguards systems. These critical systems are listed in the CNS Preliminary Safety Analysis Report (PSAR), Section I-3.

To assure that the above objectives are met, the District has established a comprehensive quality assurance program encompassing the design, manufacturing, fabrication, and construction activities for Cooper Nuclear Station. In addition to assuring reliable overall operation of Cooper Nuclear Station, the quality assurance program will provide adequate confidence that those systems, structures, and components that prevent or mitigate the consequence of postulated accidents that could cause undue risk to the health and safety of the public will perform satisfactorily in service.

To carry out the Quality Assurance Program, the District, in addition to its own personnel, Burns & Roe Engineering, and General Electric, has engaged two reputable and competent firms, Stearns-Roger Corporation and Woodward-Moorhouse & Associates, Inc., to provide independent third party quality assurance. Stearns-Roger Corporation has been retained to perform overall quality assurance of manufacturing, fabrication, testing, and construction; Woodward-Moorhouse & Associates, Inc., has been retained to administer the quality assurance program for excavation, dewatering, and backfilling operations. By utilizing Stearns-Roger and Woodward-Moorhouse & Associates, Inc., in these capacities, Nebraska Public Power District has the distinct advantage inherent in having independent quality assurance representatives. The scope of responsibilities of the District, Engineering, General Electric, Stearns-Roger Corporation, and Woodward-Moorhouse & Associates, Inc., are described later in this Appendix.

1.2 Purpose and Objectives of the Quality Assurance Program

To provide assurance that, as a minimum, the applicable Codes and Standards, the applicable regulatory requirements and the design basis as defined in the PSAR for all systems necessary for safe and reliable operation are correctly translated into specifications, drawings, procedures, and instructions.

To provide an organized systematic method for reviewing the quality control content of the contract specification with emphasis on those portions of the plant which have a direct effect on the integrity necessary for safe operation.

TABLE D(1)-1-1

Quality Assurance Manual

LIST OF ABBREVIATIONS

AEC	--	*Atomic Energy Commission*
AISC	--	*American Institute of Steel Construction*
AISI	--	*American Iron and Steel Institute*
APED	--	*Atomic Power Equipment Department (GE)*
App.	--	*Appendix*
ASME	--	*American Society of Mechanical Engineers*
ASTM	--	*American Society for Testing Materials*
AWS	--	*American Welding Society*
B&R	--	*Burns and Roe, Inc.*
BWR	--	*Boiling Water Reactor*
CM	--	*Construction Management*
CNS	--	*Cooper Nuclear Station*
DDR	--	*Deviation Disposition Request*
ECN	--	*Engineering Change Notices*
el.	--	*Elevation*
FDDR	--	*Field Deviation Disposition*
FDI	--	*Field Disposition Instruction*
GE	--	*General Electric Company*
IEEE	--	*Institute of Electrical and Electronics Engineers*
Lab.	--	*Laboratory*
MTR	--	*Mill Test Report*
NBFU	--	*National Board of Fire Underwriters*
NDT	--	*Non-Destructive Testing*
NEC	--	*National Electric Code*
NED	--	*Nuclear Energy Division (GE)*
NEMA	--	*National Electrical Manufacturers Association*
NID	--	*Nuclear Instrumentation Department (GE)*
NPPD or District	--	*Nebraska Public Power District*
NS & BWR QA	--	*Nuclear Safety & Boiling Water Reactor Quality Assurance Operation (GE)*
NSSS	--	*Nuclear Steam Supply System*
PM	--	*Project Management*
P.O.	--	*Purchase Order*
PSAR	--	*Preliminary Safety Analysis Report*
psig	--	*pounds per square inch gauge*
QA	--	*Quality Assurance*
QC	--	*Quality Control*
R & FMO	--	*Reactor & Fuels Manufacturing Operation (GE)*
R & I	--	*Receiving and Inspection*
RMS	--	*Root Mean Square*
RTD	--	*Resistance Temperature Device*
SAR	--	*Safety Analysis Report*
S-R	--	*Stearns-Roger Corporation*
Supp.	--	*Supplement*
USAS	--	*USA Standards*
USBR	--	*United States Bureau of Reclamation*
WMAI	--	*Woodward-Moorhouse & Associates, Inc.*

To assure that contractors, sub-contractors, vendors, and others responsible for supply, manufacture, fabrication, and construction comply with the contract specification quality control requirements in the performance of their work.

To ensure that the required documentation of quality control performance was generated in proper sequence at the time of performance of the work, and that such records were adequate and complete for the class of work under construction.

To provide a final permanent quality control documentation file which is identifiable and traceable to each item in the plant so covered and in the best judgement of the District meets the requirements of the contract specifications, referenced Codes and Standards, and the regulatory requirements of the AEC, State, and Local Authorities.

1.3 Definition

1.3.1 Quality Control

Quality Control consists of those activities such as testing, inspection, and identification made by an organization responsible for supplying a product to determine compliance of the product with predetermined requirements and to provide a means of notification of the acceptance or rejection of the work to appropriate parties.

1.3.2 Quality Assurance

Quality Assurance consists of the activities performed by an organization independent from the Quality Control organization whose responsibility is to provide a formal program of surveillance, evaluation, and documentation sufficient in scope to assure the District and the Regulatory Authorities that appropriate quality control measures have been properly performed and that the structure, system, or component was in compliance with the plans and specifications.

1.4 Classification of Systems, Components, and Structures

The level of quality control established by the contract specification is a function of the importance of the specified item in maintaining the integrity required for safe and reliable operation. The level of quality assurance surveillance was a function of the level of quality control required by the contract specification for the item under consideration. A classification listing for piping, equipment, and structures used at Cooper Nuclear Station is found in Appendix A. The highest level of quality assurance is placed on those systems and structures classified as Class IN and IIN (piping), Class A and B (pressure vessels), and Class I seismic (piping, equipment, and structures).

2.0 SCOPE OF RESPONSIBILITIES

2.1 Nebraska Public Power District

The District as owner and operator of Cooper Nuclear Station has full responsibility and authority for the station and will take all necessary and appropriate action to insure that the station is designed, constructed, tested, and operated in accordance with sound engineering principles and safe operating practices. The District has retained several organizations to provide the design, Construction Management, and Quality Assurance surveillance; all these organizations are directly responsible to the District Project Management. The Cooper Nuclear Station Quality Assurance Organization, Figure D(1)-2-1 shows the organizations involved and the lines of responsibilities.

Quality Assurance responsibilities for the construction phase end at the time of satisfactory completion of all construction tests for a system. Quality Assurance for the operations phase begins during the preoperational tests and continues throughout the life of the plant.

The Quality Assurance responsibilities during the operations phase are administered through the NPPD Operations organization.

The principal Quality Assurance documents to be used during operation consists of a policy document to define the Quality Assurance policy to be administered during the operations phase and a Quality Assurance program document that describes in more detail the Quality Assurance program. These documents establish the organization and the means of implementing a Quality Assurance program consistent with applicable criteria of 10CFR50, Appendix B.

Quality assurance during preoperational testing is performed by the District's Operating Group. The coordination of, and responsibility for, the quality assurance program within the Operation Group rests with the Quality Assurance Specialist who reports directly to the Station Superintendent. Those personnel performing quality assurance functions during preoperational tests are personnel from departments within the Operating Group that are qualified to evaluate quality functions and that are assigned the specific responsibility of quality assurance for a preoperational test or a group of preoperational tests. These personnel performing the quality assurance for the preoperational tests had no direct responsibility for performing the individual preoperational tests.

The implementation of the quality assurance for the preoperational test program consists of a review of the preoperational test program to assure that the program is conducted in accordance with the NPPD Preoperational Testing Program Description. The Preoperational Testing Program Description lists the responsibility for preparing preoperational test procedures and describes the system for preparing the preoperational procedures, reviewing the procedure, approving the procedure, conducting the test, making changes to the procedure, evaluating test results, identifying and correcting deficiencies, approving test results and documenting test results.

The quality assurance for the preoperational test program also includes selected audits of the actual performance of preoperational tests to verify that the test was conducted in accordance with approved procedures.

2.2 Burns and Roe - Architect-Engineer

Burns and Roe, Inc., has the direct responsibility to prepare all designs, procurement specifications, arrangement drawings, and construction specifications for CNS (except NSSS components and the switchyard). These designs, arrangements and specifications incorporate and implement all applicable design requirements and safety criteria consistent with accepted practice for the item under consideration. Burns and Roe's documents and drawings are reviewed by the Stearns-Roger quality assurance group to ensure that these documents and drawings incorporate the necessary quality control requirements. Additional services provided to NPPD by Burns and Roe include bid evaluations and contracts administration. Pertinent quality assurance comments to all contract documents prepared by Burns and Roe are submitted to NPPD and Burns and Roe for incorporation in the final contract documents.

Included in the design function is the performance of design reviews by individuals or groups other than those who performed the original designs.

Burns and Roe Engineering has the responsibility of approving all design changes, including field changes. Deviations from specifications must have the approval of Burns and Roe Engineering. Burns and Roe Engineering coordinates with and incorporates comments from the District and the Q.A. organizations before approving such contract changes or deviations. The project organization is established so that all parties concerned receive pertinent correspondence simultaneously. Final action is determined between the District and Burns and Roe who, in turn, advise the contractor in writing with copies to the District and Stearns-Roger.

2.3 Stearns-Roger - Quality Assurance

Stearns-Roger Corporation has been retained by the District to perform an overall independent quality assurance of manufacturing, fabrication, and construction of Cooper Nuclear Station. The scope of their work extends from review of preliminary contract specifications for quality controls and quality assurance content to final inspection of installed equipment prior to pre-operational testing.

Stearns-Roger quality assurance works directly with and reports directly to the District's Project Manager. Reports, description of problems, and recommendations by Stearns-Roger quality assurance are made to the District for final decision.

The Stearns-Roger quality assurance Project Manager is located at the Denver office. His staff controls the entire function as well as providing primary documentation and vendor shop inspection. A site quality assurance manager and his staff are residents at the job site and perform all construction quality assurance functions. This group reports to the Project Manager for quality assurance in the Denver office.

2.4 Woodward-Moorhouse & Associates, Inc. - Quality Assurance

Woodward-Moorhouse and Associates, Inc. (WMAI) have been retained by NPPD to administer the quality assurance for the excavation, dewatering, and backfilling operations. Woodward-Moorhouse and Associates, Inc., was also responsible for the quality control associated with the excavation, dewatering, and backfilling operations. The scope of work extends from the review of the contract specification to final certification that the work was performed in accordance with the specification.

The Woodward-Moorhouse organization at CNS reported directly to the CNS Project Management. Reports, description of problems, and recommendation by Woodward-Moorhouse-Quality Assurance are made directly to the District's Project Management.

2.5 General Electric - NSSS Supplier

The District has contracted with the General Electric Company for the nuclear steam supply system. The scope of this contract includes the engineering design, fabrication, testing, and quality control of the NSSS.

General Electric maintains a large experienced staff assigned the responsibility of establishing, documenting, and directing an overall quality system and for integrating, measuring, and auditing the quality-related work across the entire spectrum of General Electric's Boiling Water Reactor Nuclear Steam Supply System.

The General Electric quality control program is monitored by Stearns-Roger Quality Assurance.

2.6 Burns & Roe, Inc. - Construction Management

The responsibility for administering construction and installation contracts is assigned to Burns and Roe, Inc. Within the scope, Construction Management is responsible for guiding and directing the contractors in all phases of their work including conformance to the quality control requirements of the specification.

Stearns-Roger Quality Assurance will report any deviations from the contract specification to the District and to Construction Management. Construction Management has the authority to direct that the deviation be stopped and/or corrected. Construction Management has the authority to stop the work if the situation so demands.

3.0 STEARNS-ROGER QUALITY ASSURANCE

3.1 Introduction

Stearns-Roger Corporation has been retained by the District to provide independent quality assurance for manufacturing, fabrication, and construction of Cooper Nuclear Station. The scope of their work extends from review of preliminary contract specifications to final inspection of installed equipment prior to preoperational testing.

Stearns-Roger quality assurance works directly with and reports directly to the District's Project Manager. Reports, description of problems, and recommendations by quality assurance are made to the District for final decision.

The Stearns-Roger quality assurance Project Manager is located at the Denver office. His staff controls the entire function and provides primary documentation and vendor shop inspection. A site quality assurance manager and his staff are residents at the jobsite and performs all construction quality assurance functions. This group reports to the Project Manager for quality assurance in the Denver office.

3.2 Organization

The organization chart (Figure D(1)-3-1) shows diagrammatically the responsibility relationship of the Quality Assurance organization and its relation to the District and the Engineering and Construction Management functions.

Both the Q.A. Project Manager and the Q.A. Site Manager are Registered Professional Engineers possessing a Bachelors Degree in Engineering and having over fifteen years experience in design and construction.

The chief of each discipline, i.e., Mechanical, Electrical/Instrumentation and Civil/Structural have an Engineering degree plus eight years minimum experience or the equivalent.

3.3 Review of Contract Specifications

3.3.1 Review of Preliminary Contract Specifications

The Architect-Engineer, Burns and Roe, Inc., prepares preliminary contract specifications which are submitted to the District for review and approval prior to invitation for bids. Copies of these specifications are sent to Stearns-Roger quality assurance for review and comment. Receipt of specifications and status of review is maintained on a Document Review Log, Figure D(1)-3-2.

Quality Assurance reviews the specification for quality assurance and quality control content in accordance with the classification and type of work specified. The review covers, but is not limited to, the following major areas:

1. *Establishment of Stearns-Roger as the District's Quality Assurance with authority to perform the function over the contractor and his lower tiered procurement levels.*

2. *Requirement for Contractor's Quality Control.*

3. *Requirement for the Contractor to prepare and submit for review and approval of a Quality Control plan and the scope thereof.*

4. *Applicable codes and standards.*

5. *Special Quality Control requirements in addition to those contained in the codes and standards.*

6. *Materials of Construction.*

7. *Test reports and certification of materials.*

8. *Procedures for manufacturing and fabrication processes requiring review and approval prior to use.*

9. *Inspection methods and procedures requiring review and approval prior to use.*

10. *Formal qualifications of craftsmen and inspection personnel requiring review and approval.*

11. *Drawings and other documents requiring review and approval.*

12. *Final and other documents requiring review and approval.*

13. *Inspection requirements and acceptance standards.*

14. *Quality Control content of bid forms.*

3.3.2 *Bid Evaluation*

During the period of bid evaluation, copies of the bid documents are reviewed by quality assurance to determine adequacy of bidder's proposed quality control plan, past experience in performance of work to the required quality level and all other information pertaining to the bidder's capability of producing work to the specification requirements.

The results of this review are sent to the District for incorporation into the bid evaluation.

3.3.3 *Final Contract Document*

Copies of the final conformed contract specification are sent to quality assurance for their file and use. This document and the attached executed bid documents become the basis for administration and performance of quality assurance on the contract.

3.3.4 *Contract Amendments*

Quality assurance review of amendments follows the identical process as with the original contract from Proposal to final issue.

3.4 *Quality Assurance Activities - Manufactured Items*

3.4.1 *Quality Control Plan*

Each contract specification contains requirements for a quality control plan suitable for the supply of equipment and the performance of the work called for. Since the quality control plan establishes the contractor's control, and provides the framework for quality assurance monitor and audit, it was carefully reviewed prior to approval.

The primary document used for Quality Assurance is the "Cooper Nuclear Station Quality Assurance Manual". This manual sets forth the organization, defines the functions and describes the specific actions to implement the Program. The Manual is essentially a duplicate of Appendix D, Vol. VII of the SAR.

Quality Assurance personnel, knowledgeable in each applicable discipline, review quality control requirements of each contract specification. These requirements are itemized on a document check-off sheet (Figure D(1)-3-19) for each contract. It is kept up to date with each contractor submittal. Document requirements vary with each type of contract. A list of typical documents is given in Paragraphs 3.4.2 through 3.4.3.

The following major elements are reviewed for adequacy in accordance with contract specification requirements:

Organization of Contractor's Quality Control

A separate organization, not under control of production, reporting to top management with a clear definition of authority.

Engineered Quality Control

A system to insure that quality control requirements established by engineering design criteria are communicated to the quality control organization, purchasing, warehousing, production planning, production, inspection, and shipping by written documents or on drawings.

Purchasing Control

A system for quality control review of purchase order quality control content to insure that proper specification, pre-production approvals, processing, inspection, testing, preparation for shipment, and documentation requirements are clearly defined to the vendor. Where applicable, the requirements for a vendor's quality control plan must also be stated.

Document Control

a. Establishment of a central quality control function to insure that all documents issued for performance of the work are reviewed and released only by authorized personnel.

b. A system for prompt incorporation of revised documents in all phases of work performance.

c. A system for prompt removal of obsolete documents from all phases of work performance.

Control of Purchased Material, Equipment, and Services

a. Source quality control and inspection.

b. A system for receiving inspection and warehousing that provides for:

(1) Conformance to purchasing documents.

(2) Conformance to vendor documentation requirements.

(3) Inspection of material as required by specifications and procedures.

(4) Identification and marking of material and documents for traceability.

(5) Stocking of conforming material.

(6) Issuance of conforming material for production or use.

(7) Identification and separation of non-conforming material to insure it is not released for use.

(8) A system to notify vendors of non-conforming material.

(9) A system for final disposition of non-conforming material.

Control of Special Processes

a. A system for pre-production review and approval of written procedures for special processes such as cutting, forming, welding, heat treating, surface preparation, packaging, etc., to insure that they meet requirements of codes, standards, and specifications.

b. A system for pre-production review of equipment and personnel qualifications as required by special process procedures.

Control of Inspection

a. A plan to integrate inspection requirements into the production process to insure that in process inspection is performed and at the proper time during production, and that operations did not proceed until inspections have been made and properly documented.

b. Establishment of written inspection procedures for performance of the inspection.

c. Establishment of requirements for calibration, qualification and periodic examination of inspection equipment, including tools, gages, jigs, instruments, and machines.

d. Establishment of requirements for qualification of personnel to perform certain types of inspection.

e. Provide methods for marking material and/or documents to indicate that inspection was made, acceptability of the findings and the identification of the inspector performing the work.

f. Provide a system of reporting results of inspection for conforming and non-conforming material to quality control and other parties concerned.

g. Maintenance of a complete, traceable file of inspection reports and all other documents required by contract specifications.

Final Testing

a. A system to insure that final testing is performed to written approved procedures in accordance with contract specification requirements.

b. Establishment of requirements for calibration of equipment.

c. Provide identification on material and documents to certify that final testing was performed and is acceptable prior to release for shipment as required by contract specifications.

Preparation for Shipment and Final Sign-Off

a. A system to insure that all required operations, inspections, tests, and preparations have been performed and are acceptable.

b. A method of checking that all records, certifications, and other documentation required are complete and properly executed.

Quality Control Audits

a. Establishment of a system and the specific requirements for continuous and/or periodic auditing of all quality control functions throughout the performance of the work.

b. A system for initiation, follow-up, and confirmation of such corrective action that the audit may indicate as necessary.

3.4.2 Pre-Production Document Review

3.4.2.1 Special Process Procedures

Procedures are submitted by the contractor and his lower tiered vendors for review and approval prior to the start of work in accordance with the contract specifications. Operations covered by procedures varied with the work to be performed. Typical processes reviewed include, but are not limited to the following:

a. Permanent identifications and marking of material
b. Cutting
c. Forming and/or forging
d. Edge preparation
e. Welding (see Evaluation Form Figure D(1)-3-3
f. Heat treating
g. Surface preparations
h. Painting or finishing
i. Special coatings and preservatives
j. Packaging and shipping containers

Each procedure is reviewed to insure compliance with contract specifications and applicable codes and standards. Each must be identified in some manner, usually by a number, to insure no confusion exists. Revisions thereto are noted on the procedure with date of issue. Revised procedures are submitted and reviewed for approval in the same manner as the original.

Quality assurance action is noted on the procedure which is filed and a letter was written to the Engineer with copies to the District Project Manager advising them of the action taken.

3.4.2.2 Purchase Orders

When required by the contract specifications, copies of the contractors and his lower tiered vendor's purchase orders are submitted for quality assurance review and approval. Initial submittals are reviewed in detail to insure the following minimum format content:

a. Complete specifications of the material order item to contract requirements, i.e., ASTM, AISI, or other specifications.

b. Special requirements for approval of pre-production documents where required such as quality control plan, special process procedures, inspection procedures, personnel qualifications, and drawings.

c. Identification and marking requirements.

d. Documentation requirements for completed work to be supplied with shipment.

e. Inspection by the District and/or others prior to release for shipment.

f. Special packaging and other shipping requirements subject to quality control.

When confidence is established that the basic format and quality control content of purchase orders is routine, subsequent purchase orders are spot checked for conformance. A record of purchase orders received, by contract, is maintained on the purchase order status form Figure D(1)-3-4.

3.4.2.3 Material Certification

All mill test reports or certificates of compliance required by the contract specifications are reviewed for compliance with the applicable material specification for chemical, physical, and other required testing. Non-conforming records are noted and the vendor is notified. Conforming reports are filed and copies are sent to the District and the Engineer. Receipt and status record of material certifications is kept on the mill test status form Figure D(1)-3-4.

3.4.2.4 Drawings and Other Production Instruction Documents

Review of drawings, manufacturing instructions, and other production documents as required by the contract specifications is done in a similar manner to purchase orders. Initially all drawings submitted are reviewed for quality control content of the general format.

Particular attention is paid to the call out of the class of equipment and the adequacy of the quality control requirements for that class as specified on the drawings. Call outs for special processing, including welding, and for special inspection such as NDT must reference the numbers of the approved procedures. Once an acceptable format has been established, documents are reviewed for required quality control content per the specifications on a routine basis. The results of this review are reported in writing to the District and the Engineer for incorporation in the engineering comments.

Copies of approved drawings are maintained in the quality assurance files.

3.4.2.5 Special Inspection Procedures

All procedures for the performance of radiographic, ultrasonic, magnetic particle, dye penetrant, eddy current, and other special inspections are reviewed for conformance to the contract specifications and the applicable codes and standards. Requirements for qualification of the process, equipment, and personnel must be included as applicable. Clear cut acceptance standards and any restriction on repairs are special items of consideration since some codes and standards left this to an agreement between the buyer and seller.

3.4.3 In-Process Shop Inspection

Basic requirements for in-process shop inspections are established by the contract specifications and quality control plans as described under D(1)-3.4.1. Additionally, each contract specification requires the contractor to provide to the Engineer a detailed schedule for the performance of the work and periodic progress reports so that work status is known. Copies supplied to Quality Assurance provide the basis for planning in-process shop inspections. Working arrangements are established with each contractor for direct communication by Quality Assurance to determine calendar dates when specific work, inspections, or tests will be done. Quality Assurance Shop Inspectors are then assigned and scheduled to visit the shop.

Prior to shop inspections, a check list of contract specification requirements is prepared for each major item. This list provides the quality assurance inspector with a summary of basic requirements and a systematic method for review and audit of the vendor. A typical set of check sheets, those for the reactor feed pump turbines form CNS-20Z12, are shown on Figure D(1)- 3-5.

A written inspection report, Figure D(1)-3-6, is prepared for each day of each visit and forwarded to the Quality Assurance Project Manager. The District and the Engineer are advised by letter of the findings. Should a quality control problem be discovered, it is described in detail and corrective action is requested. Each inspection visit covers the items described below depending on the work status at the time.

3.4.3.1 Quality Control Audits

The initial shop inspection includes a thorough review of all facets of the contractor's quality control system. The function of each element of the plan is examined and compared to work in-process. In those areas where contract work is not yet in process, evaluation is made on the basis of other work going through the shop. Subsequent visits audit the functioning of the contractor's quality control plan by spot checks of various areas.

3.4.3.2 Production and Process Control

"On the floor" examinations and audits are made to insure that work in process is being performed under proper control. Route cards, shop travelers, or other devices used by the contractor are examined to insure that required inspection and tests are included as part of the planned production operations. Work piece status is compared with signed off completed operations on the document. Inspection records are checked for conformance with completed operations and for verification that required documentation and authorized sign-off has been accomplished.

Parts are examined for marking and identification to contract requirements. Inspection stamps, tags, or other types of marking on or attached to the work piece are checked.

Special processes are checked at the work station where they are performed. Approved procedures, readily available to the craftsmen, are compared to work being done. Identification of personnel doing the work is checked against qualification records in the production and inspection office files.

All discrepancies are brought to the immediate attention of the contractor's quality control and are included in the Quality Assurance Inspector's Report. Subsequent audits assure that corrective action has been properly taken.

3.4.3.3 Document and Records Review

Each Quality Assurance shop inspection devotes a portion of the time to review of documents and records generated during the process of the work. A portion of this review has been described in the preceding paragraph.

Audits are performed on the receiving, production, inspection, and quality control department files. Mill test reports, material certifications, processing procedures, production instructions, inspection procedures, test procedures, and drawings are checked to assure that those in use have been approved and are the latest authorized revision. Cross-checks are made between production records, inspection records, and records and stamps on actual work pieces to assure that all is in conformance and complete to date. Discrepancies and/or missing documents are noted and brought to the immediate attention of the contractor. Wherever possible, the indicated corrective action is initiated and completed in the presence of the Quality Assurance Shop Inspector. In any case, the incident becomes a part of his report and remains an open item for future audit until the corrective action has been accomplished satisfactorily.

3.4.3.4 Equipment Inspection

In-process work is inspected by the Quality Assurance Shop Inspector to an extent in keeping with the class and type under consideration. All work is given a visual inspection for general quality of workmanship.

Certain critical pieces of equipment have established "hold points" for inspections so that the inspection or testing can be witnessed by the Quality Assurance Inspector. Examples are dye penetrant, magnetic *particle, and/or ultrasonic testing of critical areas since these processes do not generate a permanent record. Where radiography is employed, Quality Assurance examines and passes upon all final radiographs on items which form the primary coolant pressure boundary. Films on other types of equipment are spot checked at each plant visit. Checks are made to confirm that films can be traced back to the area examined on the work.*

Critical dimensions are also checked by witnessing the contractor's inspection when special tools, gages, or machines are required. This check also includes the calibration records for the equipment used to assure that required accuracy was not compromised.

General documentation of inspections made are included in the Quality Assurance Inspector's report. Final documentation is maintained in the contractor's records as described in D(1)-3.4.3.3 above.

3.4.4 Final Testing and Inspection

The nature of the equipment, its functions, and the contract specifications determine the final testing and inspection required. Where hydrotests, operational tests, leak tests, and other special tests are applicable they are witnessed by the Quality Assurance Shop Inspector. Required documents such as recorder charts, test data reports, and test certificates are prepared and properly executed and certified. If a Code item is involved, the necessary inspections, witness, and signatures of the Authorized Code Inspector are confirmed.

3.4.4.1 Record Review

A review is made of the contractor's complete document file to verify that all non-conforming items have been cleared and that all the required documentation is properly completed and certified. Once again the marking of the component is checked against the records for proper identification and traceability.

3.4.4.2 Preparation for Shipment

Special Process Procedures which apply to preparation for shipment approved under the reviews of D(1)-3.4.2.1 are reviewed to assure that latest revisions are being used. Surface preparation, painting, rust preventatives, seals, and closures are checked for compliance. Requirements for special packaging are also checked to insure that the finished condition will be maintained during shipment and subsequent storage after receipt at the jobsite.

3.5 Quality Assurance Activities - Construction and Field Fabrication

3.5.1 Quality Control Plan

The requirements for a contractor's quality control plan for construction and field fabrication are generally identical to those for shop manufactured and purchased items. The review and content requirements described under D(1)-3.4.1 are also applicable to on site construction and fabrication.

3.5.2 Pre-Production Document Review

3.5.2.1 Special Process Procedures

Procedures are submitted by the contractor and his subcontractors or vendors for review and approval prior to the start of work in accordance with the requirements of the contract specifications. Operations covered by the procedures varied with the type of work covered by each contract.

Field fabrication work uses many of the same processes found in shop fabrication. Typical field fabrication process procedures include but are not limited to the following:

a. Permanent identification and marking of material and finished items.

b. Cutting of special materials.
c. Edge preparation.
d. Welding.
e. Post weld heat treatment.
f. Surface preparation.
g. Painting.
h. Special coatings and preservatives.

Typical construction process procedures include:

i. Splicing of reinforcing bars.
j. Special concrete placement.
k. Concrete repair.
l. Electrical installation.
m. Cable and Wire identification.
n. Electrical continuity testing.
o. Electrical insulation testing.
p. Mechanical equipment installation.
q. Cleaning.
u. Sealing and preservation.

Procedures are reviewed for compliance with contract specifications and applicable codes and standards. Each must be identified in some positive manner, usually by a number, to eliminate confusion. Revisions are submitted and reviewed in the same manner as originals. Revisions and dates are indicated on the document for proper control.

Quality Assurance recommendations are noted on the procedure and the copy is filed as a quality assurance record. A letter is written to the Engineer with copies to the District Project Manager advising them of the recommended action.

3.5.2.2 Purchase Orders

Control of purchase order quality control content for material or components for construction or field fabrication is identical to that described for shop manufactured items under Paragraph D(1)-3.4.2.2.

3.5.2.3 Material Certification

Review and approval of mill test reports, certificates of compliance, laboratory tests, and other documents required for field work is performed in the same manner as described under Paragraph D(1)-3.4.2.3 for shop work.

3.5.2.4 Drawings and Other Instruction Documents

Drawings, fabrication instructions, and other documents affecting the performance of the work are reviewed initially for quality control content of the general format.

Particular attention is paid to the built in format provisions for providing the quality control information needed by the craftsmen for performance of the work. The necessity for providing all the quality control and special process requirements on the construction drawings is more acute than for shop fabricated items due to conditions which are a natural part of construction work; i.e., the work is performed at locations away from the office, supervision at the working level is less concentrated, work assignments change more often and employee turnover is greater.

Drawings include the identification of equipment presented, call outs of special processes by procedure number at each location used, in-process inspection requirements at each location and final inspection and testing to be performed before the work is to be considered complete.

Results of the drawing and documents reviews are sent to the Engineer by letter with a copy to the District. Once the basic format has been established, drawing review is concentrated on proper and complete quality control call outs in keeping with the function of items represented, the type work being accomplished, and applicable specification requirements.

3.5.2.5 Special Inspection Procedures

The contract specifications set forth the requirements for inspection procedures based on the type and class of work covered. Procedures are submitted by the contractor for review and approval. They are checked for conformance to the specifications and the applicable codes and standards. Certain types of inspection require qualification tests of the procedure, the equipment used and the personnel performing the work. These are reviewed for conformance and proper certification.

The following special inspection procedures are typical of the types reviewed:

- *a. Radiography*
- *b. Ultrasonic*
- *c. Dye Penetrant*
- *d. Magnetic Particle*
- *e. Etching*
- *f. Leak Testing*
  - *(1) Vacuum Box*
  - *(2) Probe*
- *g. Hydrostatic*
- *h. Paint and Coating Thickness*
- *i. Cleanliness*
- *j. Reinforcing Bar Splices*
- *k. Electrical Insulation Testing*
- *l. Electrical Continuity Testing for Proper Terminations*

The review also emphasizes the establishment of well defined acceptance standards and repair procedures since some codes and standards require an agreement between the buyer and seller.

3.5.3 In-Process Inspections

3.5.3.1 Quality Control Audits

When a construction contractor establishes an office at the jobsite, and prior to the start of work, a meeting is held between Stearns-Roger quality assurance and the contractor's cognizant personnel. This meeting serves to establish a working relationship between quality assurance and the contractor and clarifies and emphasizes the quality control requirements applicable to the type and class of work to be performed. The agenda includes such subjects as identification of mandatory hold inspection points, access to work areas by quality assurance inspectors, clarification of communication methods, responsibilities of both parties, identification of documentation requirements and other questions of a general nature relating to work.

A detailed review and audit is made of the initial operation for each type of work as performed by each contractor. This includes auditing all facets of the contractor's quality control system.

Comparisons are made between the quality control exercised during the performance of the work and the requirements of the contract specifications as spelled out by the contractor's quality control plan.

3.5.3.2 Construction Inspection Procedures

The nature of the work and the almost continuous quality assurance surveillance of all operations permits non-conforming items to be divided and classified into two categories:

a. Discrepancy

Discrepancies are non-conforming items which are discovered before work is complete and could be brought into conformance by action during completion of the work. Items of this nature are recorded on the Inspection Punch List Report, Figure D(1)-3-7. The report is completed in detail and describes the contract number, contractor location, and nature of the discrepancy. The completed report is distributed to Construction Management, the contractor, and the District. The original is maintained in the site quality assurance punch list file, by contract, until such time that the item is corrected and inspected.

Should an error or an oversight occur such that work proceeds without the corrective action and the action could no longer be taken, the item becomes a deviation and is handled as described in the next paragraph.

b. Deviations

Deviations are non-conforming items which are found in completed work and which require repair, rework, or possibly replacement to correct. Items of this nature are recorded on the Deviation Report Form, Figure D(1)-3-8. The completed report contains the contract number, the contractor, reference specifications and drawings, location, date, and a detailed description of the item. A log is maintained for all Deviation Reports issued, by contract, and an individual serial number is assigned to each for accurate control. See Figure D(1)-3-9.

The reports are distributed to the District Site Manager and Site Representative, the Construction Manager, the contractor, and the Q.A. open file. The Q.A. file is periodically reviewed for status of open Deviation Reports and all parties are advised of remaining open items.

The authorization for disposition of a Deviation Report rests with the Engineer or the Construction Manager, depending on the nature of the item. Quality Assurance then performs such inspections as necessary for confirmation of the corrective action, countersigns the dispositioned Deviation Report, and distributes copies to all parties on the original distribution.

The decision on the method of repair or rework to attain conformance is the responsibility of construction management as long as the corrective action will be performed to previously approved procedures and the completed work will be in complete conformance with specifications and drawings.

When the corrective action will not produce complete conformance, prior written approval of the rework and end result is required from the Engineer. Site quality assurance must have a copy of this engineering decision, properly executed, before the Deviation Report will be cleared.

Decisions to "use as is" also require written approval from the Engineer which must be in possession of quality assurance before the Deviation Report is cleared.

Cleared Deviation Reports, the Engineer's approval and other back-up documentation becomes a part of the permanent quality assurance project files which are turned over to the District on completion of the project.

3.5.3.3 Construction and Process Control

a. Mechanical

Inspection is performed by Quality Assurance personnel on all items defined as mandatory inspection points as well as continuous random inspection to assure that acceptable quality control is being performed by the contractor. Inspection includes verification that instruments have been calibrated at proper intervals, that all required data is obtained accurately and recorded legibly and logically on the approved forms, that all requirements for acceptance have been fulfilled, and that acceptable material is properly identified.

Recognizing that welding and related processes constitute the primary function in mechanical construction and fabrication, an appropriate emphasis is placed on the control of these processes.

Prior to welding, a verification is made to assure that procedure and operator have been qualified; material, including filled metal, is identifiable with the appropriate mill test reports; joint design and fit up are in accord with approved procedure, and the craftsman has all required information and tools.

During welding, checks are made to determine that the welder follows prescribed procedure, preheat and interpass temperature are maintained, root pass is followed by prescribed cleaning and testing, filler passes are placed in approved size and order, cleaning between passes is thorough and that the final pass is within the reinforcement limit and properly cleaned.

After welding the following operations are verified: Post weld heat treatment is accomplished according to specification, non-destructive tests are performed and recorded, and further required rework is documented and performed according to approved procedures and work is properly identified to correspond to records.

Additional items of construction and processes which are controlled through Quality Control Audit or actual inspection include: Cleanliness to the level prescribed by specification is obtained and maintained, pipe hangers provide the specified constraint and flexibility, coatings, protective covering and insulating materials are installed and inspected as prescribed, location and size dimensions and alignment are maintained within the required tolerances.

b. Civil (Includes Structural)

Initial inspection on this type of work consists of verification that excavation sand forms are at the proper location and elevation in accordance with approved construction drawings. Embedded items such as sleeves, conduit, pipe, reinforcing bar, etc., are checked against drawings for proper size, item quantity, and location. These inspections where applicable are conducted in conjunction with the quality assurance site surveying operation described in more detail under D(1)-3.6.2, Site Surveying.

All reinforcing bar received at the site is inspected to assure compliance with the applicable specifications and drawings. Cadwell bar splices are the subject of a special process procedure and each finished splice is inspected. In addition, tension tests to destruction are run on sister splices and test splices cut from actual production on the frequency specified in the contract.

Other embedded items are inspected prior to release for use and placement. Shop fabricated or purchased items are inspected when received at the jobsite as described in D(1)-3.6.1, Site Receiving Inspection. Field fabricated items are inspected by the continuous mechanical inspection described in D(1)-3.5.3.3.a above.

Control of concrete from raw material to final placement is maintained. Details of this operation are described in D(1)-3.6.3, Concrete Control.

In-process record and sign off of completed work is recorded on the Concrete Placement checkout sheet, Figure D(1)-3-10.

A typical example of other related inspection of civil work is that applied to pipe trench backfill. The pipe backfill ticket form, Figure D(1)-3-11 is used. It is initiated when the pipe is ready for inspection in the trench and all mechanical inspection, including NDT and hydrotest, is complete. The form when completed for a section of line is distributed to construction management, the contractor, and the District. The original is retained in the quality assurance file.

c. Electrical

Quality Assurance personnel inspect all items defined as mandatory hold points. In addition, a continuous random inspection is performed on all areas of work. The Electrical Installation Check Off List, Figure D(1)-3-12 is used as a guide and record. The items on the list are completed as applicable for the system being inspected.

Documentation requirements on material and equipment are determined from the contract review. A Documentation Check List, Figure D(1)-3-20 is prepared for each system and approved before material is released for use as described in D(1)-3.6.1. The special environmental conditions required for equipment and instrument storage is monitored as described in 3.6.1.

Special emphasis is placed on those systems critical to control of the reactor and its auxiliaries. Particular attention is paid to proper cable and wire, traceability of cable and wire to material certifications, routing and separation, pulling tension, terminations and testing. All work will be audited to assure that these and other functions are performed in accordance with procedures approved under D(1)-3.5.2. The results of inspections are recorded and the corrective action documented in accordance with the procedures described under D(1)-3.5.3.

Final calibration of installed instrument and set point adjustments is made using calibrated equipment traceable to certified standards. All test results and calibrations become a part of the permanent job Quality Assurance records.

3.5.4 Final Checkout and Inspection

The final checkout and inspection of each portion of completed work is done in the same manner as for shop fabricated work as described under D(1)-3.4.4.1 preceding. The various inspection forms previously described for construction work are used as applicable.

3.6 Special Activities

3.6.1 Site Receiving and Inspection

Quality assurance operations are an integrated part of site receiving, inspection, storage, warehousing, and release of material purchased by the District or by the District's contractors. The detailed method of operation, forms used, etc., is described by "Procedure for Receiving, Inspection, Storage and Handling of Equipment and Materials".

The on-site quality assurance office is supplied with a list of required documentation to be supplied by the sub-contractor or vendor of each item. These documents are forwarded to the site quality assurance office as they are completed and received during the course of manufacture.

In some instances final test and shipping documents are sent out at the time of shipment to avoid delay. After initial receiving inspection has been performed to identify the item and determine that no damage occurred during shipment, the documentation is checked for conformance. If the documentation is not complete, the item is *retained in quarantine in accordance with Warehousing Procedure, Page 3, Paragraph 7.1, and Page C-1, Paragraph 3.1.1, a yellow tag is installed, and the vendor is notified. When the documentation arrives, the material is inspected and a new R&I Report issued. The balance of the receiving inspection operations are performed and disposition is made in accordance with the procedure. Items found damaged on arrival or failing to pass receiving inspection are red tagged and reported according to the deviation procedure. With the approval of Construction Management, a contractor may remove an item thus quarantined for use at his own risk. When this is done, a deviation report is filed as "open" on the contract item.*

Non-conforming items are identified by a "rejected" tag and held in quarantine areas until final disposition is made. Materials can not be withdrawn from these areas for use until outstanding deviations have been cleared and approved by quality assurance. At this time, the equipment is tagged as acceptable and moved to an assigned storage area where it is available for use.

3.6.2 Site Surveying

Site quality assurance includes a completely equipped experienced surveying team. General functions performed include: Setting and verification of site monuments and bench marks, orientation of contractor's surveying personnel to site control systems, verification of contractor's critical temporary bench marks, and performance of such additional survey work as may be requested by the construction management or the District.

3.6.2.1 Earthwork

Verify location of work by setting site monuments; perform all survey required by Woodward-Moorhouse Associated, Inc., for site preparation, including control of locations and elevations of heave points, settlement plates, piezometers, slope indicators, and sheet steel piling; verify grades and locations established by contractors.

Progress is confirmed on a monthly basis by running cross sections and computing quantities of earth moved.

3.6.2.2 Concrete Placement

A preplacement survey is made to assure that forms and embedded items are properly located in accordance with specifications and approved drawings. Any discrepancies found are reported on the Inspection Punch List Form, Figure D(1)-3-7, using the same procedure previously described under D(1)-3.5.3.2 Construction Inspection Procedures.

When placement is complete, a survey is made to confirm final measurements. Any deviations found are reported on the Deviation Report Form, Figure D(1)-3-8, using the procedure previously described under D(1)-3.5.3.2, Construction Inspection Procedures.

3.6.2.3 Structural Items

Surveys of structural item locations, alignment, etc., are made at the request of and in conjunction with the quality assurance civil inspection group. Any discrepancies or deviations found are reported by the inspectors as previously described.

3.6.2.4 Major Equipment and Piping Location

Surveys of major equipment and piping locations are performed at the request of and in conjunction with the Quality Assurance Mechanical and Electrical Inspection Groups. Deviations are reported by these inspectors using the procedures previously described.

3.6.3 Concrete Control

3.6.3.1 Batch Plant

Control of production is maintained by performing the following operations:

a. Review and documentation of cement mill tests and shipments.

b. Sample and test aggregate shipments.

c. Inspect truck mixer drums every 90 days.

d. Check and calibrate cement scales and meters every 30 days or more frequently if error is suspected. Check aggregate scales and water meter every 4-6 months or when error is suspected.

e. Surveillance of concrete batching. This is reported on Form CNS-L4, Figure D(1)-3-13.

f. Sample and test aggregates as used from stockpiles when weather conditions or handling necessitates a re-check of work performed in b. above.

3.6.3.2 Placing of Concrete

As the contractor completes an area in preparation for concrete placement, he obtains the signature of each craft foreman indicating that his specific work is done. This "sign-off" is done on a concrete placement checkout sheet, Figure D(1)-3-10. Upon completion of the placement sheet by the contractor, it is given to quality assurance requesting a formal pre-placement inspection.

Each discipline (structural, surveying, mechanical, and electrical) inspects the area and approves or issues an inspection punch list covering its particular phase. Quality Assurance then completes its portion of the concrete placement check out sheet and approves the area for placement of concrete.

If the inspection punch list items have not been corrected or accepted by Engineering, quality assurance does not approve the area for concrete placement. When all discrepancies have been corrected or deviations properly authorized, the check out sheet is signed off by quality assurance and construction management approves the proposed concrete placement by signing the concrete placement check out sheet. This completed form is returned to the contractor and is his release to place concrete in the subject area.

A Quality Assurance inspector monitors the placing of concrete in the area to assure that methods used in handling and compacting are in accordance with the contract requirements. After the concrete has been placed, the quality assurance inspectors monitor the curing and, if required, the weather protection of the newly placed concrete.

All deviations observed during placement or post placement inspection of the concrete are reported used the procedures previously described.

3.6.3.3 Test Laboratory

Quality Assurance has established a completely equipped and staffed concrete control laboratory at the plant site. One or more samples are taken from the pour at each structural placement in accordance with contract specifications. In addition to sampling and testing mixed concrete, test of aggregates and other materials which may have been used in the mix are also made when required.

Tests performed and forms used for record are shown below:

- a. *Gradation, cleanliness, and moisture content of aggregates. Forms No. CNS-L5 and CNS-L9, Figures D(1)-3-14 and D(1)-3-15.*
- b. *Slump, air content, and temperature of fresh concrete. Form CNS-L3, Figure D(1)-3-16.*
- c. *Compression test samples of fresh concrete. Form CNS-L1, Figure D(1)-3-17.*
- d. *Cast, cure, and test concrete cylinders for compressive strength at 7, 28, and 90 days. Form CNS-L1, Figure D(1)-3-17.*
- e. *Final report of aggregate tests and compressive strengths. Form CNS-L8, Figure D(1)-3-18.*
- f. *Adjustments to concrete mixes for variations in aggregate and yield as required by contract specifications.*
- g. *Material samples to be tested by others as required.*

3.7 *In-Process Document Control and Records*

3.7.1 *Contract Specification Requirements*

Initial Quality Assurance action on a final contract (see D(1)- 3.3.3 and D(1)-3.3.4) is a review to establish the documentation requirements specified. These requirements are listed, item by item, for each separate contract on the Documentation Requirements Form, Figure D(1)- 3-19 or Figure D(1)-3-20. This check sheet becomes the basic control and as each sheet is completed, copies are forwarded to the site Quality Assurance office for use during receiving inspection.

3.7.2 *Record System*

Although all contracts follow the same general format, the scope of coverage, the type and class of work and/or equipment differ so greatly; that it follows Quality Assurance must be organized and performed on a contract by contract basis. The check list prepared in D(1)- 3.7.1 above establishes the content and organization files and records as applicable for each consideration, both in the Denver office and at the site. Some types of documentation, such as a contractor's quality control plan, is a one-time action for a particular contract. Other types of documentation, such as mill test reports, welding procedures, etc., will accumulate a considerable volume during the course of completion of the work. Where a large degree of repetition is anticipated, special forms are developed for record purposes. These forms and their uses have been described previously.

Each contract Quality Assurance file is subdivided by document type to permit rapid access and retrieval. A typical record file for a complex contract will contain the following subdivisions:

- *Final contract specifications and amendments.*
- *Correspondence (chronologically).*
- *Contractor's quality control plan.*
- *Subcontractor's vendor's quality control plan.*
- *Special process procedures - shop fabrication.*
  - a. *Welding*
  - b. *Other manufacturing*
- *Personnel qualifications - special processes - shop.*
- *Special process procedures - field construction.*
  - a. *Welding*
  - b. *Other construction*
- *Personnel qualifications - special processes - field.*
- *Special inspection procedures - shop.*
- *Personnel qualifications - special inspection - field.*
- *Purchase orders.*
  - a. *Contractors*
  - b. *Subcontractors and vendors*

- *Material certifications.*
- *Inspection reports.*
- *Inspection punch lists.*
    - a. *Open*
    - b. *Closed*
- *Deviation reports.*
    - a. *Open*
    - b. *Closed*
- *Drawings.*
    - a. *Contract specification*
    - b. *Contractor*
    - c. *Subcontractor and vendor*
- *Inspection, test, NDT, and other certificates.*

A separate file is maintained for each of the following:

- *General project correspondence not limited to one specific contract.*
- *Transmittal letters from Burns and Roe.*
- *Transmittal letters from contractors and vendors.*

3.8 Non-Conforming Material or Workmanship

3.8.1 Shop Manufactured and Purchased Items

Non-conforming items, discovered by the various document reviews and inspections previously described, become the subject of a letter from Stearns-Roger Quality Assurance to the Engineer with a copy to the District. The problem is described in detail with specific reference to the contract specifications and the item being reviewed.

The Engineer in turn notifies the contractor of the problem and a decision with regard to corrective action is agreed upon and forwarded to Quality Assurance for follow-up.

If the problem is only concerned with non-conforming documents, revised copies are required to be resubmitted for review and approval. The approval is made by a letter from Quality Assurance to the Engineer with a copy to the District. The Engineer stamps the new document "approved" and forwards copies to the contractor, the District, and Quality Assurance. The end result produces a stamped approved copy in the Quality Assurance file.

If the problem concerns non-conforming material or workmanship as represented by a document discrepancy, the communication mechanics are the same. The decision to "use as is", repair or scrap is arrived at between the Engineer, the Contractor, and Quality Assurance and the disposition is communicated to all parties by letter from the Engineer. The item is noted in the contract file and the Quality Assurance shop inspector is advised so that he can confirm that corrective action has been taken at the vendor's plant during his next audit.

Non-conforming items identified during the course of an in-process vendor plant inspection are reported by the Quality Assurance shop inspector on the Inspection Report Form, Figure D(1)-3-6. These reports are forwarded to the Quality Assurance Project Manager and corrective action is taken as described in Paragraph D(1)-3.4.3. The Quality Assurance Project Manager initiates the requirements for corrective action using the communication sequences described above. Subsequent audits of the vendor's inspection records must confirm that corrective action was properly taken, completed, and signed-off.

3.8.2 Construction and Field Fabrication

Since site construction and fabrication is all performed within one location, the methods of communication can be altered to provide more immediate contact than with shop work.

The basic method of recording and communicating incidents of non-conformance is by use of the Inspection Punch List and the Deviation Report Forms as described under D(1)-3.5.3.2. All parties involved at the site receive their copies simultaneously, on a daily basis. When the disposition requires action by the Engineer, a copy of the report and an explanatory letter, if needed, is sent by Construction Management with copies to all parties.

The operation is further supplemented by the Project Receiving, Inspection Storage, and Handling of Equipment and Materials Procedure as described under D(1)-3.6.1.

The combined operation provides a "tightly knit" method for identification, control, disposition, correction, and documentation of non- conforming material or workmanship.

3.9 *Owner's Final Plant Records*

As each contract is completed, documentation is checked for completeness by a complete review of files in both the Denver and site Quality Assurance offices. Material, such as duplications, obsolete documents and drawings are removed and the contract file is consolidated into a finished record package. These records are then turned over to the District.

4.0 BURNS AND ROE QUALITY ASSURANCE PROCEDURE FOR ENGINEERING AND DESIGN

4.1 General

This section discusses the functions and responsibilities of the two Burns and Roe, Inc., Divisions devoted to engineering and design of the Cooper Nuclear Station. These are the Project Operations Divisions and the Engineering Division. In addition, this section covers the individual functions and responsibilities of all key personnel assigned to the project by these Divisions in order to insure a high quality plant design.

4.2 Project Operations Division

The Project Operations Division provides for overall management, cost control, and production of work, through its assigned Project Manager.

Included in the Project Operations Division are the following Departments and Sections; Project Management, Staff Engineering, Estimating and Design and Drafting. The Division provides the bulk of the manpower required for the management, engineering, and design phases of the project.

4.3 Engineering Division

The Engineering Division is responsible for the establishment of criteria and for direct technical supervision of Project Operations Division engineers, designers, and draftsmen. Technical quality is controlled through this technical supervision as well as through the review and sign-off of specifications and drawings. This is done by representatives of the Engineering Division to assure that the drawings and specifications produced quality in conformance with the established criteria. The Engineering Division assigns Chief and/or Supervisory Engineers to support the project staff, to discharge technical control responsibilities, and to enforce the engineering criteria.

The Engineering Division also provides the services of specialists in geology, stress analysis, instrumentation, reactor physics, radiation shielding, health-physics, water treatment, quality assurance, thermodynamics, and other technical skills. The work of the specialists is reviewed by the Chief/Supervisory Engineer.

Drawing sign-off authority for initial issues of all drawings plus revisions of criteria type drawings (i.e., flow diagrams, one-line diagrams) is retained by the Engineering Division. In certain areas of work, such as revisions to piping drawings, selected engineers from Project Operations Division (normally Principal Engineers) are given this authority by the Chief Engineer on a limited basis based on their experience, technical capacity, and appropriate professional licenses.

4.4 Key Personnel Related to the Project

The Vice-President and Director of each Division, through their cognizant representatives, assign "key" personnel to fulfill the requirements of the project. By Division, the following subparagraphs pertain to the function and responsibilities of key personnel assigned to the Cooper Nuclear Station. To assist in the understanding of how these key personnel functioned on the project, a flow chart is provided on Figure D(1)-4-1.

4.4.1 Project Operations Division

a) Project Manager - The Project Manager has full responsibility for the production of work within contract requirements of scope, cost, and schedules. Working under his direction are full time engineering, design and drafting, administrative and service personnel who are assigned to, and physically located within, the project office.

The Project Manager supervises the daily work and coordinates the overall project, maintains close cooperation and liaison with NPPD on job operation and progress and exercises control over the other manifold aspects of project administration. All normal communications, conferences, technical review and control are *initiated through him. The Project Manager also has responsibility for the technical coordination and administrative direction of the work. The Project Manager reports to the office of Director of the Project Operations Division.*

Upon initiation of the project, a document, the Project Guide, is prepared covering the procedures to be following during the course of the project. The Project Guide contains samples of instructions and forms that may be issued by the Project Manager to the project staff to assure that the work is performed in accordance with company practices.

A procedural flow chart showing the sequence of steps leading from initiation of engineering and design to final approved drawings and "as-built" information is shown on Figure D(1)-4-2.

b) Project Engineer - The Cooper Nuclear Station project is organized so that there are two main coordinators of effort under the Project Manager. One of these is the Project Engineer and the other the Resident Construction Manager.

The Project Engineer has the overall responsibility (among others) of technical coordination on the Cooper Nuclear Station. His principal role in this regard is to assure, together with the other appropriate project personnel, that:

1. *The technical phases are properly coordinated on the project among the various disciplines.*

2. *The engineering and design is properly coordinated and sequenced to meet schedule requirements.*

3. *Capital cost and engineering budgets are given proper weight in technical considerations.*

4. *The effect of potential change orders on contracts already let is properly evaluated. This applies particularly to design revisions.*

5. *Licensing requirements have been included.*

6. *Relationships with NPPD are considered and commitments to NPPD are met.*

7. *Project Procedures are followed.*

c) Lead Engineers - Lead Engineers for each discipline are assigned by the Project Operations Division and their functions and responsibilities are as described below. On this project, where there is more than one engineer assigned to a particular discipline, a Lead Engineer is designated who is usually a Principal Engineer - a senior classification for Engineers in Burns and Roe. The responsibilities of the Lead Engineers are:

1. *Supervise the engineers of his discipline assigned to him on a given project.*

2. *Provide information and coordination with the Design Squad Leader of his discipline.*

3. *Coordinate with the cognizant Supervising Engineer in the Engineering Division throughout the project to assure that the criteria is adhered to and that the quality of the work is maintained.*

4. *Monitor, in his discipline, the entire engineering and design effort - specifications, information needed for drawings, calculations, other engineering tasks and preparation of drawings - so that all tasks are truly complementary and on schedule. See Figure D(1)- 4-3 and D(1)-4-4.*

5. Maintain complete coordination with the other affected engineering disciplines and obtain comments and concurrence prior to issuance of the information to the design group.

6. Assure by daily coordination that his engineers are assigned the responsibility for specific drawings.

7. Exercise continuous review of drawings while in process, to minimize changes later.

8. Review with his cognizant Supervising Engineer, schedules for specific items and request appropriate criteria early enough to allow adequate time for this criteria to be generated.

9. Review his planned approach and the expected title, format, and contents of specifications with the Supervising Engineers so that approval of the finished product can be expedited.

10. Provide draft copies of specifications, prepared in conformance with the Burns and Roe, Inc., Standard Specifications wherever possible, to the Supervising Engineer in a timely manner to permit adequate review and comment.

d) Design Squad Leaders - Design Squad Leaders for each discipline are assigned by the Project Operations Division. Each Squad Leader's functions and responsibilities were:

1. Supervise the designers and draftsmen of his discipline assigned to him on a given project.

2. Provide information and data, obtained from the Lead Engineer, to his staff in an orderly and timely manner.

3. Coordinate with the Lead Engineer and cognizant engineers in his discipline to assure that information and data is used correctly in the preparation of the designs and drawings.

4. Maintain a work schedule in accordance with NPPD's and project requirements.

5. Periodically coordinate with the Chief Draftsman or his representative to assure that company standards and project procedures are being followed in maintaining the quality of the work.

4.4.2 Engineering Division

a) Director of Power Engineering - It is the function and the responsibility of the Director of Power Engineering, working with the cognizant Director of the Project Operations Division, to coordinate the activities of the various Chief Engineers and Supervising Engineers assigned to the project. It is his responsibility to assure that proper engineering supervision is given to the project. Engineering Standards developed by the Chief Engineers are approved by the Director of Power Engineering. The Director of Power Engineering may at his discretion, assign his responsibilities to the Assistant Director of the Power Engineering Division.

b) Chief Engineer and Supervising Engineer - It is the function and responsibility of each Supervising Engineer assigned to the project to establish criteria in his particular discipline for the overall plant design, to review the work on a periodic basis, and to coordinate the technical adequacy and quality of the engineering. The criteria established by the Supervising Engineer is reviewed by the Chief Engineer. It is the responsibility of the Chief or Supervising Engineer, in reviewing or approving specifications, drawings and purchase recommendations, to call upon specialists in instrumentation, stress analysis, water treatment and others to check out any items involving their specialty before sign-off. Where a Principal Engineer is assigned to a project, the Chief Engineer may delegate to the Principal Engineer sign-off responsibilities in certain areas.

c) Specialists - At the initiation of the cognizant Chief or Supervising Engineer, and in accordance with project needs, specialists are assigned by the cognizant specialist Chief/Supervising Engineer as required by the schedule and in cooperation with the Project Manager. Specialists receive assistance from engineers in the Project Operations Division as necessary.

It is the responsibility of the cognizant Chief or Supervising Engineer to approve all specialists' work in their respective disciplines to assure proper integration of the work in the overall designs.

4.5 Quality Control

a) Quality Control is the supervisory determination by the Engineering Division, on a continuing basis, that the engineering and design are being done by the project staff in accordance with the approved project criteria. Such supervision should be cognizant of any deviations that have been or are being made by the project staff before the engineering or design approached finalization.

b) The responsibility for design quality control on the project is vested in the Director or Assistant Director of the Power Engineering Division and the Chief/Supervising Engineer assigned the criteria development for the project.

c) The purpose of quality control supervision is not to perform the engineering and design required by the criteria, but to check on the design and engineering and to guide the project staff in interpretation of criteria in order to obtain a sound technical and economical project for NPPD.

d) The minimum check points for quality control are established as:

(1) Final draft of specifications. At this point, the Engineering Division representative indicates approval by signature on the draft before final reproduction copy is typed.

(2) Drawings. At the 30% completion point and at the 100% completion.

The minimums do not preclude checking at other times when problems arise or when the 30% check point indicates that a further check at some further point is needed.

e) Should the quality control supervisor feel that a member of the project staff is consistently deviating from the criteria or is not qualified to do the engineering and design required by the criteria, the problem is to be brought to the attention of the Project Manager and the cognizant Director of the Project Operations Division for further investigation and appropriate action.

f) In instances where the Engineering Division supervision is considered to be contrary to the above procedure, the problem is discussed and resolved by the Director, Project Operations Division, and the responsible Engineering Division Director.

4.6 Design Reviews

In addition to drawings and specifications control mentioned above, design reviews also cover items such as stress, thermal, hydraulic and accident analyses, compatibility of materials and of design interfaces, accessibility for inservice inspection, maintenance and repair, and delineation of acceptance criteria for inspections and tests. Reports of in-process and final design reviews are reviewed by management of Burns and Roe. Design changes including field changes to work performed by Burns and Roe are approved by Burns and Roe unless specifically designated otherwise by NPPD.

Figure D(1)-4-5 shows the flow of work, along with a description of each phase of the work for the processing of vendor and as- built drawings.

4.7 Summary

It is the intent that all the technical work on the project be checked by someone other than the person doing the work. As an example, criteria prepared by a Supervising Engineer is to be checked by a Chief Engineer. This criteria will then be turned over to a Lead Engineer who then transcribes criteria into drawings and specifications. The Lead Engineer's work is then checked by the Supervising Engineer. If, in a particular discipline, the Supervising Engineer is also acting as Lead Engineer, the cognizant Chief Engineer will check his work.

5.0 QUALITY ASSURANCE OF EARTHWORK CONSTRUCTION

5.1 Summary

Appendix A and Supplement A to Appendix A of the Cooper Nuclear Station Preliminary Safety Analysis Report (PSAR) demonstrated that the foundation foils supporting the major structures of Cooper Nuclear Station must be sufficiently dense to be safe against liquefaction induced by the hypothetical maximum possible design earthquake. To fulfill this requirement, the following compaction criteria concerning the average relative density Dr of the foundation soils were established: (1) Dr = 85% from el 903 to el 855, (2) Dr = 80% from el 855 to el 830, and (3) Dr = 75% from el 830 to bedrock surface. The foundation construction scheme that was adopted involved excavation of the in-situ soils to within nine feet of bedrock surface, compaction of the remaining in-situ soils, and construction of structural fill to the required relative densities.

This report summarizes the quality assurance program that was implemented to ensure that earthwork was constructed in accordance with the requirements contained in the PSAR and the construction plans and specifications. The report includes a description of the quality assurance program and its organization and implementation, results of observations of groundwater levels and bedrock heave during excavation, the compaction procedures developed from the results of in-situ compaction and structural fill tests fills, and construction of structural and general fills. Deviations from the requirements established at the start of construction are described and the results of standard penetration tests performed to verify the as-built condition of the structural fill are given. Detailed records of the quality assurance program are available and are briefly described in the last section of the report.

It is concluded that the earthwork was performed in accordance with the requirements.

5.2 Earthwork Quality Assurance

5.2.1 Definitions

The Woodward-Moorhouse & Associates, Inc., (WMAI) Earthwork Quality Assurance Program at Cooper Nuclear Station consisted of quality control inspection and testing, and quality assurance.

Quality control inspection and testing consisted of those acts and procedures that resulted in the acceptance or rejection of the work, and notification of the acceptance or rejection to the appropriate parties.

Quality assurance consisted of the evaluation of the observations and measurements made during quality control inspection and testing and resulted in opinions regarding the adequacy of the quality control inspection and testing and the compliance of the work with the plans and specifications.

5.2.2 Purpose and Objectives of Program

The purpose of the Earthwork Quality Assurance Program for earthwork construction was to provide a formal program of surveillance and documentation sufficient in scope and content to assure that appropriate quality control measures were properly performed in accordance with the requirements contained in Supplement A and Amendment 2 to Appendix A of the Cooper Nuclear Station Preliminary Safety Analysis Report and that the completed earthwork conformed to the contract plans and specifications.

The Earthwork Quality Assurance Program had the following specific objectives:

1. *To monitor the effectiveness of the dewatering system and to prevent the development of excess hydrostatic pressures which may cause excessive upward movement of the bedrock and loosening of the compacted in- situ material or structural or general fills;*

2. *To inspect that materials and methods employed by the earthwork contractors are in compliance with the construction plans and specifications and the requirements contained in the PSAR;*

3. To test the in-situ compacted material and the structural and general fills during and after construction to ensure that the methods employed by the earthwork contractors achieved the required relative densities;

4. To document the results of quality control inspection and testing for purposes of record and quality assurance evaluation; and

5. To provide quality assurance of the adequacy of the quality control measures and quality of the completed earthwork with respect to the construction plans and specifications and the requirements contained in the PSAR.

5.2.3 Quality Control Organization

The earthwork quality control organization at Cooper Nuclear Station reported directly to CNS project management and was represented by the resident project engineer, who was a qualified graduate civil engineer with specialty in soil mechanics and foundation engineering. Assistant project engineers, who were qualified graduate civil engineers or geologists with specialty in soil mechanics and foundation engineering, were assigned to the different construction shifts. The assistant project engineers were assisted by field engineers, inspectors, and technicians.

The number of persons involved with earthwork quality control varied with the inspection and testing requirements of the different stages of construction. The quality control organization chart is given in Figure D(1)-5-1.

A field soil testing laboratory, equipped to perform all of the required tests, was installed at the CNS site. All laboratory tests were made under the direction of an experienced soil laboratory supervisor from our permanent staff. He was assisted by laboratory technicians and reported to the assistant project engineer on shift. A flow diagram of the laboratory phase of the quality control testing of the structural and general fill soils is given in Figure D(1)-5-2.

5.2.4 Responsibilities of Quality Control Staff

The responsibilities of the quality control staff are listed as follows:

5.2.4.1 Resident Project Engineer

The resident project engineer was responsible for all earthwork quality control inspection and testing. His responsibilities included:

- *coordinating the work performed by the field, laboratory, and office staff;*

- *reviewing staff requirements and personnel qualifications, all work done by the field and laboratory personnel, and all field and laboratory quality control test procedures, and ensuring that all quality control procedures and documentation are complete and in accordance with pre- established requirements;*

- *establishing a system for intermittent internal review of the quality control measures to assure that they are effective and that the quality control organization is functioning as required;*

- *ensuring that all personnel are informed of current requirements of plans and specifications, including changes or modifications, and that all corrective earthwork construction is performed in accordance with the directions of Burns and Roe, Inc., Construction Management;*

- *participating in project coordination meetings with construction management and earthwork contractors; and*

- *communicating to Construction Management, CNS Project Management, and Burns and Roe, Inc., Engineering all instances of earthwork contractor's noncompliance with the contract plans and specifications.*

5.2.4.2 *Assistant Project Engineer*

The assistant project engineer reported to the resident project engineer. His responsibilities included:

- *organizing and directing the soil laboratory and office engineering staff;*

- *reviewing daily field inspection and testing reports;*

- *preparing daily and monthly reports which included summaries of field and laboratory quality control tests and field observations; and*

- *assuming the duties of the resident project engineer during his absence.*

5.2.4.3 *Earthwork Inspector*

The earthwork inspector reported to the resident project engineer, or in his absence, the assistant project engineer. His responsibilities included:

- *being on duty his entire working shift and observing all earthwork construction operations within the area assigned to him;*

- *observing that all the work was performed in compliance with the plans and specifications. If the earthwork contractor's work was not in compliance with the plans and specifications, he informed the resident project engineer or assistant project engineer;*

- *requesting field technicians to make necessary field tests and specifying the locations at which the field tests were made;*

- *transmitting to the earthwork inspector who relieved him, all current instruction received and other information pertinent to the work;*

- *preparing daily field inspection reports on all work performed. These reports are part of the quality control records and include the following:*

  1) *date and weather conditions;*
  2) *work area inspected;*
  3) *construction work accomplished;*
  4) *instructions given to the earthwork contractor by construction management personnel and important conversations with the earthwork contractor's personnel relative to the project;*
  5) *sketches showing areas worked and photographs, when required;*
  6) *status of the work at the end of the shift;*
  7) *noncompliance by earthwork contractor; and*
  8) *other matters of importance.*

His specific duties were to observe the following:

- *condition of surface of structural fill prior to placing new fill;*

- *type and suitability of material placed, e.g., exclusion of organic or frozen soil, and oversize material;*

- *treatment of contact surfaces at edges of fill;*

- *placement and compaction of fill, including uncompacted lift thickness, leveling, uniformity, type of compaction equipment, number of coverages, travel speed, area covered and frequency of vibratory compactors; and*

- *other matters such as slope of compacted surface and watering of uncompacted fill.*

5.2.4.4 *Earthwork Technician*

The earthwork technician reported to the earthwork inspector. His responsibilities included:

- *preparing field testing equipment for work on his shift;*

- *making field density or other tests at the locations determined by the earthwork inspector and delivering to the soil laboratory at intervals not greater than two hours the samples obtained from the tests; and*

- *construction inspection of structural and general fills in specified areas under the supervision of the earthwork inspector.*

5.2.4.5 *Laboratory Supervisor*

The laboratory supervisor reported to the resident project engineer, or, in his absence, the assistant project engineer. He was responsible for all work done in the laboratory. His responsibilities included:

- *reviewing laboratory test results;*

- *reviewing the work of the laboratory technicians to assure the accuracy of the test results and the conformance of procedures with applicable standards, and to detect major deviations from anticipated results;*

- *maintaining neat, comprehensive, and accurate records of laboratory test results;*

- *providing the necessary direction to assure the orderly and timely processing and testing of samples;*

- *directing and checking that unused portions of test samples are bagged, identified, and properly stored; and*

- *transmitting to the earthwork inspectors the current laboratory and field test results.*

5.2.4.6 *Laboratory Technician*

The laboratory technician reported to the laboratory supervisor. His responsibilities included:

- *processing the samples as they came to the laboratory;*

- *performing the laboratory tests assigned to him and computing the results; and*

- *performing other assignments as directed by the laboratory supervisor.*

5.2.4.7 Dewatering Inspection Engineer

The dewatering inspection engineer reported to the resident project engineer or in his absence, the assistant project engineer. His responsibilities included:

- *inspecting the installation of deep wells, well points, piezometers and heave points; and the cellular cofferdam construction;*
- *measuring water levels in piezometers, and river levels;*
- *determining river bed elevations at the river side of the cellular cofferdam;*
- *maintaining up-to-date records of the ground-water conditions and the performance of dewatering system;*
- *reporting deep wells, well points, or piezometers that are defective and inspecting that defects are satisfactorily repaired;*
- *estimating ground-water discharge from dewatering system;*
- *inspecting discharge water for fines;*
- *analyzing ground-water conditions to assure that upward seepage pressures are not large enough to threaten loosening of the structural or general fills; and*
- *supervising the work of dewatering technicians.*

5.2.4.8 Dewatering Technician

The dewatering technician reported to the dewatering inspection engineer. His duties included:

- *inspecting installation of the dewatering system;*
- *measuring water levels in piezometers and deep wells as directed;*
- *maintaining all water level measurement devices in good working order;*
- *making river bed soundings; and*
- *making calculations to determine ground-water and river bed elevations.*

5.2.5 Construction Noncompliance and Corrective Action

Each occurrence of the earthwork contractor's noncompliance with the construction plans and specifications was documented and the Nebraska Public Power District, Construction Management, and Engineering (Burns & Roe, Inc.) were informed in writing of the occurrence by the earthwork quality control organization.

The quality control organization was informed by construction management of the corrective action deemed necessary to correct or improve the work. The corrective action was inspected and documented.

Provisions were made for the timely reporting and correction of construction noncompliance occurrences.

5.2.6 *Quality Control Audit*

Internal audit of the site quality control inspection and testing activities were made by the Quality Assurance Program Project Manager.

The audits consisted of effectiveness review of the quality control inspection and testing records and activities to verify that pre- established quality control procedures and practices were effective and being complied with. These audits were performed intermittently; their occurrences depended upon the progress of the earthwork.

5.3 *Conclusions*

5.3.1 *Observation of Groundwater and Bedrock Heave During Excavation*

5.3.1.1 *Introduction*

It was considered that during excavation, heave of the bottom of the main excavation might occur as a result of excess hydrostatic pressures in the bedrock because of a hydraulic connection between the bottom of the excavation and the Missouri River. To detect the presence of excess hydrostatic pressures and bedrock heave, the groundwater levels in the in-situ soils and bedrock and the heave of bedrock were intermittently monitored.

5.3.1.2 *Groundwater*

To monitor groundwater levels during excavation, piezometers were installed in the in-situ soils near the top of bedrock and in bedrock at the locations shown in Figure D(1)-5-3. This type, number, and location of these piezometers were in accordance with the requirements. Water levels in the piezometers were measured daily. The results of measurements of the excavation levels and groundwater levels in the in- situ soils and in the bedrock during excavation in the reactor building area are shown in Figure D(1)-5-4. These results and the results of similar observations in the other areas of the site indicated that no excess hydrostatic pressures were developed in the bedrock.

5.3.1.3 *Bedrock Heave*

Twelve heave points were installed. The heave points were Borros' Heave Points manufactured by Borros Company Ltd., of Solna, Sweden. They were installed in bentonite-mud-filled holes and driven 6 to 15 inches into bedrock. The heave points were installed prior to the start of excavation and their elevations were intermittently determined by optical survey measurements as the level of the excavation was lowered. The results of the measurements indicated that a maximum bedrock heave of 0.08 ft. and an average heave of 0.06 ft. occurred when the excavation reached its lowest level. This amount of heave is insignificant.

No excess hydrostatic pressures in the bedrock and no significant heave of the bedrock were measured. It is WMAI's opinion that the structural integrity of the bedrock was not affected by the excavation of the overburden soils.

5.3.2 *In-Situ Compaction Test and Test Fills*

The purpose of the in-situ compaction test and test fill was to evaluate the equipment and construction procedures to be used by the contractor in compacting in-situ soil above bedrock and in constructing the structural fill to the required relative densities. In addition, the purpose of the in-situ compaction test was to obtain sufficient information to determine the depth above bedrock surface at which the excavation could be stopped.

The in-situ soil compaction criteria that were developed from the results of the in-situ compaction test are:

1. *The depth of in-situ soil compacted above bedrock shall not be greater than nine feet.*

2. The in-situ soil above bedrock shall be compacted with a Vibro-Plus CH-65 vibratory compactor operating at 1500 cycles per minute for a total of thirty coverages.

The structural fill compaction criteria that were developed from the results of the test fills are:

1. The first 12-inch loose lift of structural fill over the in-situ compacted soil shall be made with sand from the excavation and be compacted with a Vibro-Plus CH-43 vibratory compactor operating at 1600 cycles per minute for a total of twelve coverages.

2. Subsequent 12-inch loose lifts to el 830 of structural fill made with sand from the excavation shall be compacted with a Vibro- Plus CH-43 operating at 1600 cycles per minutes for a total of five coverages.

3. Twelve inch loose lifts from el 830 to el 855 of structural fill made with sand from the excavation, shall be compacted with a Vibro-Plus CH-43 operating at 1600 cycles per minutes for a total of five coverages.

4. Twelve inch loose lifts above el 855 of structural fill made with sand from the excavation shall be compacted with a Vibro-Plus CH- 43 operating at 1600 cycles per minute for a total of six coverages.

5. Twelve inch loose lifts of structural fill made with sand from the dredged sand stock pile, from one foot above the elevation of the material compacted in-situ to el 855, shall be compacted with a Vibro-Plus CH-43 operating at 1600 cycles per minute for a total of eight coverages.

6. Twelve inch loose lifts above el 855 of structural fill made with sand from the dredged sand stockpile shall be compacted with the Vibro-Plus CH-43 operating at 1600 cycles per minute for a total of nine coverages.

The compactors were towed by a crawler tractor at a speed limited by the requirements to a maximum of one and one-half miles per hour.

5.3.3 Compaction of In-Situ Material

5.3.3.1 Compaction of In-Situ Soil

Seven feet to eight and one-half feet of in-situ soil above bedrock was not excavated. This soil which consists of brown and gray coarse to medium sand with occasional pockets of fine gravel and clay, was compacted in accordance with the in-situ soil compaction criteria. The required and actual limits of compaction, the compaction surface elevations, and the average thicknesses of in-situ material that was compacted in the various areas at the bottom of the main excavation are included in Figure D(1)-5-3. Near surface clay pockets were excavated and replaced with structural fill sand before compaction.

5.3.3.2 Control of Groundwater Before, During, and After In-Situ Compaction

The groundwater level was successfully lowered before in-situ compaction by deep wells supplemented by well-points. Five well-point systems, enclosing the areas to be compacted, were installed at approximately el 840. After in-situ compaction, the well-point systems were gradually turned off. The maximum hydraulic gradient during restoration of groundwater levels was 0.05 which is insignificant with respect to loosening the compacted in-situ soil.

5.3.3.3 Relative Densities of Compacted In-Situ Soil

A total of 73 borings with standard penetration tests were made after compaction. The borings were drilled using a mixture of water and bentonite as the drilling fluid and the standard penetration tests were made at intervals of 2.5 feet. Representative results of the standard penetration tests (N values) performed in ten of the borings *and the relative densities calculated from these results are given in Figure D(1)-5-5. The results indicate that with the exception of the upper portion of the in-situ soil, the relative density of the in-situ soil is at least 75%. The upper portion was compacted to the required average relative density during compaction of the first lift of structural fill.*

5.3.3.4 Conclusions

The in-situ soil was compacted in accordance with the requirements.

5.4 Construction of Structural Fill

5.4.1 Sources and Properties of Structural Fill Sand

5.4.1.1 Source

Sand from the main excavation and sand dredged from the Missouri River were used to construct the structural fill. A relatively small volume, approximately 50,000 yd3 of sand from the main excavation was used. All other fill sand, approximately 650,000 yd3, was dredged sand which was stockpiled in an area north of the main excavation for use as structural fill.

5.4.1.2 Index Properties

Representative grain-size distribution curves of sand from the main excavation and dredged sand are given in Figure D(1)-5-6. Sand from the excavation was a brown, clean, uniform, medium to fine sand with less than 10% passing the No. 200 sieve. The dredged sand was a brown or gray, clean, uniform, medium fine sand with less than 2% passing the No. 200 sieve. The fraction passing No. 200 sieve is non-plastic. The sand from both sources meet the requirements for structural fill.

5.4.2 Method of Placement and Compaction

Placement and compaction of structural fill began after compaction of the in-situ soil. Structural fill sand was transported, dumped, spread in loose lifts, and compacted in accordance with the requirements. The first lift of structural fill was compacted with twelve coverages of a Vibro-Plus CH-43 vibratory compactor to densify the upper portion of the underlying in-situ soil.

5.4.3 Deviations from Construction Plans and Specifications

The deviation from construction plans and specifications consisted of the use of concrete and nominally compacted sand in the place of structural fill in limited areas and the inclusion of the Radwaste Building as a major structure. These deviations were studies, designed, and approved by Engineering.

5.4.3.1 Concrete

Concrete was used in place of structural fill at inaccessible locations, e.g., beneath piping, where proper structural fill construction could not be performed. There were thirty-one such locations and the total amount of concrete used in place of structural fill was approximately 700 yd3.

5.4.3.2 Nominally Compacted Sand

Above approximately el 870, the narrow spaces between the Reactor and the Radwaste Buildings and between the Reactor and the Turbine- Generator Buildings were filled with a total of approximately 1000 yd3 of nominally compacted structural fill quality sand. The sand was placed in approximately 8-inch loose lifts and each lift received one coverage of a manually-operated compactor. Measured relative densities of the sand varied from 57 to 78% and averaged 70%.

The nominally compacted sand is above the bottom of the foundations of the structures and will not be required to support structures or surcharge. It is WMAI's opinion that the behavior of the buildings will not be adversely affected as a result of the behavior of the sand under the forces induced by the hypothetical maximum possible design earthquake.

5.4.3.3 Radwaste Building Foundation Soil

After the start of construction, the Radwaste Building substructure design criteria were upgraded to meet major structure classification. The building area is located at the northwest corner of the plant. Approximately the eastern third of the area was compacted in- situ and subsequently backfilled with structural fill. The western two- thirds of the area is underlain by the in-situ sand stratum and structural fill. Structural fill exists above el 862 over the entire Radwaste Building area.

The N values obtained from standard penetration tests performed in borings drilled in the Radwaste Building area were used to calculate relative densities of the sand stratum. Based on these data and WMAI's general knowledge of sand stratum, it is WMAI's opinion that the representative relative density of the sand stratum beneath the Radwaste Building mat is 75% between el 862 and el 845 and 65% below el 845.

The liquefaction potential for the existing sand stratum and structural fill beneath the Radwaste Building mat has been evaluated in the same manner as the supplementary liquefaction analysis included in Amendment 2 of the PSAR; see Figure D(1)-5-7. Plotted in the figure as functions of elevation are: (1) the equivalent induced peak shear stress for 20 uniform cycles; and (2) the field shear stress causing liquefaction in 20 uniform cycles for structural fill at a relative density of 85% and for the sand stratum at relative densities of 75 and 65%. This figure shows that at all elevations, plot (2) is to the right of plot (1) and the factor of safety with respect to liquefaction is greater than one. Its maximum value is approximately 1.13 at el 845.

Although the factor of safety with respect to liquefaction is not as great as it is beneath the other major structures (e.g., Reactor Building, Turbine-Generator Building), it is WMAI's opinion that the factor of safety with respect to liquefaction is sufficient to ensure that there would be no detrimental effect under the forces induced by the hypothetical maximum possible design earthquake.

5.4.4 Special Precautions

Special precautions, as described below, were taken during the placement and compaction of structural fill in transition zones, during compaction of structural fill surfaces prior to constructing foundation mats, and during winter months.

5.4.4.1 Transition Zones

Transition zones consisted of temporary fill slopes between structural fill constructed under different contracts. They usually contained 1 to 3 feet of loose sand below the surface of the slope. This loose sand was removed by "benching" into the slope with a dozer blade and replaced with compacted lifts of structural fill.

5.4.4.2 Compaction of Structural Fill Surfaces Beneath Foundation Mats

Prior to constructing the foundation mats, approximately the top six inches of structural fill, was thoroughly watered and compacted to the compaction criteria by at least three coverages of a manually operated vibrating plate or roller compactor.

5.4.4.3 Winter Construction

When the temperature decreased below 32°F, special precautions were taken to ensure that frozen loose sand would not be included in the structural fill. These precautions included additional coverages, more frequent testing, limiting structural fill construction to small areas, continuous observation and probing of the surface of the fill *for signs of frost penetration, exclusion of frozen soil from the sand obtained from the borrow source, and the use of Visqueen shelters and propane heaters.*

5.4.5 Quality Control Inspection

Full-time earthwork inspectors were assigned to each shift to continuously inspect the quality of structural fill sand and its placement and compaction. To facilitate the organization and analysis of the inspection and testing results, the main excavation was separated into six structural fill construction areas. These areas are identified with respect to the major structures and are shown in Figure D(1)-5-3.

Responsibilities of inspectors included: inspection and visual classification of the sand to be used as structural fill, estimating water requirements of the fill, inspecting lift thicknesses and monitoring the following: speed and vibratory frequency of compactors, number of uniformity of compactor coverages, pattern of coverages, and amount of coverage overlap. To check the uniformity and compactness of the structural fill, the inspector intermittently hand-probed the compacted areas with a steel rod, e.g., in large and confined work areas, around piezometers and settlement plates, and at inset corners of buildings.

Inspection records consisted of written reports and sketches describing the work accomplished during each shift. Approximate locations and elevations of areas worked each shift were measured with respect to the locations and elevations of known reference points. When earthwork was performed on more than one shift, inspection shifts overlapped to ensure inspection continuity.

5.4.6 Quality Control Testing

5.4.6.1 Quality Control Tests

The required quality control tests to determine the relative densities of the structural fill were performed in accordance with pre- established requirements and procedures. They included the determination of in-situ dry unit weights from in-situ density tests using the Washington Dens-O-Meter, laboratory maximum and minimum dry unit weight determinations, standard plate load tests, dynamic cone penetration tests, and standard penetration tests.

5.4.6.2 Frequency of Testing

An average of one in-situ density test and one relative density determination were made for every 1000 yd3 of structural fill constructed. In limited areas compacted with manually-operated compactors or when changes in soil properties or equipment characteristics occurred, the average testing frequency was approximately one test per 350 yd3 of structural fill. The maximum and minimum dry unit weights were determined in the laboratory for each sample obtained from the in-situ density tests. An average of one standard plate load test was performed for every 10,000 yd3 of structural fill constructed. Dynamic cone penetration tests were performed occasionally to supplement the inspectors' judgment and confirm that all areas were compacted. Standard penetration tests were performed in thirty-eight borings to obtain N values from which relative densities were determined.

Grain-size distributions of the structural fill sand were determined once every 2000 yd3 and water content determinations were made every 1000 yd3 of structural fill.

5.4.6.3 Correlations

Correlations were used to infer relative densities of the structural fill on the basis of the results of standard plate load and standard penetration tests. No satisfactory correlation could be obtained between results obtained using a Washington Dens-O-Meter and those obtained with the nuclear device. Consequently, the nuclear device was not used.

The results of the standard plate load test were used to infer the relative density near the working surface of the structural fill in a shorter period of time than was required using the Washington Dens-O-Meter and *laboratory determinations of maximum and minimum dry unit weights. The standard penetration test results were used to infer relative densities at greater depths below the working surface of the structural fill.*

The correlation obtained between density and standard load plate deflections at 6000 lb/ft2 is given in Figure D(1)-5-8(a).

Relative densities were inferred from the results of standard penetration tests in accordance with the relationships between relative density and N value published in the Earth Manual (USBR, 1963, p314). The relationships are given in Figure D(1)-5-8(b).

5.4.6.4 Results of Relative Density Determinations and Standard Penetration Tests

Approximately 9000 yd3 of structural fill was constructed below el 830. The relative densities determined in this portion of the structural fill were all greater than the required 75% and varied from 87 to 105%.

Histograms of the relative density values obtained in the structural fill between el 830 and el 855, and above el 855 are given in Figure D(1)-5-9. The relative density values were obtained using both the Washington Dens-O-Meter and the standard plate load tests. Approximately one percent of the relative density values are less than the required minimum value. It is WMAI's opinion that these values are likely the result of procedural errors made during testing and that they are not significant with respect to evaluating the adequacy of the structural fill. Representative standard penetration test results (N values) in the structural fill are given in Figure D(1)-5-10.

5.4.7 Control of Groundwater During Construction of Structural Fill

Throughout earthwork construction, the groundwater levels in the piezometers installed in the structural fill were observed to ensure that no upward seepage forces were large enough to loosen the structural fill. The piezometers were installed in accordance with the requirements. In the course of construction, 12 type-C piezometers were damaged. These piezometers were replaced by an equal number of type-A piezometers installed at the bottom of the structural fill. Groundwater levels were controlled by the operation of the pumps in the deep wells. The rise in groundwater level was maintained at hydraulic gradients not exceeding 0.2.

Daily measurements of water levels in piezometers and rates of discharge from the dewatering system, inspections of the discharge water for fines, and periodic surveillance of the deep wells to ensure that the pumps were in working order were made. To study the behavior of the groundwater in the main excavation during construction, interpreted groundwater level contours were prepared. Typical contours are represented by the interpreted groundwater level contours for 31 March 1970 given in Figure D(1)-5-11.

5.4.8 Conclusions

The structural fill was constructed in accordance with the requirements and no loosening of the structural fill occurred during the raising of the groundwater level.

5.5 Construction of General Fill

Approximately 300,000 yd3 of general fill was constructed in the main excavation at the required locations.

The soil used for general fill was obtained from either the dredged sand stockpile or the stockpiles of select soils excavated from the main excavation. Histograms of relative density and degree of compaction values obtained in the general fill are given in Figure D(1)-5- 12. Approximately five percent of the values are less than the required minimum value. It is WMAI's opinion that these values are likely the result of procedural errors made during testing and that they are not significant with respect to evaluating the adequacy of the general fill.

The general fill was constructed in accordance with the requirements.

5.6 Verification of As-Built Condition of Structural Fill by Standard Penetration Tests

After construction of the structural fill was essentially complete, seven borings with standard penetration tests were made in the structural fill and in-situ compacted soil. The locations of the borings are included in Figure D(1)-5-3. A mixture of bentonite and water was used as drilling fluid in the borings and the standard penetration tests were performed according to ASTM designation D 1586-64T at 2.5-ft intervals. The borings and tests were continuously inspected by the earthwork inspector. The standard penetration resistance values versus effective vertical pressure are given in Figure D(1)-5-13.

The results of the standard penetration tests verify that the as-built conditions of the structural fill and in-situ compacted soil are in conformance with the requirements.

5.7 Documented Results of Quality Control Inspection and Testing and Formal Reports

Inspection and testing records are kept on file at Cooper Nuclear Station. Daily reports, with sketches and photographs, where required, were prepared. These records were condensed into monthly progress reports, giving the progress of the work and inspection and testing results. These reports were transmitted to the District, Construction Management, and Engineering. The main contents in the files are as follows:

File	*Contents*
Correspondence	*Correspondence between Earthwork Quality Control Organization and CNS Project Management, Burns and Roe, Inc., Construction Management, and Engineering, NPPD on-site representative, and other on-site quality assure personnel concerning earthwork contractor's noncompliance with plans and specifications and corrective measures taken. Reports directed to CNS Project Management documenting in chronological order the earthwork contractor's construction activities and the results of quality control inspection and testing.*
Observation of Groundwater and Bedrock Heave	*Records of measurements of water levels in piezometers during excavation, in-situ compaction, and construction of structural and general fills. Records of measurements of bedrock heave during and after excavation.*
In-Situ Compaction Test and Test Fill	*Description of construction procedures and equipment and field and laboratory test locations and results.*
Dewatering	*Records of installation of dewatering system, measurements of groundwater levels and volumes of discharge.*
Structural Fill	*Field and laboratory test results including results of standard penetration tests and inspection reports.*
General Fill	*Field and laboratory test results and inspection reports.*

6.0 GENERAL ELECTRIC QUALITY SYSTEM FOR BWR NUCLEAR STEAM SUPPLY PROJECTS

FOREWORD

The General Electric Company recognizes that a responsible and comprehensive system to attain the desired level of quality of systems and components is a necessary part of nuclear power plant safety and reliability. To that end the Nuclear Energy Division of General Electric Company has expended considerable effort in developing a quality system consistent with project requirements. The elements and details of the quality system have been evolutionary and the system is broader in scope now than it was several years ago by virtue of the many improvements in methods and practices which NED developed and by continued intensive study of the requirements of the nuclear industry and the regulatory agencies.

The information which follows reflects the General Electric Company quality system as it is structured and implemented at the time of issuance of the operating license. Changes may be made to the system as a continuing effort to further improve system efficiency and product quality.

6.1 General

6.1.1 Introduction

A quality system is provided by the Nuclear Energy Division (NED) of the General Electric Company (GE) to assure that the required effort, equipment, procedures, and management are directed toward satisfying the intent of the proposed AEC Quality Assurance Criteria for Nuclear Power Plants and the quality objectives of providing safe and reliable systems and components within the GE scope of supply.

This document describes, in summary, the quality system established by NED for application to those projects for which GE supplies the nuclear system. The principal objectives of the quality system and the key functions and elements which it contains are not expected to change over the duration of a nuclear system project. However, circumstances may make advisable changes in the organization or emphasis in the quality system; such changes will be made in accordance with normal management practice. The owner (The term "owner" is herein used to identify the applicant and/or his designated representative.) will be notified of significant changes in the quality system as set forth in this section.

The quality system is designed to assure that the quality- related work elements for systems and components supplied by NED are identified, assigned, and controlled from conceptual design through plant start-up. Specific responsibilities are assigned for quality-related activities through the major steps of a plant project encompassing the broad phases of:

- *Conceptual design*
- *Systems and components specification*
- *Systems and components design*
- *Vendor selection*
- *Material and components procurement*
- *Fabrication of components*
- *Material and components testing*
- *Shipping, site receiving, and storage*
- *Installation of systems and components*
- *Preoperational testing*
- *Start-up testing*

The quality system fully recognizes that systems and components supplied by NED come from a number of sources. NED manufactures such items as control rods, control rod drives, control rod drive system components, steam separators, reactor servicing equipment, nuclear fuel assemblies, and instrumentation and control systems and equipment. Equipment within the NED scope of supply purchased from outside NED for installation at *reactor sites includes such items as the reactor pressure vessel and internals, pumps, motors, piping valves, and heat exchangers.*

The NED staff of technical personnel, experienced in the nuclear industry, supplies designs or design specifications appropriate for nuclear applications for NED manufactured or procured equipment. Quality control organizations direct or audit the quality-related work for NED manufactured products, for vendor-supplied materials and components, and for field installation. NED quality-related preoperational testing and start-up activities are planned by engineering components within NED.

Line components with assigned quality assurance/quality control responsibilities conduct continuing audits of their activities to assure compliance with the quality system within their assigned responsibility scope. A BWR Quality Assurance staff component is responsible for conducting overall quality system audits to assure integration of, and compliance with, the quality system within the various NED organizational components contributing to the BWR business.

6.1.2 GE Organization and Responsibilities for Boiling Water Reactor Quality Control

An abbreviated NED organization chart showing specifically the quality related functions concerned with supplying boiling water reactor (BWR) nuclear systems and components is shown as Figure D(1)-6-1. The managers of the Atomic Power Equipment Department (APED), Reactor Fuels & Reprocessing Department (RF & RD), Reactor & Fuels Manufacturing Operation (R&FMO), Nuclear Instrumentation Department (NID), and Nuclear Safety & BWR Quality Assurance Operation report either directly to the NED General Manager or to the Deputy Division General Manager.

The manager of the Nuclear Safety & BWR Quality Assurance Operation has the responsibility for integrating the quality programs for the BWR business. A BWR Quality Assurance component reporting to the Manager, Nuclear Safety & BWR Quality Assurance Operation, is a staff component assigned responsibility for establishing, documenting, and directing an overall quality system and for integrating, measuring, and auditing the quality-related work across the entire spectrum of the BWR business as conducted by line components.

A BWR Quality Council, with the Manager, BWR Quality Assurance as Chairman, provides for intra-Division communication and integration of quality assurance policies, procedures, and practices. The BWR Quality Council consists of representatives from each of the contributing organization components of the BWR business and regularly met to review status of the overall quality system and to provide management reports of quality-related activities.

On a specific project, liaison with the owner on quality-related matters is through the Project Manager in APED.

The Manager, APED Design Engineering, is responsible for establishing quality requirements for systems and components within the NED scope of supply. The respective Quality Control line organizations have responsibility for assuring compliance with these quality requirements.

The tabulation at the bottom of the following page identifies the NED management having responsibilities for attainment of the quality requirements established by APED.

Detailed designs of NED supplied nuclear systems and components, whether fabricated by NED or by manufacturers outside NED, must meet the specified nuclear system requirements. A continuity of engineering control is maintained from the conceptual design phase through material procurement, manufacturing, field installation, pre-operational testing, and plant start-up. To assure that the nuclear system requirements are met and to assure compliance with the nuclear system design and design requirements, APED Design Engineering reviews and approves the appropriate detailed design documents, including selected owner documents. APED Design Engineering has design change responsibility and authority for NED Engineering components. When detailed design is provided by RF&RD or NID Engineering, these Engineering components have detailed design change responsibility and authority. However, *APED Design Engineering approval is required if deviation in the system design or the design of other components is involved.*

Quality Control Functions Required

Type of Equipment or Component	*Overall Quality Requirements*	*Design Requirements*	*Procurement Requirements*	*Manufacture Requirements*	*QC Compliance Requirements*
	Responsible Manager				
APED Engineered Equipment (Procured)	*APED Des. Engrg.*	*APED Des. Engrg.*	*APED Procurement*	*Vendor Procedures Approved by APED Design Engineering*	*Quality Control Engineered Equipment*
Fuel	*APED Des. Engrg.*	*RF&RD Engrg.*	---	*R&FMO*	*Nuclear Fuel Mfg. QC*
Reactor Equipment	*APED Des. Engrg.*	*APED Des. Engrg.*	---	*R&FMO*	*Reactor Equip QC*
NID Manufactured Instru-mentation	*APED Des. Engrg.*	*NID Engrg.*	---	*NID Mfg.*	*MOD QC*
NID Procured Instru-mentation	*APED Des. Engrg.*	*NID Engrg.*	*NID Procurement*	*Vendor*	*NID QC*

APED Development Engineering contributes to the overall quality system by providing basic technical information and advanced inspection techniques resulting from development programs conducted.

The quality control activities related to NED manufactured products are under the direction of managers of quality control sub-sections who reported directly to the managers of manufacturing sections. The quality program for APED purchased (engineered) equipment is under the direction of the Manager, Quality Control - Engineered Equipment, and the quality program for NID procured, instrumentation is under the direction of the Manager, Quality Control, NID. Field installation of NED supplied equipment and site quality control audits (In this reference, audits are defined as overall quality system effectiveness reviews of items, records, or activities, to verify that materials and products meet applicable drawings and specifications and/or that planned processed and quality-related procedures and practices have been complied with.) of field installation quality-related activities is under the direction of the Manager, Quality Control-Engineered Equipment. Quality control managers' responsibilities were divorced from those related to production scheduling and to the meeting of production schedules.

Technical direction (Technical direction is defined as technical guidance, advice, and counsel based on current engineering and installation practices given to the owner's staff.) for field installation of NED supplied systems and components, in accordance with supplied installation instructions, is provided by the APED site resident manager and staff. Pre-operational testing and start-up engineering specialists assigned to the site resident manager have the responsibility for planning and providing technical direction for the pre-operational testing and start-up activities.

6.2 Classification of Systems and Components

6.2.1 Safety Essential

Classifications have been made of those systems and components within the GE-APED scope of supply which are considered "essential" from the standpoint of safety in that their proper functioning was required for *the prevention of postulated accidents which could affect the public health and safety, or to mitigation of their consequences.*

These systems and components will be supplied to quality standards and received commensurate quality assurance and control that reflected the classification and the importance of the safety-related function(s) to be performed.

6.2.2 Non-Safety Essential

Systems and components within the GE-APED scope of supply not classified as safety "essential" are supplied to quality standards and receive commensurate quality assurance and control that reflects the importance of the overall function(s) to be performed.

6.3 Design Control

6.3.1 General

Design review, approval, release, and change control systems are documented and are in current use in the engineering components contributing to the BWR business. System and component designs are controlled from concept through the start-up of a nuclear power plant to assure consideration for performance, safety, and reliability.

Each GE BWR is identified as a particular member or variation of the BWR "product line." Each member or variation of the BWR product line is reviewed for safety and conformance to the applicable AEC regulations prior to its being committed to sale. Quality control organizations reviewed new and revised product designs for quality requirements prior to their use for procurement or production. Since several sales may be based on a particular member of a "product line" design, it is not considered necessary to perform a review for each sale.

6.3.2 System Design

Nuclear system data sheets for a specific contract are issued by Systems Engineering of APED Design Engineering to the responsible system design organization components in Plant and Equipment Engineering in the early months following the receipt of an order. The system design controlling documents which are prepared by the responsible system design engineers typically included the system design specification, piping and instrument diagrams, process flow diagrams, function control diagrams, and the instrument engineering diagrams. These documents are issued to the owner/plant designer over a period of approximately 6 to 12 months after the receipt of an order.

The nuclear system data sheets and the system design controlling documents incorporate the design and safety requirements for each plant. It is the responsibility of the Manager, Design Engineering to conduct safety analyses and to audit the plant design to ascertain conformance to established design criteria and design safety requirements. The nuclear system data sheets and the system design controlling documents are subject to a technical review and release approval by Requisition Engineering prior to being issued as a basis for component design.

Design Engineering has issued a series of general standard design specifications which establish standard requirements for designing components which satisfy the system requirements. These standard design specifications identify the industry codes and any supplemental requirements to be utilized to assure compliance with safety criteria, quality levels, and specific requirements which APED imposes to meet acceptable reliability goals. Changes to this group of design specifications must receive the approval of all affected subsection managers with APED Design Engineering. The original issue and any changes are subject to review and release approval by Requisition Engineering.

6.3.3 Overall Design Review

An overall design review is made of the engineering work after the design documents have been issued and the owner has had an opportunity to review them for adherence to the particular contract. The overall design *review is made by a task force which is directed by the requisition engineer who is responsible for total project coordination in Design Engineering but who is not directly responsible for the generation of the systems controlling documents of the design specifications. Licensing and safety representatives participate to make a comparison with PSAR and any applicable amendments. The responsible design engineers participate in the review to provide necessary design information and to initiate and to follow through on any required changes. Following implementation of any changes required as a result of the review, the design is frozen. Following the overall design review, further changes to the system documentation will only be made for the following reasons: (1) requests by the owner for changes from the original plant sold, (2) feedback from earlier plant start-ups, or (3) other information indicating that the systems may not perform as originally designed.*

Documents covered by the overall design review are the nuclear system data sheets, system design specifications, piping and instrumentation diagrams, process flow diagrams, functional control diagrams and instrument engineering diagrams.

Prior to and following the overall design review, a change control procedure established with Design Engineering is followed. The control procedure requires documentation and approval by the requisition engineer and appropriate levels of management before a change of any system controlling document can be implemented. The responsible systems design engineer is charged with the responsibility for defining all documents affected by any such change, for coordinating with other design engineers whose documents are affected, and for obtaining the necessary approvals. Distribution is made to those responsible engineers who signed the change control document, the requisition engineer, and to personnel in other subsections who have a need to know. Changes at interfaces between the owner and APED supplied equipment are reviewed between the two parties as appropriate.

6.3.4 Component Design

The design of components is initiated in accordance with plant schedule requirements using the system data sheets, system design controlling documents, and the general design specification.

6.3.4.1 Design of APED Purchased (Engineered) Equipment

The design documentation for the GE-APED purchased items normally consists of equipment procurement specifications which specify the general requirements, purchased part drawings which show the outline and interface requirements, and specific data or project sheets which define the project-unique requirements of the equipment. The responsible design engineer approves the specifications, drawings, and data or project sheets after they have been generated, and a review is made by the requisition engineer to determine that the design documents meet unique project requirements, the plant data sheets, system design documents, and the general design specifications. Equipment purchase specifications and/or purchase part drawings and data or project sheets are reviewed by Quality Control-Engineered Equipment prior to supplier bidding.

The specification outlines the engineering documents such as drawings, procedures, and calculations which must be submitted by the supplier for review and approval by Design Engineering. Any subsequent changes to the approved vendor documents are formally reviewed and require approval by Design Engineering.

6.3.4.2 Design of Mechanical Components Manufactured by Reactor Equipment Manufacturing (R&FMO)

The design documentation for equipment manufactured by R&FMO normally consists of specific detailed product drawings augmented by design and procedure specifications necessary to fabricate, inspect, and test the finished product. Design Engineering identifies the relative importance of the various design requirements defined in the controlling documents as a guide for the quality control organization in Reactor Equipment Manufacturing in establishing the quality plan. The design engineer is responsible for having the design documents reviewed for conformance to the system design control documents and the general design specifications referenced previously before releasing them to manufacturing. This review is performed by design engineers in other components with which there is an interface plus Materials Engineering (APED), Manufacturing Engineering (Reactor Equipment Manufacturing), *and Quality Control (Reactor Equipment Manufacturing). The rigid change control system described in Section D(1)-6.3.3 applied to any changes required in component design.*

6.3.4.3 <u>Design of Fuel</u>

Nuclear system requirements for fuel are specified by APED Design Engineering and transmitted to RF&RD Engineering. These requirements are reviewed and accepted by the Fuel Engineering component of RF&RD. Detailed fuel drawings and specifications are produced by RF&RD Engineering and prior to release for manufacture, are reviewed by APED Design Engineering to assure conformance with mechanical design requirements. Reviews are also conducted by RF&RD Engineering with Manufacturing Engineering (Nuclear Fuels Manufacturing) and Quality Control (Nuclear Fuels Manufacturing) to assure compatibility with manufacturing and quality control technology and capability.

Product system requirements are transmitted from RF&RD Engineering to Nuclear Fuels Manufacturing through issuance of engineering instructions which specified applicable drawings and specifications. Changes to drawings are made through use of engineering change notices (ECN) that are reviewed for consistency within RF&RD Engineering and R&FMO components. Prior to release for manufacturing, a review is held with APED Design Engineering for consistency where required.

Design review, release, and change control systems have been developed and implemented and are documented in formal document systems.

6.3.4.4 <u>Design of Instrumentation and Controls</u>

The system design controlling documentation items supplied by NID consists of design specifications, instrument engineering diagrams, function control diagrams, piping and instrument diagrams, specification control drawings, instrument data sheets and general requirements incorporated in an instrumentation and control purchase specification prepared by APED Design Engineering. The instrument data sheets define the characteristics of the measured parameter, the instrument environment, ranges, accuracies, set points, and locations of instruments required by the system design. The responsible APED engineer is required to obtain review and approval of the drawings and documents he initiates. Reviewers normally include the requisition engineer and all APED engineers responsible for equipment with which there existed an interface. The controlling documents are measured against the requirements of the nuclear system data sheets. After the overall system design review, the final review and approval of the completed documents is by the responsible APED engineer who reviews to determine that the approved changes have been accurately and properly made. Distribution of the approved documents is to the responsible APED engineer, to the unit manager of the APED units responsible for them, to the APED requisition engineer, and to NID through APED Purchasing.

Upon receipt of the APED design controlling documentation from APED Purchasing, NID Marketing reviews the documentation package for completeness and technical content and transmits copies to NID Quality Control and to NID Requisition Engineering. NID Requisition Engineering performs the detail design which encompasses the generation of manufacturing drawings, drawings for owner use, purchased part drawings, and instruction manuals. The detail design makes use of NID standard products and purchased components. The NID standard products are design to a NID approved functional specification, qualified for performance and design adequacy by a separate testing group and reviewed for critical applications (if appropriate) by a safeguards specialist. The purchased components are bought by NID Manufacturing to purchased part drawings prepared by NID Engineering and controlled by quality control procedures similar to those discussed above for APED purchased (engineered) equipment.

Certain NID documents require review and approval by APED Design Engineering prior to the start of manufacture. Upon receipt of this approval, NID Requisition Engineering transmits the production drawings along with any special assembly and testing instructions to NID Manufacturing. NID Manufacturing orders the necessary materials and plans the shop operations. NID Quality Control plans the inspection, testing, and other quality control requirements. During and following production, NID Quality Control monitors the products to assure conformance to the drawings and specifications.

The design change control system for changes generated within NID (and which do not affect APED approved documents) is initiated with the generation of an engineering change notice (ECN) by the responsible NID engineer. The ECN is reviewed and approved by NID Engineering Release Control and by the cognizant NID design engineer. NID Manufacturing, upon receipt of the ECN acknowledges receipt and implements the change. Those changes which affect APED approved documents are transmitted to APED by NID Marketing. APED approved documents may not be changed without the approval of APED Design Engineering.

6.3.5 Field Change Control

Field changes fall into two general classes: first, those generated by design changes originating in the home office and second, those initiated in the field as a result of unique field conditions. Design changes originating in the home office are generally the result of changes in licensing requirements, changes in owner requirements, or information feedback from other plants or components being constructed, tested, started up or in operation. In this case, the responsible design engineer generates a field disposition instruction (FDI) which defines in detail the component(s) affected, the changes to be made, the parts which must have been replaced, and the disposition of parts replaced. The responsible design engineer is also responsible for providing instructions for the manufacture or procurement of the replacement parts, and for assuring that instructions are issued for other projects requiring such changes. Review and approval of the FDI is by the responsible design engineer, the requisition engineer, and project management.

Field changes initiated by field organization are generally the result of deviations from the expected construction conditions. The field organization generates a field deviation disposition request (FDDR) which identifies the deviation(s) and the proposed method for making changes in the established design to compensate for the deviation. Design Engineering is responsible to review the proposed field deviation disposition request (FDDR) for compliance with the established criteria and the performance and functional design requirements. When a proposed method for correction does not comply with these criteria and requirements, it is the responsibility of Design Engineering to disapprove the FDDR and propose an alternate, acceptable solution to the problem. Final approval of the FDDR for a given project is by the responsible design engineer, the requisition engineer, and project management.

When a FDDR indicates an inherent design problem which affects more than one project, the responsible design engineer issues appropriate FDI's to effect changes in other projects where the work had already been completed and initiated and instituted ECN changes to the basic design of plants where construction had not reached the same stage of completion.

6.4 NED Manufactured Products

6.4.1 Product Scope

NED manufactured products include such items as control rod drives, control rods, steam separators, reactor servicing equipment, nuclear fuel, and instrumentation and control systems.

6.4.2 General

A quality system encompassing the effort, equipment, procedures, policies, and management required to manufacture and deliver quality products is formally documented and implemented within the manufacturing components of NED. Prime elements of the manufacturing quality system include:

- *Preproduction quality evaluation*
- *Quality planning*
- *Purchased material control*
- *Product and process control*
- *Inspection and test*
- *Discrepant material control*
- *Training, qualification, and certification of personnel*

- *Quality information equipment control*
- *Quality information feedback and corrective action*
- *Work instructions, procedures, and drawings*
- *Identification, status, and control of material, parts, and components*
- *Special processes control*
- *Shipment release control*
- *Handling, storage, preservation, packing, and shipping control*
- *Related activities*

6.4.3 Preproduction Quality Evaluation

Preproduction quality evaluations are conducted by engineering, manufacturing, and quality control components on new and revised product designs prior to release for full production. Evaluations are conducted to assure that:

- *Design quality requirements are clearly defined.*
- *The required manufacturing equipment and processes are documented or developed to a capability consistent with product quality requirements.*
- *The quality system by which required product quality characteristics are attained, maintained, and measured, is planned, documented, and implemented.*
- *The required personnel, facilities, equipment, and materials are made ready for production and qualified where necessary.*

6.4.4 Quality Planning

Product and process quality planning is provided by NED quality control organizations for all major items manufactured or procured by manufacturing components to assure conformance with applicable drawings, specifications, acceptance criteria, and special instructions. Formally documented product and process quality planning is oriented toward assuring product operational dependability, and compliance with applicable codes and standards. The planning emphasizes prevention of discrepancies, control of materials, products, process, and procedures, corrective action, appraisal of product quality characteristics, and control of discrepant material.

Typical planning documents generated are:

- *Master product quality control plans*
- *Process quality plans*
- *Product quality control plans*
- *Receiving inspection plans for standard new material*
- *Receiving inspection plans for specific parts*
- *Purchased material quality control plans*
- *Quality control inspection instructions*
- *Quality control test instruction*
- *Quality inspection standards*
- *Audit plans*
- *Quality standing instructions*
- *Operating instructions*
- *Manufacturing administrative and operative procedures*

6.4.5 Purchased Material Control

Purchased material control is exercised for the purpose of assuring that vendor-supplied materials, equipment, and services are provided at proper quality levels and conform to the specifications of purchase.

Requests for production material are reviewed by quality control personnel before submittal for purchasing, and necessary quality requirements are added to the material request. These requirements include, where applicable, review of vendor planning, documentation required, objective evidence of quality to be supplied by the vendor, hold points for source inspection by NED quality control personnel, qualification and certification requirements, and receiving inspection coding.

Vendors selected are qualified by virtue of past performance, vendor survey, or a specific program in which the vendor is qualified by demonstrating the ability to perform. Vendors are required to maintain a quality system commensurate with design and quality assurance requirements. On certain designated items, Quality Control maintains surveillance of fabrication and testing at vendor's plants and furnishes reports of source inspections and tests.

Incoming vendor items are inspected and approved by NED quality control components in accordance with the quality requirements as specified in the purchase order, material specifications, standard practices, and receiving inspection plans.

Acceptable parts and materials are appropriately identified at receiving inspections and released for production control accumulation.

6.4.6 Product and Process Control

Product and process control activity is oriented toward assuring that quality planning is properly understood and followed, equipment and processes meet design and quality requirements, materials, parts, and components are identified and controlled, and only finished goods meeting design and quality requirements, including those of applicable codes and standards, are released for shipment. Audits are conducted to assure that quality planning is properly implemented and that products meet applicable quality requirements.

6.4.7 Inspection and Test

Receiving, in-process, and final inspection and testing are performed in compliance with planned, documented inspection and test instructions and standards to assure conformance with applicable drawings, specifications, and special instructions. As required by quality planning, inspection and test results are documented to provide objective evidence that quality requirements have been satisfied.

6.4.8 Discrepant Material Control

Quality control components document, maintain, and implement systems for the handling and control of discrepant material. These systems provide for the physical identification, segregation, documentation, and timely disposition of nonconforming materials and products. Whenever a process is performed in such a manner as to cast doubt on the acceptability of a product or whenever a material or product is found by inspection or test not to meet applicable drawings or specifications, the affected items are rejected and processed in accordance with the discrepant material control system.

6.4.9 Training, Qualification, and Certification of Personnel

Formal programs are provided for the training, qualification, and certification of shop operations and quality control personnel to assure that these individuals are qualified and certified to perform key quality-related activities including those identified in applicable codes, standards, and regulatory requirements.

6.4.10 Quality Information Equipment Control

A system has been developed, documented, and implemented to assure that gauges, instruments, and measuring devices necessary to control and measure product quality are calibrated, adjusted, repaired, or replaced in a systematic and timely manner. The system provides for calibration of such equipment against measurement standards that are traceable to national standards.

6.4.11 Quality Information Feedback and Corrective Action

Quality information feedback systems make provision for timely reporting of the overall status of product quality and quality-related plans and programs to management and others having quality system responsibility. Quality information feedback provides input for the initiation of corrective action deemed necessary to correct or improve quality system performance.

6.4.12 Work Instructions, Procedures, and Drawings

The NED quality system provides for the documentation, in formally controlled document systems, of those work instructions, procedures, and drawings having an affect on product quality.

6.4.13 Identification, Status, and Control of Materials, Parts, and Components

The NED quality system provides the appropriate identification and control of materials, parts, and components from receiving inspection through fabrication steps to assure that only finished goods that meet quality requirements are released for shipment. The system is designed to assure that incorrect or defective items are not incorporated in the product and that the inspection and test status of raw, in-process, and finished goods is known at all times.

6.4.14 Control of Special Processes

Special processes such as welding, heat treating, cleaning, and nondestructive testing are controlled by formalized procedures and practices. The quality system provides for performance of such special processes by qualified personnel using qualified procedures in accordance with applicable codes, standards, regulatory criteria, and other special instructions.

6.4.15 Shipment Release Control

A product quality check list system is used by quality control components to assure that significant quality-related work elements are completed prior to product shipment release. A responsible engineer reviews and verifies by signature that items on the check list have been accomplished and that the product is suitable for shipment.

6.4.16 Handling, Storage, Preservation, Packing, and Shipping Control

The quality system for NED manufactured products provides for control of the handling, storage, preservation, packing, and shipping of supplied systems and equipment to prevent their inadvertent damage or deterioration prior to delivery to the owner.

6.4.17 Related Activities

Related quality control activities such as special quality studies, post-production quality service, record accumulation and maintenance, and management of the quality control functions are a part of the quality system and are documented in formal document systems.

6.5 APED Purchased (Engineered) Equipment

6.5.1 Product Scope

APED purchased equipment include such items as the reactor pressure vessels and internals, pumps, motors, piping, valves, and heat exchangers.

6.5.2 General

The quality system for engineered equipment is initiated with the review of purchase specifications and/or purchased part drawings and data or project sheets, and is implemented during vendor selection, and during phases of vendor design, fabrication, test, inspection, cleaning, and packaging.

Quality system policies, procedures, or instructions are documented for the following:

- *Advance review of purchase specifications*
- *Quality control plans for engineered equipment*
- *Implementation of quality control plan on bid requests and purchase orders*
- *Vendor evaluation and selection*
- *Product quality control check lists*
- *Document change control*
- *Review and approval of special processes*
- *Non-conforming material control*
- *Quality information feedback*
- *Shipment release control*

6.5.3 Quality Planning

Quality control plans are issued by Quality Control - Engineered Equipment for all major components, are directly referenced in bid requests and purchase orders, and are designed to complement and assure conformance with the purchase specifications and drawings. Design Engineering reviews the quality control plans prior to issuance.

Quality control plans require that the vendor establish and maintain a quality system commensurate with the complexity and importance of the component. Major equipment suppliers are required to demonstrate adequate control in areas such as:

- *Document change control*
- *Preproduction quality planning*
- *Purchased material quality control*
- *Material identification*
- *Control of processes such as welding, heat treating, cleaning, and nondestructive examination*
- *Qualification of equipment, procedures, and operators*
- *Product quality records*
- *Deviating material*
- *Calibration of measurement equipment*
- *Handling, storage, preservation, packing, and shipping*

6.5.4 Quality Implementation

Responsibility for quality planning and implementation for purchase equipment is assigned to Quality Control - Engineered Equipment. Quality control engineers and quality control field representatives within Quality Control - Engineered Equipment are typically assigned responsibilities as listed below:

(a) Quality Control Engineers

- *Conduct preprocurement reviews with Design Engineering and Procurement to ensure clear understanding of quality requirements.*

- *Provide quality-related review of design specifications, drawings, manufacturing procedures, and quality control procedures.*

- *Establish quality control plans and check lists which define quality audit requirements to vendors and the quality control representative.*

- *Conduct or direct preproduction reviews with vendor personnel to assure clear and mutual understanding of quality requirements.*

- *Provide technical guidance to the quality control field representatives.*

- *Audit the vendor quality control program before and during fabrication.*

- *Review quality problems encountered during fabrication and during or after installation or equipment, and initiate corrective action.*

(b) Quality Control Field Representatives

- *Review purchase specifications and drawings.*

- *Conduct preproduction reviews with vendor personnel to assure mutual understanding of quality requirements.*

- *Review vendors' detail drawings and manufacturing and quality control procedures.*

- *Review vendors' detailed fabrication process sheets to assure proper sequencing and adequate in-process inspection, test, and control.*

- *Witness and audit the various qualifications, tests, and inspections.*

- *Audit cleaning, preserving, packing, and packaging activities.*

- *Audit vendor conformance with established procedures such as:*

  - *Product and process quality planning*
  - *Document change control*
  - *Deviating material control*
  - *Material identification and traceability*
  - *Calibration of measuring equipment*

- *Complete product quality lists prior to release of assigned equipment.*

6.5.5 Discrepant Material Control

APED Design Engineering and Quality Control - Engineered Equipment review and approve all vendor deviations from specified requirements. When it is inappropriate to revise the approved drawings, specifications, or procedures, a deviation disposition request (DDR) form or equivalent vendor form is used to formally document and control deviation approvals.

6.5.6 Product Quality Check Lists

A product quality check-list system is used on engineered equipment as a means of assuring systematic verification of vendor conformance during fabrication and prior to release for shipment. The check lists summarizes the quality verification performed during and after fabrication, test, and inspection of purchased equipment.

Examples of items verified on the check list are:

- *Use of approved drawings and specifications*
- *Use of approved welding, heat treating, cleaning, and nondestructive examination procedures*
- *Procedure and operator qualification*
- *Material test results*
- *Dimensional measurements*
- *Radiographs and other examination results*
- *Performance testing*
- *Heat treatment*
- *Cleaning*
- *Deviation approvals*
- *Product Quality records*

On selected equipment, the use of product quality check lists is extended to include verification of materials such as castings, forgings, pipe fittings, and plate.

The APED quality control representatives date and initial each check list. All items on the check list are verified prior to APED release for shipment unless specific arrangements are made to complete fabrication and/or verification after shipment. Such arrangements must have the advance approval of the project manager and the Manager-Quality Control - Engineered Equipment. A copy of each completed check list is forwarded to the project manager and other NED personnel, as required.

6.6 NED Installation Control

6.6.1 General

It is the responsibility of NED to deliver systems and components to a predesignated location. It is the responsibility of the owner to receive and install the supplied equipment. NED provides technical direction as required by the contract. The following paragraphs identify those contributions to installation quality controls made by NED.

6.6.2 Component Receiving, Inspection, Handling, and Storage Control

Instructions for site receiving, inspection, handling, and storage control are provided by NED for the equipment and components supplied by NED.

6.6.3 Installation Instructions

Separate Installation Instructions or installation instructions included in Operation and Maintenance Manuals will be supplied for assemblies and equipment within the NED scope of supply. NED will supply installation Instructions for: the reactor recirculation piping, the primary steam piping, and the reactor vessel and internals. These installation instructions, which are reviewed by Quality Control and reviewed and approved by the responsible Design Engineering component, define the requirements which must be met for the installation, examination, and testing of the system and interconnecting weld joints of piping or components.

NED will supply Cleaning Instructions for systems and equipment within the NED scope of supply.

NED technical specialists provide technical direction for the field installation and cleaning of systems and equipment within the NED scope of supply. Audit of the field installation and cleaning is provided by NED to assure that the requirements of the Installation Instructions, Cleaning Instructions, and Operation and Maintenance Manuals are met.

6.6.4 Technical Direction

The site resident manager and staff provide technical direction of the installation of NED-supplied equipment and components in accordance with the contract and applicable NED installation instructions. Technical direction is technical guidance, advice, and counsel, based upon current engineering and installation practices, given to the owner's staff. The objective of the technical direction is to assure that supplied nuclear systems and equipment are properly installed by the owner or his agents.

6.6.5 Quality Planning and Implementation

Quality planning is provided by the owner to meet the quality criteria objectives of the installation specifications and instructions provided by NED.

Responsibility for the NED contribution to installation quality control, which is to provide quality requirements and audit of the owner's quality activity, is assigned to Quality Control - Engineered Equipment. This organization provides quality control engineers who are assigned responsibility for planning and directing the installation-related quality activity. Quality control site representatives are provided and are responsible for assuming proper understanding of, and conformance with, the requirements of NED. Although the quality control site representatives are members of Quality Control - Engineered Equipment, they work closely with the site resident manager and receive their project oriented administrative guidance from him. Typical activities assigned to the quality control engineer and the quality control site representative are as follows.

6.6.5.1 Quality Control Engineer Activity

- *Conduct preinstallation reviews with the responsible Design Engineering components, installation technical specialist, and quality control management to ensure clear delineation and understanding of NED quality requirements.*
- *Provides quality-related review of detailed drawings, specifications, installation instructions, and procedures.*
- *Reviews adequacy of owner's installation quality control plan with respect to NED-supplied equipment.*
- *Develops plans for APED audit of installation quality activities.*
- *Provides guidance to the quality control site representative.*
- *Audits the owner/constructors' site control program.*

6.6.5.2 Quality Control Site Representative Activity

- *For NED-supplied equipment, conducts quality-related review of NED-approved drawings, specifications, instructions, procedures, and manuals.*
- *Conducts preinstallation reviews with APED site resident manager, technical specialists, and the owner's Quality Control representative to ensure mutual understanding of quality requirements.*

- *Reviews NED installation instructions and owner/constructors' procedures to ensure proper sequence and adequate in-process inspection and control.*
- *Audits conformance with owner/constructors' installation procedures and in-process controls.*
- *Reviews quality control records.*
- *Witnesses and audits the various installation test, qualifications, and inspections.*
- *Ensures orderly processing and formal disposition of quality-related discrepancies and deviations.*

6.7 Preoperational Testing

6.7.1 General

The nuclear system is made operational by the owner under the technical direction of NED as required by the contract. To implement technical direction, NED provides preoperational test specifications and instructions for NED-supplied systems and equipment.

6.7.2 Preoperational Test Specifications and Instructions

Preoperational test specifications identify the systems and equipment which must be tested and state the requirements of the tests necessary to assure safe performance during testing. Test specifications are reviewed and approved by the responsible design engineering component prior to release.

Preoperational test instructions provide the necessary information and the essential steps to be taken to fulfill the requirements of the preoperational test specifications.

6.7.3 Preoperational Test Implementation

As provided by the contract, NED supplies field engineers with extensive product knowledge and wide start-up experience, to provide technical direction of the preoperational tests.

6.7.4 Preoperational Testing Check-Off

Upon completion of preoperational tests, the NED technical specialist and an owner representative formally check-off that the tests have been completed and the results are in accordance with applicable specifications and instructions.

6.8 Plant Start-Up

6.8.1 General

Initial fuel loading, nuclear system start-up, and operational testing is performed by the owner under the technical direction of NED personnel. To facilitate technical direction of initial fuel loading and power testing, start-up test specifications, calculations, and instructions are provided by NED.

6.8.2 Start-Up Test Specifications, Calculations, and Instructions

Start-up test specifications define the minimum test program for safe and efficient start-up and authorize and require the performance of the described tests. The specifications limit and define the freedom for changes *during the start-up test activities and are reviewed and approved by the responsible design engineering component. Each required test must be performed to the extent specified.*

Start-up test calculations contain the results of analyses made to facilitate start-up testing activities required by the start-up test specifications.

Start-up test instructions present the recommended test method and describe the steps necessary to perform the test defined in the start-up test specification. Other test methods may be employed. However, the resulting data must be equivalent in quality and quantity to the data which would result from the recommended test method. The start-up test instructions also contain criteria for judging the test results, where applicable, and data and calculation sheets for site analysis of the data.

6.8.3 Technical Direction

NED supplies field engineers with extensive product knowledge and wide start-up experience to provide technical direction for the start-up test program. Results of the start-up test program are analyzed at the reactor site as the data becomes available and periodic reports of the results of the program are issued during the course of testing activities.

6.8.4 Start-Up Testing Check-Off

Upon completion of start-up testing, the NED field engineers and an owner representative formally check off that the start-up tests have been completed and report that the results meet the intent of the specifications, calculations, and instructions.

6.9 Quality Records

6.9.1 General

For essential items of equipment under the NED scope of supply for which there are no code requirements for record retention or transmittal, designated quality records such as "as built" outline drawings, purchase specifications, material specifications, inspection and test data are provided to, or provisions made for maintenance for the owner, in accordance with the contractual agreement with the owner.

For items of equipment under the NED scope of supply for which there are code requirements for record retention or transmittal, the requirements of the codes in effect at the time of placement of the order for the equipment component are followed. Further, the owner is advised of any record requirements in codes which have been issued prior to component order placement, but which are not yet mandatory, and given the option of obtaining such records.

7.0 PREOPERATIONAL TESTING

7.1 Introduction

Adequacy of design is verified by a series of preoperational tests performed by the Nebraska Public Power District with assistance from the General Electric Company for the Nuclear Steam Supply System and Burns & Roe for the Balance of Plant. Prior to preoperational testing, a series of construction tests will be performed. Flow sheets for development, performance, and evaluation of the construction tests and preoperational tests are included as Figures D(1)-7-1 and D(1)-7-2.

7.2 Construction Tests

Construction tests are performed by the contractor responsible for installation of the equipment. Stearns-Roger Quality Assurance will witness these tests and certify that the equipment mets contractural requirements.

Construction tests, where required, include but are not limited to the following examples:

1. *Containment over pressure test.*

2. *System hydrostatic tests.*

3. *Cleaning, flushing, and leak testing - piping and equipment.*

4. *Nondestructive testing of field welds.*

5. *Electrical system tests, e.g., checking grounding, checking circuit breaker operation and controls, continuity checks, and megger tests.*

6. *Initial adjustment and bumping of motors.*

7. *Check control and interlock functions to verify wiring and/or pneumatic tubing per design.*

8. *Pneumatic test of instrument and service air system and blow out of lines.*

9. *Adjustments such as alignment, lubrication of equipment, and tightening of bolts.*

10. *Tests of motor-operated valves including adjusting limitorque switches and limit switches, measuring operating speed, and checking leak tightness of stem packing.*

11. *Tests of air-operated valves including pilot solenoids, adjusting limit switches, measuring operating speed, checking leak tightness of stem packing and valve seat during hydrotests, and checking leak-tightness of pneumatic operators.*

7.3 Preoperational Tests

Following acceptance as a result of successful construction tests, the various systems will be subjected to a series of preoperational tests by the Nebraska Public Power District Operating Group. These preoperational tests will have been prepared by Burns & Roe Engineering personnel augmented with trained District personnel. The basis for the tests will be systems descriptions provided by General Electric for the Nuclear Steam Supply System and Burns & Roe Engineering for the Balance of Plant. Procedure approval, authorization to perform, certification of completion, and certification of test results will be recorded on the cover sheet for each preoperational test procedure, a sample of which is included as Figure D(1)-7-3. After the calibrations on specific systems, as discussed in Section D(1)-7.4, are completed, the following preoperational tests will be performed:

Reactor Safety and Relief Valves
Containment Isolation
Control Rod Drive Hydraulic System
Control Rod Drive Manual Control
Reactor Recirculation System
Reactor Core Isolation Cooling System
Residual Heat Removal System
Reactor Water Cleanup System
Standby Liquid Control System
Core Spray System
Fuel Pool Cooling and Filter Demineralizer System
Fuel Handling and Vessel Servicing Equipment
High Pressure Coolant Injection System
Feedwater Control System
Reactor Protection System
Neutron Monitoring System
TIP Calibration System
Process Radiation Monitoring
Area Radiation Monitoring
Nuclear System Leak Detection
Rod Worth Minimizer
Process Computer
Dry Well and Suppression System Leak Rate
Containment Inerting System
Turbine Lube Oil System Transfer and Oil Purification
Turbine Control and Instrumentation
Turbine Drains, Extraction, and Steam Valves
Generator Cooling
Generator Excitation System
Condenser and Auxiliaries
Condensate and Feedwater System
Main Circulating Water System, Screen Wash, and Trash Rake
Service Water System
Condensate Filter Demineralizer System
Plant Make-Up Water Treatment System
Turbine Building Closed Cooling Water System
Reactor Building Closed Cooling Water System
Instrument and Service Air System
Plant Fire Protection System
Plant Heating Boiler
Reactor Building Ventilation Systems
Turbine Building Ventilation Systems
Diesel Generator Building Ventilation Systems
Heating Boiler Building Ventilation Systems
Water Treatment Room Ventilation Systems
Machine Shop Ventilation Systems
Control Building Ventilation Systems
Radwaste Building Ventilation Systems
Office Building Ventilation and Air Conditioning
Computer Room Air Conditioning
Main Control Room Air Conditioning
Intake Structure Ventilation Systems
Change Area Ventilation Systems
Drywell Cooling and Ventilation
Standby Gas Treatment System/Reactor Building Leak Rate
Condensate and Demineralized Water Storage and Demineralized Water Transfer System
Radioactive waste Disposal System

Standby Diesel Generator
Plant Communications System
Electrical Auxiliary Power Systems
Isolated Phase Bus Duct Cooling System
D.C. Power Systems

7.4 *<u>Instrument Calibration</u>*

Prior to preoperational testing, the District will inspect the test instrumentation for adequacy and perform or witness all calibrations on this equipment. Specific systems which will then be calibrated and tested by District personnel include:

Neutron Monitoring System
Process Radiation Monitoring System
Area Radiation Monitoring System
Process Computer
Main Turbine Electro-Hydraulic Control
Reactor Recirculation Control System
Feedwater Control System
Reactor Protection System
Control Rod Drive Scram Test

Typically, various instruments are calibrated using the following techniques:

All instruments shall be checked at approximately each 10% of range. Where several instruments are used to produce the necessary indication, the final unit, such as a receiver-indicator and/or recorder, shall be calibrated first and the transmitter last. After the transmitter is calibrated and before disconnecting the test equipment, a system calibration shall be performed with all the instruments from the transmitter to the receiver connected for normal operation. The system calibration check shall also be performed at approximately each 10% of range.

On instruments with a milliampere input and/or output, the signal shall be checked by measuring the millivolt signal across a test resistor with a potentiometer or digital voltmeter.

Low pressure instruments shall be calibrated using a pneumatic loader with a digital indicator, test gage, or manometer.

High pressure instruments shall be calibrated using a dead weight tester.

Thermocouple instruments shall be calibrated using a temperature potentiometer.

RTD instruments shall be calibrated using a decade resistance box.

Thermocouples and RTD's shall be checked for accuracy by comparison to a calibrated RTD. When connected to the instrument, a check shall be made for upscale indication when load is applied.

Source range neutron monitors shall be calibrated using a pulse generator and electronic counter.

Intermediate range neutron monitors shall be calibrated using a wide range oscillator and RMS voltmeter.

Power range neutron monitors shall be calibrated using a current source.

Area radiation monitors shall be calibrated using a pulse generator and electronic counter. Final check shall be made with a known gamma radiation source.

The above does not include all instrumentation involved but will serve as examples of the method of performing instrument calibration.

8.0 COMPARISON OF COOPER NUCLEAR QUALITY ASSURANCE WITH AEC QUALITY ASSURANCE CRITERIA

8.1 Organization

The Cooper Nuclear Station Quality Assurance Program as set forth establishes the organization and the means of implementation to satisfy the requirements of these criteria.

The program defines the authority and duties of persons and organizations performing quality assurance functions and provides the organizational freedom to perform them. The organization described provides the Owner the capability to define quality problems, to initiate, recommend or provide solutions, and to verify the implementation of solutions.

8.2 Quality Assurance Program

The implementation of the program described herein provides the required quality assurance control. This is accomplished by design review, verification, inspection, and documentation over activities affecting the quality of identified structures, systems, and components to an extent consistent with their importance to safety.

8.3 Design Control

Design control for the nuclear steam supply is the responsibility of the supplier, General Electric Company. Control of design for the balance of the plant is the responsibility of the engineer, Burns and Roe. The methods by which control of design is performed to meet this criteria are described in Sections D(1)-4 and D(1)-6.

The design requirements affecting quality are made a part of the contract specifications which are subsequently developed into specifications, procedures, instructions, and drawings by each contractor and his suppliers. Quality assurance review of these documents and performance of the work as described under D(1)-3.3, D(1)-3.4, D(1)-3.5, and D(1)-3.6 adequately meets the requirements for this criteria.

8.4 Procurement Document Control

The requirements of this criteria are met by the review described under D(1)-3.4.1, D(1)-3.4.2.2, D(1)-3.5.1, and D(1)-3.5.2.2.

8.5 Instructions Procedures, and Drawings

The requirements for, and the review and audit of, working documents for quality control are adequately covered by the pre-production and in-process document reviews for both manufactured items and field construction and fabrication. These activities are described in D(1)- 3.4 and D(1)-3.5.

8.6 Document Control

This criteria is satisfied by the document control requirements set forth in D(1)-3.4.1.4 and D(1)-3.5.1. This is further supplemented by the in-process inspection audit described under D(1)-3.4.3 and D(1)-3.5.3. Overall project document control is described under D(1)-3.7.

8.7 Control of Purchased Material, Equipment, and Services

The various activities of the quality assurance program described under D(1)-3.3, D(1)-3.4.1, D(1)-3.4.2.2, D(1)-3.4.3, D(1)-3.5.1, D(1)-3.5.2.2, D(1)-3.4.2.3, D(1)-3.5.3, and D(1)-3.6.3 meet the requirements for this control criteria.

8.8 Identification and Control of Materials, Parts, and Components

Requirements for identification of material, parts, and components are initially covered by contract specification requirements reviewed under D(1)-3.3. Detailed requirements are once again established by the requirements of the contractor's quality control plans as defined under D(1)-3.4.1 and D(1)-3.5.1. Continuing audit, review, and inspection of work as described under D(1)-3.4.3 and D(1)-3.5.3 provided a final check that requirements of this criteria are being met.

8.9 Control of Special Processes

The review of contract specification requirements described under D(1)-3.3 assures establishment of applicable codes, standards, and other specific affecting special processes. Review and approval of contractor's and vendor's procedures under D(1)-3.4.2.1 and D(1)-3.5.2.1 and audit and inspection of his work under D(1)-3.4.3 and D(1)-3.5.3 provides the program control required here.

8.10 Inspection

Contract specification requirements for inspection are reviewed and established under D(1)-3.4. These requirements are implemented by in-process and final inspections as described under D(1)- 3.4.3, D(1)-3.4.4, D(1)-3.5.3, D(1)-3.5.4, D(1)-3.6.1, D(1)-3.6.2, D(1)- 3.6.3, and D(1)-3.8.

8.11 Test Control

Control of testing is covered by many facets of the quality assurance program. Initial action is performed during review and approval of the contractor's quality control plans as covered by D(1)- 3.4.1 and D(1)-3.5.1. Specific performance testing, hydrotest, leak test, etc., are reviewed once again under D(1)-3.4.4 and D(1)-3.5.4. All of these operations include the requirements for written test procedures and test documentation.

Preoperational testing of completed systems and installed components is covered under D(1)-7.0.

8.12 Calibration of Measurements and Test Equipment

Requirements for calibration of measurement and test equipment are covered by contractor's quality control plans and final testing and inspection as described in D(1)-3.4.1, D(1)-3.4.2.5, D(1)-3.4.3, D(1)- 3.4.4, D(1)-3.5.1, D(1)-3.5.2.5, D(1)-3.5.3, and D(1)-3.5.4.

Calibration of equipment for preoperational testing is covered under D(1)-7.0.

8.13 Handling, Storage, Shipping, and Preservation

This criterion is met by program items D(1)-3.4.2.1, D(1)- 3.4.4.2, D(1)-3.5.2.1, D(1)-3.5.4, D(1)-3.6.1, and D(1)-7.0.

8.14 Inspection, Test, and Operating Status

Each of the contractor's quality control plans provides for a method of identifying the inspection and test status of each item. These requirements are also included in the site receiving and inspection procedure. The requirements are described under D(1)-3.4.1, D(1)-3.4.2.5, D(1)-3.4.3, D(1)-3.4.4, D(1)-3.5.1, D(1)-3.5.2.5, D(1)-3.5.3, D(1)-3.5.4, D(1)-3.6.1.1, D(1)-3.7, and D(1)-3.8.

Status of preoperational tests in covered in D(1)-7.0.

8.15 Non-Conforming Material, Parts, and Components

Procedures for identification, documentation, segregation, disposition, and notification of affected parties are included as a requirement of all contractor's quality control plans as described under D(1)-3.4.1 and D(1)-3.5.1. The requirements of this criterion are further described for the entire project under D(1)-3.8.

8.16 Corrective Action

The requirements of this criterion are incorporated into all phases of the program along with handling of non-conforming material. The program references of D(1)-8.15 apply here also.

8.17 Quality Assurance Records

The entire quality assurance program is designed to produce the required in-process and final records. See items D(1)-3.7 and D(1)- 3.9.

8.18 Audits

Quality audits under this program are performed both at the contractor's plants and at the jobsite. These are described under D(1)- 3.4.3, D(1)-3.4.4, D(1)-3.5.3, D(1)-3.5.4, D(1)-3.6, D(1)-3.7, and D(1)- 3.8.