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**Programme in the Construction
of a Nuclear Facility**

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QUALITY CONTROL PROGRAMME IN THE CONSTRUCTION OF A NUCLEAR FACILITY

By

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SYNOPSIS

Amongst different construction works, the construction of a nuclear facility is highly sensitive from public safety point of view, and consequently requires Quality Assurance Programme commensurate with requirements laid down by the body certifying it to be safe for operation.

The programme assures practices, procedures to be adopted by which the structures, systems and components important to safety are designed, fabricated, erected and tested to adequate quality standards. The most important part of a programme is the maintenance, upkeep and accuracy of records and documentation of each vital step during the construction phase. Audit of this quality assurance programme is a continuous process which assures its efficiency and workability.

Procedures have to be developed to provide in details How-to-do of each work, and the work has to be performed by qualified personnel as specified. Each work has to be subsequently tested to approved standards with equipment of sufficient accuracy as desired in the specifications. All the construction materials must be tested to be in conformance to the required standards before they are used in the construction.

Any non-conformance, deviation from the approved work has to be identified and a corrective action is required to be taken, so that the item must be restored to a condition such that the capability of that item to function is not affected even though the item may not conform to the original shape or form. A subsequent verification of repair and check by quality assurances shall follow.

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Introduction

Amongst different construction works, the construction of a nuclear facility is highly sensitive from public safety point of view, and consequently requires a quality assurance programme that would satisfy the requirement laid down by the body or the authority certifying it be safe for operation.

The purpose of this paper is to high light guide lines concernng the execution of a Quality Assurance Programme in the construction phase of a nuclear installation. Basically the idea is to spell out good practives to be used to assure that structure, system and components important to safety are designed, fabricated, crected and tested to adequate quality standards.

The most important part of the quality assurance programme is the maintenances, upkeep and accuracy of records an documentation of each vital step during the construction phase.

Audit of this programme is a continuous process of overseeing the work of Quality Assurance, its workability and efficiency, consistent with requirement as laid down by the regulatory body.

The term construction as used in the section-III of the ASME, Boiler and pressure Vessel code states that,

“Construction as used in this esction of the code is an all inclusive term comprising materials, design, fabrication, examinations, testing, inspection and certification required in the manu-
facture and istallation of components, parts and appurtenances”.

But in the following pages, discussion shall be limited to the installation, inspection and testing of structural concrete in the construction of a nuclear facility only.

General Requirements

Documentation

Documentation of installation, inspection and Testing Operations has to be maintained to verify their conformance to the specified requirements. Procedures have to be developed which will ensure the preparation of such documentation.

The specification, drawings and material lists must be reviewed to make certain that provision for inspection and testings have been adequately accounted for therein.

Procedures

Procedures and work instructions be developed to document the activities falling within the scope of the guide lines. These procedures are to be comprehensive, providing in detail How-to-do of the each item of work required to be done in theprpcess of construction. The procedures shall be updated and kept current as necessary.

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Procedures shall also be developed to delineate methods to retrieve records and that they are identifiable. The retention, Security and Storage facilities of records must also be specified.

Test Results

The inspection and test results shall be compiled in a test report. It will include an evaluation of the acceptability of inspection and test results and identify the individual who performed the test.

Personnel

The personnel performing the tests shall be properly qualified individuals, who have been particularly trained in the performance of a particular test such as performing non-destructive examinations.

Test Equipment

The measuring and test equipment shall be properly calibrated and of quality which provides sufficient accuracy as desired in the specifications.

Verification of Construction Materials

Before a material is used at site, it is imperative that it is checked to be in accordance with the specified requirements and in a satisfactory condition for installation. Verification shall include;

1. Visual examination.
2. Review of manufacturers documentations, tests, reports and other evidence of quality conformance.
3. Performance of qualification test to assure its conformance to specifications.

The construction materials, viz, Concrete Aggregates, Cement, Admixtures, Fly Ash Pozzolans, Water and Ice, liquid membrane forming curing compounds, sheet materials for concrete curing, concrete mixes and reinforcement must be tested to be in accordance with required specifications.

Pre-Requisites

Inspections shall be performed to ensure that prerequisites for control of construction such as welding, bolting, structural reinforcement, splicing and curing have been accomplished. These inspections shall include verifications that;

- 1) The process has been qualified as required.
- 2) The process controls are in effect.
- 3) Qualified procedures, instruction manual or both, if required for specific equipment, are available for use during construction.
- 4) The process is suitable for particular application.
- 5) Manpower, equipment and materials are readily available and adequate to perform the work in accordance with drawings and specifications requirements.

Concrete Construction Inspection

General

It shall be assured during concrete construction that inspection for proper storage conditions and handling techniques of materials, inspection for measuring and mixing, transporting, placing, curing, and in process testing is being carried out to assure conformance to specified requirements.

The purpose of this paper is not to delineate actual testing procedures, but to provide guideline as required in the Quality Assurance Programme. Therefore, only the requirements of a particular test have been given. Test methods prescribed by the pertinent ASTM designation have also been mentioned, but equivalent test methods prescribed by any other code or standard as outlined in the specifications may be employed.

Materials

Inspections have to be performed to verify that the materials are properly stored. This would include; inspection of cement to verify that it is not damp, aggregates to verify that they are free from deleterious material and mud, and moreover, adequate water supply is available to assure regular supply of concrete.

Measuring and Mixing of Concrete

The proper apportioning of concrete must be assured, devices for measuring and weighing must be checked to assure that proportions of cement, aggregates and water are in accordance with the specified requirement, mixing time and water temperatures are controlled to specified requirement.

Concrete Placements

Concrete placement should be carefully monitored to keep the rate of placing and placing sequences under control and according to specifications. The hot and cold weather concreting practices must be observed.

The concrete is to be compacted properly by approved devices, such as vibrators and that unwanted materials are not embedded in the concrete. Proper care is exercised in keeping clearances from reinforcements as specified.

Concrete must be finished by approved devices only, such as steel trowels or wood floats. The final finish after removal of work should be free of voids and honeycombing and as specified. Appropriate repairs should be made to the affected surfaces as per approved procedures.

Curing

Curing is an extremely important sequence in the construction process. It must be ensured that curing is performed as per approved method, which has been specified, such as use of wet burlap, ponding or curing compound. It must be ensured that curing temperature is maintained during the period of curing. It should be observed that shuttering is not removed until the concrete has reached the specified strength.

Testing of Concrete and Steel Reinforcement

Testing of concrete shall be performed to ensure control during construction, according to specified requirement.

A list of usual tests for concrete, aggregates, admixtures, fly ash pozzolans, cement and reinforcement are given below. This is, however, not an all inclusive list.

Only the requirements of a particular in-process test have been given and the actual test method and the details of the test have not been provided, because it is not within the scope of this paper.

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S. No.	Material	Requirement	ASTM designation for test	Remarks	
1.	Concrete	Sampling method	ASTM C - 172	A minimum of two cylind for each 50 cu. yards of concrete. The minimum strength shall be 3000 psi after 28 days.	
		Compressive Strength			
		Slump	ASTM C - 143		One test for each 50 cu yard and it shall not be less than 1" nor more than 3"
		Air Content	ASTM C - 173		To be taken with each set of compressive cylinders.
		Temperature			To be taken for each 50 cu yards of concrete.
		Unit weight	ASTM C - 138		
2.	Grout	Compressive Stength	ASTM C - 109		
3.	Aggregates	Gradation	ASTM C - 136		
		Moisture Content	ASTM C - 566		
		Organic Impurities	ASTM C - 40		
		Light weight pieces.	ASTM C - 123		
		Los Angles	ASTM C - 131 or		
		Abrasion test.	C - 535		
Potential	ASTM C - 289				
Reactivity Soundness	ASTM C - 88				
4.	Admixtures	Chemical composition.			
5.	Fly Ash & Pozzolans	Chemical and physical properties.	ASTM C - 311		
6.	Cement	Standard physical and Chemical properties.	ASTM C - 150		
7.	Reinforcing steel	Physical properties of full section test specimen.	ASTM A - 370	One test for each 50 tons. The minimum yield strength shall be as specified such as 36 KSI for A-36	

Non-Conformances

A procedure shall be developed to deal with materials or the actual construction which is not conforming to the required specifications.

The purchaser and supplier shall document measures for the identification, control and disposition of items and services that do not meet procurement document requirements.

The procedure should include but is not limited to the identification of non-conformance, its verification by QA personnel, and the subsequent corrective action required which may be, accept as is, Repair or Replace as the case may be. The item must be however restored to a condition such that the capability of item to function is not affected even though the item may not conform to the original form or shape.

A verification of repair and check by Quality Assurance shall follow.

SUGGESTED LIST OF REFERENCE DOCUMENTS

American Concrete Institute

ACI 211	Recommended Practice for Selecting Proportions for No Slump Concrete.
ACI 211.1	Recommended Practice for Selecting Proportions for Normal Weight Concrete.
ACI 211.2	Recommended Practice for Selecting Proportions for Structural Lightweight Concrete.
ACI 214	Recommended Practice for Evaluation of Compression Test Results of Field Concrete.
ACI 304	Recommended Practice for Measuring, Mixing, and Placing Concrete.
ACI 305	Recommended Practice for Hot Weather Concreting.
ACI 306	Recommended Practice for Cold Weather Concreting.
ACI 311	Recommended Practice for Concrete Inspection.
ACI 318	Building Code Requirements for Reinforced Concrete.
T - 26	Method of Test for Quality of Water to be Used in Concrete.

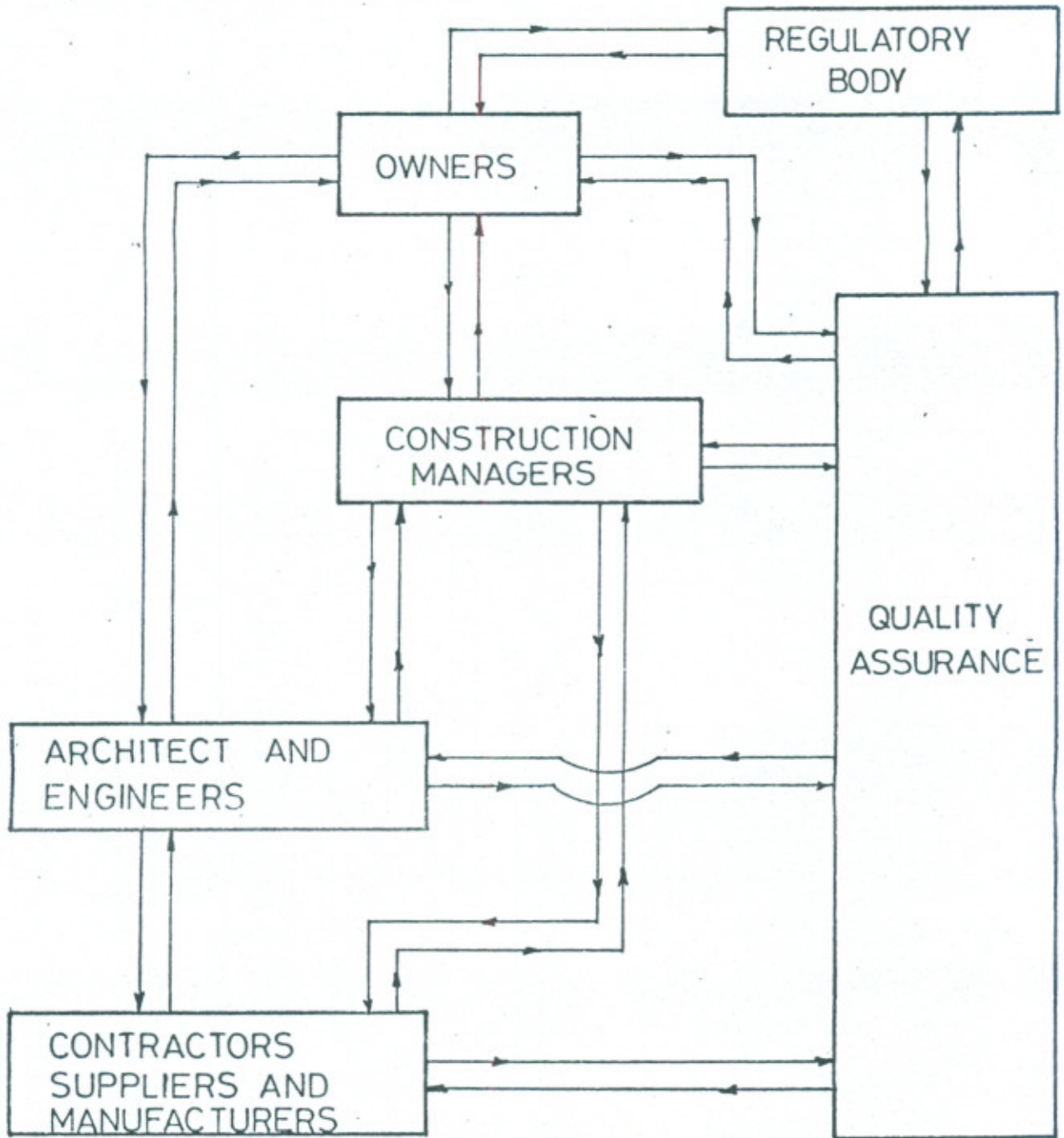
American Institution of Steel Construction

AISC, 8th Edition Manual of Steel Construction

American Society for Testing and Materials

ASTM A - 36	Structural Steel
ASTM C - 33	Standard Specification for Concrete Aggregates.
ASTM C - 39	Test for Compressive Strength of Molded Concrete.
ASTM C - 40	Test for Organic Impurities in Sands for Concrete.
ASTM C - 88	Test for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
ASTM C - 94	Standard Specification for Ready Mixed Concrete.
ASTM C - 117	Test for Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washi ⁿ .
ASTM C - 123	Test for Lightweight Pieces in Aggregate.

ASTM C - 131	Test for Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine.
ASTM C - 136	Test for Sieve or Screen Analysis of Fine and Coarse Aggregates.
ASTM C - 138	Tentative Method of Test for Unit Weight, Yield and Air Content (Gravimetric) of Concrete.
ASTM C - 142	Test for Friable Particles in Aggregates.
ASTM C - 143	Test for Slump of Portland Cement Concrete
ASTM C - 150	Specification for Portland Cement
ASTM C - 171	Specification for Sheet Materials for Curing Concrete.
ASTM C - 172	Sampling Fresh Concrete
ASTM C - 173	Test for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C - 183	Standard Methods of Sampling Hydraulic Cement
ASTM C - 191	Time of Setting of Hydraulic Cement by Vicat Needle.
ASTM C - 192	Making and Curing Concrete Test Specimen in the Laboratory.
ASTM C - 231	Test for Air Content of Freshly Mixed Concrete by the Pressure Method.
ASTM C-235	Standard Method of Test for Scratch Hardness of Coarse.
ASTM C - 260	Standard Specification for Air Entraining Admixture for Concrete.
ASTM C - 289	Standard Method of Test for Potential Reactivity of Aggregates (Chemical Method)
ASTM C - 309	Specification for Liquid Membrane – Forming Compounds for Curing Concrete.
ASTM C - 311	Sampling and Testing Fly Ash for Use as an Admixture in Portland Cement Concrete.
ASTM C - 494	Standard Specification for Chemical Admixture for Concrete.
ASTM C - 535	Test for Resistance to Abrasion of Large Size Coarse Aggregate by Use of the Los Angeles Machine
ASTM C - 566	Standard Method of Test for Total Moisture Content of Aggregate by Drying.
ASTM C - 618	Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolans for Use in Portland Cement Concrete.
ASTM D - 512	Test for Chloride Ion in Industrial Water and Industrial Waste Water.



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SHOWING INTER RELATIONSHIP OF QUALITY ASSURANCE WITH
DIFFERENT AGENCIES INVOLVED IN CONSTRUCTION OF A
NUCLEAR FACILITY