

AMERICAN NATIONAL STANDARD
REACTOR PLANTS AND THEIR MAINTENANCE

Supplementary Quality Assurance Requirements for
Installation, Inspection, and Testing of Structural
Concrete and Structural Steel During the
Construction Phase of Nuclear Power Plants

ANSI N45.2.5 - 1974

SECRETARIAT

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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FOREWORD

(This Foreword is not a part of American National Standard Supplementary Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants, N45.2.5.)

This standard delineates the requirements for the installation, inspection, and testing of structural concrete and structural steel in a nuclear power plant during its construction phase. The standard was developed by the American National Standards Committee N45 on Reactor Plants and Their Maintenance. This committee has been chartered to promote the development of standards for the location, design, construction, and maintenance of nuclear reactors and plants embodying nuclear reactors, including equipment, methods, and components specifically for this purpose.

In April of 1970, the N45 Committee established a subcommittee N45-3, to guide the preparation of nuclear quality assurance standards. The subcommittee is responsible for establishing guidelines and policy to govern the scope and content of the various standards; monitoring the status of standards in process; recommending preparation of additional standards; and final approval of standards prior to their submittal to the N45 Committee for balloting.

In November of 1970, the N45-3 Subcommittee established an Ad Hoc Committee N45-3.5 on Quality Assurance Requirements for Civil and Structural Work. The purpose of this committee was to prepare a standard for general industry use that would define the installation, inspection, and testing requirements for structural concrete and structural steel items that would result in or assure attainment of quality construction. The Ad Hoc Committee was composed of representatives of key segments of the nuclear industry including utilities, reactor suppliers, architect-engineers, reactor constructors, consultants, and national laboratories. The standard contained herein was developed from this activity.

The initial draft of this standard was prepared in September of 1971.

Working with the N45-3 Subcommittee and concurrently with the development of this standard, other ad hoc committees of N45 are developing a series of standards that set forth more detailed technical requirements for certain activities to assure quality during the construction phase of nuclear power plants. These requirements will be coordinated with the requirements of this standard as they are developed.

In September 1971, these ad hoc committees were changed to work groups. In October 1972, the N45-3 Subcommittee was renumbered N45-2, and the work groups were renamed accordingly. As of August 1973, the following associated standards were in preparation or issued:

Working Group	Standard in Preparation or Issued	
	N45.2	Quality Assurance Program Requirements for Nuclear Power Plants
N45-2.1	N45.2.1	Cleaning of Fluid Systems and Associated Components During the Construction Phase of Nuclear Power Plants
N45-2.2	N45.2.2	Packaging, Shipping, Receiving, Storage and Handling of Items for Nuclear Power Plants (During the Construction Phase)
N45-2.3	N45.2.3	Housekeeping During the Construction Phase of Nuclear Power Plants
N45-2.4	N45.2.4	Supplementary Quality Assurance Requirements for Installation, Inspection and Testing of Instrumentation and Electric Equipment During the Construction of Nuclear Power Generating Stations
N45-2.6	N45.2.6	Qualifications of Inspection, Examination and Testing Personnel for the Construction Phase of Nuclear Power Plants
N45-2.9	N45.2.9	Requirements for Collection, Storage and Maintenance of Quality Assurance Records for Nuclear Power Plants

Working Group	Standard in Preparation or Issued	
N45-2.10	N45.2.10	Quality Assurance Terms and Definitions
N45-2.11	N45.2.11	Quality Assurance Requirements for the Design of Nuclear Power Plants
N45-2.12	N45.2.12	Requirements for Auditing of Quality Assurance Programs for Nuclear Power Plants
N45-2.13	N45.2.13	Quality Assurance Requirements for Control of Procurement of Equipment, Materials and Services for Nuclear Power Plants
N45-2.4	N45.14	Quality Assurance Requirements for the Design and Manufacture of Class 1E Instrumentation and Electric Equipment for Nuclear Power Generating Stations
N45-2.2	N45.2.15	Requirements for the Control of Hoisting, Rigging, and Transporting of Items at Nuclear Power Plant Sites
N45-2.4	N45.2.16	Supplementary Quality Assurance Requirements for the Calibration and Control of Measuring and Test Equipment Used in the Construction and Maintenance of Nuclear Facilities
N45-2.17	N45.2.17	Quality Assurance Requirements for Control of the Welding Process for Nuclear Power Plants

Suggestions for improvement gained in the use of this standard will be welcomed. They should be sent to the Secretary, American National Standards Committee N45, The American Society of Mechanical Engineers, 345 East 47th Street, New York, N.Y. 10017.

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in this standard. Additional definitions of terms are included in ANSI N45.2.10.

Class of Concrete—Identifies each individual design mix.

Curing—The process of maintaining a satisfactory moisture content and a favorable temperature in concrete during hydration of the cementitious materials so that desired properties of the concrete are developed.

Finishing—The process of obtaining specified surface characteristics of hardened concrete.

Qualified Procedures—Procedures which incorporate applicable codes and standards, manufacturer's parameters, and engineering specifications.

Qualification Tests—Tests performed to qualify the basic material source or manufacturer. These tests are mandatory unless current documentary test data are available to establish complete confidence in conformance to specification requirements.

In-Process Tests—Tests performed during the course of construction to maintain control of structural materials. These tests may be performed by the manufacturer or supplier, but samples for these tests must be taken from the lot or batch of materials supplied to the site for use.

Sampling Point—The point at which the concrete leaves the last piece of mixing or agitating equipment prior to being discharged to conveying equipment systems.

1.5 Referenced Documents

Other documents that are required to be included as a part of this standard are identified at the point of reference and listed in Section 8 and the Appendix of this standard. The issue or edition of the referenced document that is required is specified in the Appendix.

2. GENERAL REQUIREMENTS

2.1 Planning

Measures shall be established and implemented for documenting installation, inspection, and testing operations to verify conformance to specified requirements.

Planning shall take into account the need for the preparation and control of procedures and work instructions necessary to comply with requirements for installation, inspection, and testing.

Planning shall include a review of the structure, system, or component design and procurement specifications, materials lists, drawings, construction work

plans, procedures, and schedules to assure that installation, inspection, and testing activities have been incorporated; that they can be accomplished as specified; and that time and resources are sufficient to accomplish the scheduled construction without degradation of quality.

2.2 Procedures and Instructions

Installation, inspection and test procedures, and work instructions shall be prepared and documented for those activities falling within the scope of this standard. These documents shall be kept current and revised as necessary to assure that installation, inspections, and tests are performed in accordance with latest information and shall include as appropriate:

1. Installation specifications.
2. Inspection and test objectives and requirements.
3. Precautions to avoid component or system damage during installation, inspection, and following inspection but prior to use.
4. Inspection and test equipment required.
5. Sequence of tests (if applicable).
6. Sequential actions to be followed.
7. Frequency of inspections and tests.
8. Prerequisites.
9. Approvals.
10. Data report form.
11. Identification of test equipment and date of required recalibration where required for interpretation of test results.
12. Inspection and test acceptance limits.

2.3 Results

Inspection and test results shall be documented in a suitable test report or data sheet. Each report shall identify the item to which it applies, the procedures or instructions followed in performing the task, and the identification of the following:

1. Pertinent inspection and test data such as identification of location where testing was performed or where test samples were taken.
2. Significant dates and times.
3. Inspection acceptance and test completion signatures.
4. Conditions encountered which were not anticipated, including nonconformance.

Test reports and data sheet shall include an evaluation of the acceptability of inspection and test results and provide for identifying the individual who performed the evaluation.

2.4 Personnel Qualifications

Personnel performing tests and inspections required by this standard shall be qualified in accordance with ANSI N45.2.6. Personnel performing field inspection and testing activities shall be certified for Level I capability. On-site supervisors of Level I personnel shall be certified for Level II capability and shall be responsible for the proper performance of on-site inspections and tests. Persons charged with engineering managerial responsibility of the inspection and testing organization at the site in either a resident or nonresident capacity shall be certified for Level III capability. Personnel performing nondestructive examinations shall be qualified to appropriate levels of capability as specified in American Society for Nondestructive Testing Recommended Practice SNT-TC-1A.

2.5 Measuring and Test Equipment

2.5.1 Selection. Measuring and test equipment used to implement the requirements of this standard shall be selected on the basis of accuracy sufficient to determine conformance to specified requirements.

These measuring devices shall include but not be limited to thermometers, balances, scales, air entrainment meters, humidity meters, volumetric buckets, field soil density measuring devices, pressure gages, and torque wrenches.

2.5.2 Calibration and Control. The equipment shall be adjusted or calibrated or both at prescribed intervals against certified standards having known valid relationships to national standards, where such exist. If no national standards exist, the basis for the adjustment or calibration shall be documented. Records shall be maintained and equipment suitably marked to indicate calibration status. Measures shall be taken to assure proper handling, storage, and care of installation of inspection and testing equipment after calibration in order to maintain the required accuracy of such equipment.

Test equipment found to be out of calibration shall be clearly identified as such. When discrepancies, malfunctions, or inaccuracies in inspection and testing equipment are found during calibration, all items inspected with that equipment since the last previous calibration shall be considered unacceptable until an evaluation has been made by the responsible authority and appropriate action taken.

2.6 Housekeeping

In areas, facilities, and environments where installation, inspection, and testing of structural concrete and structural steel items are performed in accordance

with the requirements of this standard, the housekeeping requirements shall be in accordance with ANSI N45.2.3.

3. PRECONSTRUCTION VERIFICATION

3.1 General

While it is recognized that the requirements for initial receipt inspections and storage are covered by another standard, ANSI N45.2.2, it is necessary to verify that the quality of an item has not suffered during the interim period. It is not intended to duplicate inspections but rather to verify that items are in a satisfactory condition for installation. The verification shall include:

1. Visual examination of materials for proper identification, physical damage, and contamination.
2. Review of manufacturer's documentation, test reports, or other evidence of quality conformance for correctness and compliance with specifications if not reviewed at time of receipt.

3.2 Materials Suitability

Verification that materials meet specified requirements shall be accomplished through qualification tests and in-process tests.

3.2.1 Qualification Tests. Qualification tests shall be performed and the results evaluated prior to the initial use of the materials to establish conformance of the materials to the specified requirements. A list of minimum required qualification tests or certifications is contained in Table A. This list contains tests necessary to qualify materials for normal application. Additional tests may be required to qualify materials for special applications.

3.3 Construction Processes

Inspections shall be performed to verify that the prerequisites for control of construction processes such as welding, bolting, structural reinforcement splicing, and concrete measuring, mixing, transporting, placing, and curing have been accomplished. These inspections shall include:

1. Verification that the process has been qualified as required.
2. Verification that process controls are in effect.
3. Verification that qualified procedures, instruction manuals, or both, if required for specific equipment, are available for use during construction.

Table A Required Qualification Tests

Material	Test For	Test Method
Concrete Aggregates	Compliance with ASTM C33	As referenced in ASTM C33
Cement	Compliance with ASTM C150	As referenced in ASTM C150
Admixtures	Compliance with ASTM C260 or C494 whichever is applicable	Manufacturer's certification
Fly Ash & Pozzolans	Compliance with ASTM C618	As referenced in ASTM C618
Water & Ice	Compliance with AASHTO T-26 for effect on: Compressive Strength Setting Time Soundness	ASTM C109 ASTM C191 ASTM C151
Liquid Membrane Forming Curing Compound	Compliance with ASTM C309	As referenced in ASTM C309
Sheet Materials for Concrete Curing	Compliance with ASTM C171	As referenced in ASTM C171
Concrete Mixes	Compliance with ACI 211	As referenced in ACI 211
Reinforcement	*Physical properties of full section test specimen per ASTM A615	*One full section test in accordance with ASTM A370 for each bar size
Structural Steel	Compliance with appropriate specifications such as ASTM A36, A440, etc.	Manufacturer's certification
High Strength Bolts	Compliance with ASTM A325 or A490	Manufacturer's certification

*Reduced section test specimen may be used for determination of the percentage of elongation.

4. Verification that the process is suitable for the particular application.
5. Verification that manpower, equipment, and materials are readily available and adequate to perform the work in accordance with drawing and specification requirements.

4. INSPECTION OF CONCRETE CONSTRUCTION

4.1 General

Inspection of concrete construction shall include inspections of preparations for concreting, as well as in-process inspections of concrete measuring, mixing, transporting, placement, curing, and protection to assure conformance to specified requirements. The inspection shall follow the Recommended Practice for Concrete Inspection, ACI 311.

4.2 Protection of Materials

Inspections shall be performed to verify the adequacy and proper maintenance of material storage conditions and handling techniques. These inspections shall include the following:

1. Inspection of cement storage facilities to verify

weather tightness, cement temperature and the absence of lumps, and review of records to verify type and age of cement.

2. Inspection of aggregate stockpiles to verify handling techniques are not resulting in segregation; storage and handling adequately prevent contamination with deleterious substances; proper temperature and uniform moisture control; and use of frozen materials is prevented.
3. Inspection of admixture storage and handling facilities to verify that deterioration and contamination are prevented.
4. Inspection of water sources and cooling and heating facilities to verify the specified water quality and assure that the specifications for concrete temperature are met.

4.3 Measuring, Mixing, and Transporting Equipment

Inspections shall be performed prior to and during the production of concrete to verify the adequacy and proper operation of measuring, mixing, and transporting equipment in accordance with ACI 304, ASTM C94, and National Ready Mix Concrete Association Concrete Plant Standard and Truck Mixer and Agitator Standard. These inspections shall include the following:

1. Inspection of measuring facilities for the specified accuracy of measuring, weighing, and weight recording devices to control the following:
 - a. Proportions of cement, water, and aggregates
 - b. Quantities of admixtures
 - c. Aggregate moisture compensation
 - d. Mixing time
 - e. Temperature control: Heating or cooling of concrete.
2. Inspection of central mix plant and truck mixers for wear of drum blades, function of revolution counter and water measuring device, proper speed of rotation, and ability to mix concrete completely in the specified time.

4.4 Preplacement Preparations

Inspection of preparations for concrete placement shall include the following:

1. Inspection of compacted structural fill during placement to verify correct material, condition of material, gradation, moisture content, in-place density, and compliance with compaction procedures.
2. Inspection of rock surfaces which will be in contact with structural concrete to verify surface cleanliness, removal of loose rock and free water, correct contour, and specified subgrade condition.
3. Inspection of previously placed concrete to verify proper preparation for the next lift.
4. Inspection of formwork, reinforcing and embedded items to verify: correct location and configuration of formwork; installation and integrity of water stops and membrane waterproofing; condition of form material to produce the specified concrete finish; installation of ties, anchors, bracing, shoring and supports; correct size, orientation, and installation of reinforcing steel and embedded items; correct location and dimension of control joints, expansion joints, construction joints, blockouts, and waterstops; proper form coating; and cleanliness.
5. Inspection of mechanical reinforcing bar splicing operations to verify conformance to the requirements of Section 4.9.
6. Documentation of inspections (1) through (5) above shall be verified as being complete and indicate that all results are satisfactory.

4.5 Concrete Placement

Inspection of concrete placement shall be performed to verify the following:

1. Specified tests of concrete have been performed.

2. Adherence to specified requirements for: class of concrete, age, rate of placement, lift height, placing sequence, and hot or cold weather concreting practice. (ACI 305-72 or ACI 306-66 respectively)
3. Proper use of adequate conveying and placing equipment.
4. Adequate concrete consolidation equipment and technique of operation.
5. Embedded items are not disturbed nor forms displaced.

4.6 Finishing and Repair

Inspections shall be performed to verify that specified finishes, i.e., wood float, steel trowel, as cast, or other type, are obtained. After forms have been removed, inspections shall be performed to verify that the formed surfaces have been repaired and finished in accordance with specified requirements.

Any indications of voids or contamination, such as at a construction joint, shall be explored, by physical removal of concrete if necessary, to determine the extent of such voids or contamination. Appropriate repairs shall be made.

4.7 Curing

Inspections shall be performed throughout the specified curing period to verify the following:

1. Correct curing method is used, i.e., use of ponding, fog spray, wet burlap, curing compound, or other method in accordance with specified requirements.
2. Concrete is kept continuously, i.e., not periodically, wet during the entire curing period, if one of the wet curing methods is used.
3. Membrane curing compounds are specifically approved for use prior to application.
4. Curing temperature is maintained within specified limits during the entire curing period.
5. Shoring and forms are left in place until concrete has reached the specified strength necessary to preclude the possibility of damage from construction loads.

4.8 In-process Tests on Concrete and Reinforcing Steel

In-process tests shall be performed during the course of construction to maintain control of structural concrete. A list of the required in-process tests is contained in Table B. The test frequencies given shall be considered minimums. In-process tests shall be performed more frequently if test results are erratic or if the trend of results or an apparent change

Table B Required In-process Tests

Material	Requirement	Test Method	Test Frequency
Concrete	Mixer uniformity	ASTM C94	Initially and every 6 months thereafter
	Sampling method	ASTM C172	
	Compression cylinders	ASTM C31	
	Compressive strength	ASTM C39	2 cylinders for 28-day test from each 100 cu yd or a minimum of 1 set/day for each class of concrete
	Slump	ASTM C143	First batch produced each day and every 50 cu yd placed
	Air content	ASTM C173 or C231	First batch produced each day and every 50 cu yd placed
	Temperature		First batch produced each day and every 50 cu yd placed
	Unit weight/yield	ASTM C138	Daily during production
Grout	Compressive strength	ASTM C109	Daily during production
Aggregate	Compliance with requirements for:		
	Gradation	ASTM C136	Daily during production
	Moisture content	ASTM C566	Daily during production
	Material finer than No. 200 sieve	ASTM C117	Daily during production
	Organic impurities	ASTM C40	Weekly during production*
	Friable particles	ASTM C142	Monthly during production*
	Lightweight pieces	ASTM C123	Monthly during production*
	Soft fragments	ASTM C235	Monthly during production*
	Los Angeles abrasion	ASTM C131 or C535	Every 6 months*
	Flat and elongated particles	CRD C119	Every 6 months*
	Potential reactivity	ASTM C289	Every 6 months*
Soundness	ASTM C88	Every 6 months*	
Water & Ice	Compliance with AASHTO T26 for effect on:		
	Compressive strength	ASTM C109	Every 6 months
	Setting time	ASTM C191	Every 6 months
	Soundness	ASTM C151	Every 6 months
Admixtures	Chemical composition	Infrared spectrophotometry analysis	Composite of each shipment
Fly Ash & Pozzolans	Chemical & physical properties per ASTM C618	ASTM C311	Each 200 tons
Cement	Standard physical and chemical properties	ASTM C150	Each 1200 tons ASTM C183
Reinforcing Steel	**Physical properties of full section test specimen per ASTM A615	ASTM A370	**One full section test for each bar size for each 50 tons or fraction thereof from each heat
Cadweld Reinforcing Bar Splices	Section 4.9.3	Section 4.9.3	Section 4.9.4

*These test frequencies shall be considered minimum unless current documentary test data are available to establish complete confidence in conformance to specification requirements.

**Reduced section test specimen may be used for determination of the percentage of elongation.

in material characteristics indicate that the frequency should be increased. Samples for in-process tests of concrete shall be taken at the sampling point in accordance with ASTM C172. This point may be at the truck mixer discharge if the last piece of conveying equipment is a chute, bucket, conveyor system, or similar equipment. Pumped concrete must be sampled from the pump line discharge. No water or other ingredients may be added to any concrete batch at the sampling point for in-process tests. Samples shall not be taken from concrete after it has been deposited in the form.

4.9 Mechanical (Cachweld) Splice Testing

4.9.1 Qualification of Operators. Prior to the production splicing of reinforcing bars, each member of the splicing crew (or each crew if the members work as a crew) shall prepare two qualification splices for each of the splice positions (e.g., horizontal, vertical, diagonal) to be used. The qualification splices shall be made using the same materials (e.g., bar, sleeve, powder) as those to be used in the structure. To qualify, the completed splices must meet the specified visual inspection acceptance requirements and meet the tensile test requirements of Section 4.9.3. Each member of the splicing crew (or each crew if the members work as a crew) is subject to requalification (1) if the specific splice position (e.g., horizontal, vertical, diagonal) has not been used by member or crew for a period of three months or more or (2) if there is another reason to question their ability, such as the completed splices not passing visual inspection or tensile testing. The requalification procedure should be identical to the original qualification procedure.

4.9.2 Visual Inspection. All completed mechanical splices shall be inspected at both ends of the splice sleeve and at the tap hole in the center of the splice sleeve for longitudinal centering of sleeve on the spliced ends, permissible gap between rebar ends, allowable voids in filler metal, extent of leaking of filler metal, gas blowout, amount of packing and slag at the tap hole. All visual inspections on completed splices shall be performed only after the splices have cooled to ambient temperatures. Splices that fail to pass visual inspection shall be discarded and replaced and shall not be used as tensile test samples.

4.9.3 Tensile Testing. Splice samples may be production splices (i.e., those cut directly from in-place reinforcing) or sister splices (i.e., those removable splices made in place next to production splices and under the same conditions). A record shall be kept of all splices tested, showing the splice location, splice identification number, and whether the tested splice

was a production or sister splice. Splice samples shall be subjected to tensile tests in accordance with the sampling frequency specified in Section 4.9.4 to determine conformance with the following acceptance standards:

1. The tensile strength of each sample tested shall equal or exceed 125 percent of the minimum yield strength specified in ASTM A615 using loading rates set forth in ASTM A370.
2. The average tensile strength of each group of 15 consecutive samples shall equal or exceed the ultimate tensile strength specified for the reinforcing bar.

Since curved reinforcing bars will not tensile test accurately, production splice samples should not be removed from curved reinforcing bars for tensile testing. Straight sister splice samples should be made for each of the required curved reinforcing bar production splices. Production samples should also not be cut from the structure where the mechanical splicing sleeve is welded to an anchorage in a region of high stress concentration, or at a leak tight barrier (e.g., embedded structural steel sections or liner plate). Representative sister splice samples shall be used in such cases. The sampling frequency specified in Section 4.9.4(2) should then be followed, except that all splices tested shall be sister splices.

4.9.4 Tensile Test Frequency. Separate test cycles shall be established for mechanical splices in horizontal, vertical, and diagonal bars, for each bar size, and for each splicing crew as follows:

1. *Test Frequency for Production Splice Test Samples.* If only production splices are tested, the sample frequency shall be:
 - a. One of the first 10 splices.
 - b. One of the next 90 splices.
 - c. Two of the next and subsequent units of 100 splices.
2. *Test Frequency for Combinations of Production and Sister Splices.* If production and sister splices are tested, the sample frequency shall be:
 - a. One production splice of the first 10 production splices.
 - b. One production and three sister splices for the next 90 production splices.
 - c. Three splices, either production or sister splices for the next and subsequent units of 100 splices. At least $\frac{1}{4}$ of the total number of splices tested shall be production splices.

4.10 Welded Reinforcing Bar Splices

Welded reinforcing bar splices shall be subject to the requirements of Section 5.5, except that provisions of AWS D12.1 shall apply.

5. INSPECTION OF STEEL CONSTRUCTION

5.1 General

Inspection of steel construction in accordance with the AISC Manual of Steel Construction shall include inspection of assembly and erection operations, fastening or connecting operations such as high strength bolting, and welding and finishing operations to include cleaning and protective painting or coating.

Inspection of steel construction shall include inspection of related items, such as anchor bolts and base plates, which may be part of the supporting structure and installed as part of structural concrete work.

5.2 Supporting Structures

Prior to erection of steel, anchor bolts and base plates and other structural embedments shall be checked for correct orientation, spacing, and elevation. Base plate surfaces and supporting concrete surfaces shall be checked to verify satisfactory condition for grouting.

Grouting of base plates, beam pockets, etc., shall be controlled to assure that only specified materials are used, proportioned properly, placed correctly, and cured properly to achieve the specified compressive strength.

5.3 Assembly and Erection

Assembly and erection operations shall be inspected to verify compliance with installation procedures and work instructions. Alignment operations shall be carried out early enough and as often as is necessary as erection progresses to insure that specified requirements are met.

Particular attention shall be given to verification of the condition of contact surfaces of friction type connections and bolt hole alignment. Correction of fabrication errors shall be closely controlled to prevent correction of misaligned holes by reaming in excess of AISC tolerances. Burning of bolt holes is not permitted. All equipment used in connecting operations shall be inspected to verify conformance with specification requirements. For example, air compressors must be of sufficient capacity to maintain the required operating pressure for impact tools.

5.4 High Strength Bolting

Bolt tightening shall be in accordance with the specified method, i.e., automatic cut-off impact wrench or turn-of-nut method. If the turn-of-nut method is used, inspections shall be made to verify that the bolting crew understand the meaning of

"snug tight" condition before the nut is turned through the required angle. If an automatic cut-off impact wrench is used, it shall be calibrated at least twice daily. The calibration of automatic cut-off impact wrenches shall be performed by tightening in a device capable of indicating actual bolt tension, using no less than three typical bolts of each diameter from the bolts being installed. Installation of bolts shall be done in accordance with "Specifications for Structural Joints Using ASTM A325 or A490 Bolts."

Inspection of bolting shall include visual inspections of bolting operations and torque wrench inspection of completed connections. All connection points shall be visually inspected for the following items:

1. Bolts are the correct length as indicated by at least two threads extending beyond the nut.
2. Correct type bolt is used as indicated by the manufacturer's marking on the head.
3. Torque has been applied as indicated by the burnishing or peening of the corners of the nut.
4. Turning elements are on the correct face; washers are used when required.

Hand torque wrenches used for inspection shall be controlled in accordance with Section 2.5.2 and must be calibrated at least weekly and more often if deemed necessary. Impact torque wrenches used for inspection must be calibrated at least twice daily. The schedule of bolt tension inspection shall be as specified in the latest edition of "Specification for Structural Joints Using ASTM A325 or A490 Bolts." In addition, at the beginning of tightening operations, all bolts tightened by each bolting crew shall be checked until the results are consistently acceptable.

5.5 Welding

Inspection of structural steel welding shall be performed in accordance with the provisions of AWS D1.1, Section 6, entitled "Structural Welding Code," and supplemental addenda. This inspection shall include visual examination of preparations, welding processes, and post-welding operations. Prior to welding, verification of welding procedure and welder qualification shall be documented and shall include all essential variables identified in the procedure. In-process inspections shall include joint fit up prior to start of welding, preheat and interpass temperature requirements, filler metal, control of distortion, and post-weld heat treatment and cleaning requirements. Procedures shall be established to control the purchase, receiving, distribution, storage, and use of welding electrode.

Weld repairs necessitated by visual or nondestructive examinations shall be made in accordance with the procedure used to perform the original weld or a

qualified repair procedure and re-inspected by the same method which disclosed the repairable defect. All weld repairs necessitated by nondestructive examination shall be documented.

6. DATA ANALYSIS AND EVALUATION

6.1 General

Procedures shall be established for processing inspection and test data and their analysis and evaluation. These procedures shall provide for acquisition and preparation of inspection and test data for prompt evaluation against acceptance criteria, operating limits, and performance standards. The data processing procedures shall provide for "on-the-spot" evaluation to determine the validity of the inspection and test results, and the appropriateness of continuing the inspection or test. The data shall be analyzed and evaluated to verify the completeness of results, achievement of inspection and test objectives, and to identify additional inspection and tests required; and necessary changes to the installation inspection or test procedures. Inspection and test results that include inspection and test data, together with a report of its analysis and evaluation, shall be prepared as specified in Section 7.

6.2 Concrete and Mechanical (Cadmold) Splice Test Data Evaluation and Analysis

6.2.1 Evaluation of Concrete Test Results. Standard deviation data shall be developed, evaluated, and maintained for permanent records in accordance with 11.2.14. Concrete quality and acceptance criteria shall conform to the requirements of ACI 318, Chapter 4.

6.2.2 Evaluation of Mechanical (Cadmold) Splice Test Results. The following procedure shall be used for substandard tensile test results.

1. If any production or sister splice tested fails to meet the tensile test specification of Section 4.9.3(1) and the observed rate of splices that fail the tensile test at that time does not exceed one for each 15 consecutive test samples, the sampling procedure shall be started anew. If any production or sister splice used for testing fails to meet the tensile test specification in Section 4.9.3(1) and the observed rate of splices that fail the tensile test exceeds one for each 15 consecutive test samples, mechanical splicing shall be stopped. In addition, the adjacent production splices on each side of the last failed splice and four other splices dis-

tributed uniformly throughout the balance of the 100 production splices under investigation shall be tested, and an independent laboratory analysis shall be made to identify the cause of all failures. The results of these tests shall be evaluated by the responsible engineering organization to determine the required corrective action. The responsible engineering organization shall specify the extent of repairs necessary and the actions required to prevent further failures from the identified causes. If two or more splices from any of these six additional splice samples fail to meet the tensile test specification of Section 4.9.3(1) the balance of the 100 production splices under investigation shall be rejected and replaced. When mechanical splicing is resumed, the sampling procedure shall be started anew.

2. If the average tensile strength of the 15 consecutive samples fails to meet the provisions of Section 4.9.3(2), the responsible engineering organization shall evaluate and assess the acceptability of the reduced average tensile strength with respect to the required strength of the location from which the samples were taken.

6.3 Steel Construction Test Data Evaluation and Analysis

These data shall be evaluated for conformance to project specifications, the AISC Manual of Steel Construction and AWS D1.1 and supplemental addenda.

7. RECORDS

Record copies of completed procedures, reports, personnel qualification records, test equipment calibration records, test deviation or exception records, and inspection and examination records shall be prepared. These shall be placed with other project records as required by code, standard, specification, or project procedures.

Collection, storage, and maintenance of records shall be in accordance with ANSI N45.2.9.

8. REVISIONS OF AMERICAN NATIONAL STANDARDS REFERRED TO IN THIS DOCUMENT

When the following standards referred to in this document are superseded by a revision approved by the American National Standards Institute, the revision shall apply:

N45.2 Quality Assurance Program Requirements

- | | | | |
|---------|----------------------------------------------------------------------------------------|----------|--------------------------------------------------------------------------------------------------------------------|
| | for Nuclear Power Plants | N45.2.6 | Qualifications of Inspection, Examination and Testing Personnel for the Construction Phase of Nuclear Power Plants |
| N45.2.2 | Packaging, Shipping, Receiving, Storage and Handling of Items for Nuclear Power Plants | N45.2.9 | Requirements for Quality Assurance Records for Nuclear Power Plants |
| N45.2.3 | Housekeeping During the Construction Phase of Nuclear Power Plants | N45.2.10 | Quality Assurance Terms and Definitions |

APPENDIX

This Appendix is not a part of ANSI Standard N45.2.5 but is included for information purposes only.

LIST OF REFERENCE DOCUMENTS

American Concrete Institute

- ACI 211-65 Recommended Practice for Selecting Proportions for No Slump Concrete
- ACI 211.1-70 Recommended Practice for Selecting Proportions for Normal Weight Concrete
- ACI 211.2-69 Recommended Practice for Selecting Proportions for Structural Lightweight Concrete
- ACI 214-65 Recommended Practice for Evaluation of Compression Test Results of Field Concrete
- ACI 304-72 Recommended Practice for Measuring, Mixing, and Placing Concrete
- ACI 305-72 Recommended Practice for Hot Weather Concreting
- ACI 306-66 Recommended Practice for Cold Weather Concreting
- ACI 311-64 Recommended Practice for Concrete Inspection
- ACI 318-71 Building Code Requirements for Reinforced Concrete

American Welding Society

- AWS D1.7-72 Structural Welding Code
- AWS D12.1-61 Recommended Practice for Welding Reinforcing Steel, Metal Inserts and Connections in Reinforced Concrete Construction

American Association of State Highway Officials

- T-26-70 Method of Test for Quality of Water to be Used in Concrete

American Institute of Steel Construction

- AISC, Manual of Steel Construction
7th Edition

American Society for Nondestructive Testing

- SNTC-TC-1A, Recommended Practice
Third Edition

National Ready Mix Concrete Association

- Concrete Plant Standards of the Concrete Plant Manufacturers Bureau, 4th Revision, March 1, 1970
- Truck Mixer and Agitator Standards of the Truck Mixer Manufacturers Bureau, 9th Revision, November 1, 1971

American Society for Testing and Materials

- ASTM A36-70a Structural Steel
- ASTM A325-71 High Strength Bolts for Structural Steel Joints
- ASTM A370-71 Mechanical Testing of Steel Products
- ASTM A490-71 Quenched and Tempered Alloy Bolts for Structural Steel Joints
- ASTM A615-70 Deformed Billet-Steel Bars for Concrete Reinforcement
- ASTM C31-69 Making and Curing Concrete Compressive and Flexural Strength Test Specimens in the Field
- ASTM C33-71a Standard Specification for Concrete Aggregates
- ASTM C39-71 Test for Compressive Strength of Molded Concrete Cylinders
- ASTM C40-66 Test for Organic Impurities in Sands for Concrete
- ASTM C42-68 Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
- ASTM C88-71a Test for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
- ASTM C94-72 Standard Specification for Ready Mixed Concrete
- ASTM C109-70T Standard Method of Test for Compressive Strength of Hydraulic Cement Mortar. (Using 2" Cube Specimen)
- ASTM C117-69 Test for Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing
- ASTM C123-69 Test for Lightweight Pieces in Aggregate
- ASTM C131-69 Test for Resistance to Abrasion of Small Size Coarse Aggregate by Use

REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 1.94

QUALITY ASSURANCE REQUIREMENTS FOR INSTALLATION, INSPECTION, AND TESTING OF STRUCTURAL CONCRETE AND STRUCTURAL STEEL DURING THE CONSTRUCTION PHASE OF NUCLEAR POWER PLANTS

A. INTRODUCTION

Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," establishes overall quality assurance requirements for the design, construction, and operation of safety-related structures, systems, and components of nuclear power plants. This guide describes a method acceptable to the NRC staff for complying with the Commission's regulations with regard to quality assurance requirements for installation, inspection, and testing of structural concrete and structural steel during the construction phase of nuclear power plants. This guide applies to all types of nuclear power plants. The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position.

B. DISCUSSION

Working Group N45.2.5 of the American National Standards Committee N45, Reactor Plants and Their Maintenance, has prepared a standard that includes quality assurance requirements for installation, inspection, and testing of structural concrete and structural steel during the construction phase of nuclear power plants. This standard was approved by Subcommittee N45-2, Nuclear Quality Assurance Standards, of the American National Standards Committee N45, and the full committee. It was subsequently approved and designated N45.2.5-1974¹ by the American National Standards Institute on July 8, 1974.

*Lines indicate substantive changes from previous issue.

¹ANSI N45.2.5-1974, "Supplementary Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants." Copies may be obtained from the American Society of Mechanical Engineers, 345 East 47th Street, New York, New York 10017.

C. REGULATORY POSITION

The requirements and guidelines that are included in ANSI N45.2.5-1974 for installation, inspection, and testing of structural concrete and structural steel during the construction phase of nuclear power plants are generally acceptable to the NRC staff and provide an adequate basis for complying with the pertinent quality assurance requirements of Appendix B to 10 CFR Part 50, subject to the following:

1. Subdivision 1.5 of ANSI N45.2.5-1974 states: "Other documents that are required to be included as a part of this standard are identified at the point of reference and listed in Section 8 and the Appendix of this Standard." The specific applicability or acceptability of documents listed in Section 8 has been covered separately in other regulatory guides. Other standards and codes listed in ANSI N45.2.5-1974 provide useful guidance for the installation, inspection, and testing of structural concrete and structural steel. Prior to use of these other referenced codes and standards, however, the suitability of the standard or code should be reviewed for the particular application under consideration.

2. Subdivision 2.1 of ANSI N45.2.5-1974 includes general provisions for planning the installation, inspection, and testing of structural concrete and structural steel. In this regard the provisions of Subdivision 2.1 of ANSI N45.2.5-1974 should be used in conjunction with Regulatory Guide 1.55, "Concrete Placement in Category I Structures."

3. Subdivision 4.5 of ANSI N45.2.5-1974 provides, in part, that inspection of concrete placement shall be performed to verify the adequacy of concrete consolidation equipment and technique of operation. ACI 309-72,

USNRC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

Comments and suggestions for improvements in these guides are encouraged at all times, and guides will be revised, as appropriate, to accommodate comments and to reflect new information or experience. This guide was revised as a result of substantive comments received from the public and additional staff review.

Comments should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Section.

The guides are issued in the following ten broad divisions:

- | | |
|----------------------------------|-----------------------|
| 1 Power Reactors | 6 Products |
| 2 Research and Test Reactors | 7 Transportation |
| 3 Fuels and Materials Facilities | 8 Occupational Health |
| 4 Environmental and Siting | 9 Antitrust Review |
| 5 Materials and Plant Protection | 10 General |

Copies of published guides may be obtained by written request indicating the divisions desired to the U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Director, Office of Standards Development.

"Recommended Practice for Consolidation of Concrete,"² should be used as a basis for determining the adequacy of the equipment for concrete consolidation and of the technique of operation.

4. Subdivision 4.10 of ANSI N45.2.5-1974 states: "Welded reinforcing bar splices shall be subject to the requirements of Section 5.5, except that provisions of AWS D 12.1 shall apply." In addition, the provisions of Articles CC4334 and CC4330 of the "Code for Concrete Reactor Vessels and Containments" (ASME Boiler and Pressure Vessel Code, Section III, Division 2, 1975 Edition)³ for testing of welded reinforcing bar splices

²Copies may be obtained from The American Concrete Institute, P.O. Box 4754, Detroit, Michigan 48219.

³Copies may be obtained from the American Society of Mechanical Engineers, 345 East 47th Street, New York, N.Y. 10017.

should be used as guidance pending endorsement of that Code by the NRC staff.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants regarding the NRC staff's plans for using this regulatory guide.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used in the evaluation of construction permit applications docketed after October 15, 1976. The methods described herein will continue to be used until this guide is revised as a result of suggestions from the public or additional staff review.



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