INSPECTION PROCEDURE 88132

STRUCTURAL CONCRETE ACTIVITIES

PROGRAM APPLICABILITY: 2630

88132-01 INSPECTION OBJECTIVES

01.01 To determine whether the technical requirements detailed or referenced in the Construction Authorization Request (CAR); the U.S. Nuclear Regulatory Commission, Safety Evaluation Report (SER); and the approved Mixed-Oxide Project Quality Assurance (QA) Plan (MPQAP), associated with structural concrete construction and quality control (QC) for Seismic Category I (SC-I) and SC-II structures, have been adequately addressed in the licensee and/or contractor construction specifications, drawings, and work procedures, and whether the established system of management controls is adequate.

01.02 To determine whether QA plans, instructions, and procedures for structural concrete construction activities have been established in the facility QA manual.

01.03 To determine, by direct observation and independent evaluation, whether work and inspection performance relative to structural concrete construction activities are being accomplished in accordance with design specifications, drawings, and procedures.

01.04 To determine whether the licensee system for preparing, reviewing, and maintaining records relative to structural concrete construction activities is functioning properly, and to determine whether the records reflect work accomplishment consistent with specifications and procedures.

01.05 To determine, by direct observation of work activities and review of records, whether inadequacies in work activities, associated with structural concrete construction activities, indicate any potentially generic problems, management control inadequacies, or other weaknesses that could have safety significance.

88132-02 INSPECTION REQUIREMENTS

02.01 For each onsite organization with QA or QC responsibilities regarding structural concrete construction activities, the inspector should refer to the appropriate Mixed-Oxide Fuel Fabrication Facility QA inspection procedures. If there are multiple contractors with QA/QC responsibilities in this area, inspect a sample, using engineering judgment, regarding the safety significance and the complexity of each work activity.

02.02 Review the construction specifications related to structural concrete construction and ascertain whether the specified technical requirements conform to the commitments contained in the CAR. Review concrete construction procedures and verify that they specify provisions for adequate on-site engineering direction, are appropriate and adequate related to procurement and use of materials, specify adequate control of hold points, and provide adequate controls for design changes and incorporation of design changes into as-built drawings. Determine whether appropriate and adequate procedures in the following areas are compatible with the QA program, and prescribe adequate methods to meet the construction specifications, where applicable:

a. Qualification of materials (cement , water, aggregate, and admixtures).
b. Concrete mix design.
c. Concrete batch plant.
d. Preplacement activities (concrete forms, rebar and splices, embedded items, cleanliness, and inspection).
e. In-process testing of plastic concrete (slump, entrained air, temperature, unit weight, and cast cylinders).
f. Concrete placement activities and inspection of concrete placement activities.
g. Post-placement activities (adequate curing and identification and repair of defects).
h. Evaluation and review of concrete test results.
i. Engineering direction.
j. Qualifications of QC personnel.

02.03 By direct observation of concrete work activities for SC-I and SC-II structures (including the Emergency Generator Building and other civil structural systems described in Chapter 11 of the CAR), ascertain whether the following applicable structural concrete construction activities are being controlled and accomplished in accordance with the requirements of the documents reviewed in 02.02, above:

a. Qualification of materials - Review the qualification testing for the materials (cement , water, aggregate, and admixtures) selected for use in the concrete. Review the qualification tests for other hardware associated with structural concrete, such as reinforcing steel, rebar splices, curing compounds, embedded items, etc.

b. Concrete mix design - Review the concrete mix designs, supporting material qualifications, and testing to be used in SC-I AND SC-II structures. If more than three concrete mix designs are used, review a sample of the highest strength or most-used mixes, and the associated material qualifications. Rereview may be necessary if significant mix changes are made during construction, or if sources of concrete materials are changed.

c. Concrete batch plant. Verify the following:

    1. Batch plant has been inspected and certified to National Ready Mixed Concrete Association standards. Scales and meters are calibrated at necessary frequency and to specified tolerances. Mixer-efficiency tests are being performed in accordance with American Society for Testing and Materials (ASTM) C-94, at proper interval. Batch plant is inspected to verify

equipment performs properly - rotation speed, timing, and blade wear are not excessive. There should be no contamination of materials or concrete mix. Batch records are generated, controlled, and indicate placement location, mix, volume, date, time, and special instructions.

2. Materials are properly qualified and traceable to approved sources. Storage and handling of materials are controlled:

   - Cement (and fly ash, if used) are protected from moisture;
   - Aggregate is not subject to excessive segregation of sizes or contamination from debris, dirt, other materials, or mixing with other sizes of aggregates;
   - Admixtures are prevented from freezing; and
   - There are provisions for production of concrete in hot weather (replacing water with ice in concrete mix) and cold weather (heating mix water).

3. Batch water-quality requirements are met and water is adjusted to account for moisture-content of aggregates. Aggregate moisture-content tests are representative of actual stockpile conditions and are taken periodically, during daily concrete production.

4. Concrete transporting equipment is suitable and in an acceptable condition.

d. Preplacement activities (concrete forms, rebar and splices, embedded items, cleanliness, and inspection). Verify the following items have been implemented:

   1. Reinforcing steel and embedments, such as anchor bolts, waterstops, or embedded plates, are installed in accordance with specifications, codes, drawings, and procedures. Reinforcing steel size, spacing, lap and mechanical splices, and embedments, are located properly within the forms, are secured and clean (i.e., free from oil, paint, weak dried mortar, dried mud, loose rust, etc.) and have proper clearances. The areas where embedded plates with anchors such as Nelson studs are to be set in concrete should have sufficient concrete to provide bond and should not be excessively congested with reinforcing steel. Reinforcing steel bending is properly performed and controlled. Piping or conduit embedments in or through concrete should be capped or plugged before to concrete placement.

   2. Mechanical Rebar Splices. Verify the following:

      - Process (e.g., cadweld or bar-lock couplers) and crews are qualified.

      - Each splice is defined by materials used, location, crew, type of splice, and heat number (if applicable).

      - Sampling and testing are performed at proper frequency and acceptance criteria are defined.

      - Inspections are performed during and after splicing by qualified inspection

personnel.

3. Preplacement planning and training have been completed, as required, to ensure good-quality construction, and to protect against unplanned construction joints.

4. The placement has been cleaned and joint preparation is as specified in the construction specification. Locations of construction joints are as shown on the drawings. Forms are secure, leak-proof, and free from water, ice, or snow.

5. The QC pre-placement inspection should be completed before any concrete is placed. Records should document that all preplacement inspections have been completed.

6. The equipment to deliver concrete to the actual placement location is suitable and in an acceptable condition - conveyors, lines, pumps, buckets, etc. Ensure that there are enough concrete vibrators on hand, with extras on standby, for consolidating concrete. Sufficient access available to placement location for vibrator operators, concrete placement equipment, inspection personnel, and other craftsman. Adequate preparations for curing, protection from rain, and hot or cold weather protection are completed before the start of concrete placement activities.

e. In-process testing of plastic concrete. The following items should be verified in the review of the testing program conducted during concrete placement:

1. Concrete is sampled at the proper frequency for determination of temperature, slump, air content, and unit weight.

2. Taking of a sample and testing techniques conform to the procedures specified in applicable ASTM standards. Samples for pumped concrete are required to be obtained from the end of pump line, at point of placement.

3. Test specimens (cylinders), for concrete strength testing are sampled at the required location and frequency. Cylinders are molded, handled, and cured in accordance with specified requirements. Curing boxes are available to properly store and cure cylinders for the first 24 hours, per the requirements of ASTM C-31.

4. Testing apparatuses in the onsite laboratory used to perform testing on materials and plastic concrete are being calibrated at the required frequency. Observed testing conforms to the procedures specified in the ASTM standards.

5. Personnel performing sampling and testing are trained and qualified.

6. Concrete-testing personnel have authority to reject concrete batches not meeting specification requirements.

f. Concrete placement activities. The following items should be verified during observation of concrete placement activities:

1. Concrete batch tickets are reviewed for verification of proper mix, placement location, and amount of water, if any, withheld from the batch. The quantity of withheld water, also referred to as retempering water, is determined based on the maximum water-cement ratio. Time limit (normal maximum of 1.5 hours) between mixing and delivery has not been exceeded, and the total number of revolutions of the truck mixer does not exceed 300. (See ASTM C-94.)

2. Specification temperature limits have been met.

3. Addition of superwater-reducing (super plasticizers) admixturers to concrete batches are controlled. When admixtures or withheld water are added after concrete is discharged from batch plant, remixing in the truck for a minimum of an additional 30 revolutions of the truck mixer is required to conform to ASTM C94, on uniformity of mix. After addition of super plasticizers or withheld water and remixing, slump tests should be performed to confirm the slump is within specification limits.

4. Placement drop distances do not exceed specification requirements and do not result in segregation.

5. Vibrators are approved, tested for frequency, and are used properly by trained individuals.

6. Special attention is given to areas of high reinforcing or embedment steel congestion, to preclude areas of voids or honeycombing.

7. Inspections during placement are performed as required and by qualified personnel.

8. Records are produced, reviewed, and indicate mix, location, time placed, water additions, and temperature of the concrete mix and ambient conditions. Records reflect the results of inspections, the actual field conditions, testing frequency requirements, and that data calculations are checked.

g. Post-placement activities (adequate curing and identification and repair of defects)

1. Verify that curing is performed in accordance with specifications and procedures with regard to the method, materials, duration, temperature (concrete and ambient). Verify that inspections (during curing and after form removal) are performed and documented in QC records.

2. Verify that concrete placements are inspected after form removal to identify any defects in concrete. Examples of defects are voids (honey comb), cold joints, excessive cracking, delaminations, excessive entrapped air voids (bugholes), or evidence of form-related defects such as sand streaking or

inadequate bracing. All identified defects require documentation, evaluation, and repair, in accordance with the licensee's QA program.

h. Evaluation and review of concrete test results

Verify that the final inspection results after form removal, test results, and other information related to the placement (including deficiencies, defects, etc.) have been reviewed before acceptance of the placement, and that the as-built documentation is complete. Verify test results are evaluated at an appropriate level and evaluation includes trending analysis. All non-conforming conditions identified during concrete construction activities require documentation, evaluation, and repair, in accordance with the licensee's QA program.

i. Engineering direction.

Verify that engineering direction is available, onsite, to monitor structural concrete construction activities. The onsite engineering staff should be supplemented by an experienced structural engineer to approve design changes, monitor and review QC test results, and identify changed conditions. The onsite engineering staff should be involved in disposition of nonconformance reports, and preparation of field change requests, for approval by the design-engineering organization.

j. Qualifications of QC personnel

Verify that personnel qualifications (education and experience) of testing and inspection personnel have been verified by the employing organization. Personnel qualifications must be supported by documentation. Conduct informal interviews with QC inspection personnel to determine how well the QC inspectors know the requirements of their work activity. Also, obtain a sense of the degree of the adversarial or intimidating relationship QC inspection personnel have with the construction forces. Any perceived lack of management support should be identified and discussed with Regional management. Ascertain whether a sufficient number of adequately qualified QC personnel are at the construction site, commensurate with the work in progress, and adequately performing their assigned duties through the established organizational structure.

02.04 Special Considerations - The following items should be incorporated in the inspection of concrete placements when appropriate (refer to American Concrete Institute standards for additional guidance):

a. Hot and Cold Weather - Provisions for maintaining concrete temperature within specification must be provided. Hot - - cold weather conditions must be defined, to avoid confusion.

b. Pumping Concrete - Slump and air-content losses must be monitored to ensure placement and adequate consolidation. Samples for pumped concrete are required to be obtained from end of pump line, at point of placement.

c. Large Placements - Planning sessions must assure consideration of all

contingencies, [e.g., adverse weather, loss of power, concrete production delays (batch plant breakdowns)].

02.05 Determine whether the licensee has an established audit program (including plans, procedures, and schedule) covering the SC-I and SC-II work control functions, in the area of structural concrete construction activities. An audit program should review by examination of objective evidence that construction personnel who perform structural concrete construction work are qualified to perform their assigned work.

02.06 Review the documentation generated for structural concrete construction activities. Determine whether the licensee/contractor system for documenting safety-related work is functioning properly. The record-keeping activities should reflect the actual conditions encountered in the field and provide adequate documentation of work and inspections. Determine whether records are being maintained, reviewed, and approved, as specified. This is important in activities such as review of concrete strength. A comparison of the actual concrete strength can help in determining the reason for low strengths relatively early in the construction phase, before the completion of extensive concrete work. Records should include sufficient detail to document that: (1) rebar installation met requirements; (2) the concrete strength meets design requirements; (3) curing was adequate; and (4) repairs, if necessary... completed in accordance with design requirements. Records should be legible, complete, reviewed by QC and/or engineering personnel, and readily retrievable. Review a sample of the following records:

a. Receipt Inspection and Material Certification.

   Applicable for materials purchased from offsite suppliers, such as cement, concrete aggregate (sand and gravel), concrete admixtures, and reinforcing steel, splices, and other components. Records confirm that required material characteristics, performance tests, nondestructive test, and other specification requirements were met.

b. Installation Inspection.

   1. Records confirm that concrete production, concrete placement, and installation of components were performed as specified.

   2. Records confirm that the required inspections (including concrete form removal) were performed and acceptance criteria defined.

   3. Records indicate specified concrete strength was obtained.

c. Nonconformance/Deviation Record - Records include current status of these items. Nonconformance reports include the status of corrective action or resolution e.g., if adequate corrective action were taken when concrete vibration was determined to be inadequate, or concrete strength-test results were not within acceptance criteria.

d. Training/Qualification Records of Craft, QA, and QC Personnel - Records establish that QA/QC personnel are adequately qualified to perform their assigned duties and

responsibilities and that craft personnel have been trained in their assigned tasks. Records are complete and current and show which activities inspectors are qualified to perform.

e. QA Audits - Records establish that the required audits were performed and that deficiencies identified during audits were corrected, and that corrective action was such that repetition of the deficiency, or similar deficiencies, would be precluded.

88132-03 INSPECTION GUIDANCE

General Guidance.

Applicable portions of the CAR, the SER, and approved MOX Project QA Plan should be reviewed to determine licensee commitments regarding construction and inspection requirements, before performing this inspection. The inspector should then use these documents during the review of the construction specifications, drawings, work procedures, and QA implementing procedures. Structural concrete construction activities should also be reviewed to ascertain they are consistent with standard industry practices.

The American Concrete Institute "Manual of Concrete Inspection" is a good reference, which should be used during the conduct of this inspection. However, the licensee's specific documents, which include specifications, drawings, and procedures, specify and control the construction and inspection processes.

Because of the difficulty in performing remedial work and inspections on completed concrete structures, the first use of safety-related concrete should receive special emphasis. In most cases these first use safety-related activities will be associated with large basemat structural concrete foundation placements. Periodic observation of concrete placements, as required in Section 02, above, will provide assurance that conformance to applicable requirements is being accomplished.

Selection of placements to be observed should provide for diversification of placement type and importance to safety. Placement types to be selected should therefore include:

- Basemats;

- Building walls (early and late placements, which contain numerous openings, are heavily reinforced, and contain numerous embedded items (pipe sleeves, embed plates, conduit, waterstops, etc.);

- Roof slabs; and

- Columns, shear walls, beams, and slabs.

Before any concrete placement, a specific technical review of concrete-mix designs and supporting material qualifications should be performed. The inspectors should also verify that the batch plant has been inspected and certified before placement of any safety-related concrete. QA/QC inspection and construction procedures should be reviewed and

compared with the requirements of the applicable codes and construction specifications. The technical adequacy of implementing construction and QC procedures must be determined. For these reasons, this inspection procedure should be performed by an inspector who is able to evaluate civil engineering activities. The inspector should use judgment in determining sample selection during inspection activities. Sample selection should reflect the importance of the activity to safety. The inspectors at various stages of completion, should observe work and independently verify critical activities, such as rebar placement, cleanliness of concrete forms, and dimensions etc. and the inspectors should also observe testing activities performed in the onsite testing laboratory.

The licensee is responsible for implementing or having implemented, the approved QA program and the commitments described in the CAR . The inspector must determine if this program is implemented in an adequate and timely manner for the work that is important-to-safety. QA/QC procedures must provide for effective inspections which will ensure that work is performed in accordance with specification requirements. Laboratory and field-testing procedures must provide for verification of correct material usage and correct selection of reference standards. The afore, testing procedures should include a prohibition against contractor QC personnel from making a discretionary selection of inspection and testing parameters. Qualified personnel should review test results and determine if results are acceptable. Construction procedures must reference the required inspection hold points and must also address the QA/QC department stop-work authority.

Specific information about the licensee's plans and schedules for performing comprehensive audits and on-going surveillance of concrete construction activities should be reviewed during this inspection. Information should be obtained concerning audit procedures, schedules, scope, and auditor qualifications. Licensee onsite QA staffing and surveillance plans should ensure that QC activities are sufficiently monitored and evaluated. QA audits should identify procedural inadequacies and the root-cause of repetitive nonconforming conditions. Inspections should require verification of specified controls and should not be accomplished merely by surveillance. Evaluations should result in an indication that all quality-related construction and inspections will be adequately performed by qualified personnel and will be based on appropriate criteria and further, that the results of inspections will be transmitted to responsible QA and management personnel.

Findings from this inspection activity should address each element as being satisfactory, unresolved and/or requiring resolution, or in violation and requiring correction. When significant inadequacies are identified in specifications or procedures indicating weakness within the preparing organization, the inspector should inform cognizant regional management. The issue should be addressed at the appropriate level of licensee management.

Some general guidelines to determine how the project is actually being run, regarding to design-construction interfaces, construction discipline interfaces, and the control exercised by the licensee, are listed below. The list is not intended to be all-inclusive but to provide some highlights regarding this subject.

1. Check design documents (specifications, drawings, etc.) for evidence of coordination with other disciplines and designers, suppliers, and contractors which address items such as embedded piping, and electrical, mechanical, and major-

equipment supports.

2. Examine how well the design office is permanently represented at the site and if the representatives spend time out in the work areas. Determine how often design engineers come on site and actually follow-up at the work site, as part of their design is being constructed, and determine the methods of interchange between designer, constructors, inspectors, and managers. Determine how well the licensee's engineering function is represented by other than permanent personnel.

3. Determine whether field engineering and construction personnel are reviewing drawings, specifications, etc., released for construction, for errors or omissions, and inconsistencies with other documents or instructions. Determine the licensee's real role in this process.

4. Check field-construction progress and release of engineering design drawings, including the revisions or changes, to determine if the design and the construction efforts are synchronized; (i.e, after design drawings are released for construction, design engineering should not make last-minute changes and revisions just before concrete placements are made, without close coordination with construction).

5. Determine how construction workers and QA/QC personnel view training and how well training is completed and used at the site.

6. Look at the dynamics of the work force, including the turnover rate, the attitudes in work crews, and relations between construction personnel and QA/QC personnel. Look for changes in the organization of the field construction forces, or QA and QC personnel organization.

7. Look at the controls and coordination exercised when a new work activity begins. Check the controls used to ensure that all embedded items, including reinforcing, are, in fact, in place, before concrete placement.

8. Determine whether the construction labor forces also perform their own checks of work as it is completed, or if they rely solely on QA/QC.

9. Look at how the QA/QC inspectors perform their inspection and check-offs. Is it done sequentially as work is being done? For example, during reinforcing steel placement, do they wait until 2 weeks of reinforcing steel placement have been made, and then, on the day before concrete placement, identify bars placed on day number 4, in the sequence, as being out of tolerance.

10. Look at the level (experience, training, and number) of supervision during concrete-placement activities.

03.01 Specific Guidance

Note: The numbering of the guidance below refers to specific subsections of 02, above.

02.01 The inspector should review the appropriate version of Subpart 2.5, “Quality

Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete, Structural Steel, Soils, and Foundations for Nuclear Power Plants", of ASME NQA-1. Specific attention should be given to the QA program needs that may result from distribution of design and construction responsibilities. Examples of these needs may be: provisions for adequate onsite engineering direction; appropriate and adequate procedures related to procurement and use of materials; and adequate control of hold points.

02.02 The construction specification must translate design requirements into details sufficient to define the technical requirements for concrete construction activities. The specifications should provide for control of design changes and the issuance of design change notices. The review of procedures, specifications, and drawings should ensure that concrete construction and inspection activities are controlled and performed in accordance with applicable requirements. QA/QC procedures should specify acceptance-testing requirements and should specify the personnel and interface responsibilities required to define, control, and resolve field problems or design problems that are evidenced during construction. QA/QC procedures must provide for effective inspections that will assure that work is performed in accordance with specification requirements. The procedures should require verification of specified controls and should not be accomplished merely by surveillance. Laboratory and field-testing procedures must provide for verification of correct material usage, correct selection of reference standards, and should prohibit discretionary selection of inspection and testing parameters. Construction procedures must reference the required inspection hold points and must also address the QA department authority to stop work.

02.03a. Qualification of Materials

Chemical and physical tests for all materials used must indicate that specifications have been met. Testing needs to be performed at the required frequencies. Tests results may be provided by the manufacturers via certified materials test reports, or may be performed at an independent or in the onsite testing laboratory. Test results should be reviewed for the following materials:

1. Concrete-mix materials (cement, fly ash, sand, aggregate, water, admixtures, etc.) and all constituents used in other cement-like materials, such as gunite, grout, dry pack or manufactured materials such as epoxy;

2. Reinforcing steel;

3. Reinforcing splicing materials;

4. Waterproof membranes, water stops, joint materials and sealants;

5. Embedded mechanical items such as piping, conduit, mechanical and electrical penetrations (sleeves), sumps, drains, and grating material, etc;

6. Off-the-shelf anchorage components and embedments (bolts, hangers, inserts, etc.), and embedded structural steel items (shear connectors, embedded plates, etc.);

7. Materials used during construction such as for construction joint preparation, form-release agents, and curing compounds; and

8. Other structural concrete materials that may be used.

0203b. Concrete-Mix Design

A concrete-mix design must be completed for each type/strength of concrete mix to be used in SC-I and SC-II structures. The mix design must be completed using the qualified materials (see 02.03a, above), sufficiently in advance of the planned concrete-placement start dates, to demonstrate that the concrete mix will satisfy the job requirements for slump, air entrainment, strength and any other specified parameters. Test cylinders need to be molded, cured and tested to demonstrate that the required design requirements will be achieved within the specified time period (e.g., 7, 28, or 90 days). It is not an acceptable practice to attempt to base the final concrete design strength on incomplete test results (e.g., estimating the 28-day strength, based on results of test cylinders tested at ages of 7 and 14 days). If the sources of materials used in the concrete are changed, new mix designs need to be qualified, before placement into SC-1 and SC-2 structures.

02.03c1 Concrete batch plants providing concrete for use at nuclear facilities must be certified under the NRMCA program. This certification provides evidence that a registered professional engineer has reviewed the facility and has seen evidence that certain necessary capabilities exist to produce quality concrete. Any other batch-plant certification should include the inspection attributes, listed in the NRMCA checklist, which are used to inspect the facility before any recommendation for certification. As part of the certification process, concrete uniformity testing must be performed in accordance with ASTM C-94, at periodic intervals. Verify that the batch plant scales have been calibrated through their full range of use on the project. Water meters and admixture dispensers also require calibration. During observation of concrete batching operations, verify that the scales rezero after each batch.

02.03c2 Materials need to be properly stored at the batch plant. Non conforming or unqualified materials are required to be segregated from qualified materials. Storage of cement and admixtures require control so that shelf life is controlled and older materials are used before recently received materials. Cement and flyash are required to be protected from moisture. Generally, cement should be used within 180 days of manufacture. Admixtures must be used within the shelf life specified by the vendor. Admixtures need to be protected from freezing. An adequate supply of all materials needs to be available at the batch plant, to complete the placement, with sufficient reserves of materials to make up for concrete batches that may be rejected because of noncompliance with specification requirements.

02.03c3 In regard to water quality, potable water is generally suitable for making concrete. However testing (chemical analysis) of the water should be performed to verify that it does not contain impurities that may be detrimental to the concrete or reinforcing steel. Also concrete should be batched using the site water and compared to concrete batched using distilled water. In this test, the normally accepted standard is that the site water is deemed acceptable if samples batched from site water do not result in a reduction in strength of more than 10 percent less than samples batched using distilled water. The moisture content determination of aggregates is an important test to accurately calculate the total water in each batch of concrete. Fine and coarse-aggregate-moisture-content testing needs to be performed periodically, throughout daily concrete production. Frequency of testing will be determined based on weather conditions and variations in the moisture content.

02.03c4 Trucks used to transport concrete from the batch plant to the job site need to be inspected to ensure that they are clean and free from dirt/debris and/or water which could become mixed with, and contaminate, the concrete. Truck mixers need to be certified in accordance with NRCMA standards. The certification process also requires concrete uniformity testing in accordance with ASTM C-94, at periodic intervals, if mixing of the concrete is performed in the trucks, or water or other ingredients are added to the concrete batch after the concrete is discharged from the batch plant. Verify that the drum revolution counters are operable and reset after each batch is discharged.

02.03d1 Storage of reinforcing steel should be examined to verify that storage conditions are adequate to ensure that rebar will not become contaminated with materials such as mud, excessive rust, grease, oil, etc., which could affect the bonding of the rebar and concrete. Completed reinforcement placement should be checked for size, spacing, splice locations, bending, proper clearances from face of forms or excavated surfaces (i. e., verify rebar will have minimum required cover, in addition to the correct “d” distance), and anchorage. Reinforcing steel needs to be free from oil, grease, paint, loose rust, dried mud, weak mortar, etc. The steel needs to be firmly held within the forms (usually tie wire is used), to prevent the rebar from being displaced by movement of the plastic concrete, or by other construction activities, such as concrete vibration, or by movement of construction personnel in the form areas. Particular attention needs to be directed to installation of column ties, stirrups, and dowels. Verify that other hardware items to be embedded in the concrete placement are clean, properly located, and firmly anchored.

02.03d2 For splices, review the mechanical splicing instructions issued by the vendor. This document usually specifies the proper performance of all

mechanical splicing operations. Ascertain whether it is being used.

1. Cadwelding

When Cadwelding operations are being performed, verify that specified materials (sleeves, powder, packing) are properly stored, and that Cadwelding fixtures are in good condition. The reinforcing steel to be Cadwelded should be cleaned shortly before Cadwelding, to remove all nonadherent rust. The reinforcing steel ends should be aligned and butted within the tolerances specified, using the spacers provided with the cadweld kits.

Observe the placement of sleeves and the use of a marking system to ensure centering. When the firing is completed and packing removed, examine the sleeve and reinforcing steel to ensure that metal is showing at the vent (no slag at the tap hole), and each end of the sleeve shows proper fill (allowable void area not exceeded).

Ascertain whether each Cadweld sleeve is identified. By interviews with two Cadwelding inspectors, ascertain whether they are familiar with the details of Cadwelding requirements; also determine whether inspection of Cadwelding conforms to the specified frequency, whether inspection (QC) records are being maintained, and whether records are traceable to installation location, and identification of the cadwelder (craftsman).

2. Other types of mechanical splices, (e.g., Bar-Lock splices, if used)

Verify that the NRC has approved use of the type splice. Review the CAR, SER, and manufacturer's instructions to determine specific installation and testing requirements. Review the laboratory test data used to qualify the splices and verify that the licensee's installation procedures will result in an installed configuration that will reflect the laboratory testing conditions. Typical inspection parameters for all types of mechanical splices require cleanliness of the ends of the rebar to be spliced, verification of adequate embedment of the rebar ends, within the splicing sleeve, and verification that the sleeve is centered over the ends of both bars to be spliced. Identification of each splice and the craftsman/crew who completed the splice is also generally required. All craftsmen are required to be trained. All splices require inspection and acceptance by qualified QA/QC inspectors. A testing program will normally be specified to ensure the splices fabricated at the job site meet design requirements.

02.03d4 The area where concrete is to be placed needs to be clean and free of debris. Materials such as sawdust, wood, dried mortar, tie wire, and other debris need to be removed from the forms before placement of concrete. Access ports are usually provided in the forms to permit cleaning and inspection. Water jets and/or compressed air should be used for cleaning. Forms must be well secured and braced so they will

not be displaced by the fresh concrete or concrete-placement activities. The permitted rate of rise of the fresh concrete need to be specified, to avoid excessive loads on the forms, caused by hydraulic forces from the fresh concrete. Otherwise, there could be form failures (blow-outs) resulting in injuries to construction personal and/or damage to safety-related structures or components.

02.03d5 Inspection personnel must inspect pre-placements within a timeframe that represents the actual conditions before the placement. Quality control pre-placement inspections must not be unnecessarily rushed by advancing concrete work, especially during large slab or basemat placements. When possible, verify the actual as-built condition of reinforcing steel, with respect to the engineering drawings. If deviations exist, verify that proper engineering evaluations have been performed. Records need to document that all pre-placement construction and inspection activities have been completed. Concrete surfaces (joints) on which additional concrete is to be placed should be roughened, and all loose materials removed to ensure good bonding of the new concrete to existing concrete.

The joints should be kept damp for a specified period, usually 12 to 24 hours, before concrete placement. There should be no standing water in the forms.

02.03d6 In addition to having adequate equipment available to complete the concrete placement, extra equipment, such as vibrators, concrete trucks, and concrete pumps need to be available. Enough personnel need to be available, to fill in; and to keep concrete placement personnel from becoming fatigued by long work hours, which could lead to errors and substandard construction. Necessary equipment needs to be available to form construction joints on short notice, in case of an unforeseen stoppage of the concrete placement. Equipment needs to be available to protect the new concrete from all weather conditions, including rain, heat and cold.

02.03f1 The practice of withholding water at the batch plant and then tempering at the point of placement should take into account the results of air content and slump measurements taken at the point of placement. Efficient radio communications between the batch plant and field QC testing personnel will minimize the need for water tempering at the point of placement and thus result in more uniform batching. Check time (90 minutes max) of concrete receipt for truck transported, centrally mixed concrete, and number of truck-mixer revolutions (300 max). Also, verify the amount (quantity should be documented) of water added, if permitted, and re mixing (minimum 30 revolutions).

02.03f4 Concrete should not strike forms or bounce against reinforcing bars causing segregation of aggregates from the mix.

02.03f5 There should be a sufficient number of vibrator operators and,

preferably, some spare vibrators, that should be checked for proper operation, before starting to place concrete. Vibrators less than (3 inches) diameter are generally designed to operate at about 7000-8000 vibrations per minute, when immersed in concrete. Large vibrators, used in heavy-section concrete placement, operate at about 6000 vibrations per minute. Vibrators less than (3 inches) in diameter can be operated by one man; (4 inches) or larger vibrators are two-man tools. Proper vibrator operation involves duration of vibration, distance between vibrator insertions, and depth of insertions. The vibrators should be handled and operated vertically and never "cast" away from the operator horizontally and then retrieved. Concrete should be placed horizontally, in about (12 inch) layers, and never allowed to pile much higher in one area of the form than another. The vibrator should penetrate through the new concrete well into the previously placed layer, to avoid any "layer-cake" effect. Occasional contact of a vibrator with the forms is permissible, and with the reinforcement is desirable. Form vibration is generally not desirable, and care should be taken that reinforcement is not displaced by vibrators, or by people walking on the steel. Vibrators should not be used to move concrete laterally. Any excess water in the forms should be removed and not permitted to mix with the concrete.

02.03g1 The concrete needs to be protected from damage and properly cured. Proper curing requires keeping the surface of the concrete moist, and, in cold weather, warm, so that hydration of the cement continues until the concrete achieves design strength. Curing can be accomplished using moisture (water sprays, etc.) or by use of a curing compound. However curing compounds should not be used on construction joints unless they are removed prior to the next placement. Curing compounds used on construction joints may act as a bond breaker and result in successive placements not achieving good bond. Minimum curing times should be specified in the construction records. Formation of ice (freezing of the curing water) on surfaces of the concrete during the curing period should not be permitted. Forms need to remain in place for the period specified in the procedures. The time to remove the concrete forms is often based on achieving a minimum concrete strength.

02.03g2 Defective areas in concrete should be repaired as soon as possible after the forms are removed. Design engineering approval should be obtained for all concrete repair methods. It is not acceptable to repair concrete defects by merely plastering over them with mortar. Concrete defects need to be cut to a depth to expose sound concrete and filled with concrete of the same strength as that in the structure. Repair of defects are usually classified as cosmetic if they are shallow surface defects, and structural if they extend to a depth below the outer layer of rebar. Locations of concrete defects and repair methods need to be documented in licensee inspection records. Note that areas repaired are required to be protected from the elements and cured to achieve

adequate design strength.

02.03h This portion of the inspection may require subsequent followup, to determine that final inspection, evaluation, and acceptance are being controlled and accomplished in accordance with QA/QC requirements. Final inspection procedures should include verifying embed locations and identification of any defects and required repairs. Review the results of compressive strength determinations. Verify that results are being evaluated in accordance with ACI 214, “Recommended Practice for Evaluation of Compression Test Results of Field Concrete”. During this portion of the inspection, also review the results of strength tests on mechanical reinforcing steel splices.

Records should be verified to show that mix specified was delivered and placed. Structural drawings or specifications will indicate the design concrete strength. Evaluate the licensee's trending analysis of nonconforming items and determine if generic items are being identified and corrected.

02.03j Particular attention should be directed toward the qualification of personnel and their work performance. In the past, at some projects, there was a tendency for some organizations to hire untrained personnel residing near the site who had no prior work experience in concrete materials testing or inspection, train them, and certify them. Although the individuals were trained and certified, in some instances inexperience of personnel and the lack of depth of knowledge was been found to be detrimental to an effective QA/QC program. Changing of personnel between different jobs and turnover of personnel can also result in problems.

In determining the adequacy of QA/QC staffing; the effectiveness of their activities must be considered. Insufficient or unqualified personnel, or inadequate management, may result in inadequate inspections of concrete-construction activities. Capabilities and effectiveness, rather than only the number of personnel, are the principal criteria to be used.

02.04a During periods when concrete is to be placed or cold weather is expected during the curing time, provisions must be made to keep the concrete above [40°Fahrenheit (F)], preferably in the range of [(50 to 60°F)]. If concrete is being mixed or transported in weather below (40°F), the ingredients may be pre-warmed so that the temperature of the concrete after placement is elevated to account for losses. Heating the water is the most effective and most easily controlled technique, but the aggregate must not be frozen. The water should not be so hot as to cause "flash set" of the cement during mixing; that is, the temperature of the mortar should not exceed (100°F). If hotter water is required to warm the aggregate, the water and aggregate may be mixed before addition of cement. If the aggregate is heated, close

control must be exercised, and the aggregate must be frequently checked for variations in moisture content caused by local variations in heating. Direct fired heaters may produce carbon dioxide, in the exhaust fumes, forming calcium carbonate on the surface of fresh concrete. Also, use of chemicals should not be permitted to accelerate the concrete set times in cold weather.

Where the ambient temperature during concreting rises much above (70°F), consideration must be given to the effect of high temperatures on the concrete. Although concrete cured at temperatures up to (100°F) gives higher early strength, with little degradation of long-term strength, high temperatures during mixing, transportation, and placement can be seriously detrimental. The most obvious effect is that the concrete requires more water for work ability or the use of additives. A less obvious effect is the need for special attention to curing, because the higher temperature increases water evaporation from the concrete.

Exposure to strong summer sun can raise the temperature of ingredients, equipment, forms, etc., far above the air temperature. If this occurs, provisions should be made for appropriate shades or screens, and the equipment, forms, and metallic embedments, etc., should be wetted just before concrete placement. If the ambient temperature is high enough so that the bulk temperature of freshly mixed concrete exceeds (80°F or 90°F), consideration should be given to some method of cooling the ingredients, such as chilling the water, or using ice. If ice is used, it must be crushed or flaked so that all the ice is melted by the time mixing is completed.

03.02 Prevalent Errors and Recent Concerns

a. This section is included to provide background, for inspectors, on past structural concrete problems that have been identified and on certain areas that should be more closely scrutinized, so as to give NRC early information on potential problems. The following are potential problems identified as concrete-related violations at previous projects. (Note - These are not listed in order of their perceived importance to safety.)

1. Inadequate QA/QC records documenting concrete work activities.

2. Improper use of vibrators.

3. Exceeding allowable time to place concrete.

4. Improper sampling of aggregates.

5. Improper curing of concrete test cylinders.

6. Exceeding allowable concrete temperatures.

7. Materials improperly certified.

8. Concrete cylinder compression test records exceed allowable coefficient of variation.

9. Improper splicing practices (reinforcement cleaning, alignment, gage marks, thread damage, and inadequate swagging force, etc.).

10. Inadequate concrete curing.

11. Samples of concrete not taken where and when required.

12. Excessive doses of concrete admixtures.

13. Inadequate cleanliness of placement.

14. Omission of reinforcing steel, incorrect spacing of reinforcing steel, and/or improper anchorage (failure to firmly tie the rebar) of the steel.

15. QC inspections not done conscientiously.

16. Excessive drop of concrete.

17. Batch plants improperly qualified.

18. Improper repair of concrete defects.

19 Intentional violation of work procedures by craft personnel to avoid rejection of their work, or to simplify their work. Examples included melting of tie wire into ends of completed cadwelds, unauthorized addition of water to concrete, and covering concrete defects (honeycomb) with mortar to prevent detection by QA/QC inspectors

20 Construction personnel and supervision intimidation of QA/QC inspectors.

03.03 Background Information. This information is to be used as reference material, however, the site specifications govern. The information may be valuable in discussions about the adequacy of the specifications.

88132-04 RESOURCE ESTIMATE

This inspection procedure is expected to take, on the average, 24 to 32 hours for each review of licensee/contractor activities. This procedure should be performed every 3 months. During the first year of placement of SC-I and SC-II concrete, select at least two placements. Thereafter, select at least two placements per year. Regional Management should use inspector observations regarding the relative complexity of required SC-I concrete work activities and observed competency of licensee and contractor personnel.

Duke, Cogema, Stone and Webster, “Mixed-Oxide Fuel Fabrication Facility, MOX Project Quality Assurance Plan (MPQAP)”, Docket Number 070-03098, under US Department of Energy Contract DE-AC02-99-CH10888, latest revision accepted by NRC.

Duke, Cogema, Stone and Webster, “Mixed-Oxide Fuel Fabrication Facility Construction Authorization Request”, latest revision accepted by NRC.

Code of Federal Regulations 10 CFR Part 50, Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants”.

Code of Federal Regulations 10 CFR Part 70, “Domestic Licensing of Special Nuclear Material.”

Code of Federal regulations 10 CFR Part 21, “Reporting Defects and Noncompliance.”

U.S. Nuclear Regulatory Commission Regulatory Guide 1.28, “Quality Assurance Program Requirements (Design and Construction)”, Revision 3.

American Concrete Institute (ACI)

ACI 116 “Cement and Concrete Terminology.”

ACI 117 “Standard Specification for Tolerances for Concrete Construction and Materials.”

ACI 211.1 “Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete.”

ACI 212.1 “Admixtures for Concrete.”

ACI 212.2 “Guide for Use of Admixtures in Concrete.”

ACI 212.4 “Guide for Use of High-Range Water-Reducing Admixtures (Superplasticizers) in Concrete.”

ACI 214 “Evaluation of Strength Test Results of Concrete.”

ACI 221 “Guide for Use of Normal Weight and Heavyweight Aggregates in Concrete.”

ACI 301 “Specifications for Structural Concrete.”

ACI 304 “Guide for Measuring, Mixing, and Placing Concrete.”

ACI 304.2 “Placing Concrete by Pumping Methods.”

ACI 305 “Hot Weather Concreting.”

ACI 306 “Cold Weather Concreting.”

ACI 308 “Guide to Curing Concrete.”

ACI 309 “Guide for Consolidation of Concrete.”

ACI 311 “Recommended Practice for Concrete Inspection.”

ACI 311.1 “ACI Manual of Concrete Inspection.”

ACI 311.4 “Guide for Concrete Inspection.”

ACI 311.5 “Guide for Concrete Plant Inspection and Testing of Ready Mixed Concrete.”

ACI 315 “Details and Detailing of Concrete Reinforcement.”

ACI 318 “Building Code Requirements for Structural Concrete.”

ACI 347 “Guide to Formwork for Concrete.”

ACI 349 “Code Requirements for Nuclear Safety-Related Concrete Structures.”

ACI 359 “Code for Concrete Reactor Vessels and Containments, Section III, Division 2."

ACI 503 “Use of Epoxy Compounds With Concrete”

ACI 503.4 “Standard Specification for Repairing Concrete With Epoxy Mortar.”

ACI 504 “Guide to Sealing Joint in Concrete Structures.”

ACI 530-02 “Building Code Requirements for Concrete Masonry Structures.”

American Society of Mechanical Engineers (ASME)

ASME NQA-1 “Quality Assurance Requirements for Nuclear Facility Applications.”

ASME NQA-2 “Quality Assurance Requirements for Nuclear Power Plants.”

American Welding Society (AWS)

AWS D1.1 “Structural Welding Code.”

AWS D1.4 “Structural Welding Code - Reinforcing Steel.”

American Society for Testing and Materials

ASTM A-615 “Deformed Billet-Steel Bars for Concrete Reinforcement.”

ASTM A-706 “Standard Specification for Low-Alloy Steel Deformed Bars for Concrete Reinforcement”.

ASTM C-29 “Test for Unit Weight of Aggregate.”

ASTM C-31 “Making and Curing Concrete Compressive and Flexural Strength Test Specimens in the Field.”

ASTM C-33 “Standard Specification for Concrete Aggregates.”

ASTM C-39 “Test for Compressive Strength of Molded Concrete Cylinders.”

ASTM C-94 “Standard Specification for Ready Mixed Concrete.”

ASTM C-109 “Standard Method of Test for Compressive Strength of Hydraulic Cement Mortar (Using 2-in. Cube Specimen).”

ASTM C-117 “Test for Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing.”

ASTM C-127 “Test for Specific Gravity and Absorption of Coarse Aggregate.”

ASTM C-128 “Test for Specific Gravity and Absorption of Fine Aggregate.”

ASTM C-136 “Test for Sieve or Screen Analysis of Fine and Coarse 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-192 “Making and Curing Concrete Test Specimens in the Laboratory.”

ASTM C-231 “Test for Air Content of Freshly Mixed Concrete by the Pressure Method.”

ASTM C-260 “Standard Specifications for Air Entraining Admixtures for Concrete.”

ASTM C-309 “Specification for Liquid Membrane - Forming Compounds for Curing Concrete.”

ASTM C-494 “Standard Specification for Chemical Admixture for Concrete.”

ASTM C-566 "Standard Method of Test for Total Moisture Content of Aggregate by Drying>'

ASTM C-642 "Test for Specific Gravity, Absorption, and Voids in Hardened Concrete."

ASTM D-512 "Test for Chloride Ion in Industrial Water and Industrial Waste Water."

ASTM D-1888 "Tests for Particulate and Dissolved Matter in Water."

U. S. Army Corps of Engineers, Handbook for Concrete and Cement, Published by US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Miss.

NRC Publications

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.28, "Quality Assurance Program Requirements (Design and Construction)". (Rev. 3)

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.29, "Seismic Design Classification".

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.38, "Quality Assurance Requirements for Packing, Shipping, Receiving, Storage, and Handling of Items for Water-Cooled Nuclear Power Plants".

U.S. Nuclear Regulatory Commission, 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".

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.136," Materials, Construction, and Testing of Concrete Containments".

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.142, "Safety-Related Concrete Structures for Nuclear Power Plants (Other Than Reactor Vessels and Containments)".

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.199, "Anchoring Components and Structural Supports in Concrete."

National Ready Mixed Concrete Association (NRMCA)

NRMCA, "Concrete Plant Standards of the Concrete Plant Manufacturers Bureau."

NRMCA, "Truck Mixer and Agitator Standards of the Truck Mixer Manufacturers Bureau."

Others

Concrete Manual, published by the Bureau of Reclamation.

Publications of the Portland Cement Association.

For information and standards for studs (proprietary name: Nelson Studs), which are used to secure embedded item such as pipe sleeves and plates, to concrete structures, refer to Chapter 8, “Stud Welding”, Volume 2 of the Welding Handbook, Seventh Edition, published by the American Welding Society.

END

ATTACHMENT 1

Revision History for IP 88132

Commitment Tracking Number	Issue Date	Description of Change	Training Needed	Training Completion Date	Comment Resolution Accession Number
	10/25/06 CN 06-031 06-NMSS	IP 88132 is a newly issued procedure. Issued for MOX inspection program to improve effectiveness and efficiency by incorporating and consolidating inspection requirements involving structural concrete inspection activities.	None	N/A	