

NRC INSPECTION MANUAL

DQASIP

INSPECTION PROCEDURE 63050

CONTAINMENT STRUCTURAL INTEGRITY TEST

PROGRAM APPLICABILITY: 2512

63050-01 INSPECTION OBJECTIVES

To determine whether the containment structural integrity test (SIT) program, instructions, procedures, actual test performance, and evaluation of test results are consistent with regulatory requirements and licensee commitments.

Inspection Schedule

May Be Started

One or two months
before performance
of SIT

Must Be Started

Before performance
of SIT

Must Be Completed

Before issuance of
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63050-02 INSPECTION REQUIREMENTS

The inspection requirements of this inspection procedure consist of a review of: (1) the SIT program, procedures, and instructions; (2) test witnessing, if necessary; and (3) review of the test records. Within each inspection area the inspection requirements detailed in Sections 02.01 through 02.03, below, consist of general requirements and those specifically for concrete or steel containments.

02.01 Review of SIT Program, Procedures, and Instructions

a. General

1. Review applicable portions of the facility SAR 3.8 and associated regulatory requirements or licensee commitments.
2. Determine whether the SIT program, procedures, and instructions have been approved by authorized licensee personnel.
3. The type, location, range, accuracy, and calibration of instrumentation and the method of application of test loads meets requirements and is predetermined.

4. The maximum rate of pressurization, including pressurization increments, and depressurization of the containment is specified. Often the SIT immediately precedes the containment integrated leakage rate test (10 CFR 50 Appendix J). In those cases the appropriate holding time at reduced pressure must be considered as a prerequisite to the start of the Appendix J test.
 5. Only nonflammable gas shall be used for pneumatic testing.
 6. Environmental conditions are specified for conducting the test and are monitored during the test.
- b. Concrete Containment. Determine whether the procedures and instructions address the following:
1. Surface crack patterns of cracks larger than 0.01 inch in width are required to be recorded at specified locations and:
 - (a) At atmospheric pressure before the test.
 - (b) At maximum pressure level during the test.
 - (c) At atmospheric pressure immediately after the test.
 2. At each specified equal increment of pressure increase, approximately constant pressure should be retained for at least one hour before recording deflections and strains.
 3. The test pressure is specified to be at least 1.15 times the containment design pressure.
- c. Steel Containment. Determine whether the procedures and instructions incorporate the following:
1. The rate of pressurization after achieving 50% of the final test pressure is to be increased in steps of approximately 1/10 of the test pressure up to 1.10 times the design pressure but not more than the maximum permissible test pressure prescribed by stress limits.
 2. The holding time for the test pressure is to be at least 10 minutes.
 3. After the holding time at the test pressure, examinations for leakage are to be made at the specified fraction of the test pressure or at design pressure, whichever is greater. These examinations are to be at locations specified by the ASME Code or test procedure.

02.02 SIT Witness

a. General

1. For non-prototype containment structures where usual design features have been confirmed by one or more SITs, the witnessing of the SIT is not required.
2. For other containment structures or for those of particular interest, determine whether the following SIT activities meet the requirements and commitments.

- (a) Select two pressure gages and verify the type, location, range, accuracy, and calibration.
- (b) The rate of containment pressurization does not exceed any specified limits.
- (c) Increments of pressure increase with specified holding time are being observed.
- (d) Evaluate overall performance of SIT crew:
 - (1) Test performance is adequately coordinated.
 - (2) SIT crew is familiar with test program and procedures (interview two lead members).
 - (3) SIT crew is familiar with application and reading of instrumentation.
 - (4) Test data are accurate and precisely recorded. Sample two recordings at test pressure.
 - (5) Unusual data points, trend, sudden changes, etc. if observed, are "flagged" for evaluation and necessary corrective action.
- (e) Final containment test pressure and specified holding time complies with requirements.
- (f) The rate of depressurizing including increments and holding time are being observed as specified. Often the SIT immediately precedes the containment integrated leakage rate test (10 CFR 50 Appendix J). In those cases the appropriate holding time at reduced pressure must be considered as a prerequisite to the start of the Appendix J test.
- (g) No adverse environmental conditions, such as high wind, snow or extreme temperatures differentials, affect the SIT.
- (h) Retests may be required if significant damage or leakage requires repair work or if structural changes are made. If repair work is done, verify that the repair work and structural changes are recorded.

b. Concrete Containment. Determine whether the following are being met:

- 1. Crack pattern mapping is being performed at atmospheric pressure prior to the test, during maximum test pressure, at atmospheric pressure after the test, and at the specified locations. Sample two of the above three periods for crack pattern mapping and verify at least two crack dimensions and the accuracy of recording crack locations.
- 2. Select two instruments to measure deflections and verify the accuracy and proper application of these instruments.
- 3. Select three strain gages, if they are being used and verify the type, location, proper installation, range, and accuracy are as specified.
- 4. Radial and vertical deflection readings and recordings are made at specified locations.

5. Radial and tangential deflection measurements are taken at locations around the largest containment penetration or opening, and, if required, the second largest containment penetration or opening.
 6. Deflection, strain readings (if required), and recordings are made at times specified.
- c. Steel Containments. Determine whether the specified test pressure is maintained for 10 minutes and then reduced to the greater of either the design pressure or the specified fraction of the test pressure for examination of leakage.

02.03 Review of Test Records

a. General

1. Review the records pertaining to the instrumentation used during the SIT and determine whether the equipment, calibration, and range are consistent with the following:
 - (a) Strain measuring devices were in good working condition with an accuracy of $\pm 5\%$ of the maximum strain measured.
 - (b) The gage length is 4 inches or more for concrete strains.
 - (c) Load cells for tendon force measurement, if utilized, have an accuracy of at least $\pm 3\%$ of the tendon force.
 - (d) Indicating pressure gages have a graduated dial of not less than 1-1/2 times the test pressure and not more than 2 times test pressure.
 - (e) Pressure gages were calibrated against a standard deadweight test or a calibrated master gage prior to the test.
2. Review the data analysis and determine the following:
 - (a) The evaluation and data analysis were performed by qualified and experienced persons.
 - (b) Discrepancies between measured and predicted extremes of deformation and strains were resolved satisfactorily.
 - (c) No permanent damage to the concrete structure or steel liner plates has been observed.

b. Concrete Containments

1. Select a sample of the records of the deflection readings for: (a) vertical deflection measurement of the dome and/or springline; (b) radial deflection measurement of the containment wall; (c) radial deflection around the largest opening. Determine whether these measurements have been consistent with the following:
 - (a) Location of selected measurements comply with predetermined locations in the program.

- (b) Instrumentation used to measure deflections was calibrated to comply with accuracy requirements specified by the test procedure or applicable codes.
 - (c) Test results are within the predetermined design acceptance criteria.
- 2. Strain Measurements (prototype concrete containments only). Select the records of strain measurements for the test readings near the intersection of the containment wall and the basemat, the readings at the springline of the dome, and at the largest opening, and determine from these records whether these measurements have been obtained in compliance with the following:
 - (a) Strain measurements are within the predetermined design acceptance criteria.
 - (b) If any significant modifications or repairs were made to the containment after the test, the test is to be repeated.
- c. Steel Containments. Review the records of the SIT and determine whether the test was conducted in compliance with the following:
 - 1. The test pressure of more than 1.10 times and less than the specified maximum pressure was retained 10 minutes or more.
 - 2. All joints, penetrations, connections and regions of high stress were examined for leakage.
 - 3. If necessary, leaks were properly eliminated after which the system was retested in compliance with the requirements of the original test.

63050-03 INSPECTION GUIDANCE

General Guidance. The containment structural integrity test (SIT) demonstrates the capability of the primary reactor containment to withstand specified internal pressure loads. For concrete containments the actual building response is compared with the predicted response and whether cracks in the concrete surface are within acceptable limits.

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

03.01 Specific Guidance

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

02.01a The inspector should examine the program, procedures and instructions pertaining to the test, including essential drawings, sketches etc. at the earliest possible time (about 1-2 months prior to the test) to permit the licensee to make any necessary corrections prior to the SIT.

02.01a3 For concrete containments, radial deflections should be measured at several points along six meridians spaced around the containment, including locations with varying stiffness characteristics such as buttress, wall, air locks, other large openings and

connections with other structures. Regulatory Guide 1.18 indicates locations for points of measurements for vertical and radial deflections and for cylindrical and cone-cylinder containments. For prototype concrete containments, Regulatory Guide 1.18 also specifies the locations for strain measurements -- top of basemat, largest opening, and dome springline.

02.01a4 Past experience has indicated that an optimum, not safety-related rate of pressurization of the containment is in the range of about 10 psi per hour. Normally the pressurization rate will be limited by compressor capacity.

02.01a5 The containment structure should be pressurized, using a medium that is reasonably clear, dry, and free of contaminants. Repressurizing facilities should be available for adjusting to subsequent atmospheric changes as necessary to meet specific requirements, or if leaks are identified.

02.01b1 Most common locations for crack formation are at the base-wall intersection, at the springline of the dome, and around large openings. At the mid-height of the wall, crack monitoring should also be performed. For pre-stressed containments cracks are monitored at the critical areas which include the intersection between the buttress and the wall, the wall and the ring girder, and on the top shelf of the ring girder.

At each of the above locations an area of at least 40 square feet should be mapped for crack pattern where the cracks are expected to exceed 0.01 inch in width.

Specific regions of expected high surface tensile strain (designated as control regions) may require mapping of cracks as small as 0.005 inch in width.

It is good practice to apply white paint on the surfaces of these critical areas a few days prior to the SIT; this helps the inspector observe the crack pattern.

02.01b3 It is not recommended to exceed the 1.15 times the design pressure. Excess crack formation may affect the structural integrity.

02.01c1 The pressure shall be gradually increased to not more than one-half the test pressure, thereafter the increments of one-tenth of the test pressure are steps used to locate possible leaks.

02.01c3 After the test pressure has been retained for a minimum of 10 minutes, the pressure should be reduced to the specified fraction of the test pressure or design pressure (whichever is greater) for the examination of leakage of all joints, penetration units, connections, and high stress regions such as thickness-transition and regions around openings.

Leaks shall be repaired and thereafter the system shall be retested as before.

02.02a2(d) During the interview of lead men, the inspector should inquire about subjects such as instrument calibrations, their applications, pressure limits, pressure holding time, crack pattern mapping, deflection measurements, etc.

02.02a2(f) Depressurization rate and unloading increments should parallel the loading cycle.

02.02b1 When sampling crack dimensions, special emphasis should be placed on borderline cracks which are about 0.01 inch in width and the verification of dimensions pertaining to the location of crack pattern area.

02.02b4 For nonprototype structures, instrumentation for measurement of overall and deformation is required, such as radial deflection of the containment at 02.02b5 several points along six meridians spaced around the containment, vertical deflections of the containment at the apex and the springline of the dome, and radial and tangential deflections of the containment wall adjacent to the largest opening.

Deviations from predetermined locations of measurements, accuracy requirements of instrumentation, and measurements exceeding design parameters should be evaluated. The disposition of the deviation and corrective measures should be explained in the final test report with a discussion of the calculated safety margin provided by the structure as deducted from the test results.

02.02c Examination for leakage shall be made at all joints, connections, and all regions of high stress, such as regions around openings and thickness-transition sections. Leaks shall be eliminated, after which the containment shall be retested.

02.03a1 The final SIT test results should include the records pertaining to the test instrumentation calibration and recalibrations.

02.03a2 After the SIT, test results, records, data, and analysis should be reviewed and examined, placing special emphasis on the review of the resolutions pertaining to discrepancies between predicted and measured extremes. Unusual data points and their dispositions should receive special attention during the record review. Acceptance of the SIT should comply with applicable code and SAR requirements.

02.03a2(a) After the SIT is completed, verify that the test data are evaluated by the designer.

02.03a2(b) Satisfactory resolutions pertaining to discrepancies between measured and predicted extremes of deformation are made through NRR. The inspector should keep informed about NRR resolutions.

02.03a2(c) If any damage has occurred, the test results shall include corrective measures, an analysis of the calculated safety margin provided by the structure, and a discussion of the final resolutions.

63050-04 REFERENCES

Regulatory Guide 1.18, Structural Acceptance Test for Concrete Primary Containments.¹

Regulatory Guide 1.136, Materials, Construction, and Testing of Concrete Containments.

ASME B&PV Code, Section III, Division 2 (ACI Standard 359).

ASME B&PV Code, Section III, Division 1, Subsection NE.

END

¹ This Regulatory Guide was withdrawn by Regulatory Guide 1.136, Revision 2, June 1981. Implementation of Regulatory Guide 1.136, Revision 2 is for applications docketed after May 1981.