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Information Notice No. 98-26: Settlement Monitoring and Inspection of Plant Structures Affected by Degradation of Porous Concrete Subfoundations

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

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NRC INFORMATION NOTICE 98-26: SETTLEMENT MONITORING AND INSPECTION OF PLANT STRUCTURES AFFECTED BY DEGRADATION OF POROUS CONCRETE SUBFOUNDATIONS

Addressees

All holders of operating licenses for nuclear power reactors; all holders of or applicants for licenses to operate Independent Spent Fuel Storage Installations; and designers and fabricators of Independent Spent Fuel Storage Installations.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees who own and operate facilities with plant sites that include structures with porous concrete subfoundations of the possibility of degradation of these subfoundations. Such degradation could have deleterious effects on structures, systems, and components (SSCs).

It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

The containment structure at Millstone Nuclear Power Station, Unit 3 (MNPS-3), has a 3.05-meter (10-foot) thick reinforced-concrete basemat founded on rock. Between the foundation rock surface and the underside of the basemat are several layers of different materials. These layers consist of (1) a 25.4-cm (10-inch) thick leveling layer of porous concrete made of coarse aggregates and Portland cement, (2) a 0.16-cm (1/16th-inch) thick butyl rubber waterproofing membrane, (3) a 5.08-cm (2-inch) thick Portland cement mortar seal, (4) a second layer of 22.86-cm (9-inch) thick porous concrete made of coarse aggregates and calcium aluminate (high-alumina) cement, and (5) a thin mortar seal on the top of the upper layer of the porous concrete. In the upper porous concrete layer, 15-cm (6-inch) diameter porous concrete pipes are installed to collect and drain ground water, which may seep down along the periphery of the containment wall. The collected water drains into two sumps inside the engineered safety features (ESF) building.

The MNPS-3 licensee, Northeast Nuclear Energy Company, identified the issue of cement erosion from the porous concrete drainage system in 1987 upon examination of the accumulated white residue in the two lower drain sumps in the ESF building. IN 97-11, "Cement Erosion From Containment Subfoundations at Nuclear Power Plants," was issued on March 21, 1997, to alert addressees to the potential for erosion of cement from porous concrete subfoundations.

The main concern raised by the cement erosion at MNPS-3 is the continued ability of the degraded porous concrete subfoundations to transfer the loads of seismic Category I structures to the underlying foundation medium without detrimental settlement. To address the question of whether other nuclear power plant sites have this condition, the staff reviewed the updated final safety analysis reports (UFSARs) of 24 plants selected on the basis of the unique practice of the constructor or the architect/engineer (A/E) firm to use porous concrete subfoundations, and a sampling of other A/E firms. This limited-scope review revealed that at least 12 other reactor units have porous concrete subfoundations (reference: IN 97-11). A survey of these 12 units indicated that the licensees of three units (i.e., Millstone 3, Nine Mile Point 2, and Maine Yankee) have implemented surveillance programs to monitor for possible cement erosion from the subfoundations beneath the containment basemats. In addition, the Perry licensee has reported that dissolved calcium carbonate is being carried to the drainage pipes and the sumps, where it is solidifying as a hard scale. The Perry licensee also discovered an accumulation of mineral deposits that is clogging the pores of the porous concrete pipes. Although most of the surveyed licensees report that there is no evidence of cement erosion from the porous concrete subfoundations, a review of their reports indicates that there is some discharge of water (including some leachate) in several of the plants.

Discussion

Various types of porous concrete subfoundations may have been constructed at other plants. The degradation of porous concrete leading to the creation of voids and local pockets of loose concrete could eventually result in undesirable settlement of a structure. An effective way to determine the presence of such effects is to inspect and monitor seismic Category I structures (that have porous concrete subfoundations) and the associated systems and components for evidence of structural settlement.

The settlement of a structure can give rise to a number of effects, some that are observable by inspection and some that are not so visible. If settlement is uniform, that is, all parts of the basemat settle an equal amount, the structure itself may not show appreciable distress. However, the alignments of the attached piping, electric cable lines, and instrument lines would be changed from their original, as-built configuration. If settlement is not uniform, the effects could be visible on a concrete structure in the form of cracking near areas of stress concentration, such as at discontinuities and large penetrations.

The differential settlement could cause overstressing in a steel structure and could also affect the alignment of, and stresses in, the attached piping, electric cable lines, and instrument lines. Moreover, the differential settlement could cause misalignment of cranes and monorails. GDC 16 of Appendix A to 10 CFR Part 50 requires that "reactor containment and associated systems shall be provided to establish an essentially leaktight barrier against the uncontrolled release of radioactivity to the environment and to assure that the containment design conditions important to safety are not exceeded for as long as postulated accident

conditions require." GDC 55 (referring to reactor coolant pressure boundary penetrating containment) requires, in part, that "other appropriate requirements to minimize the probability or consequences of an accidental rupture of these lines or of lines connected to them shall be provided as necessary to assure adequate safety." As explained in the preceding paragraphs, detrimental settlement as a result of erosion of cement from the porous concrete subfoundation could result in overstressing of the pipes (lines) penetrating the containment structure and increase the probability of an accidental rupture of these lines or of lines connected to them. Criterion XVI of Appendix B to 10 CFR Part 50 requires licensees to take appropriate corrective actions when conditions adverse to quality and safety are detected. Detrimental settlement of a structure (for any reason) can be characterized as a condition adverse to quality and safety.

Safety-related and certain non safety-related structures are required by the maintenance rule (10 CFR 50.65) to be within the scope of the licensee's structural monitoring program. NUMARC 93-01⁽¹⁾ provides guidelines to the industry for monitoring the effectiveness of maintenance at nuclear power plants in accordance with the requirements of the maintenance rule. NRC Regulatory Guide (RG) 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," Revision 2, March 1997, endorses NUMARC 93-01, Revision 2. Section C.1.5 of RG 1.160 describes the attributes of an acceptable structural monitoring program for the purposes of complying with the maintenance rule and evaluating structural degradation resulting from degraded conditions such as porous concrete erosion.

The NRC staff may inspect licensees' subfoundation monitoring and preventive maintenance programs as part of the NRC inspection program as described in NRC Inspection Procedures IP 62002 and IP 62003.

Related Generic Communications

IN 97-11, "Cement Erosion From Containment Subfoundations at Nuclear Power Plants, dated March 21, 1997."

This information notice requires no specific action or written response. However, recipients are reminded that they are required to consider industry-wide operating experience (including NRC information notices) where practical, when setting goals and performing periodic evaluations under 10 CFR 50.65, "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants." If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

Original signed by
Jack W. Roe, Acting Director
Division of Reactor Program Management
Office of Nuclear Reactor Regulation
Technical contacts: R. Pichumani, NRR
301-415-2734
E-mail: rxp@nrc.gov
H. Ashar, NRR
301-415-2851
E-mail: hga@nrc.gov

W. Burton, NRR
301-415-2853
E-mail: wfb@nrc.gov

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¹. NUMARC 93-01, "Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," Revision 2, April 1996.

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