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Improved Identification Techniques Against Alkali-Silica Reaction Concrete Degradation at Nuclear Power Plants; Request for Comments on Petition for Rulemaking

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Submitter Information

Name: David Lochbaum
Address:
PO Box 15316
Chattanooga, TN, 37415
Email: dlochbaum@ucsusa.org

General Comment

Having found that (a) existing inspections will not ensure that concrete degradation caused by alkali-silica reaction is detected, (b) concrete degradation caused by alkali-silica reaction can have adverse nuclear safety implications, and (c) the measures requested in the petition are appropriate solutions to the problem, the Union of Concerned Scientists concludes that the Nuclear Regulatory Commission should revise its regulations to ensure that alkali-silica reaction effects are effectively managed.

Attachments

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Union of Concerned Scientists
ucsusa.org Two Brattle Square, Cambridge, MA 02138-3780 t 617.547.5552 f 617.864.9405
1825 K Street NW, Suite 800, Washington, DC 20006-1232 t 202.223.6133 f 202.223.6162
2397 Shattuck Avenue, Suite 203, Berkeley, CA 94704-1567 t 510.843.1872 f 510.843.3785
One North LaSalle Street, Suite 1904, Chicago, IL 60602-4064 t 312.578.1750 f 312.578.1751

February 26, 2015

Comments by David Lochbaum
Director, Nuclear Safety Project

On

Improved Identification Techniques Against Alkali-Silica Reaction Concrete Degradation at Nuclear Power Plants; Request for Comments on Petition for Rulemaking

Docket ID NRC-2014-0257

Submitted electronically to www.regulations.gov

SUMMARY

Having found that (a) existing inspections will not ensure that concrete degradation caused by alkali-silica reaction is detected, (b) concrete degradation caused by alkali-silica reaction can have adverse nuclear safety implications, and (c) the measures requested in the petition are appropriate solutions to the problem, the Union of Concerned Scientists concludes that the Nuclear Regulatory Commission should revise its regulations to ensure that alkali-silica reaction effects are effectively managed.

THE PROCESS

In reviewing the petition for rulemaking (hereafter referred to as 'petition') submitted by the C-10 Research and Education Foundation (C-10), the Union of Concerned Scientists (UCS) identified three key questions:

1. Will existing inspections detect concrete degradation caused by alkali-silica reaction (ASR)?

2. Can concrete degradation caused by ASR have adverse safety implications?

3. Are the measures sought by C-10's petition appropriate remedies?

If the answer to the first question is yes, then the other two questions become moot and the actions sought by the petition are not necessary. The existing inspections will suffice without augmentation.

If the answer to the second question is no, then the third question becomes moot and the actions sought by the petition are not justified. Even if ASR degrades concrete, nuclear safety margins will not be compromised.

If the answer to the third question is no, the actions sought by the petition are not necessary. Concrete degradation caused by ASR has nuclear safety implications, but the proposed actions are not a suitable solution to the problem.

However, if the answer to the first question is no and the answers to the other two questions are yes, then the measures sought by the petition provide a reasonable solution to a nuclear safety problem. In that case, the ensuing rulemaking process will resolve this nuclear safety problem.

THE OUTCOME

After reviewing applicable records, the UCS concluded that existing inspections might detect concrete degradation caused by ASR. But existing inspections might just as easily fail to detect such concrete degradation. Among the evidence lessening the certainty of detection is the fact that the NRC required Seabrook's owner to implement aging management measures for concrete degradation in order to get a renewed operating license. The NRC did not make the owners of the more than 70 reactors it had already relicensed go back and institute these mandated measures; consequently, the absent or voluntary measures have low reliability. Therefore, the UCS answered this question 'no' and proceeded to question two.

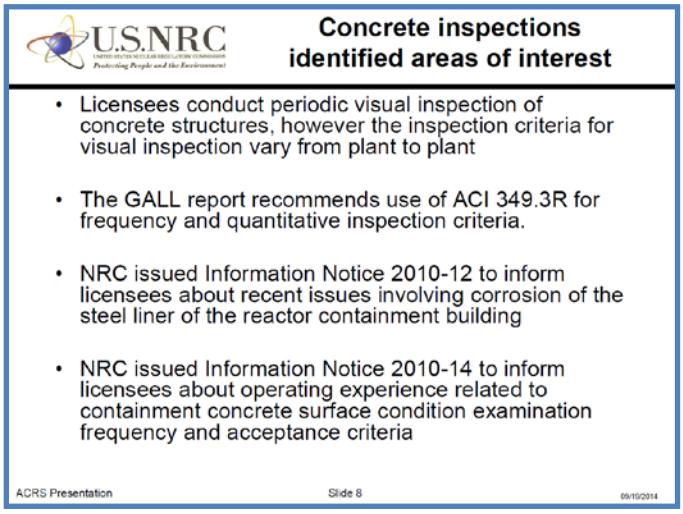
The record clearly shows that ASR degraded can weaken concrete and compromise safety margins. The NRC's response to ASR degradation at Seabrook demonstrates the safety implications—Seabrook's owner had to develop and implement measures to manage the adverse effects of ASR.

The record also clearly shows that the two measures sought by C-10 in its petition are appropriate remedies. The NRC has already recommended that owners follow one of the measures sought by C-10; namely, visual inspections of concrete per ACI 349.3R. But not all owners are required to conduct concrete inspections per this accepted standard. C-10 seeks to transform the NRC's recommendation into a regulatory requirement. The NRC has stated that C-10's second measure, petrographic examinations of concrete samples, is the "only" way to confirm whether ASR degradation is present. Thus, the two measures sought in C-10's petition are appropriate measures.

The UCS concludes that (1) existing inspections cannot be relied upon to detect ASR degradation, (2) that ASR degradation has adverse nuclear safety implications, and (3) that the two measures sought by C-10's petition are appropriate methods for properly managing ASR degradation.

Question 1: Will Existing Inspections Detect Concrete Degradation Caused by ASR?

The NRC's Advisory Committee on Reactor Safeguards (ACRS) examined concrete degradation due to various causes, including ASR, during a meeting on September 19, 2014.[1]



On slide 8 in its presentation to the ACRS, the NRC staff noted that while plant owners (licensees) periodically perform visual inspections of concrete structures, the criteria applied during these inspections varies.

For example, the NRC's maintenance rule (10 CFR 50.65) "*requires that licensees monitor the performance or condition of structures, systems, and components (SCCs) against licensee-established goals in a manner sufficient to provide reasonable assurance that such SSCs are capable of fulfilling their intended function. The regulations in 10 CFR 50.65 require that these goals be established commensurate with safety and, where practical, take into account industry-wide operating experience. In practice, for concrete structures, this usually translates into periodic visual inspection; however, specific inspection criteria related to ASR are generally not included*."[2]

Concrete degradation caused by ASR was identified during inspections supporting the application for renewal of the operating license for the Seabrook nuclear plant. As the NRC noted:

> *The NRC staff is currently reviewing the license renewal application for Seabrook Station submitted in accordance with 10 CFR 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants." The Seabrook Station is the first plant to address ASR-induced concrete degradation as part of license renewal. The licensee for Seabrook Station is developing aging management programs that will include additional measures and actions to manage the effects of aging from ASR-induced degradation during the period of extended operation. In support of its license renewal application, the licensee for Seabrook Station will submit additional information that the NRC staff will review to ensure the licensee develops an acceptable program to manage the effects of ASR.* [3]

Thus, the NRC will determine whether "additional measures and actions to manage the effects of aging from ASR-induced degradation" constitute "an acceptable program to manage the effects of ASR" — measures and actions which have not been required for any of the more than 70 reactors with renewed operating licenses before Seabrook's discovery. If an NRC reviewed and approved program is necessary to support acceptable management of ASR effects, than lack of NRC reviewed and approved programs at these nearly six dozen reactors is prima facie evidence that their existing programs cannot be relied upon to detect degradation caused by ASR.

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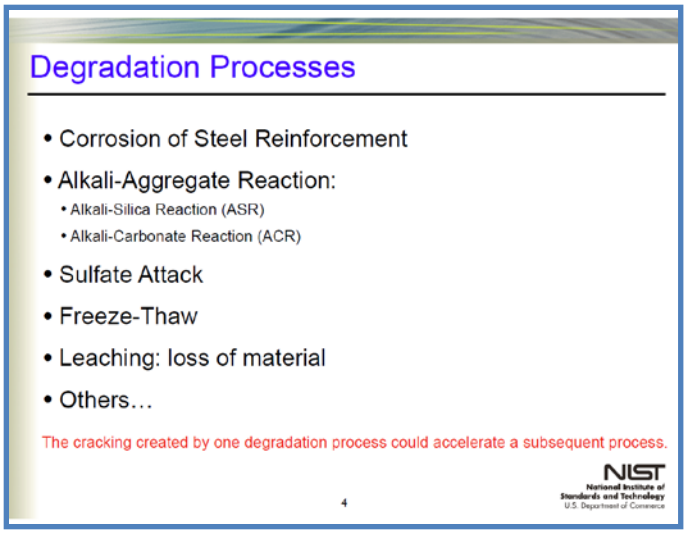
[1] A copy of the ACRS meeting transcript along with presentation slides used during the meeting is available in the NRC's online electronic library (ADAMS) under accession number ML143282A172.
[2] NRC Information Notice 2011-20, "Concrete Degradation by Alkali-Silica Reaction," November 18, 2011.
[3] NRC Information Notice 2011-20, "Concrete Degradation by Alkali-Silica Reaction," November 18, 2011.

If "additional measures and actions" that NRC determines to constitute "acceptable program to manage the effects of ASR" are required at Seabrook, then they are equally necessary at all other operating reactors. Yet that comparable NRC stamp of approval does not exist for these other reactors.

A staffer from the National Institute of Standards and Technology (NIST) also made a presentation to the ACRS during the September 19, 2014, meeting. The NIST staffer observed that concrete can experience degradation due to a number of causes. The NIST staffer pointed out a potential synergistic effect between causes; namely, that cracking from one cause could aid and abet degradation from another cause.



ASR involves a chemical reaction between water and constituents of the concrete. Thus, cracking from freeze-thaw or another process could provide a pathway for water to penetrate into concrete and react with it.

When inspection regimes do not explicitly include criteria for evaluating potential ASR degradation, it is entirely possible that cracking due to freeze-thaw could be identified and properly evaluated as not compromising structural integrity by itself. By not examining whether such cracking promotes ASR degradation, the conclusion about structural integrity may not be applicable for all degradation processes.

The synergistic effects are not speculative—the NRC attributes the ASR degradation experienced at Seabrook to another degradation mechanism that opened a pathway for water to penetrate the concrete and trigger ASR:

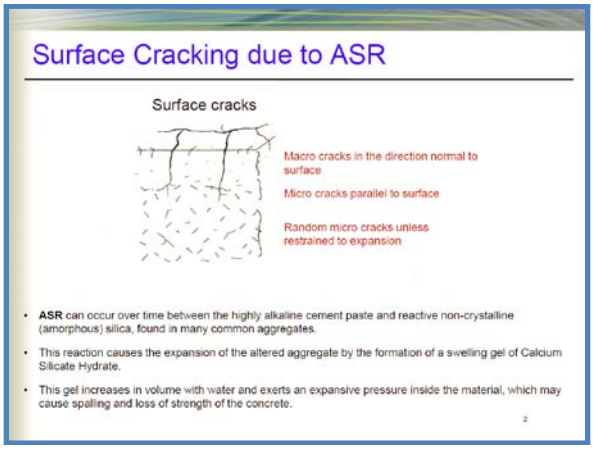
> *The Seabrook Station final safety analysis report specifies concrete testing during construction using ASTM C289 and ASTM C295, which were the accepted standards at the time of construction. However, ASR-induced degradation still occurred.*
>
> *The licensee believes that the waterproof membrane was damaged during original installation or backfill activities causing water intrusion that resulted in the ASR problems. Water intrusion was exacerbated by the fact that dewatering channels were abandoned.* [4]

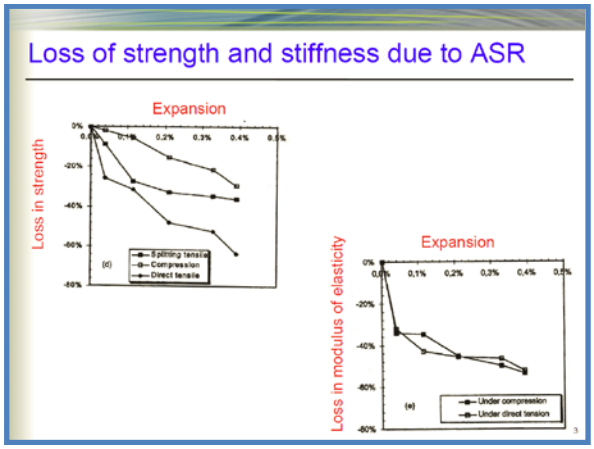
The answer to whether existing inspections will detect concrete degradation caused by ASR is no. The record clearly shows that existing inspections vary from reactor to reactor and, with the exception of Seabrook, do not specify explicit criteria about ASR. While ASR may be detected via existing inspections, existing inspections cannot be relied upon to detect ASR degradation. If existing inspections were sufficiently reliable, then the NRC would not have required "additional measures and actions" be undertaken at Seabrook. Existing inspection regimes at all other operating reactors lack these additional measures and actions and are therefore insufficient.

[4] NRC Information Notice 2011-20, "Concrete Degradation by Alkali-Silica Reaction," November 18, 2011.

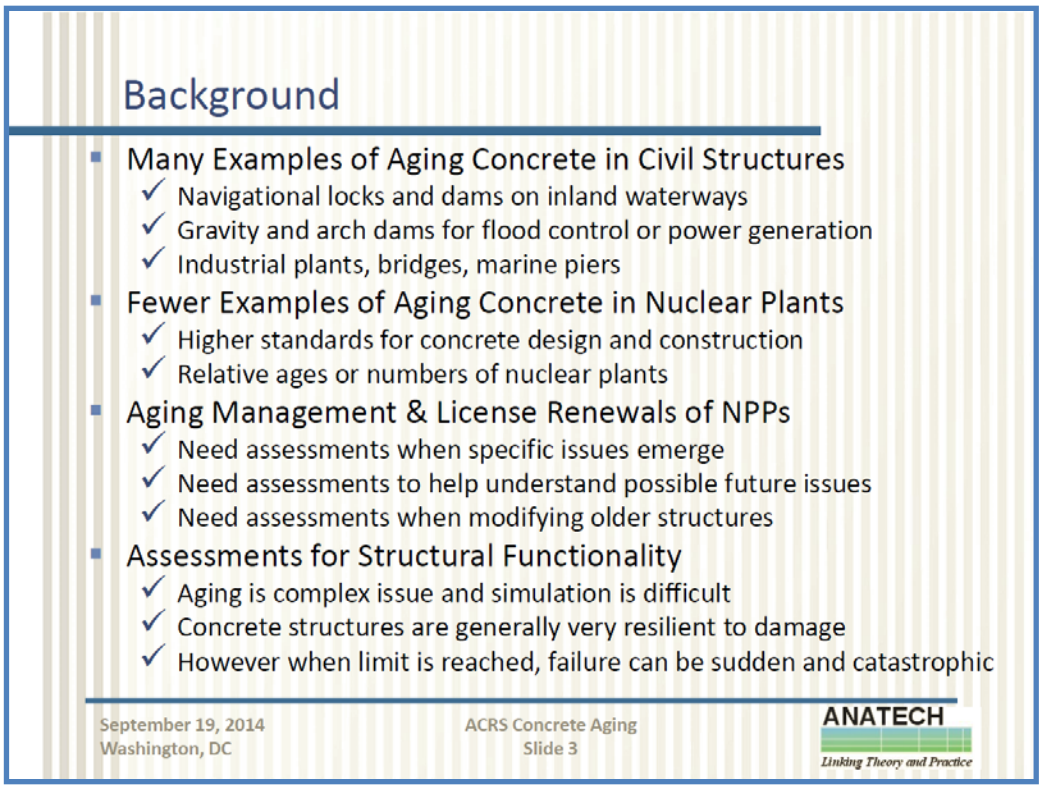
Question 2: Can Concrete Degradation Caused by ASR Have Adverse Safety Implications?

As these slides from a presentation to the ACRS during its September 19, 2014, meeting[5] on concrete degradation show, ASR degradation can cause more than cosmetic damage to concrete. The gel formed by ASR can swell, exerting expansive pressure on the concrete that has been measured to reduce the concrete's strength.





Another presenter commented to the ACRS during the September 19, 2014, on the potential catastrophic outcome from reduced concrete strength:



[5] A copy of the ACRS meeting transcript along with presentation slides used during the meeting is available in the NRC's online electronic library (ADAMS) under accession number ML143282A172.

In its notice to plant owners about ASR degradation discovered at Seabrook, the NRC noted that it can invalidate safety margins established in the original designs of the nuclear plants:

> *ASR degrades the measured mechanical properties of the concrete at different rates. Therefore, relationships between compressive strength and tensile or shear strength and assumptions about modulus of elasticity that were used in the original design of affected structures may no longer hold true if ASR-induced degradation is identified.* [6]

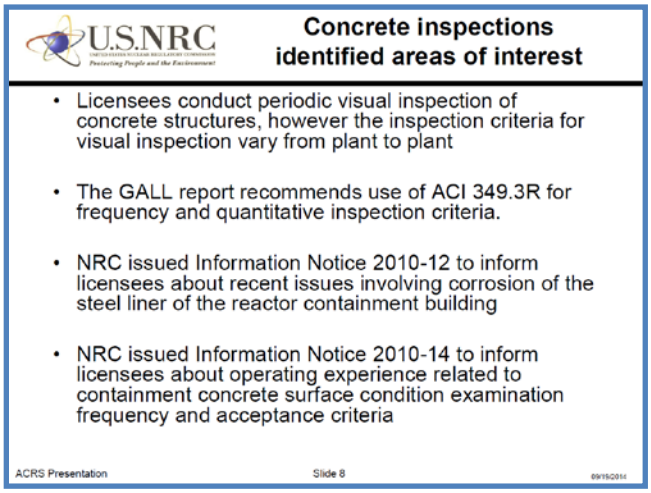
The answer to whether concrete degradation caused by ASR has adverse nuclear safety implications is yes. The record clearly shows that ASR degradation can reduce safety margins and potentially result in catastrophic failures.

This answer is reinforced by the NRC's response to the discovery of ASR degradation at Seabrook. If SR degradation could have no adverse nuclear safety implications, the NRC would not have required Seabrook's owner to develop and implement measures to manage the ASR effect.

[6] NRC Information Notice 2011-20, "Concrete Degradation by Alkali-Silica Reaction," November 18, 2011.

Question 3: Are the Measures Sought by C-10's Petition Appropriate Remedies?

C-10's petition requested the NRC to revise its regulations to require that all plant owners comply with American Concrete Institute (ACI) standard 349.3R, "Evaluation of Existing Nuclear Safety-Related Concrete Structures," and American Society for Testing and Materials (ASTM) standard C 856-11, "Standard Practice for Petrographic Examination of Hardened Concrete."



In his presentation to the ACRS during its September 19, 2014, meeting on concrete degradation, Mr. John Burke of the NRC's Office of Nuclear Reactor Regulation stated:

For those plants that have a renewed license, the GALL report, the generic aging lessons-learned report for license renewal, recommends the use of ACI 349.3R for the frequency and inspection criteria. [7]

C-10 seeks to transform a mere recommendation about concrete degradation inspections into a reliable requirement.

But reliable visual inspections alone are not sufficient as the NRC stated in its notice to plant owners about ASR degradation at Seabrook:

> *ASR can be identified as a likely cause of degradation during visual inspection by the unique "craze," "map" or "patterned" cracking and the presence of alkali-silica gel (see Figure 1 in the enclosure). However, ASR-induced degradation can only be confirmed by optical microscopy performed as part of petrographic examination of concrete core samples.* [8]

"ASR-induced degradation can only be confirmed by … petrographic examination of concrete core samples" — the testing governed by ASTM C 856-11.

The answer to whether the measures sought by C-10's petition constitute appropriate remedies is clearly yes. The NRC recommends the visual inspection frequency and acceptance criteria in ACI 349.3R for ASR and acknowledges that petrographic examination such as those governed by ASTM C 856-11 are the only way to confirm whether ASR-induced degradation exists.

[7] A copy of the ACRS meeting transcript along with presentation slides used during the meeting is available in the NRC's online electronic library (ADAMS) under accession number ML143282A172. Revision 2 of the Generic Aging Lessons Learned (GALL) report is available in ADAMS under accession number ML103490041.
[8] NRC Information Notice 2011-20, "Concrete Degradation by Alkali-Silica Reaction," November 18, 2011.