February 5, 2014

MEMORANDUM TO: Patrick L. Hiland
Division of Engineering
Office of Nuclear Reactor Regulation

FROM: Robert O. Hardies, Sr. Level Advisor ***/RA/***
Division of Engineering
Office of Nuclear Reactor Regulation

SUBJECT: SUMMARY OF DECEMBER 5, 2013, PUBLIC MEETING TO DISCUSS REACTOR PRESSURE VESSEL ISSUES

On December 5, 2013, a Category 2 public meeting was held between the U.S. Nuclear Regulatory Commission (NRC) staff and representatives of industry to allow an exchange of information about reactor vessel integrity issues. A portion of the meeting related to the possibility of NRC licensees discovering quasi-laminar indications (planar-type indications oriented nearly parallel to the inner and outer surfaces of the reactor vessel) in reactor pressure vessel (RPV) ring forgings. A large number of quasi-laminar indications were found in 2012 during ultrasonic inspections of two RPVs in Europe. Other topics addressed included reactor vessel surveillance programs, Title 10, *Code of Federal Regulations*, Part 50, (10 CFR 50) Appendices G and H evaluations, boiling water reactor (BWR) leak test temperatures, status of the NRC Regulatory Guide for Alternate Pressurized Thermal Shock (PTS) Rule Implementation and a discussion of codes and standards status.

The probable cause of the quasi-laminar indications in the European RPVs was hydrogen flaking, which occurs during the forging process, and is not an in-service degradation mechanism. The NRC met with U.S. licensees and Materials Issue Programs on March 5, 2013 (Agencywide Documents Access and Management System (ADAMS) accession number ML13066A725) to assess the potential existence and impact of quasi-laminar indications in RPV forgings in domestic plants. At that meeting, industry representatives described plans to perform probabilistic fracture mechanics analyses of hypothetical quasi-laminar indications. This meeting opened with industry representatives presenting results of those analyses, which indicated a frequency of vessel fracture lower than $1x10^{-7}$ per year for the bounding case. The NRC staff requested access to the report for information.

In an effort to document whether construction inspections would have been capable of identifying hydrogen flaking, industry reviewed the type of non-destructive testing equipment and procedures used during construction. By evaluating the ultrasonic inspection techniques and acceptance criteria in effect when U.S. forged vessel components were originally examined, they concluded that quasi-laminar indications of the type discovered in the European reactor vessels would have been both detectable and recordable using the equipment and recording criteria in place at the time of manufacture. Furthermore, the indications were acceptable according to the applicable codes and standards. The NRC staff requested access to the report for information.

Licensees who own vessels that contain shell-course ring forgings reviewed their ultrasonic testing reports for evidence of quasi-laminar indications. According to industry representatives, no quasi-laminar indications similar to those discovered in the two RPVs in Europe were identified. The staff requested access to the ultrasonic examination reports from construction records for information purposes.

The industry discussed an assessment of the risk associated with American Society of Mechanical Engineers (ASME) Section XI Appendix G pressure-temperature (P-T) limit methodology. The assessment included shallow surface breaking flaws and concluded that conventional P-T limits from Appendix G for high embrittlement vessels can produce relatively high conditional probabilities of failure if they are applied without consideration of vessel-specific operational constraints. Industry is considering performing additional analyses to define adjustments to P-T curves that may be needed to ensure very low conditional probabilities of failure. The NRC staff requested access to the analysis report when available for information.

The industry described supplemental surveillance programs intended to generate high fluence surveillance data. The program takes advantage of existing surveillance capsules in a variety of different individual licensee surveillance programs, but extends and coordinates withdrawal schedules targeted at accumulating higher fluence data. Additionally, there are plans to design, fabricate and install two new capsules that will contain previously irradiated specimens from a variety of materials, and to irradiate those capsules for an additional 10-12 years. Additionally, the industry also has plans to perform metallurgical evaluation of previously irradiated and tested surveillance specimens to support research into embrittlement mechanics. The industry expressed concern with the licensing resources that may be needed to request permission to perform metallurgical research on archived, previously tested surveillance specimens.

The industry continued their presentations with an assessment of BWR leak test temperature requirements. There are plans under consideration to evaluate the risk associated with normal leak test procedures to determine whether the current ASME Code requirements to maintain a minimum margin on K_{IC} of 1.5 would continue to ensure adequately low conditional probability of failure.

The NRC staff presented results of probabilistic analyses of BWR leak tests considering the effect of hypothetical small surface breaking flaws and noted that, in some cases, the analytical results exhibited relatively high conditional probabilities of failure. The staff plans to summarize this work in a paper at the 2014 ASME Pressure Vessels and Piping Conference.

The Chairman of ASTM International (formerly known as the American Society of Testing and Materials) Subcommittee E10.02 on Behavior and Use of Nuclear Structural Materials discussed proposed changes to ASTM Standards E185, “Standard Practice for Design of Surveillance Programs for Light-Water Moderated Nuclear Reactor Vessels,” and E2215, “Standard practice for Evaluation for Surveillance Capsules from Light-Water Moderated Nuclear Power Reactor Vessels.” Changes from the 1982 version of E185, which is currently referenced in 10 CFR 50, Appendix H, were described. The NRC was encouraged to update 10 CFR 50, Appendix H requirements to permit use of the most recent versions of these consensus standards. The staff discussed plans to request permission to begin rulemaking to permit the use of updated and modern revisions of these standards. The industry requested that, if Appendix H is to be revised, that the requirement to submit the test results within one year be increased to at least 18 months. The longer reporting time is intended to mitigate scheduler

complications that modern integrated programs have experienced related to the logistics of withdrawal, shipping, testing and reporting results of testing of surveillance capsules. Industry also noted that, in some cases, higher fluence capsules need to spend time decaying in the spent fuel pool a before the capsule residual radioactivity is low enough to accommodate traditional shipping methods.

The NRC staff discussed the reactor embrittlement archive project. This project catalogues historical records of surveillance data and research irradiation information. The staff also presented plans and a tentative schedule for issuing a draft Regulatory Guide describing implementation of the Alternate Pressurized Thermal Shock Rule, and a draft Regulatory Issue Summary (RIS) on extended beltline issues.

Action items captured during the meeting were as follows:

1. Industry will investigate how the ultrasonic testing performed on RPV forgings for new reactors will incorporate lessons learned from the discovery of quasi-laminar indications in forgings in the two European RPVs.
2. Industry will provide reports regarding probabilistic fracture mechanics evaluation of hypothetical quasi-laminar indications, evaluation of ultrasonic inspection practices with regard to quasi-laminar indications, and ultrasonic inspection records of RPV forgings to the NRC for information.
3. The NRC staff will communicate with the Electric Power Research Institute Materials Reliability Project regarding the value of submitting a petition for rulemaking to request 10 CFR 50, Appendix H be updated to permit use of current revisions of consensus standards.
4. Industry will evaluate how much additional time higher fluence surveillance capsules may need to decay so that activity decreases to levels that permit standard shipping methods. This information would be used to inform possible future changes to the current requirement that capsules be tested within one year of being pulled.

A list of attendees is enclosed. The slide presentations presented by the NRC staff and the industry representatives can be found in the Agencywide Documents Access and Management System at Accession Number ML13339A971.

Enclosure:
List of Attendees

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OFFICIAL RECORD COPY

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