



[7590-01-P]

## NUCLEAR REGULATORY COMMISSION

[NRC-2014-0023]

### Effect of LWR Water Environments on the Fatigue Life of Reactor Materials

**AGENCY:** Nuclear Regulatory Commission.

**ACTION:** NUREG; issuance.

**SUMMARY:** The U.S. Nuclear Regulatory Commission (NRC) is issuing NUREG/CR-6909, Revision 1, "Effect of LWR Water Environments on the Fatigue Life of Reactor Materials." This report summarizes the results of NRC research efforts and work performed at Argonne National Laboratory on the fatigue of piping and pressure vessel steels in light-water reactor (LWR) environments. Revision 1 of this report provides updates and improvements to the environmental fatigue correction factor approach based on an extensive update to available laboratory fatigue data from testing and results available since this report was first published in 2007. This final document also incorporates changes to address public comments provided on the draft of Revision 1 of NUREG/CR-6909.

**ADDRESSES:** Please refer to Docket ID **NRC-2014-0023** when contacting the NRC about the availability of information regarding this document. You may obtain publicly-available information related to this document using any of the following methods:

- **Federal Rulemaking Web Site:** Go to <http://www.regulations.gov> and search for Docket ID **NRC-2014-0023**. Address questions about NRC dockets to Jennifer Borges; telephone: 301-287-9127; e-mail: [Jennifer.Borges@nrc.gov](mailto:Jennifer.Borges@nrc.gov). For technical questions, contact the individuals listed in the **FOR FURTHER INFORMATION CONTACT** section of this document.

- **NRC's Agencywide Documents Access and Management System (ADAMS):** You may obtain publicly-available documents online in the ADAMS Public Documents collection at <http://www.nrc.gov/reading-rm/adams.html>. To begin the search, select "ADAMS Public Documents" and then select "Begin Web-based ADAMS Search." For problems with ADAMS, please contact the NRC's Public Document Room (PDR) reference staff at 1-800-397-4209, 301-415-4737, or by e-mail to [pdr.resource@nrc.gov](mailto:pdr.resource@nrc.gov). The ADAMS accession number for each document referenced (if it is available in ADAMS) is provided the first time that it is mentioned in this document. Revision 1 of NUREG/CR-6909 is available in ADAMS under Accession No. ML16319A004.

- **NRC's PDR:** You may examine and purchase copies of public documents at the NRC's PDR, Room O1-F21, One White Flint North, 11555 Rockville Pike, Rockville, Maryland 20852.

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**SUPPLEMENTARY INFORMATION:**

The American Society of Mechanical Engineers Boiler and Pressure Vessel Code (Code) provides rules for the design of Class 1 components of nuclear power plants. Appendix I to Section III of the Code contains fatigue design curves for applicable structural materials. However, the effects of LWR water environments are not explicitly addressed by the Code design curves. The existing fatigue strain-vs.-life ( $\epsilon$ -N) data illustrate potentially significant effects of LWR water environments on the fatigue resistance of pressure vessel and piping steels. Under certain environmental and loading conditions, fatigue lives in water relative to those in air can be significantly lower for austenitic stainless steels, nickel alloy materials, carbon steels, and low-alloy steels. In March 2007, Revision 0 of NUREG/CR-6909 (ADAMS Accession No. ML070660620) was issued. That report was the technical basis document for NRC Regulatory Guide (RG) 1.207, Revision 0, "Guidelines for Evaluating Fatigue Analyses Incorporating the Life Reduction of Metal Components Due to the Effects of the Light-Water Reactor Environment for New Reactors" (ADAMS Accession No. ML070380586). Revision 0 of NUREG/CR-6909 summarized the work performed at Argonne National Laboratory on the fatigue of piping and pressure vessel steels in LWR

coolant environments. That report evaluated the existing laboratory fatigue data to identify the various materials, environmental, and loading parameters that influence fatigue crack initiation and summarized the effects of key parameters on the fatigue lives of pressure vessel and piping steels. The report presented models for estimating fatigue lives as a function of material, loading, and environmental conditions, and described the environmental fatigue correction factor for incorporating the effects of LWR coolant environments into Code fatigue evaluations.

Revision 1 of NUREG/CR-6909 provides updates and improvements to the environmental fatigue correction factor approach based on additional laboratory fatigue data and other results available since 2007. On April 17, 2014 (79 FR 21811), a draft of Revision 1 was noticed in the *Federal Register* for public comment under Docket ID **NRC-2014-0023**. The public comment period ended on June 2, 2014. The final version of Revision 1 of NUREG/CR-6909 reflects changes made to address the public comments. Appendix F of the document provides responses to the public comments received.

Revision 1 of NUREG/CR-6909 is the technical basis document for Revision 1 of RG 1.207, "Guidelines for Evaluating the Effects of Light-Water Reactor Water Environments in Fatigue Analyses of Metal Components" (ADAMS Accession No. ML16315A130). This RG describes methods and procedures that the NRC staff considers acceptable for use in determining the acceptable fatigue lives of components evaluated by a cumulative usage factor calculation in accordance with the fatigue design provisions in Section III, "Rules for Construction of Nuclear Power Plant Components," of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code to account for the effects of LWR water environments. The NRC is issuing Revision 1 of

RG 1.207 concurrently with Revision 1 of NUREG/CR-6909 under a separate notice associated with Docket ID **NRC-2014-0244**.

The NRC notes that Revision 1 of RG 1.207 was issued in draft form as a draft RG (DG-1309). The NRC published a notice of the availability of DG-1309 in the *Federal Register* on November 24, 2014 (79 FR 69884), under Docket ID **NRC-2014-0244**, with a public comment period that closed on January 24, 2015. Public comments on DG-1309 and the NRC staff's responses are available in ADAMS under Accession No. ML16315A127.

Dated at Rockville, Maryland, this 30<sup>th</sup> day of May, 2018.

For the Nuclear Regulatory Commission.

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[FR Doc. 2018-11996 Filed: 6/4/2018 8:45 am; Publication Date: 6/5/2018]