

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO EXEMPTION FOR USE OF OPTIMIZED ZIRLO™

RENEWED FACILITY OPERATING LICENSE NO. NPF-42

WOLF CREEK NUCLEAR OPERATING CORPORATION

WOLF CREEK GENERATING STATION

DOCKET NO. 50-482

1.0 INTRODUCTION

Pursuant to 10 CFR 50.12, "Specific Exemptions," Wolf Creek Nuclear Operating Corporation (WCNOC, the licensee) by application dated January 27, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16033A470), as supplemented by letter dated May 19, 2016 (ADAMS Accession No. ML16161A509), requested exemption from the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.46, "Acceptance criteria for emergency core cooling systems [ECCS] for light water reactors," and 10 CFR Part 50 Appendix K, "ECCS Evaluation Models." The proposed exemption request would permit the use of Optimized ZIRLO™ alloy clad fuel rods in Wolf Creek Generating Station (WCGS). Since the requirements in 10 CFR 50.46 specifically, and 10 CFR Part 50, Appendix K implicitly, refer to the use of zircaloy or ZIRLO™ cladding, an exemption is required to use fuel rods clad with an advanced zirconium-based alloy that is neither zircaloy or ZIRLO™.

2.0 REGULATORY EVALUATION

The licensee plans to use Optimized ZIRLO™ fuel cladding for the core reload scheduled for WCGS in spring 2017. The Optimized ZIRLO™ fuel cladding is different from standard ZIRLO™ in two respects: (1) the tin content is lower; and 2) the microstructure is different. This difference in tin content and microstructure can lead to differences in some material properties and the industry has committed to provide irradiated data and validate fuel performance models ahead of burnups achieved in batch application. Westinghouse topical report WCAP-12610-P-A and CENPD-404-P-A, Addendum I-A, "Optimized ZIRLO™" (ADAMS Accession No. ML062080576), provides the details and results of material testing of Optimized ZIRLO™ compared to standard ZIRLO™ as well as the material properties to be used in various models and methodologies when analyzing Optimized ZIRLO™.

The primary difference between the new fuel and the resident fuel at WCGS is the use of different zirconium-based alloy (Optimized ZIRLO™) for fuel cladding. The requirements of 10 CFR 50.46(a)(1)(i) state, in part:

*Each boiling or pressurized light-water nuclear power reactor fueled with uranium oxide pellets within cylindrical zircaloy or ZIRLO cladding must be provided with an emergency core cooling system (ECCS) that must be designed so that its calculated cooling performance following postulated loss-of-coolant accidents conforms to the criteria set forth in paragraph (b) of this section. ECCS cooling performance must be calculated in accordance with an acceptable evaluation model and must be calculated for a number of postulated loss-of-coolant accidents of different sizes, locations, and other properties sufficient to provide assurance that the most severe postulated loss-of-coolant, accidents are calculated...*

Since 10 CFR 50.46 specifically refers to fuel with zircaloy or ZIRLO cladding, the use of fuel clad with zirconium-based alloys that do not conform to either zircaloy or ZIRLO requires a temporary exemption from this section of the regulations.

Paragraph I.A.5, *Metal – Water Reaction Rate*, of 10 CFR 50, Appendix K states, in part,

*The rate of energy release, hydrogen generation, and cladding oxidation from the metal/water reaction shall be calculated using the Baker-Just equation (Baker, L., Just, L.C., "Studies of Metal Water Reactions at High Temperatures, III. Experimental and Theoretical Studies of the Zirconium-Water Reaction," ANL-6548, page 7, May 1962).*

Baker-Just equation presumes the use of zircaloy or ZIRLO cladding. The use of zirconium based cladding material other than zircaloy or ZIRLO requires a temporary exemption from 10 CFR 50 Appendix K.

According to 10 CFR 50.12, the Commission may grant exemptions from the requirements of the regulations of this part for reasons which are (1) the exemption is authorized by law, (2) the exemption will not present an undue risk to the public health and safety, (3) the exemption is consistent with the common defense and security, and (4) special circumstances are present. The requested exemption to allow the use of Optimized ZIRLO™ fuel rod cladding rather than zircaloy or ZIRLO at WCGS satisfies the criteria as described below.

- (1) The law authorizes the exemption. NRC has the authority under Section 50.12 to grant exemptions from the requirements of Part 50 upon showing proper justification. The fuel that will be irradiated at WCGS contain cladding material that does not conform to the cladding material that is explicitly defined in 10 CFR 50.46 and implicitly defined in 10 CFR 50 Appendix K. However, the criteria of these sections will continue to be satisfied for the operation of the WCGS core containing Optimized ZIRLO™ fuel cladding.
- (2) The standards for temporary exemption are also satisfied since the exemption will not present an undue risk to public health and safety. The NRC approved

topical reports (ADAMS Accession No. ML062080576) have demonstrated that predicted chemical, thermal, and mechanical characteristics of the Optimized ZIRLO™ alloy cladding are bound for those approved for ZIRLO under anticipated operational occurrences (AOOs) and postulated accidents. The facility operating license requires that reload cores be operated in accordance with the operating limits specified in the TSs and COLR. Thus, the granting of this exemption request will not pose an undue risk to public health and safety.

- (3) The exemption request is to allow the licensee to use an improved fuel rod cladding material. The licensee has documented compliance with the conditions and limitations of the NRC safety evaluation (ADAMS Accession No. ML112420611) and has committed to ensuring compliance for future reloads (ADAMS Accession No. ML16033A470 as supplemented by ML16161A509). Use of Optimized ZIRLO™ fuel rod cladding in the WCGS core will not affect plant operations and is consistent with common defense and security.
- (4) The special circumstance that necessitates the request for exemption to 10 CFR 50.46 and 10 CFR 50 Appendix K is that neither of these regulations explicitly allows the use of Optimized ZIRLO™ fuel rod cladding material. The ultimate objective of 10 CFR 50.46 is to ensure that nuclear power reactors fueled with uranium oxide pellets within zircaloy or ZIRLO cladding must be provided with an emergency core cooling system (ECCS) designed to provide core cooling following postulated loss-of-coolant accidents (LOCA). Westinghouse demonstrated in its NRC approved topical report (ADAMS Accession No. ML062080576), that ECCS effectiveness will not be adversely affected by a change from zircaloy or ZIRLO clad fuel to Optimized ZIRLO™ clad fuel. Normal safety analyses performed prior to core reload will confirm that there is no adverse impact on ECCS performance.

The objective of 10 CFR 50.46(b)(2) and (b)(3), and 10 CFR 50 Appendix K I.A.5 is to ensure that cladding oxidation and hydrogen generation are appropriately limited during a LOCA and conservatively accounted for in ECCS evaluation model. Appendix K of 10 CFR 50 requires that the Baker-Just equation be used in the ECCS evaluation model to determine the rate of energy release, cladding oxidation, and hydrogen generation. Westinghouse has shown in Addendum 1-A to WCAP-12610-P-A (ADAMS Accession No. ML062080576), that the Baker-Just model is conservative in all post-LOCA scenarios with respect to the use of the Optimized ZIRLO advanced alloy as a fuel cladding material.

### 3.0 TECHNICAL EVALUATION

Section 50.12 of 10 CFR Part 50, "Specific Exemptions," states, among other items, that the Commission may, upon application by any interested person or upon its own initiative, grant exemptions from the requirements of the regulations of this part, which are authorized by law, will not present an undue risk to the public health and safety, and are consistent with the common defense and security. The Commission will not consider granting an exemption unless special circumstances are present. In accordance with 10 CFR 50.12(a)(2)(ii), special circumstances are present whenever application of the regulation in the particular

circumstances would not serve the underlying purpose of the rule or is not necessary to achieve the underlying purpose of the rule.

By letter dated June 10, 2005 (ADAMS Accession No. ML051670403), the NRC staff issued a safety evaluation (Addendum 1 safety evaluation) approving Addendum 1 to Westinghouse Topical Report WCAP-12610-P-A and CENPD-404-P-A, "Optimized ZIRLO™", wherein the NRC staff approved the use of Optimized ZIRLO™ as a fuel cladding material. The NRC staff approved the use of Optimized ZIRLO™ as a fuel cladding material based on: (1) similarities with standard ZIRLO™, (2) demonstrated material performance, and (3) a commitment to provide irradiated data and validate fuel performance models ahead of burnups achieved in batch application. The NRC staff's safety evaluation for Optimized ZIRLO™ includes 10 Conditions and limitations for its use.

The underlying purpose of 10 CFR 50.46 is to establish acceptance criteria for adequate ECCS performance. As previously documented in the NRC staff's review of topical reports submitted by Westinghouse, and subject to compliance with the specific conditions of approval established therein, the NRC staff finds that the applicability of these ECCS acceptance criteria to Optimized ZIRLO™ has been demonstrated by Westinghouse. Ring compression tests performed by Westinghouse on Optimized ZIRLO™ (NRC-reviewed, approved, and documented in Appendix B of WCAP-12610-P-A and CENPD-404-P-A, Addendum 1-A, "Optimized ZIRLO™," July 2006, ADAMS Accession No. ML062080576) demonstrate an acceptable retention of post-quench ductility up to 10 CFR 50.46 limits of 2200 °F and 17% equivalent clad reacted (ECR). Furthermore, the NRC staff has concluded that oxidation measurements provided by the licensee (letter from Westinghouse to NRC, "SER Compliance with WCAP-12610-P-A & CENPD-404-P-A Addendum 1-A 'Optimized ZIRLO™'," LTR-NRC-07-58, November 6, 2007, ADAMS Accession No. ML073130562) illustrate that oxide thickness (and associated hydrogen pickup) for Optimized ZIRLO™ at any given burnup would be less than both zircaloy-4 and ZIRLO™. Hence, the NRC staff concludes that Optimized ZIRLO™ would be expected to maintain better post-quench ductility than ZIRLO™. This finding is further supported by an ongoing Loss-Of-Coolant Accident (LOCA) research program at Argonne National Laboratory, which has identified a strong correlation between cladding hydrogen content (due to in-service corrosion) and post-quench ductility.

In addition, utilizing currently-approved LOCA models and methods, the licensee will perform an evaluation to ensure that the Optimized ZIRLO™ fuel rods continue to satisfy 10 CFR 50.46 acceptance criteria. For the reasons above, granting the exemption request will ensure that the underlying purpose of the rule is achieved for WCGS.

Paragraph I.A.5 of Appendix K to 10 CFR Part 50 states that the rates of energy release, hydrogen concentration, and cladding oxidation from the metal-water reaction shall be calculated using the Baker-Just equation. Since the Baker-Just equation presumes the use of zircaloy clad fuel, strict application of the rule would not permit use of the equation for Optimized ZIRLO™ cladding for determining acceptable fuel performance. However, the NRC staff has found that metal-water reaction tests performed by Westinghouse on Optimized ZIRLO™ (NRC-reviewed, approved, and documented in Appendix B of WCAP-12610-P-A and CENPD-404-P-A, Addendum 1-A and subject to compliance with the specific conditions of approval established therein) demonstrate conservative reaction rates relative to the Baker-Just

equation. Thus, the NRC staff agrees that application of Appendix K, paragraph I.A.5 is not necessary to achieve the underlying purpose of the rule in these circumstances.

Accordingly, the NRC staff has determined that the special circumstances required by 10 CFR 50.12 (a)(2)(ii) for granting an exemption from the aforementioned specific paragraphs of 10 CFR 50.46 and Appendix K of 10 CFR Part 50 exist for WCGS.

#### 4.0 CONCLUSION

Based on the staff evaluation, as set forth above, the NRC staff concludes that application of 10 CFR 50.46 and Appendix K to 10 CFR Part 50 are not necessary for the licensee to achieve the underlying purposes of the regulations. In addition, the NRC staff has determined that, pursuant to 10 CFR 50.12(a), the exemption is authorized by law, will not present an undue risk to the public health and safety, and is consistent with the common defense and security. Therefore, the NRC staff approves an exemption from the requirements of 10 CFR 50.46 and Appendix K to 10 CFR Part 50 for WCGS.

Principal Contributor: J. Kaizer, NRR/DSS/SPNB

Date: August 2, 2016