STATUS OF THE LICENSING PROCESS FOR ACCIDENT TOLERANT FUEL

A Report for the
Senate Committee on Environment and Public Works and the
House Committee on Energy and Commerce

By the U.S. Nuclear Regulatory Commission

Enclosure

INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) developed this report in accordance with Section 107 of the Nuclear Energy Innovation and Modernization Act (NEIMA), which requires the NRC to submit to Congress a report describing the status of the licensing process for accident tolerant fuel (ATF) not later than one year after the date of enactment of the Act. NEIMA defines ATF as "a new technology that (1) makes an existing commercial nuclear reactor more resistant to a nuclear incident (as defined in Section 11 of the Atomic Energy Act of 1954 (42 U.S.C. 2014)); and (2) lowers the cost of electricity over the licensed lifetime of an existing commercial nuclear reactor."

Based on interactions with staff from the U.S. Department of Energy (DOE) and representatives from the U.S. nuclear industry, the NRC staff assessed its regulatory framework when developing the ATF Project Plan (Reference 1) and found it suitable for the review and licensing of ATF designs, needing only minimal adjustments to the framework for near-term ATF concepts such as fuel pellets with additives and coated zirconium fuel rod cladding. The NRC staff has already approved the use of fuel pellets with additives in pressurized- and boiling-water reactors and is in the final stages of developing guidance for the safety review of chromium-coated fuel rod cladding.

The NRC also considers the existing regulatory framework to be generally acceptable for licensing fuel designs with increased enrichment of uranium-235 (from 5 to approximately 8 percent by weight) and higher fuel burnup limits (fuel rod averages from 62 to 75 gigawatt-days per metric ton of uranium) in the near-term by using amendments and exemptions. Should widespread adoption of these technologies become apparent, the NRC staff will utilize the longer-term strategy of rulemaking to update existing regulations to facilitate a more predictable licensing process. The NRC staff assessed the licensing actions needed for fuel facilities and fuel transportation packages to support increased enrichment and higher burnup limits and transmitted a letter (Reference 2) to the Nuclear Energy Institute (NEI) detailing the submittal timeline necessary to meet the industry's proposed deployment date of 2023. The NRC is currently prepared to review these licensing actions.

The NRC staff continues to engage with DOE, the nuclear industry, and other external stakeholders to determine whether, and to what extent, changes to the regulatory framework may be needed to license longer-term ATF concepts (e.g., uranium silicide fuel pellets, silicon carbide fuel cladding, and extruded metallic fuel).

BACKGROUND

The U.S. nuclear industry, with the assistance of DOE, is planning to deploy near-term ATF concepts in batch reloads[1] in the U.S. operating fleet by the early to mid-2020s. The NRC staff has established a strategy in the NRC's ATF Project Plan (Reference 1) to enable timely regulatory actions on ATF concepts while providing reasonable assurance of adequate protection of public health and safety.

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[1] A batch reload is a fuel optimization pattern in which a portion of the fuel assemblies are replaced in the reactor core after each operating cycle, generally around one-third of the total fuel assemblies in the core. The new fuel assemblies are arranged within the reactor core along with the remaining fuel assemblies from the prior operating cycles in order to optimize the use of their fissionable material.

The ATF Project Plan covers the entire fuel cycle for both near-term and longer-term ATF concepts. The plan will ensure that the NRC staff is ready to review submitted ATF fuel designs and supporting methodologies by early 2020, as well as transportation and plant-specific licensing actions in 2020–2022, to support batch reloads of near-term ATF concepts in 2023. The ATF Project Plan is a living document that may be updated as (1) ATF concepts are more clearly defined, (2) schedules are refined, (3) the knowledge level of specific concepts increases as experimental testing programs are completed, and (4) potential extensions to the current operating envelope of fuel are identified.

Lead Test Assemblies

Lead test assemblies (LTAs) are used to establish the technical and safety bases for the licensing of new fuel designs. LTAs containing fuel rods that apply near-term ATF concepts are currently being irradiated in a number of U.S. commercial power reactors. In June 2019, the NRC staff clarified its position on appropriate regulatory pathways for the use of LTAs in a letter to industry (Reference 3).

The NRC staff also issued two authorization letters for the shipment of ATF LTAs from two licensees to reactor sites in transportation packages with NRC certificates of compliance. The letter authorizations are subject to limitations on the number of ATF rods and the number of LTAs and specify necessary transportation package modifications (References 4 and 5). Additionally, the NRC issued a revision to a certificate of compliance for one transportation package in order to authorize that design for the transport of LTAs for certain ATF concepts (Reference 6).

Fuel Design Technical Basis

The NRC staff considers the existing NRC regulatory framework to be suitable for the review and safe licensing of near-term ATF fuel concepts. Within this framework, batch reloading of most new fuel designs in an operating commercial power reactor requires an amendment to the reactor's license.

License amendment requests for new fuels are typically supported by a technical basis contained in topical reports from the licensees and vendors, which are reviewed, approved and used for reference by the NRC staff. The NRC staff has already reviewed topical reports on fuel pellets with additives and is prepared to carry out the technical reviews of anticipated topical reports related to the implementation of near-term ATF concepts. The NRC staff is reviewing two topical reports for chromium-coated fuel. Other topical reports for near-term ATF concepts are scheduled to be submitted through 2023.

Chromium-Coated Fuel Rod Cladding

Consistent with the ATF Project Plan (Reference 1), the NRC staff has engaged stakeholders and is prepared to license chromium-coated fuel rod cladding. The NRC staff contracted with the DOE's Pacific Northwest National Laboratory (PNNL) to develop a preliminary report (Reference 7) on degradation and failure phenomena related to this ATF concept. The NRC staff then convened an expert panel to identify mechanisms important to the safe application of the concept in reactors and included the panel's findings in an updated version of the report (Reference 8).

Based on the findings in the PNNL report and feedback from external stakeholders and members of the NRC's Advisory Committee on Reactor Safeguards received at public meetings, the NRC staff developed draft guidance for the safety review of chromium-coated fuel rod cladding (Reference 9) and published a request for public comment in the *Federal Register* (Reference 10). The NRC staff is now in the process of addressing the public comments received and expects to issue final guidance by March 2020.

Higher Burnup and Increased Enrichment

The NRC staff revised the ATF Project Plan (Reference 11) in October 2019 to include Appendix A, "Fuel Burnup and Enrichment Extension Preparation Strategy," to prepare for the industry's plans to request higher fuel burnup limits (fuel rod averages from 62 to 75 gigawatt-days per metric ton of uranium) and increased enrichment (from 5 to about 8 weight-percent uranium-235). The NRC staff made a draft of Appendix A publicly available on September 3, 2019 (Reference 12) and held a public meeting on September 12, 2019, to discuss it with external stakeholders.

The NRC staff expects that a significant number of licensing activities will be required to extend burnup and enrichment limits as well as for licensing near-term ATF fuel for use in reactors. In September 2003, the NRC staff approved a topical report (Reference 13) that applies to light water reactors, is relevant to high burn ups, and could facilitate obtaining information to support licensing higher burnups.

A key element for licensing increased fuel enrichment will be addressing the front end of the fuel cycle (e.g., fuel enrichment, fabrication, and transportation). Thus, the NRC staff assessed the current regulatory framework and identified enrichment facility licensing, feed material transportation package certification, fuel fabrication facility licensing, and fresh fuel shipping container certification as critical path items for batch reloads to occur in 2023. In a letter to NEI, the staff detailed these critical path items and the dates by which applications for licensing actions supporting these items would need to be submitted to the NRC by the licensees or certificate of compliance holders (Reference 2). The NRC staff is prepared to review these applications to support timely licensing of burnup and enrichment extensions.

The NRC is expecting three applications in fiscal year 2020: one to allow an enrichment facility to enrich fuel above 5 weight-percent, one to allow a fuel fabrication facility to manufacture such fuel, and one to allow transportation of this enriched fuel with or without other ATF features (including chromium coating). The NRC is also expecting applications for increased enrichments of both standard uranium dioxide fuel pellets as well as fuel pellets with additives. The NRC staff will continue to monitor industry's plans to submit licensing requests and will adjust the NRC's activities as appropriate. The NRC staff does not anticipate any significant technical challenges or gaps that would prevent the timely review of these requests.

Longer-Term ATF Concepts

The NRC staff monitors DOE and industry progress on the development of longer-term ATF concepts. The NRC staff frequently interacts with both DOE and the industry to understand the current status and progress on the development of longer-term ATF concepts. Understanding that certain longer-term ATF concepts will require greater than 10 weight-percent uranium-235 enrichment, the NRC staff has begun research to determine whether, and to what extent, changes to the existing regulatory framework may be needed. The NRC staff is also exploring

the extent to which DOE and industry computer codes could be used in the NRC's timely review.

CONCLUSION

The NRC staff is prepared to conduct licensing reviews of ATF concepts in a manner consistent with the agency's mission of protecting public health and safety and the industry's projected schedules, which indicate commercial deployment of near-term concepts in the early to mid-2020s. The NRC staff will continue to engage with DOE, the nuclear industry, and other external stakeholders to determine whether, and to what extent changes to the existing regulatory framework may be needed to review and to license longer-term ATF concepts safely.

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References

1. NRC ATF Project Plan, Version 1.0, "Project Plan to Prepare the U.S. Nuclear Regulatory Commission for Efficient and Effective Licensing of Accident Tolerant Fuels," September 2018 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML18261A414).

2. Letter from Kathryn M. Brock, NRC, to Janet R. Schlueter, Nuclear Energy Institute, "Preparing for Efficient and Effective Licensing of Accident Tolerant Fuel with Higher Enrichment," August 26, 2019 (ADAMS Accession No. ML19235A261).

3. Letter from Ho K. Nieh, NRC, to Dr. Jennifer L. Uhle, Nuclear Energy Institute, "Clarification of Regulatory Path for Lead Test Assemblies," June 24, 2019 (ADAMS Accession No. ML18323A169).

4. Letter from John McKirgan, NRC, to Scott P. Murray, Global Nuclear Fuel, "Special Authorization to Use the RAJ-II Package for GNF FeCrAl Lead Test Assemblies," February 5, 2019 (ADAMS Accession No. ML19036A737).

5. Letter from John McKirgan, NRC, to Wes Stilwell, Westinghouse Electric Company, "Special Authorization for a One Time Shipment of the Model No. Traveller Package," December 20, 2018 (ADAMS Package Accession No. ML18354B136).

6. Letter from John McKirgan, NRC, to Timothy J. Tate, Framatome Inc., "Revision No. 11 of Certificate of Compliance No. 9319, for the Model Nos. MAP-12 and MAP-13 Transportation Packages," January 10, 2019 (ADAMS Package Accession No. ML19011A011).

7. PNNL-28437, "Degradation and Failure Phenomena of Accident Tolerant Fuel Concepts: Chromium Coated Zirconium Alloy Cladding," prepared for the U.S. Department of Energy by the Pacific Northwest National Laboratory, January 2019 (ADAMS Accession No. ML19036A716).

8. PNNL-28437, Revision 1, "Degradation and Failure Phenomena of Accident Tolerant Fuel Concepts: Chromium Coated Zirconium Alloy Cladding," prepared for the U.S. Department of Energy by the Pacific Northwest National Laboratory, June 2019 (ADAMS Accession No. ML19172A154).

9. ATF Interim Staff Guidance ATF-ISG-2019-XX, "Supplemental Guidance Regarding the Chromium-Coated Zirconium Alloy Fuel Cladding Accident Tolerant Fuel Concept," October 2019 (ADAMS Accession No. ML19276G621).

10. U.S. Nuclear Regulatory Commission, "Supplemental Guidance Regarding the Chromium-Coated Zirconium Alloy Fuel Cladding Accident Tolerant Fuel Concept," Federal Register, Vol. 84, No. 206, October 24, 2019, pp. 57057-57058.

11. NRC ATF Project Plan, Version 1.1, "Update to the Project Plan to Prepare the U.S. Nuclear Regulatory Commission for Efficient and Effective Licensing of Accident Tolerant Fuels," October 2019 (ADAMS Accession No. ML19297F703).

12. NRC draft High Burnup and Increased Enrichment Project Plan, "Fuel Burnup and Enrichment Extension Preparation Strategy," August 2019 (ADAMS Accession No. ML19242E192).

13. Westinghouse Owners Group Topical Report WCAP-15604-NP, Rev. 2-A, (Non-Proprietary), "Limited Scope High Burnup Lead Test Assemblies" September 2003 (ADAMS Accession No. ML070740225).