From: Hoellman, Jordan
To: steve.nesbit@lmnt-consulting.com; Sowder, Andrew; Marciulescu, Cristian
Subject: RAI Transmittal for Topical Report EPRI-AR-1, UCO TRISO Coated Particle Fuel Performance
Date: Thursday, January 02, 2020 7:51:00 AM
Attachments: Final TRISO RAIs.pdf

Good Morning,

By letter dated May 31, 2019, the Electric Power Research Institute (EPRI) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review, "Uranium Oxycarbide (UCO) Tristructural Isotropic (TRISO) Coated Particle Fuel Performance, Topical Report EPRI-AR-1" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML19155A173). The NRC staff is reviewing the submittal to enable the staff to reach a conclusion on the safety of the UCO TRISO particle fuel performance.

The NRC staff has identified that additional information is needed to continue the review. The staff's request for additional information (RAI) is contained in the attachment to this email.

These RAIs were discussed during a public meeting on December 9, 2019. To support the review schedule, you are requested to respond within 30 days of the date of this email.

If you have any questions or comments, please contact me at 301-415-5481.

Sincerely,
Jordan

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Request for Additional Information (RAI)

Uranium Oxycarbide (UCO) Tristructural

Isotropic (TRISO) Coated Particle Fuel Performance Topical Report

Issue Date: January 2, 2020
Applicant: Electric Power Research Institute
Docket No: 99902021

By letter dated May 31, 2019, the Electric Power Research Institute (EPRI) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review, "Uranium Oxycarbide (UCO) Tristructural Isotropic (TRISO) Coated Particle Fuel Performance, Topical Report EPRI-AR-1" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML19155A173). This topical report provides a baseline set of data in order to establish a foundation for TRISO fuel performance, based on testing performed as part of the U.S. Department of Energy (DOE) Advanced Gas Reactor (AGR) Fuel Development and Qualification Program. During the course of the technical review, NRC staff has identified areas where additional information and detail are needed to make a safety finding.

This topical report does not have a specific regulatory requirement associated with it because how the TRISO fuel meets regulations will depend on the plant design and other systems, structures and components (SSCs) credited in the overall safety of the design. No matter the design, however, 10 CFR 50.34(a)(3)(i) requires in part that an applicant for a construction permit to build a power reactor provide principal design criteria (PDC) for the facility. Similar regulatory requirements exist for design certification, combined license, and standard design approvals (10 CFR 52.47(a)(3)(i), 10 CFR 52.79(a)(4)(i), and 10 CFR 52.137(a)(3)(i), respectively). The PDC establish requirements for SSCs, and based on historical practice, designs with TRISO fuel have used a safety strategy focused on the radionuclide retention capabilities of the TRISO particles.

General Design Criterion (GDC) 10, "Reactor design", requires that the reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences. Although GDC 10 applies only to light water reactor (LWR) designs, the staff expects non-LWR designs to have a similar GDC. Examples of substitute GDC can be found in Regulatory Guide (RG) 1.232 "Guidance for Developing Principal Design Criteria for Non-Light-Water Reactors", which provides guidance for developing PDC for non-LWR designs. Establishing fuel design limits and ensuring these limits are not exceeded represent a fundamental underpinning of the safety assessment of a nuclear power plant required by 10 CFR 50.34(a)(1). This topical report forms the basis for establishing the design limits for TRISO fuel.

10 CFR 50.34(a)(1)(ii)(C) requires an applicant describe the extent to which the reactor incorporates unique, unusual or enhanced safety features having a significant bearing on the probability or consequences of accidental release of radioactive materials. TRISO fuel presents a unique safety case in a "functional containment" approach for reducing the release of

radioactive materials, and the mechanisms by which TRISO fuel restricts the release of radioactive materials are described in this topical report. Such an approach could also impact any PDC proposed for containment.

RAI 1

Conclusion 1 of the topical report (TR) states that “testing of UCO TRISO-coated fuel particles in AGR-1 and AGR-2 constitutes a performance demonstration of these particle designs over a range of normal operating and off-normal accident conditions.” Discussions under the conclusion reference a compact-averaged burnup of 7.3-19.6% fissions per initial metal atom (FIMA) and time averaged maximum temperatures of 1069-1360°C. Are there other relevant performance parameters that bound the data set, such as those referenced in Figure 4-6 (packing fraction, fluence, power density)? Based on the discussion in the report, it appears some of these parameters could influence particle performance, but these values are not provided as bounds for the “range of normal operating and off-normal accident conditions”. Provide context for what constitutes a “range of normal operating and off-normal accident conditions” (e.g. reference a table), or provide a justification for why burnup and time averaged temperature are sufficient.

RAI 2

Conclusion 2 of the TR states “UCO TRISO-coated fuel particles that satisfy the parameter envelope defined by these measured particle layer properties in Table 5-5 can be relied on to provide satisfactory performance.” While Table 5-5 provides a list of physical parameters for fuel specifications, it does not appear to directly cover all of the parameters that govern the specifications that constitute the parameter envelope applicable to the tested AGR fuel. Some elements in particular that the report highlights as important but that are not directly referred to in Table 5-5 include kernel-to-buffer ratio for the fuel particle (and potentially its associated size), columnar grain structure of the SiC, and carbon content of the UCO. It is not clear to the staff how these limits are applicable to the conclusions in the report. Provide a justification for how these parameters are implicitly captured in Table 5-5, supplement the report to include these parameters as limits for TR applicability, or provide justification for why these elements are not important.

Further, the report references the importance of an uninterrupted coating process in the manufacturing of the fuel. Do the parameters in Table 5-5 adequately restrict fuel particle specifications such that this process does not need to be explicitly required? If not, provide a justification, consider restricting the applicability of the TR to fuel manufactured using a similar process, or add a proxy measurable parameter to Table 5-5 that does provide assurance that an uninterrupted coating process has been followed.

RAI 3

The TR states that “fuel particles tested in AGR-1 and AGR-2 exhibited property variations…with remarkably similar excellent irradiation and accident safety performance

results. The ranges of those variations in key characteristics of the kernels and coatings are reflected in measured particle layer properties provided in Table 5-5 from AGR-1 and AGR-2." Table 5-5 provides a set of characteristics for both tested fuel and specified ranges for "acceptable" fuel, both for mean values and extremes. In some cases, the specification range is larger than the tested fuel range, sometimes substantially. Based on the provided data, there is a clear basis for use of the measured values in Table 5-5, but the basis for the specified range and especially the Maximum Allowable Fraction Beyond the Critical Limit(s) is not clear. Additionally, the table references the AGR-1 and -2 dataset separately in some cases. Provide a table with a clear requested range for each property for approval to be referenced in the conclusions. Further, provide a basis for useage of the values in this table for ranges beyond the tested ranges, paying particular attention to Maximum Allowable Fraction Beyond the Critical Limit(s), where the allowed particles may be substantially "worse" than those tested.

RAI 4

TR conclusion 3 states "fission product release data and fuel failure fractions, as summarized in this report, can be used for licensing of reactors employing UCO TRISO-coated fuel particles that satisfy the parameter envelope defined by measured particle layer properties in Table 5-5." The phrases "as summarized in this report" and "can be used for licensing of reactors" lack specificity, though the subsequent discussion is relatively clear.

(a) Consider revising to more specifically reference the data presented, and narrow the scope of the request "can be used for licensing of reactors" to something more appropriate for the TR.

(b) Conclusion number 3 further states that the aggregate AGR-1 and AGR-2 fission product release data and fuel failure fractions can be used for licensing of reactors employing UCO TRISO-coated fuel particles that satisfy the parameter envelope detailed in the topical report. The staff notes that while the topical report supports fission gas release rates for most isotopes, it does not cover short-lived isotopes which decayed away before the particles discussed in EPRI-AR-1(NP) could be characterized. Therefore, the data set does not cover all of the fission gas release data necessary for licensing. Provide justification to support the statements in conclusion number 3 or limit the conclusion to the isotopes covered by the topical report.