1. INTRODUCTION AND BACKGROUND

By letter dated May 8, 2020 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML20132A014), Westinghouse Electric Company (Westinghouse) (applicant) submitted to U.S. Nuclear Regulatory Commission (NRC) Topical Report (TR) WCAP-18482-P/WCAP-18482-NP, Revision 0, “Westinghouse Advanced Doped Pellet Technology (ADOPT™) Fuel,” for review and approval (Ref. 1). ADOPT™ (ADOPT) fuel is proposed to be a direct replacement for standard uranium dioxide (UO₂) fuel and provides enhanced fuel pellet properties to enable higher burnup and improved accident tolerance. ADOPT fuel is a standard UO₂ pellet doped with small amounts of chromia (Cr₂O₃) and alumina (Al₂O₃). The additives facilitate greater densification and diffusion during sintering, resulting in a higher density and an enlarged grain size as compared to undoped UO₂. Westinghouse will utilize the most recent NRC approved fuel performance methodology as documented in WCAP-17642-P-A (PAD5) (Ref. 2) to model the mechanical performance of ADOPT fuel.

The purpose of the TR is to provide a detailed description of the ADOPT fuel pellets and to describe and characterize the material properties through a review of past operating history and qualification data. This TR focuses specifically on the methods associated with Westinghouse and Combustion Engineering (CE) pressurized water reactor (PWR) fuel types and for use with NRC approved zirconium-based cladding materials.

The application references several analyses or documents that are not provided as part of the application or are not provided in the reference section. In order to confirm that the analyses and references support the requested licensing action, the NRC staff plans to perform an audit of the listed documents related to fuel and cladding related areas of ADOPT fuel in the Information Request section below.

2. REGULATORY AUDIT BASES

The regulatory audit is based on the TR WCAP-18482-P/WCAP-18482-NP, Revision 0. The format of the regulatory audit is based on the NRC Nuclear Reactor Regulation Office Instruction, LIC-111, “Regulatory Audits.”
The NRC staff considered the following regulatory requirement during its review of the TR:

Criterion 10 of Appendix A to Title 10 of the Code of Federal Regulations (10 CFR) Part 50 General Design Criteria (GDC) for nuclear power plants, that 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.

The guidance of SRP Section 4.2 is established to provide assurance of the following:

(1) the fuel system is not damaged as a result of normal operation and anticipated operational occurrences (AOOs);

(2) fuel system damage during postulated accidents is never so severe as to prevent full control and shutdown rod insertion within the assumed rod drop time when it is required;

(3) the number of fuel rod failures is not underestimated for postulated accidents;

(4) core coolability is always maintained.

The acceptance criteria listed in SRP Section 4.2 that are applicable to the review of the TR are:

II.1.A – Fuel System Damage – See Section 6.1 of this TR.
II.1.B – Fuel Rod Failure – See Section 6.1 of this TR.
II.1.C – Fuel Coolability – See Section 6.1 and Section 6.2 of this TR.
II.2 – Description and Design Drawings – See Section 1 of this TR.
II.3.A/B – Operating Experience / Prototype Testing – See Section 1 of this TR.
II.3.C – Analytical Predictions – See Section 6.2 of this TR.
II.4 – Testing Inspection and Surveillance Plans – No different than standard UO2.

Review of the TR is also based on SRP Chapter 6.2.1 related to containment integrity following postulated loss-of-coolant accident (LOCA), steam line, or feedline break accidents.

Review of WCAP-18482-P also uses guidance from SRP Chapter 15 acceptance criteria applicable to AOOs and postulated accidents.

3. **REGULATORY AUDIT SCOPE**

The regulatory audit will focus on the following:

- Details of applicability of Westinghouse Fuel Criteria Evaluation Process (FCEP) on fuel performance and safety analysis analytical modeling for ADOPT fuel: Fuel assembly design and cladding materials, Nuclear design methods, Thermal hydraulic design, Safety analysis, LOCA and non-LOCA, Radiological consequence
- Microstructure of UO₂ with additive materials
- Thermal properties of ADOPT fuel
- Mechanical properties of ADOPT fuel
- Irradiation programs - Fission gas release, Dimensional variations
- 3 -

- Corrosion and hydrogen pickup
- Fuel fragmentation, relocation and dispersal (FFRD)
- Reactivity initiated accidents (RIA) and related tests
- Licensing applications – fuel performance models, fuel design criteria
- LOCA and non-LOCA analyses with ADOPT fuel
- Uncertainty calculations
- Calibration, verification, and validation of reported data in the TR

4. INFORMATION REQUEST

Most of the performance characteristics of ADOPT fuel, including, fuel thermal-mechanical properties, microstructure, and cladding thermal-mechanical properties. Irradiation experience and licensing application are summarized in the TR. However, details such as calculations, data analysis, uncertainty calculations, validation and verification of data, details of the tests, are not given in the TR. The related calculations, and data analysis shall be provided during the audit.

The NRC staff requests the following documents/data analysis/calculations related to topics/areas listed below:

1. PAD5 TR (Ref. 2) was approved for PWR fuels with a range of grain sizes, certain percentage of theoretical density and a higher burnup. Westinghouse is proposing an increased grain size range, increased theoretical density (TD), and increased burnup for its ADOPT fuel.
   a. Please provide documents to justify the use PAD5 fuel performance methodology to analyze the ADOPT fuel at different range of grain size, TD, and burnup.
   b. Provide documentation and discuss the impact of increased grain size, TD, and burnup on creep, grain growth, fission gas release, and mechanical properties of the fuel.

2. Please provide documents supporting the new microstructure of ADOPT fuel with additives. (Section 3.1)

3. Provide the documentation and data analysis for the thermal properties of ADOPT fuel: specific heat, diffusivity and thermal conductivity, melting temperature, and thermal expansion. (Section 3.2)

4. Provide documentation for the mechanical properties discussed in Section 3.3 of the TR.

5. Please provide documentation with details of data analysis for irradiation programs described in Section 4: specifically ramp and bump testing, fission gas measurements, fuel pellet cracking, and cladding metallography.

6. Please provide documentation and data analysis for corrosion, fuel swelling, and steady state fission gas release. (Section 5)

7. Please provide documents related to licensing applications described in Section 6 of the TR: (A00 analyses, safety analyses, and thermal-hydraulic design analysis (DNB).

8. Please provide details of uncertainty analyses and details of validation and verification of test results.
5. **TEAM ASSIGNMENTS**

The review team will consist of the following staff:

Mathew Panicker, NRC Technical Reviewer (DSS/SFNB)
Josh Whitman, NRC Peer Review (DSS/SFNB)
Paul Clifford, NRC Review Consultant (DSS)
Ekaterina Lenning, NRC Project Manager (DORL)
Robert Lukes, Chief, Nuclear Methods and Fuel Analysis (DSS/SFNB)

6. **LOGISTICS**

The audit will be conducted virtually via electronic reading room, which is requested to be open from November 9 through November 13, 2020.

The electronic reading room or portal should employ measures to prevent the downloading, copying, or otherwise storing of any online portal documents by the NRC staff accessing the portal.

As necessary, clarification calls will be requested regarding the documents under audit.

7. **SPECIAL REQUESTS**

None

8. **DELIVERABLES**

A regulatory audit summary and request for additional information (RAI) on open audit issues will be completed after the closure of the audit.

9. **REFERENCES**
