NRR-DMPSPEm Resource

From: Steinman, Rebecca L:(GenCo-Nuc) <Rebecca.Steinman@exeloncorp.com>
Sent: Tuesday, January 8, 2019 5:58 PM
To: Wiebe, Joel
Subject: [External_Sender] Bryon ATF Audit Follow-Up
Attachments: ATF Markup TS 4-2-1.pdf; Excerpt from original Byron ATF LAR.pdf

Joel,

As I think you were aware, I was on vacation during the Bryon ATF audit last Friday. I wanted to confirm the staff expectations for the information Exelon agreed to provide in an additional supplement to the LAR. We are preparing a supplement that addresses the following items:

1. A revision to the proposed license condition and TS 4.2.1.
   Exelon has decided that it would be appropriate to remove the originally proposed license condition and revise TS 4.2.1 to address the fact that the rods containing ADOPT fuel pellets are nonlimiting under steady state reactor conditions, but could be limiting under non-steady state conditions. Our intended TS 4.2.1 revision is attached so that the staff can verify that the proposed revision adequately addresses the 1/4/19 audit discussion points.

2. To explicitly address PAD-ATF applicability to the ADOPT pellets.
   Page 12 of 20 of the original LAR (see highlighted excerpt attached to this email) states that the current PAD code is capable of modeling the ADOPT pellet and then goes on the discuss the modification of the material properties and fuel performance models are being updated for coated cladding and uranium silicide fuel, which is designated as PAD-ATF. Separately on page 14 of 20, there is a paragraph discussing the fuel performance of the ADOPT pellets that states that the ADOPT pellet has essentially the same heat capacity, thermal diffusivity, thermal expansion coefficient, and melting temperature as standard uranium dioxide. I understood that the staff was looking for the supplement to tie these two statements together by clarifying that PAD-ATF is applicable to the ADOPT pellet for the same reasons the current PAD code (without the modifications for uranium silicide and the coated clad) is applicable to the ADOPT pellet.

There was a question of whether or not there was a third item related to the ADOPT fuel melt temperature, but it is possible that issue was actually part of item two above since the original LAR correctly states that the ADOPT pellet melting temperature is essentially the same as standard UO_2.

Our current schedule for submittal of the 3rd supplement addressing the above items is Tuesday, 1/15/19. If our planned submittal as outlined above is missing something that the staff is expecting based on the discussion at the audit, I would appreciate clarification since I was unable to personally participate in the audit exit discussion.

Sincerely,

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4.0 DESIGN FEATURES

4.1 Site

4.1.1 Site Location

The site is located in Rockvale Township, approximately 3.73 mi (6 km) south-southwest of the city of Byron in northern Illinois.

4.1.2 Exclusion Area Boundary (EAB)

The EAB shall not be less than 1460 ft (445 meters) from the outer containment wall.

4.1.3 Low Population Zone (LPZ)

The LPZ shall be a 3.0 mi (4828 meter) radius measured from the midpoint between the two reactors.

4.2 Reactor Core

4.2.1 Fuel Assemblies

The reactor shall contain 193 fuel assemblies. Each assembly shall consist of a matrix of Zircaloy, ZIRLO®, or Optimized ZIRLO™ clad fuel rods with an initial composition of natural or slightly enriched uranium dioxide (UO_2) as fuel material. Limited substitutions of zirconium alloy or stainless steel filler rods or vacancies for fuel rods, in accordance with approved applications of fuel rod configurations, may be used. Fuel assemblies shall be limited to those fuel designs that have been analyzed with applicable NRC staff approved codes and methods and shown by tests or analyses to comply with all fuel safety design bases. A limited number of lead test assemblies (LTAs) that have not completed representative testing may be placed in nonlimiting core regions.

During Unit 2 Cycles 22, 23, and 24, two LTAs containing up to twenty lead test rods may be placed in the reactor for evaluation. The LTA rods containing uranium silicide fuel pellets and rods containing standard UO_2 fuel pellets with coated cladding shall be nonlimiting. The LTA rods containing ADOPT™ fuel pellets may be loaded in core regions which are nonlimiting under steady state reactor conditions and shall comply with fuel limits specified in the COLR under all operational conditions.

4.2.2 Control Rod Assemblies

The reactor core shall contain 53 control rod assemblies. The control material shall be silver indium cadmium, hafnium, or a

An assessment will be performed to validate that the LTR thermal-hydraulic reload design evaluations remain bounded by the current analyses. A bounding current analysis will be confirmed by placing the LTRs in non-limiting core locations to assure non-peak LTR power, verifying there is no change to the current DNB correlations and DNBR limits, and verifying that impacts to all other reload safety analysis and design inputs are negligible.

An evaluation will be performed to confirm there are no adverse effects on the thermal-hydraulic design of the reload core due to the presence of the LTRs/LTAs. These evaluations include a comparison of surface roughness and friction between the LTRs and standard rods, and a mechanical consistency and cooling check of key core components. Any impact on the cycle specific crud-induced power shift (CIPS) and crud-induced localized corrosion (CILC) analysis due to the LTRs/LTAs will also be assessed.

Fuel Rod Design

In general, the impact of fuel rod lead use materials (i.e., coated cladding, ADOPT™ pellets, and uranium silicide pellets) on fuel performance will be beneficial. Relative to standard fuel rods, the chromium-coated cladding will exhibit less corrosion and hydrogen pickup. The ADOPT™ pellets will exhibit improved performance during transients with less fission gas release and more fuel plasticity; and the uranium silicide will operate at a lower fuel temperature due to its higher thermal conductivity. The anticipated improved fuel swelling rate and fission gas release for uranium silicide fuel remain to be experimentally verified at higher burnup; however, no adverse effects are anticipated from the proposed activity, particularly with the additional protection from the uranium silicide fuel capsule and segmented rod.

While the current PAD code (i.e., fuel performance code) is capable of modeling the ADOPT™ fuel pellet, material properties and fuel performance models are being updated for coated cladding and uranium silicide fuel with known correlations from literature, test reactor data and results of atomistic modeling. This information, along with ATF material properties and updated fuel temperature models, are being incorporated into the developmental PAD-ATF fuel performance code. Key aspects of the chromium-coated clad modeling include the corrosion and hydrogen pickup models. Key aspects of the uranium silicide modeling include thermal conductivity, thermal expansion, Young's modulus, densification, swelling, and relocation. Preliminary results to date indicate that, compared to uranium dioxide, uranium silicide will operate at a lower temperature with less fission gas release and less gaseous swelling for the same dimensional design and linear heat rate. It is noted that, considering the design of the subject uranium silicide segmented LTR, the additional layer of cladding and gap from the LTR capsule will increase the uranium silicide fuel temperature above the expected temperature of uranium silicide pellets loaded in a standard fuel rod. The chromium-coated cladding will exhibit reduced oxidation and hydrogen pickup in the base material during normal operation.

Fuel Handling, Storage, and Shipping

The LTAs are not expected to have an impact on any aspect of the criticality analyses. This includes criticality analyses for the Spent Fuel Pool, New Fuel Vault, Traveller™ PWR Fuel Shipping Package Arrays, and fuel handling equipment. Impacts to criticality for dry cask storage will be analyzed in the future. Specific to the Spent Fuel Pool and New Fuel Vault, several evaluations were performed to assess the impact of an Optimized Fuel Assembly with four uranium silicide LTRs. These evaluations showed a negligible impact on reactivity.

Similarly, with respect to fuel burnup, calculations show that the reactivity trajectory of the LTAs with exposure will be very similar to that of the standard fuel assemblies when placed in the Spent Fuel Pool Racks or dry casks. Additionally, evaluation of the Traveller™ container rod pipe arrays and transportation package arrays indicates that margin exists below the upper subcritical limit for all normal and accident conditions. It is concluded that the LTAs will have a negligible impact on reactivity associated fuel handling, storage or shipping.

Best Estimate Analyzer for Core Operations Nuclear (BEACON™) Core Monitoring System

Online core monitoring with the BEACON™ Core Monitoring System (i.e., the Power Distribution Monitoring System) will not be affected by the LTAs or LTRs, and the ability to accurately calculate the reactor 3-dimensional power shape will not be affected. The placement of the LTRs in the LTAs, and the placement of the LTAs in the core, will be designed to have a negligible effect on the measurements of the incore flux detectors and the excore nuclear instrumentation system detectors. Nuclear data libraries for the uranium silicide and ADOPT™ LTRs will be developed so these rods can be explicitly modeled.

Alternate Source Term

The radiological source term will not be significantly affected by the LTRs and LTAs. The fissile material (i.e., low enriched uranium) has not changed, the fuel form and chemical properties are not significantly different, and the fission product retention properties of the fuel have not been reduced. The timing, magnitude, and chemical form of fission products released during an accident will not be significantly different. In the unlikely event of a total failure of all LTRs, the very small number of LTRs contained in the LTAs provides assurance that the radiological release limits for design basis accidents will not be challenged.

3.5 ADOPT™ Fuel Description

Advanced Doped Pellet Technology (ADOPT™) fuel is uranium dioxide fuel containing additions of chromium and aluminum oxides. The additives facilitate greater densification and diffusion during sintering, which result in a higher density and an enlarged grain size compared to undoped uranium dioxide. While achieving the desired pellet properties, the amount of additives has been kept at a minimum in the ADOPT™ design. This has the benefit of reducing the amount of parasitic neutron absorption introduced by the additives such as chromium. Aluminum oxide can, to some extent, be used as a substitute for chromium oxide. The available data suggests beneficial rod performance properties such as improved resistance to post failure degradation and increased pellet clad interaction (PCI) margins for ADOPT™ in comparison to undoped uranium dioxide pellets. It has also been shown through power ramp tests and bump tests, that there is significantly less gas release from the ADOPT™ fuel during transients.

The ADOPT™ uranium dioxide fuel pellets are very similar to standard uranium dioxide fuel. As noted, ADOPT™ pellets incorporate very small amounts of aluminum- and chromium-oxide based dopants (typically several hundred ppm) to modify the pellet viscoplastic characteristics, which results in improvements in density, plasticity, and grain size, and which in turn results in improved accident tolerance; otherwise, ADOPT™ is identical to standard uranium dioxide.

The use of ADOPT™ pellets poses negligible risk. ADOPT™ is the standard Westinghouse BWR fuel product in Europe, and for many years has been licensed for use in multiple international BWRs. The first ADOPT™ -fueled test rods were inserted in 1999, and since that time over 1800 fuel assemblies containing ADOPT™ fuel have been irradiated. ADOPT™ fuel has reached exposures of 60.8 MWd/kg average fuel assembly burnup and 72 MWd/kg fuel rod average burnup. Hot cell examinations and poolside examinations have verified acceptable fuel pellet performance. As such, substantial commercial reactor operating experience exists for ADOPT fuel.

Fuel assemblies containing segmented fuel rods with ADOPT™ fuel pellets have also been irradiated in European commercial PWRs, starting in 2007 and reaching 58 MWd/kg fuel assembly burnup without any issues. The performance of ADOPT™ fuel in a PWR environment is anticipated to be similar to that observed in BWRs. Four LTRs containing ADOPT™ uranium dioxide fuel pellets with be included in one of the two LTAs as previously discussed.

The fuel performance of ADOPT™ pellets is well understood. The ADOPT™ pellets exhibit satisfactory thermal physical and chemical properties, and dimensional, densification and swelling performance. ADOPT™ fuel has essentially the same heat capacity, thermal diffusivity, thermal expansion coefficient, and melting temperature as standard uranium dioxide. The ADOPT™ pellets will be enriched to levels characteristic of standard pellets and will not impair any aspect of neutronic behavior, including thermal margin, hot and cold reactivity, reactivity coefficients and reactor kinetics, and stability. All primary operational parameters such as DNBR, fuel temperature, linear heat rate, fuel enthalpy, clad strain, and fuel burnup will be negligibly impacted by the use of ADOPT™ pellets; however, sufficient design margin will be employed.

The use of ADOPT™ pellets will have a negligible impact on the mechanical design of the assembly. There is no direct effect on the fuel rod clad. The fuel rod interface with all fuel assembly subcomponents will be unaffected, and the ADOPT™ pellet dimensions will be very similar to the dimensions of standard uranium dioxide pellets, and the weight of an ADOPT™ rod will be similar to the weight of a standard rod. The thermal-hydraulic performance and seismic performance of the LTR and LTA will not be affected by the slightly different ADOPT™ pellet. Westinghouse has significant experience with the fabrication of ADOPT™ pellets and subsequent full fuel assembly fabrication, and therefore no issues are expected. Westinghouse has a large amount of operating experience with ADOPT™ fuel, and the fuel performance of ADOPT™ pellets and ADOPT™ -fueled rods is well understood and can be accurately modeled. Any modifications to NRC-approved fuel or reactor analysis methods to accommodate the use of ADOPT™ in a PWR will be minor and will pose negligible risk.

The use of ADOPT™ pellets will not affect any aspect of the chromium-coated fuel rod cladding performance. The ADOPT™ pellets are very similar to standard uranium dioxide pellets and any differences will be transparent to the cladding. ADOPT™ has improved pellet-clad interaction performance when compared to standard uranium dioxide, which will be a beneficial effect. There will be no adverse LOCA or non-LOCA impacts, because the ADOPT™ pellet decay heat, stored energy, thermal conductivity, neutronic characteristics, and kinetic characteristics are very similar to standard uranium dioxide pellets.