# SAFETY EVALUATION REPORT

**Docket No. 72-11**
**Sacramento Municipal Utility District**
**Rancho Seco Independent Spent Fuel Storage Installation**
**License No. SNM-2510**
**Amendment No. 3**

## SUMMARY

This Safety Evaluation Report (SER) documents the review and evaluation of an amendment to Special Nuclear Materials License No. 2510 for the Rancho Seco Independent Spent Fuel Storage Installation (ISFSI). By application dated November 5, 2008, as supplemented January 27, 2009, March 4, 2009, July 1, 2009, and July 29, 2009 (Agencywide Documents Access and Management System Accession Nos. ML083190252, ML090370875, ML090820276, ML0919504570, and ML092220241 respectively), the Sacramento Municipal Utility District submitted a request to the U.S. Nuclear Regulatory Commission (NRC) in accordance with Title 10 of the Code of Federal Regulations (10 CFR) 72.56, "Application for amendment of license," to amend the License to allow the storage of six damaged fuel assemblies in five fuel-with-control-component dry storage canisters (DSCs).

The NRC staff has reviewed the application, including the justifications for the proposed change. Based on the statements and representations in the application, as supplemented, and the conditions specified in the license and technical specification (TS), the staff concluded that the proposed change to the Rancho Seco ISFSI TS meets the requirements of 10 CFR Part 72.

## 1.0 GENERAL DESCRIPTION

In mid-1996, the applicant performed a visual inspection of the spent nuclear fuel (SNF) to assess the condition of the fuel and to determine the extent of cladding damaged on the visible fuel pins. All fuel inspections were systematically video taped and retained for long-term record storage. At the time the fuel was surveyed, the applicant classified SNF as damaged if cladding failures with breeches greater than 25% of the circumference of the fuel pin and at least the length of a fuel pellet ($\approx$ 0.34 inches across the cladding and 0.7 inches along the cladding) were present. The applicant used the results of this inspection to determine which assemblies must be placed in a failed fuel (FF) DSC.

The inspection criteria used by the applicant in the late 1990s were based upon the best available guidance at the time. However, over time, the criteria have evolved and by the time the ISFSI Final Safety Analysis Report was issued, the criteria used to inspect and classify the fuel became more restrictive. TS 1.1 defines an intact fuel assembly as one with no known or suspected cladding defects greater than hairline cracks or pinhole leaks. The applicant identified six fuel assemblies that had been loaded as intact by the old definition (defects greater than 0.34 inches across the cladding and 0.7 inches along the cladding), but which must be classified as damaged by the new definition (defects greater than hairline cracks or pinhole leaks). These six assemblies were loaded into five fuel-with-control-component (FC) DSCs.

TS 2.1.1 only allows intact fuel to be placed in a fuel-only (FO) DSC. Therefore, to restore compliance with the ISFSI TS, the applicant submitted an amendment to revise TS 2.1.1 to add a footnote allowing these six damaged fuel assemblies to be stored in FC-DSCs.

## 2.0 STRUCTURAL EVALUATION

As described in the Safety Evaluation (Attachment 2 to the application), since the damaged SNF loaded into the FC-DSCs were at one time deemed intact, by an older definition of damaged fuel, the defects in the fuel pins are relatively small. Additionally, the functional design differences between the FF-DSC and the FC-DSC only relate to transportation and not storage conditions. Further, as determined in the initial licensing of the ISFSI, tip-over is not a credible accident condition at the Rancho Seco ISFSI. Therefore, the DSC in storage conditions will sit on the DSC support rails inside the horizontal storage module (HSM) even after the postulated seismic event analyzed in the Rancho Seco ISFSI FSAR Volume II, Section 8.3.2. Therefore, the structural considerations for this license amendment are within the bounds of previously-approved analyses.

## 3.0 THERMAL EVALUATION

The functional design differences between the FF-DSC and FC-DSC are not related to storage, but to transportation and individual fuel assembly handling during canister loading and unloading operations. This amendment only addresses storage conditions. Further, none of the six fuel assemblies in question have structural damage or cladding damage that could be expected to result in loose pellets. Based on the analyses in attachment 2 to the applicant's Safety Evaluation, the staff agrees that the loose-fuel-pellet analyses for the five FC-DSCs containing damaged fuel is bounded by the loose-fuel-pellet analysis performed for the FF-DSC. Therefore, the staff agrees that the design differences between FF-DSC and FC-DSC do not preclude safe continued storage of the six damaged fuel assemblies.

The applicant analyzed the impact of loading damaged fuel assemblies into a FC-DSC, assuming the assemblies had the characteristics of the design-basis fuel approved for the site. For the normal operating condition (at the time of loading) analysis, the applicant assumed a conservative cooling time of 5.5 years (corresponding to a heat load of 18.34 kW per DSC), as compared to the design-basis cooling time of 7 years (corresponding to a heat load of 13.5 kW).[3] Even with these conservatisms, the applicant calculated a resulting maximum cladding temperature of 701$^{o}$F, which is bounded by the design-basis temperature of 714$^{o}$F.[4] Therefore, the staff concludes that the thermal analysis performed by the applicant is conservative and acceptable to ensure the cladding temperature and other material temperatures remain acceptable for the continued storage of the six identified damaged fuel assemblies in the five identified FC-DSCs.

The applicant also analyzed the impact of loading damaged fuel assemblies into a FC-DSC, using characteristics of the fuel assemblies that were actually loaded. The staff confirmed that the assumed heat load of 8.156 kW, used for the thermal analysis per FC-DSC with damaged fuel, was the maximum decay heat at the time of loading into the canister. To account for the uncertainty in fuel assemblies, the fuel cladding temperature was calculated by reducing the effective fuel conductivity by 20%. This is a conservative approach since it's applied to all 24 fuel assemblies in the FC-DSC, considering that a maximum of only 2 fuel assemblies were placed in an FC-DSC. Furthermore, for conservatism, the fuel loading configuration with the highest average heat load at the center four fuel assemblies of the 24-fuel assembly canister was selected as the bounding case for the steady-state analysis. The predicted maximum cladding temperature of 544$^{o}$F is bounded by the allowable limit of 752$^{o}$F. The staff concludes that with the heat load (at time of loading) much lower than the design heat load and the corresponding thermal calculation, the continued storage of the six damaged fuel assemblies in the five identified FC-DSCs is acceptable from a thermal perspective.

The staff agrees with the applicant's conclusions that the predicted fuel cladding temperature is bounded by the previously-calculated safety limit. Further, the staff agrees with the applicant's conclusion that the loose-fuel-pellet analysis is bounded by the prior analyses. The staff concludes that the existing, designed heat removal capability of the cask system, considering the placement of the six damaged fuel assemblies in the five identified FC-DSCs, will not be degraded by further storage of the fuel assemblies in the FC-DSCs.

The staff confirmed that the design burnup and the maximum vacuum drying time for FC-DSCs with damaged fuel assemblies are 38,286 MWd/MTU and 56.2 hours, respectively, which are within the burnup limit of 45,000 MWd/MTU and incubation time limit of 100 hours determined for the onset of fuel oxidation. Therefore, the staff agrees that under this premise, no further propagation of fuel cladding cracks during vacuum drying process would occur.

Based on the functional design features of FC-DSC in storage and the applicant's conservative safety analysis, the staff concludes that the six damaged fuel assemblies identified in the application may remain safely loaded in FC-DSCs, and that the requested license amendment meets the thermal requirements of 10 CFR Part 72.

References

1. Technical Specifications for the Rancho Seco ISFSI, Appendix, June 2000.

2. FO/FC DSC Thermal Analysis for Storage Conditions," TRANSNUCLEAR, Calculation No. NUH005.0451, Rev. 4.

3. "Thermal Evaluation of FC DSC Loaded with Damaged Fuel Assemblies", TRANSNUCLEAR, Calculation No. 13302.0404, Rev. 0.

4. Sacramento Municipal Utility District, Rancho Seco ISFSI, "Vacuum Drying Durations and DSC Loading Data," July 26, 2007.

5. Transient Thermal Analysis of FO/FC Canister during Vacuum Drying", TRANSNUCLEAR, Calculation No. 13302.0403, Rev. 0.

6. R. Einziger and R. Strain, "Behavior of Breached Pressurized Water Reactor Spent Fuel Rods in an Air Atmosphere between 250 and 360$^{o}$C," Nuclear Technology, Vol. 75, pp. 82-95, Oct. 1986.

## 4.0 SHIELDING EVALUATION

The applicant performed a calculation and determined that the source term for the FC-DSCs containing the damaged fuel assemblies is bounded by the design-basis source term for the FC-DSCs. The FC-DSCs were licensed for 24 B&W 15x15 pressurized-water-reactor fuel assemblies, with burnups less than or equal to 40,000 MWd/MTU and cooling times of greater than or equal to 5 years. The six damaged fuel assemblies loaded into the FC-DSCs had burnups ranging from 27,728 to 38,268 MWd/MTU, and cooling time ranging from 8 to 25 years.

The staff agrees with the applicant's conclusion that, since the source term from the 6 damaged fuel assemblies is less than the design-basis source term, the dose rates of the FC-DSCs loaded with the damaged fuel assemblies should be bounded by the design-basis dose rates for the ISFSI. Therefore, the staff finds that the requested license amendment meets the shielding requirements of 10 CFR Part 72.

## 5.0 CRITICALITY EVALUATION

The staff reviewed the proposed amendment to ensure that all credible normal, off-normal and accident conditions have been identified and their potential consequences on criticality considered such that storage of SNF in the Rancho Seco ISFSI meets the regulatory requirements of 10 CFR Part 72. The staff reviewed both the revised TS and the applicant's criticality safety evaluation of the NUHOMS-24P FC-DSCs to determine the acceptability of the proposed amendment.

The FC-DSC is designed to store up to 24 intact B&W 15x15 fuel assemblies. The design-basis fuel assemblies are limited to a maximum assembly average initial enrichment of 3.43 wt.% U-235. The maximum assembly average initial enrichment of the six damaged fuel assemblies is 3.18 wt.% U-235. No burnup credit is taken for spent fuel. No new fuel assembly types were added in this amendment.

The applicant modeled the FC-DSC using the appropriate geometry options in KENO V.a of the CSAS25 module in SCALE-4.4, with the 44 Group ENDF/B-V cross section library. To be conservative, a KENO V.a base case model was generated for a Fuel-Only Dry Shielded Canister (FO-DSC), i.e., a fuel assembly without any associated non-fuel hardware. Since the presence of control components in “unborated water” results in a reduction in moderation and reduces reactivity, this model conservatively bounds the FC-DSC. The KENO V.a base case model (based on the design basis models from the SAR) utilized the maximum enrichment of 3.43 wt.% U-235 for all 24 fuel assemblies. The actual “as loaded” enrichment (corresponding to the worst DSC for damaged fuel evaluation) consists of a maximum of three fuel assemblies at the highest evaluated enrichment of 3.43 wt.% U-235, resulting in further conservatism. The fixed neutron poison material in the canister baskets in the calculation was modeled as a mixture of aluminum and boron carbide. All other components of the FO-DSC, including the lead blanket for shielding, four axially oriented support rods, and twenty-six spacer discs were explicitly modeled with conservative dimensions as previously documented in the SAR.

For the base case model, the applicant performed a number of parametric cases assuming optimum internal moderator density (i.e., 100%) to determine the maximum $k_{eff}$ as a function of the external moderator density. The results indicate that external moderator density does not have a systematic influence on the $k_{eff}$ of the system. The maximum calculated $k_{eff}$ was 0.9298, which is below the upper subcritical limit (USL) of 0.9425. Staff reviewed the applicant's models and agrees that they are consistent with the description of the canister and contents given in the proposed amendment. The staff also reviewed the applicant's methods, calculations, and results and agrees that the most reactive combination of canister parameters and dimensional tolerances were incorporated into the calculation models.

The second set of KENO V.a models are derived from the base case model and serve to model the “as loaded” configuration of the “worst case” FC DSC that has damaged fuel (i.e., two damaged fuel assemblies in a FC-DSC). The enrichment of the fuel assemblies modeled in these representations range from a minimum of 3.00 wt.% U-235 to a maximum of 3.43 wt.% U-235. Only one of the FC-DSCs had two damaged fuel assemblies. When compared to the actual enrichment distribution for this DSC, as shown in the applicant's criticality safety evaluation, the models evaluated are conservative. The maximum calculated $k_{eff}$ was 0.9119 for the most conservative "as loaded" configuration of fuel assemblies.

The most conservative "as-loaded" KENO V.a model, corresponding to a minimum U-235 enrichment of 3.18% in a fuel assembly, was also used to consider the effects of having damaged fuel assemblies in a canister. The applicant modeled the damaged fuel assemblies assuming that one row of rods in both of the damaged fuel assemblies is bare (no cladding). This model serves to represent damaged assembly geometries with cracked or damaged cladding. The applicant modeled the removed cladding with water. The applicant also considered the effects of rod segments or rod pellets being separated from the damaged fuel assembly and dropping to the bottom of the canister. The rod segments were modeled by adding an additional 6.25 inches (the remaining space to the bottom of the canister) to each damaged fuel assembly. The rod pellets were modeled by adding up to a 2-inch high 40x40 array of fuel pellets with and without cladding adjacent to the bottom of the baskets. The maximum calculated $k_{eff}$ for the damaged assembly configurations was 0.9151.

The staff's confirmatory calculations, the results of which were comparable with those of the applicant, used the CSAS26 modules (KENO VI) in the SCALE 5.1 computer code with the 44 Group ENDF/B-V cross section library. The staff also used the 238 Group ENDF/B-V cross section library to check the adequacy of using the 44 Group library in these calculations. The staff also considered the effects of one of the damaged fuel assemblies having all rods lose cladding. The results from this very conservative calculation showed a small positive change in reactivity, which was still significantly below the USL.

The most reactive damaged assembly configuration (following an accident) is the "double-ended" shear configuration where one row of rods is assumed to shear off from the fuel assembly and undergo further shearing in the axial direction resulting in half of the fuel assembly containing an extra row of rods. The applicant did not evaluate this configuration, because the extent of the damage for the damaged fuel assemblies being considered in this amendment is quite small. Therefore, it is not believed that such a configuration is credible. The staff performed calculation analyses for the "double-ended" shear configuration by modifying the rod pitch to determine the optimum pitch for one damaged fuel assembly in both a $k_{eff}$ and a $k_{inf}$ calculation. Although the "double-ended" shear configuration showed a small positive change in reactivity, the results were still significantly below the USL.

Results of the applicant's criticality analysis show that the $k_{eff}$ of the FC-DSC with the proposed amended changes will remain below 0.95 for all allowed fuel loadings. The staff reviewed the applicant's calculated $k_{eff}$ values and USL and agrees that these values have been appropriately calculated to include all biases and uncertainties at a 95% confidence level or better.

Based on the applicant's criticality evaluation, as confirmed by the staff, the staff concludes that the proposed changes in the amendment to the FC-DSC will remain subcritical with an adequate margin of safety under all credible normal, off-normal, and accident conditions. Further, the applicant performed benchmark comparisons on selected critical experiments similar to those performed in the original approved license. The staff reviewed the applicant's method for determining the USL and found it to be acceptable and conservative, and that the requested license amendment meets the criticality requirements of 10 CFR Part 72.

## 6.0 CONFINEMENT EVALUATION

The confinement evaluation is not impacted by the changes requested in this amendment.

## 7.0 MATERIALS EVALUATION

The definition of damaged fuel has not been changed by this request. Subsequent interpretation of the visual examinations indicated fuel assemblies that were classified as "intact" that should have been classified as "damaged" and thus were improperly loaded into an "intact" slot. The applicant's analysis showed that the improperly classified fuel assemblies were not exposed to air (during fuel loading operations) long enough for any potential oxidation to occur. Therefore, the staff finds that the requested license amendment meets the materials requirements of 10 CFR Part 72.

The staff notes that under current guidance, visual examination alone is no longer a sufficient method for classifying assemblies as damaged or intact. Prior to transporting the fuel stored at Rancho Seco, fuel classification may need to be revisited, and the damaged fuel assemblies (and potentially the intact fuel assemblies) may need to be placed into damaged-fuel cans to be transportable.

## 8.0 TECHNICAL SPECIFICATIONS AND OPERATING PROCEDURES

The applicant submitted proposed edits to TS 2.1.1, "Fuel Stored at the ISFSI," to allow storage of the six fuel assemblies, with known or suspected cladding defects greater than hairline cracks or pinhole leaks,   The staff reviewed the proposed edits and finds them acceptable.

The operating procedures are not impacted by the proposed amendment.

## REQUIREMENTS FOR NOTICING PROPOSED ACTION

The staff considered the amendment's potential impact on the health and safety of the public. The staff determined that the proposed amendment does not present a genuine issue as to whether public health and safety will be significantly affected. A *Federal Register* notice of the proposed amendment will give interested persons an opportunity to request a hearing on whether this licensing action should be rescinded or modified.

## ENVIRONMENTAL REVIEW

The staff finds that this license amendment does not involve any changes in the scope or type of operations presently authorized by the license. The staff has determined that the changes will not result in: (1) a significant increase in the amounts of any effluents; (2) a significant increase in individual or cumulative occupational radiation exposure; (3) a significant construction impact; or (4) a significant increase in the potential for or consequences from radiological accidents.

Accordingly, pursuant to 10 CFR 51.22(c)(11), neither an environmental assessment nor an environmental impact statement is warranted for this action.

**CONCLUSION**

The NRC staff concludes that the Rancho Seco ISFSI License (SNM-2510) can be revised to allow the storage of the six damaged fuel assemblies loaded into the five identified FC-DSCs. This change to the License will not affect the ability of the Rancho Seco ISFSI to safely store spent fuel consistent with the requirements of 10 CFR Part 72.

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