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K-Basin Fuel Characterization Program Technical Baseline Summary

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Abstract:

This document provides a summary of the systematic process used by the SNF Project to characterize K-Basin spent fuel, and to develop and apply the appropriate conservative safety margins to the resulting parameters for technical designs and safety analyses.

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K-Basin Fuel Characterization Program Technical Baseline Summary

SNF-5165

September 15, 1999

Issue

What is the technical basis for the position that the characterization program for the spent nuclear fuel stored in the K-Basins provides adequate data to safely bound the conditions and behavior expected during the retrieval, drying, and storage of this material?

Facts

The SNF Project has used a systematic process of characterizing K-Basin spent fuel and applying appropriate conservatism to the results for design and safety analyses. The investigative process consisted of literally thousands of visual examinations, liquid and gas samples, measurements, tests, and technical literature research. Each test was specifically designed, based upon prior analysis and detailed fuel studies, to address the characteristics of key parameters needed to assure ample operational safety margins in the project's system designs. In addition, extremely conservative safety margins were assigned to safety related systems when the value of critical fuel parameters was uncertain or based upon limited data. This assured that any parameter uncertainties resulting from limited characterization sample size would not challenge the design limits or the operational safety envelope.

Characterization Testing

The characterization program for SNFP consisted of literature searches, in-basin measurements, non-destructive laboratory testing, and destructive testing. The key parameters derived from the fuel characterization program are summarized in the table on page 3.

All of the sampling and testing activities were performed based upon data quality objectives documents (DQO's) written for three fuel sample retrieval campaigns (two campaigns in K-West and one in K-East), for two campaigns of gas/liquid sampling, and for tests performed in the small furnace. The rest of the activities are discussed in the DQO documents associated with fuel retrieval from the basins, or covered in strategy documents or test plans. DQO preparation is described in the "SNF Project Characterization Data Quality Objectives Strategy" WHC-EP-0795.

In-situ (in-basin) characterization testing consisted of a progression of the following tests:

- Basin-wide Fuel Survey. Visual examination of the tops of elements in open canisters in the K-East basin was performed on about 70% of the entire K-East basin population using an underwater camera. Approximately 70,000 fuel elements, including both inner and outer elements, were visually examined and their condition assessed.
- Gas and Liquid Samples. 60 canisters (120 barrels) were sampled for gas and liquid in K-West basin. These samples indicated the extent of fuel corrosion within the closed canisters as verified by later visual examination of some of these canisters.

- Lift & Look. Guided by the results of the data described above, Lift-and-Look examinations were performed on 250 assemblies from K-East and 250 assemblies from K-West.
- Coating Measurements. Eddy current measurements were performed on 45 elements to determine $\text{Al}(\text{OH})_3$ coating thickness and other associated parameters.
- Shipping Data. Data was taken during retrieval and shipment to lab of 19 elements from K-West and 11 elements from K-East.

Nondestructive laboratory examinations conducted included:

- Whole Element NDE. Comprehensive visual examinations, as well as, other selective measurements (weight, density, etc) were performed on 11 elements.

Destructive laboratory examinations consisted of:

- Sludge Drying. 14 samples of sludge recovered from K-East canisters were subject to thermo-gravimetric analysis to study water loss kinetics. French researchers evaluated 13 samples of unirradiated uranium hydrate, which was created in the lab. Total of 27 samples.
- Whole Element Drying. Eight whole fuel elements were evaluated in a furnace to mimic the SNF drying process.
- Small Sample Tests. 39 samples from two K-West fuel elements were processed through a small furnace for drying, ignition and conditioning studies. 53 samples from the same two K-West fuel elements were subjected to thermo-gravimetric analysis (39 oxidation samples, plus 14 for hydrogen content or drying studies). Total of 92 samples.
- Other Destructive Tests. Eight metallography samples from one K-West element were checked for hydrides, cladding adherence, cracking, etc. Coatings scraped from seven elements were subjected to various chemical analyses. Eight samples of internal (subsurface) sludge recovered from three elements were subjected to various chemical analyses. Total of 23 samples.

Design and Safety Analysis

Several parameters used in design and safety calculations were determined or confirmed (from literature sources) using characterization data. These parameters include particulate mass, fuel surface area, uranium oxide hydrates, aluminum hydroxide, free water, and oxidation reaction rates.

For each parameter, two values were developed and entered in the SNF Project Technical Databook (this is a configuration controlled technical baseline document). The design basis value is used for design calculations, where an expected value is needed. The safety basis value bounds all values that are expected in actual fuel loaded into MCOs. Determination of the safety basis value required consideration of both available literature data and SNF characterization data. In cases where the data was limited or uncertain, conservatism was added to assure that the value selected was truly bounding. In all cases, a thorough peer review from well-qualified reviewers was utilized to assure that the safety basis value was defensible to technical experts. These peer reviews were fully documented.

Parameters Significant to Safety Basis and Derived from Characterization Data

Parameters Significant to Safety Basis and Derived from Characterization Data			Sample Size		
Parameter		Document	Literature Data		
Particulate Mass		HNF-1527	Basin-wide Fuel Survey	open literature	
Fuel Surface Area		HNF-SD-SNF-CN-017	70,000 visual		
Water Content	Uranium Oxide Hydrates	HNF-1523	Gas Samples	60 canisters	
	Aluminum Hydroxide		Liquid Samples		
	Free Water	HNF-1851	Lift & Look	250 KW & 250 KE elements	
	Oxidation Reaction Rate	HNF-4165	Sludge Drying	27 samples	
			Coating Measurements	45 elements	
			Shipping Data	19 KW & 11 KE elements	
			Whole Element NDE	11 elements	
			Small Sample Tests	92 samples	
			Whole Element Drying	8 elements	
			Other Destructive Tests	23 samples	
			Conservative Assumptions	(see notes below)	

Notes:

	Denotes parameters where characterization data was utilized
=	Modest conservatism to assure bounding value
+	Large conservatism to account for range of fuel conditions
>	Enhancement factor to recognize uncertainty

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