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February 2007

Technical Work Plan for:

Development of Technical Data Needed to Justify Full Burnup Credit in Criticality Safety Licensing Analyses Involving Commercial Spent Nuclear Fuel

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CHANGE HISTORY

Revision Number	ICN Number	Date of Change	Description of Change
00	00	01/15/07	Initial issue.
01		02/08/07	Incorporated OCRWM review comments: added text to indicate that the Gantt chart in Appendix B represents an initial working schedule; added text to indicate that a BCP or other appropriate funding mechanism will be utilized to enable the data purchases that were not budgeted in the AWPs; improved the resolution in Appendix B to enhance readability; and removed QA requirements for pretest predictions. Changes are denoted by change bars.

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ACRONYMS AND ABBREVIATIONS

AB	authorization basis
ATM	Approved Test Material
AWP	annual work plan
BCP	baseline change proposal
BUC	burnup credit
BWR	boiling water reactor
C/E	calculated to experimental
CSNF	commercial spent nuclear fuel
DOE	U.S. Department of Energy
ENDF	U.S. Evaluated Nuclear Data File
EPRI	Electric Power Research Institute
EXFOR	EXchange FORmat
FEPs	features, events, and processes
GWd	gigawatt day
HTC	*Haut Taux de Combustion* (Fr.; high burnup)
IHECSBE	*International Handbook of Evaluated Criticality Safety Benchmark Experiments*
IRMM	Institute for Reference Materials and Measurement
LA	license application
LCE	laboratory critical experiment
MOX	mixed oxide
MTU	metric ton of uranium
MWd	megawatt day
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
OCRWM	Office of Civilian Radioactive Waste Management
OLM	DOE Office of Logistics Management
ORNL	Oak Ridge National Laboratory
PF	*produits de fission* (Fr.; fission products)
PNNL	Pacific Northwest National Laboratory
PWR	pressurized water reactor

ACRONYMS AND ABBREVIATIONS (Continued)

QA	quality assurance
QARD	*Quality Assurance Requirements and Description*
QSL	qualified supplier list
RCA	radiochemical analysis
RPC	Records Processing Center
SNF	spent nuclear fuel
SNL	Sandia National Laboratories
S/U	sensitivity and uncertainty
TAD	transport, aging, and disposal
TCO	Test Coordination Office
YMP	Yucca Mountain Project

1. WORK SCOPE

This technical work plan (TWP) describes the planning of burnup credit (BUC) experimental work to be implemented by the U.S. Department of Energy (DOE) Office of Civilian Radioactive Waste Management (OCRWM) Lead Laboratory for Repository Systems. This TWP serves to coordinate and integrate a program to implement Work Packages S31023 to S31036 of the fiscal year 2007 annual work plan (AWP) for the Lead Laboratory. The work scope involves the development, performance, technical integration, and oversight of measurements and collection of relevant data, guided by analyses and demonstration of need.

The development and execution of this TWP are implementation actions listed in the memorandum *Decision on Approach to Burnup Credit* from M.H. Williams to E.F. Sproat, dated December 8, 2006 (Williams 2006); this memorandum is included as Appendix A for reference purposes. Relevant background information, as well as discussion on the issues, options, impacts, risks, recommendations, decisions, and implementation actions for commercial spent nuclear fuel (CSNF) burnup credit is provided in the memorandum.

The ultimate goal of the work described in this TWP is to develop and/or obtain the technical data needed to justify full (actinide and fission product) burnup credit in criticality safety licensing analyses involving CSNF. As data from this program becomes available and qualified, these data will be implemented in the supporting documents to the license application (LA). Data developed or that become available subsequent to the LA submittal will be used in license amendments and/or license defense. This goal is consistent with the recommendations and decisions listed in the aforementioned memorandum. The objective of this TWP is to describe the overall framework for obtaining and using these data. As such, this TWP is a planning document used to facilitate the necessary activities to be considered for a five-year, multi-organizational experimental program, and hence includes tasks for the development of more detailed and task-specific planning documents. Specifically, testing will not be conducted under this TWP. Rather, detailed TWPs or test experimental plans will be developed to guide specific tests. This TWP provides the framework within which these detailed plans will fit.

Organizations expected to play a role in this work include, but are not limited to, DOE OCRWM, the OCRWM Lead Lab, selected DOE national laboratories, and selected U.S. nuclear power generating utilities. Interactions to share information with the U.S. Nuclear Regulatory Commission (NRC) and the Electric Power Research Institute (EPRI) are anticipated.

This TWP has been prepared in accordance with SCI-PRO-002, *Planning for Science Activities*.

1.1 OBJECTIVES

The overall technical and performance objectives of this work are to support the DOE in areas related to Yucca Mountain Project (YMP) postclosure criticality analysis. The objective of the work scope is to develop and/or obtain the scientific and technical data needed to justify burnup credit, including credit for the principal fission products, in criticality safety licensing analyses involving the transport, aging, and disposal (TAD) of CSNF, including both pressurized water reactor (PWR) and boiling water reactor (BWR) fuel.

The data needs are related to validation of computer codes and nuclear data (e.g., cross-sections and associated uncertainties), in accordance with applicable consensus standards (such as the ANSI standards listed in Section 3.1), that will be used in the criticality safety licensing evaluation. Except as required by agreements with owners of existing data, all scientific and technical information developed or obtained under this project will be made publicly available. The primary data needs have been determined through consultation with experts in the field, including NRC staff, and review of the current NRC Spent Fuel Project Office staff guidance on burnup credit, Interim Staff Guidance (ISG-8), Revision 2, [*Burnup Credit in the Criticality Safety Analyses of PWR Spent Fuel in Transport and Storage Casks* (NRC 2002)] and the "Safety Evaluation Report for Disposal Criticality Analysis Methodology Topical Report, Revision 0*"* (Reamer 2000). These needs include:

- Radiochemical analyses (RCAs) to provide measured isotopic compositions of CSNF to support depletion code/data validation
- Laboratory critical experiments (LCEs), including LCEs with fission products, to support criticality code/data validation
- Fission product cross-section measurements for selected nuclides, as needed, to improve confidence in reactivity predictions of the fission products
- A database of reactor operational history information to support justification of depletion parameters and assumptions used in the licensing safety analysis.

The primary tasks listed in the following section address each of these data needs and include tasks for management and technical integration of the data collection and measurement tasks to ensure the data tasks remain focused on addressing the priority data needs essential to justify implementation of burnup credit, to the extent needed. Detailed experimental planning documents for these components will be prepared, subsequent to approval of this document. The most current and relevant NRC staff guidance for the use of burnup credit is provided in ISG-8, Revision 2 (NRC 2002), which limits burnup credit to the actinide compositions. Although the ISG-8 was developed for transport and storage casks, the data development activities outlined in this TWP are to obtain the necessary data to support a criticality safety evaluation consistent with the principles of ISG-8, Revision 2. Extensions to the ISG-8 recommendations, e.g., credit for fission products, will be taken where they can be technically or operationally justified. In general, the licensing approach for the repository will attempt to satisfy the NRC staff (ISG-8) recommendations for code/data validation, while extending regulatory guidance for transport in other areas (e.g., burnup credit for BWR CSNF, administrative safety margin and reduced credit for fixed poisons). The ISG-8 recommends a two-step validation process: (1) use of fuel assay (RCA) measurement data to benchmark the depletion computational tools/data and validate the isotopic concentration predictions in CSNF and (2) use of benchmark experiments (LCEs) to benchmark the cross sections and reactivity contribution of credited isotopes.

In 2004, Oak Ridge National Laboratory (ORNL) prepared a plan of activities (Parks and Wagner 2005) to develop and/or obtain the scientific and technical information necessary to support preparation and review of a safety/licensing evaluation for high-capacity transport cask designs that use full (actinide and fission product) burnup credit. Subsequently ORNL worked cooperatively with the NRC, EPRI, and the DOE Office of Logistics Management (OLM), formerly the DOE Office of National Transportation, to execute the project plan. Similar to this TWP, the ORNL plan called for existing LCE and RCA measurement data to be obtained and assessed for technical value in developing an adequate safety evaluation that includes both actinide and fission product credit, as well as the development of new/additional data on an as-needed basis.

However, one significant difference between the ORNL plan for transportation burnup credit and this TWP is that credit was sought for relatively few fission products (focus was on the top fission products, as ranked in terms of reactivity worth). This TWP was developed with the goal of achieving credit for the 29 principal isotopes (14 actinides and 15 fission products, which are listed in Table 1), as outlined in the *Disposal Criticality Analysis Methodology Topical Report* (YMP 2003), as well as reevaluating the technical basis for crediting ^{133}Cs, which is not one of the 29 principal isotopes. Cost/benefit analyses will be performed under this TWP to reevaluate the number of isotopes for which credit is needed and/or cost effective. The DOE OLM burnup credit project was halted several months after the DOE OCRWM decision to use the relatively low-capacity TAD (DOE 2006a) canister system, which brought into question the need for full burnup credit for CSNF transportation. The technical data developed/obtained and lessons learned from that program have been used in the development of this TWP.

Table 1. Principal Isotopes for CSNF Burnup Credit

Actinide Isotopes		Fission Product Isotopes	
^{233}U	^{239}Pu	^{95}Mo	^{149}Sm
^{234}U	^{240}Pu	^{99}Tc	^{150}Sm
^{235}U	^{241}Pu	^{101}Ru	^{151}Sm
^{236}U	^{242}Pu	^{103}Rh	^{152}Sm
^{238}U	^{241}Am	^{109}Ag	^{151}Eu
^{237}Np	^{242m}Am[1]	^{143}Nd	^{153}Eu
^{238}Pu	^{243}Am	^{145}Nd	^{155}Gd
		^{147}Sm	

1.2 PRIMARY TASKS

Primary tasks to support the objectives of this TWP are described as follows.

1.2.1 Management

The principal objective of this task is to provide management oversight for the entire project to ensure the project achieves its stated goal of developing and/or obtaining the technical data needed to justify full (actinide and fission product) burnup credit in criticality safety licensing analyses involving CSNF. The specific tasks address issues such as management of the project cost and schedule, establishment of subcontracts, managing accountability of suppliers and subcontractors, authorization and execution of major TWP purchases and decisions, and creation of task-specific planning documents to implement various elements of the program.

[1] The *m* refers to a long-lived metastable state of Am-242.

There are risks associated with designing and executing the experimental program because many of the measurement techniques are not well established and such measurements are infrequently performed. Although not expected, it is possible that the experimental results will not corroborate the computer codes used to predict isotopic concentrations or reactivity. These risks must be recognized and managed, to the extent possible, with careful experiment design that includes detailed technical scrutiny, close management, and frequent communication and coordination (technical integration) among the activities. As will become apparent in the following sections, a number of the tasks are interdependent and complex. For a variety of reasons, including potential opportunities (e.g., CSNF rods/samples available from another program) or unexpected results, this TWP has been prepared to be flexible to accommodate new information (e.g., greater clarity in cost and schedule information) as it becomes available.

1.2.2 Technical Integration

The principal objectives of this task are to integrate, guide, and provide technical oversight of the data collection and measurement tasks to ensure they remain focused on addressing the priority data needs essential to justify implementation of burnup credit, to the extent needed, in the transport, aging, and disposal of CSNF. The purpose of several of the subtasks is to establish and document the bases for the data needs and to document how the data are expected to be used in the post-closure criticality safety licensing evaluation. Although this TWP generally assumes that the most reactive conditions/configurations throughout postclosure are intact fuel, this task includes activities to evaluate limiting configurations and specify data needs for integration into the measurement programs. The extent of the data needs (i.e., addressing the question of "how much is enough?") will be determined within this task and integrated into the data collection and measurement tasks. Many of the experimental activities are dependent upon subtasks within this technical integration task. Although some of the subtasks listed in Section 2.1.2 may be considered already either partially or fully completed, it is considered prudent to include them in this plan to ensure the issues are addressed in a complete manner and consistent with the configurations relevant to postclosure criticality safety.

1.2.3 Radiochemical Analysis Measurements

The principal objective of this task is to obtain sufficient measured isotopic composition data from representative U.S. CSNF to enable validation of depletion codes and data used to predict CSNF isotopic compositions in the licensing safety evaluation. This includes advanced approaches (see for example DeHart 2001 and Gauld 2003) that have been shown to provide an accurate, yet bounding, estimate of the effects of nuclide uncertainty by combining the uncertainties in a more realistic manner. The product of this activity will be RCA data to enable validation consistent with the expectations of the NRC staff guidance [ISG-8, Revision 2 (NRC 2002)]. Many of the activities in this primary task are not routinely performed, and hence have uncertainties and risks related to cost, schedule, and measurement outcome. As such, this task includes a number of activities that require detailed planning, decision making, and authorizations.

The scope of the RCA task will be adapted, as appropriate, to capitalize on potential opportunities for cost/schedule sharing with other programs. For example, fuel shipments to Pacific Northwest National Laboratory (PNNL) are planned for the tritium-producing burnable absorber rods, and Crystal River is currently planning to ship fuel to ORNL for post-irradiation evaluation. Activities such as these will be monitored and evaluated for potential synergisms. The main elements and/or strategy for this primary task are:

(1) Identification and prioritization of candidate fuel for RCA measurement

(2) Selection of primary and confirmatory laboratories for performing measurements on new fuel samples

(3) Preparation of relevant quality assurance (QA) plans and procedures

(4) RCA measurements for ~10 samples at PNNL that remain available from the Approved Test Material (ATM) program

(5) Three staggered fuel shipment and handling campaigns (two shipments of PWR fuel and one shipment of BWR fuel; six rods per shipment) to ship fuel from utilities to the primary lab and segment the fuel

(6) Three fuel sample shipments from the primary lab to the confirmatory lab

(7) Three campaigns of RCA measurements at the primary and confirmatory labs to generate new data for 72 samples (three campaigns of six rods with four samples/rod [3×6×4=72]; 48 PWR samples, 24 BWR samples)

(8) Analysis and documentation of measured data.

Because the reactivity of individual BWR assemblies is considerably lower than the reactivity of PWR assemblies with comparable enrichment, the needs for crediting the reactivity reduction due to burnup to demonstrate criticality safety are considerably less for BWR fuel (than for PWR fuel). Consequently, greater emphasis is placed on RCA data for PWR CSNF than BWR CSNF in this plan. The end result of this task will be a set of nearly 100 new RCA measurements for the full set of nuclides listed in Table 1. A more detailed discussion of these activities is provided in Section 2.1.3.

1.2.4 Laboratory Critical Experiments

Historically, benchmark experiments have been performed in the laboratory representing the configuration and materials of interest requiring a safety evaluation—laboratory critical experiments. The principal objective of this task is to obtain sufficient LCE data to enable effective validation of criticality codes and data for U.S. CSNF in relevant transport, aging, and disposal canister configurations. The products of this activity will be LCE data to enable validation of actinide and fission product isotopes, consistent with the expectations of the NRC staff guidance [ISG-8, Revision 2 (NRC 2002)] and applicable consensus standards. These data are needed to support the exclusion of current [*Screening Analysis of Criticality Features, Events, and Processes for License Application* (BSC 2004, Sections 6.8.2, 6.8.6, 6.8.10, and 6.8.14)] and future screening justifications for the in-package criticality features, events, and processes (FEPs). The main elements and/or strategy for this primary task are:

(1) Obtain needed safety basis approvals to conduct the experiments

(2) Prepare relevant QA plans and procedures

(3) Design and plan for a series of experiments that are applicable to the design basis configurations of the CSNF to be disposed of in Yucca Mountain

(4) Re-perform critical experiments (Harms et al. 2004) for ^{103}Rh in order to establish quality objectives for subsequent LCEs

(5) Perform critical experiments for additional fission product nuclides in order of prioritization and material availability (prioritization developed in the technical integration subtask, *Evaluate Cost/Benefit of Data Needs*, in Section 2.1.2)

(6) Analyze and document the measured data.

A more detailed discussion of these activities is provided in Section 2.1.4.

1.2.5 Fission Product Cross-Section Measurements

Current fission product cross-section data are deficient relative to major actinides, which can impact the validation process. This deficiency exists because fission products have been studied and measured much less than the major actinides.

The principal objective of this task is to develop new fission product nuclear cross-section and cross-section uncertainty data, as needed, to supplement the fission product cross-section data libraries. The products of this activity will include: (1) measured nuclear data and evaluated nuclear data files for inclusion in the U.S. Evaluated Nuclear Data File (ENDF) (National Nuclear Data Center 2004) and (2) cross-section and cross-section uncertainty libraries for use with the depletion and criticality codes.

Where new measurements are performed, the technical rigor (physics measurements and evaluations to smoothly fit data over the entire energy range) in the measured and evaluated data will be consistent with that of the current data for the major actinides. The main elements and/or strategy for this primary task are:

(1) Establish QA procedures and requirements

(2) Obtain needed safety basis approvals to conduct the experiments

(3) Design and plan for measurements

(4) Perform measurements for additional fission product nuclides in order of prioritization and material availability

(5) Prepare data evaluations and cross-section libraries.

A more detailed discussion of these activities is provided in Section 2.1.5.

1.2.6 Reactor Operational History Data

The principal objective of this task is to identify appropriate bounding values for reactor operating parameters (e.g., moderator temperature, soluble boron concentration, exposure to burnable poisons, etc.) to be used in fuel depletion calculations performed to support burnup credit. Overly conservative reactor operating parameters lead to unnecessarily restrictive burnup-credit loading curves, and hence reduced CSNF loading acceptance. For example, the use of overly conservative bounding operational parameters could easily offset the benefit (credit) of several of the lower-worth fission products. Extensive reactor operating data for commercial nuclear power plants will be obtained and utilized to maximize the benefits of burnup credit while maintaining adequate subcritical margin. The product of this activity will be an extensive database of representative reactor operating history data that will provide a technical basis for bounding, yet not overly conservative, values that should be used in the safety analysis. A more detailed discussion of these activities is provided in Section 2.1.6.

1.3 RESPONSIBLE ORGANIZATIONS

The Lead Lab Postclosure Criticality team is responsible for the execution and oversight of the work identified in this TWP and the preparation of task-specific planning documents. The work will be performed by Lead Lab personnel at the Summerlin campus, as well as personnel at Sandia National Laboratories (SNL), ORNL, PNNL, and other, yet to be determined, DOE national laboratories. Experimental operations will be managed by the Test Coordination Office (TCO).

1.4 TESTING AND PRETEST PREDICTIONS

Experimental components of the burnup credit data program include RCAs, LCEs, and cross-section measurements. The detailed experimental planning documents for these components will be prepared, subsequent to approval of this document, and include pretest predictions to assist in the design of the experiments and post-test verification of measurements. For the LCEs, these predictions will enable design and optimization of experimental configurations to ensure applicability for intended use, selection of equipment, specification of isotopic concentrations, and contribute to safe operation. For RCAs, pre-test predictions will assist with selection of isotopic measurement approaches/instruments consistent with expected concentrations and type, provide a reference of comparison for the measured results, and contribute to safe operations. For cross-section measurements, pre-test predictions will contribute to selection of equipment and samples, specification of isotopic concentrations, and safe operation.

2. SCIENTIFIC APPROACH OR TECHNICAL METHODS

2.1 WORK ACTIVITIES

This section describes each of the primary tasks discussed in Section 1. Subtasks and associated descriptions are also provided, and these correspond to elements listed in a Gantt chart to illustrate the schedule, approximate task durations, and how the tasks fit together is included as Appendix B. The Gantt chart is subject to change as planning and program implementation proceed, for example to capitalize on unanticipated opportunities, react and overcome unforeseen difficulties, and accommodate new and/or more accurate information (e.g., greater clarity in cost and schedule information) as it becomes available.

2.1.1 Management

Following is a list of the major subtasks within the management primary task.

Develop Project Plan – This TWP is a high-level planning document designed to coordinate the implementation of a complex multi-year, multi-organization program. Numerous organizations provided input to this plan, including technical, cost, and schedule information. However, this information is not sufficiently complete to govern experimental activities. Therefore, subsequent to the approval of this document, task-specific planning documents containing operational details and constraints will be developed to implement the elements of this program. As noted, the Gantt chart in Appendix B presents these elements and represents an initial working schedule; the actual schedule is controlled by the AWP. Budget estimates for each primary task and fiscal year are provided in Appendix C.

Communicate Proposed Project Plan to Customer (DOE) – **Milestone/Deliverable**. This milestone refers to the delivery of this TWP.

Initiate Purchase of French HTC LCE Data – This task involves enabling the purchase of rights to use the French *Haut Taux de Combustion* (HTC; French designation for "high burnup") LCE data (Institut de Radioprotection et de Sûreté Nucléaire 2006a; 2006b; 2006c; 2006d), which has been shown to be highly relevant/applicable for criticality code/data validation for actinides in CSNF (Mueller and Wagner 2005; ORNL 2006a) for repository use. These data should be purchased as soon as reasonably possible to enable its usage in the criticality safety evaluation to support the initial LA.

Since 1988 the French company Cogema has sponsored a series of experiments in order to address burnup credit experimental needs. Under the OLM burnup credit project for transportation, a contract was negotiated between ORNL and Cogema, on behalf of the DOE OCRWM, to purchase the rights to various relevant data sets. To date, DOE has purchased the rights for non-repository use of the set of critical experiments, referred to as the HTC experiments, which were performed at the Valduc facility in France. The experiment data describe 156 critical experiments with fuel pins having uranium and plutonium isotopic compositions that were designed to be similar to PWR fuel that had an initial enrichment of 4.5 wt% ^{235}U and was burned to 37,500 megawatt days per metric ton of uranium (MWd/MTU). Sensitivity/uncertainty (S/U) analyses (Mueller and Wagner 2005; ORNL 2006a) performed at ORNL, using analysis tools developed at ORNL (Broadhead et al. 2004) and incorporated within Version 5 of the SCALE code system (ORNL 2006b) have shown that these experiments are useful for validation of actinide-only burnup credit.

The HTC experiments are reported in four groups and include (1) 18 simple square-pitched arrays with pin pitch varying between 1.3 and 2.3 cm, (2) 41 simple arrays with either natural gadolinium or boron in solution in the moderator and reflector, (3) 26 configurations simulating four fuel assemblies in a storage-rack environment (some of these configurations include borated steel, Boral®, or cadmium panels on the outside of each assembly with the spacing between assemblies varied), and (4) 71 configurations similar to the third group except that thick lead or steel reflectors are placed around the outside of the four assemblies to simulate a cask environment. The experiments have been evaluated and documented in a format consistent with the requirements of the *International Handbook of Evaluated Criticality Safety Benchmark Experiments* (IHECSBE) (NEA 2005), which is the internationally accepted archive for critical experiment benchmark data. As these data were not developed under DOE's *Quality Assurance Requirements and Description* (QARD) (DOE 2006b), these data must be qualified prior to use as direct inputs into the analyses supporting criticality FEPs screening. It is anticipated that the data can be readily qualified via Technical Assessment, as outlined in Lead Lab Procedure SCI-PRO-001, *Qualification of Unqualified Data*.

<u>Complete Purchase of French HTC LCE Data</u> – **Milestone**.

(Note: The purchase of this data was not budgeted in FY07 or FY08 because the decision to purchase was not made prior to the annual work planning process. Therefore, a baseline change proposal (BCP) or other appropriate funding mechanism will be utilized to enable this data purchase.)

<u>If Recommended, Initiate Purchase of French PF LCE Data</u> – This task is dependent upon a positive evaluation outcome in the subtask, *Evaluate French PF LCE Data*, under the technical integration primary task, Section 2.1.2, and involves enabling the purchase of rights to use the French Produits de Fission (PF) (i.e., fission products) LCE data (Institut de Radioprotection et de Sûreté Nucléaire 2005a; 2005b; 2005c; 2005d; 2005e), which is anticipated to be relevant/applicable for criticality code/data validation. Given a positive evaluation outcome, these data should be purchased as soon as reasonably possible to enable its usage in the criticality safety evaluation to support the initial LA. An early decision is also needed to support planning for performance of new LCEs.

The option to purchase the rights to use the PF data is included in the contract between ORNL and Cogema. Unless the contract is revised, this option must be exercised on or before June 30, 2007. ORNL is in possession of the complete data for these experiments and has initiated a complete and thorough evaluation of their relevance and applicability for criticality code/data validation for selected fission products (^{103}Rh, ^{133}Cs, ^{nat}Nd, ^{149}Sm, ^{152}Sm, and ^{155}Gd) in CSNF. As with the HTC experiments, these experiments were performed at the Valduc facility in France. The series includes 147 critical configurations, 74 of which include one or more of the following fission products: ^{103}Rh, ^{133}Cs, ^{nat}Nd, ^{149}Sm, ^{152}Sm, or ^{155}Gd. The availability of critical experiment data for ^{133}Cs within this data set contributes to the interest in evaluating the technical basis for crediting ^{133}Cs, which is not one of the 29 principal isotopes The experiments were divided up into five groups; a summary of each group is provided below for informational purposes. As with the HTC experiments, the PF experiments have been evaluated and documented in a format consistent with the requirements of the IHECSBE (NEA 2005), which is the internationally accepted archive for critical experiment benchmark data. Furthermore, selected critical experiments from this series involving ^{149}Sm have been submitted and accepted for inclusion in the IHECSBE (designated LEU-COMP-THERM-050). Hence, although these data were not developed under the QARD (DOE 2006b), they are anticipated to be readily qualified under Lead Lab Procedure SCI-PRO-001.

Group 1 of the French fission product experiments includes 47 configurations that are similar to the ^{149}Sm critical experiment evaluation LEU-COMP-THERM-050 in the IHECSBE (NEA 2005). These experiments involve a solution tank sitting in the middle of a water-moderated and reflected array of low-enrichment UO_2 rods. Thirty-two of these configurations include one or more of the following fission products: ^{103}Rh, ^{133}Cs, ^{nat}Nd, ^{149}Sm, ^{152}Sm, and ^{155}Gd. These experiments did not include any plutonium.

Group 2a includes 68 configurations that involve an 11×11 array of rods (54 configurations with UO_2 and 14 configurations with the HTC mixed oxide (MOX) rods) inside a tank that is surrounded by water-moderated and reflected UO_2 rods. The rods in the central tank are moderated by either water or fission product solution. The MOX rods are from the HTC experiment program and were fabricated to have uranium and plutonium compositions that are similar to what $U(4.5\%)O_2$ would have after accumulating a burnup of 37.5 gigawatt days (GWd)/MTU. Twenty-eight of the UO_2 configurations included fission products, and seven of the MOX rod configurations included fission products. While seven of the 68 configurations contain both fission products and MOX fuel pins, the reactivity of the array is driven primarily by the UO_2 fuel rods that surround the MOX rods.

Group 2b includes 18 configurations that involve an 11×11 array of rods (ten configurations with UO_2 and eight configurations with HTC MOX rods) inside a tank that is surrounded by water-moderated and reflected UO_2 rods. Three of the MOX rod configurations include fission products. While three of the 18 configurations contain both fission products and MOX fuel pins, the reactivity of the array is driven primarily by the UO_2 fuel rods that surround the MOX rods.

Group 3a includes seven configurations that involve arrays (up to 26×26) of UO_2 rods in a large tank filled with depleted uranyl nitrate. These configurations contain no fission products.

Group 3b includes seven configurations that involve arrays (up to 44×44) of HTC MOX rods in a large tank filled with depleted uranyl nitrate. Four of the configurations include fission products.

Complete Purchase of PF Data – **Milestone**. It should be noted that, unless the contract between Cogema and ORNL is revised, this option **must be exercised on or before June 30, 2007**.

(Note: The purchase of this data was not budgeted in FY07 or FY08 because the decision to purchase was not made prior to the annual work planning process. Therefore, a BCP or other appropriate funding mechanism will be utilized to enable this data purchase.)

Purchase RCA Data from International MALIBU Program – This task involves enabling the purchase of rights to use the RCA data from the MALIBU program (Marloye 2002), which is an international collaboration led by Belgonucleaire. The following data for UO_2 fuels are available from this program: two PWR 15x15 samples (Gosgen reactor), 4.3 wt %, 47 GWd/MTU and 68 GWd/MTU; 1 PWR 17x17 sample (Ringhals reactor); 3.7 wt%, 68 GWd/MTU; three BWR SVEA 96 (10x10) samples (Leibstadt reactor); 4.46 wt%, ~50-70 GWd/MTU. The data for these fuels will be purchased as soon as reasonably possible to enable their use in the criticality safety evaluation to support the initial LA. Since these data were not developed under the QARD (DOE 2006b), these data must be qualified prior to use as direct inputs into the analyses supporting criticality FEPs screening. Given the numerous international participants and associated experience gained from previous similar programs (e.g., the ARIANE (ORNL 2003; Murphy and Primm 2002) and REBUS (D'hondt et al. 2005; Lance et al. 2005) programs), it is anticipated that the data can be readily qualified via technical assessment, as outlined in Lead Lab Procedure SCI-PRO-001.

(Note: The purchase of this data was not budgeted in FY07 or FY08 because the decision to purchase was not made prior to the annual work planning process. Therefore, a BCP or other appropriate funding mechanism will be utilized to enable this data purchase.)

Finalize Site Selections to Perform RCAs – **Milestone**. Site selection recommendations are developed in the subtask, *Select Laboratories for Performing RCAs*, of the RCA measurements primary task.

Development of Detailed Task-Specific Plans – The purpose of this task is to manage and coordinate the development of detailed, task-specific planning documents, as needed. Activities for which detailed planning documents are needed include, but are not limited to, the following: performance of LCEs, shipment and handling of CSNF, performance of RCAs, and the performance of the cross-section measurements.

RCA Authorizations – This task consists of the initial set up, operational readiness checks, and Lead Lab authorizations for laboratories performing the RCA measurements.

LCE Authorizations – This task consists of the initial set up, operational readiness checks, and Lead Lab authorizations for SNL, the laboratory performing the critical experiments.

Cross-Section Authorizations – This task consists of the initial set up, operational readiness checks, and Lead Lab authorizations for performing the cross-section measurements.

Management Oversight – This task covers the management oversight needed to ensure the project achieves its stated goal of developing and/or obtaining the technical data needed to justify full burnup credit in criticality safety licensing analyses involving CSNF. The task addresses issues such as management of the project cost, schedule, subcontracts, accountability of suppliers and subcontractors, authorization and execution of major TWP purchases and decisions, and plan revision as opportunities and/or obstacles arrive.

2.1.2 Technical Integration

The following is a list of the major subtasks within the technical integration primary task. The technical approaches and governing procedures for calculations performed within the subtasks will be established, as appropriate, in task-specific planning documents to be developed for this element of the experimental program.

Define Specifics of BUC Methodology Implementation – This task will summarize the BUC methodology implementation to facilitate understanding among the TWP participants. Details on planned data usage and methodology assumptions will be documented in a manner consistent with appropriate procedures (e.g., LS-PRO-001, *Technical Reports*), and data usage will drive the data collection planning.

Develop Data Requirements/Needs for Implementing BUC Methodology – Consistent with the previous subtask, this task involves preparing a document to summarize the burnup credit data requirements and needs for implementing the burnup credit methodology and will serve to facilitate understanding among TWP participants, as well as help to evaluate data collection activities. Although the need for crediting the 29 principal isotopes and ^{133}Cs will be evaluated in a subsequent subtask, all tasks in this TWP assume data are needed to support credit for the 29 principal isotopes.

Determine RCA Measurement Requirements/Needs & Specifications – This task coordinates the efforts of the following subtasks to define the RCA measurement requirements, needs and specifications for both PWR and BWR CSNF:

- Assess Existing RCA Measurement Data from Other Programs – This task will assess and consolidate the relevant existing RCA measurement data to establish a baseline of currently available RCA data, and hence assist in defining the RCA data needs. This task should take advantage of previous, similar efforts performed for DOE and NRC and provide recommendations with regard to the use of the various currently available data, and where appropriate, needs and prospects for data qualification. Efforts have already been made on this under the DOE OLM burnup credit project.

- Identify Number/Characteristics of CSNF Samples to be Measured – This task will utilize the information developed in the previous task and consideration of the validation goals to define the desired number (e.g., 48 PWR and 24 BWR) and characteristics (e.g., burnup, initial enrichment, assembly design, and operational conditions, such as burnable poison rod, control rod, and axial power rod exposure) of the CSNF samples to be measured.

- Identify Nuclides for Measurement and Target Accuracies – Although the nuclides and target accuracies have already been preliminarily determined (see Table 2) and used to solicit information for the RCA primary task, this task is included to ensure this information is captured here and to enable an opportunity for review and modification. This task is important to ensure important nuclides that do not have direct relevance to burnup credit, but are important for other uses (e.g., burnup indicators or important precursors), are not neglected. With a few exceptions, the impact on cost and schedule of measurement of additional nuclides with relevance to burnup indication and/or broader repository interests (e.g., source term and decay heat) are marginal compared to the other associated costs (e.g., laboratory setup, fuel shipment, receipt, handling, segmentation, and disposal). The preliminary target experimental accuracies for the program in percent relative standard deviation are:

    - Major U + Pu isotopes < 2%
    - Minor U and Pu < 5%
    - Am and Cm isotopes < 5-10%
    - Burnup indicators < 3%
    - Metallic fission products (may require residue analysis) 10%
    - Others < 5%

Table 2. Requested Isotopes for RCA Measurement

Element (Z)	Isotope (A)				
92-U	234	235	236	238	
94-Pu	238	239	240	241	242
93-Np	237				
95-Am	241	242m	243		
96-Cm	242	243	244	245	246
38-Sr/39-Y	90				
55-Cs	133	134	135	137*	
57-La	139*				
58-Ce	144				
60-Nd	143	145	148*		
61-Pm	147				
62-Sm	147	149	150	151	152
63-Eu	151	153	154	155**	
64-Gd	155				
44-Ru	101	106			
45-Rh	103				
42-Mo	95				
43-Tc	99				
47-Ag	109				
51-Sb	125				

NOTE: Shaded nuclides indicate metallic fission products.

* Burnup indicators in fuel.

** Precursor to important nuclide.

- Specifications – **Milestone:** Prepare report consistent with appropriate procedures, e.g., LS-PRO-001, *Technical Reports*; predecessor for several RCA measurement-related tasks.

Determine LCE Measurement Requirements/Needs & Specifications – This task coordinates the efforts of the following subtasks to define the LCE measurement requirements, needs and specifications for both PWR and BWR CSNF:

- Assess Existing LCE Data From Other Programs – This task will serve to assess and consolidate the relevant existing critical experiment data to establish a baseline of currently available LCE data, and hence assist in defining the LCE data needs. This task should take advantage of previous, similar efforts performed for DOE and NRC and provide recommendations with regard to the use of the various currently available data, and where appropriate, needs and prospects for data qualification. Efforts have already been done on this under the DOE OLM burnup credit project.

- Evaluate French PF LCE Data – This task involves a thorough evaluation of the French fission product data (PF experiments) and the formulation of a recommendation as to whether or not DOE should purchase these data to support the repository LA. The evaluation will include an assessment of the applicability of these data to code/data validation of fission products in criticality safety licensing analyses involving CSNF, an estimation of the bias and bias uncertainty associated with each fission product based on these data, and considerations of aspects related to data qualification.

- Provide Recommendation on Purchasing French PF Data – **Milestone**.

  (Note: The purchase of this data was not budgeted in FY07 or FY08 because the decision to purchase was not made prior to the annual work planning process.)

- Qualify HTC Data – This task involves developing and executing the strategy for QA qualification of the French HTC LCE data if the rights to use the data for disposal applications are purchased. This purchase was not budgeted in the FY07 or FY08 AWPs prepared by the Lead Laboratory for DOE. The data are anticipated to be readily qualified via Technical Assessment, as outlined in Lead Lab Procedure SCI-PRO-001.

- If Recommended, Qualify PF Data – This task involves developing and executing the strategy for QA qualification of the French PF LCE data. The data are anticipated to be readily qualified via Technical Assessment, as outlined in Lead Lab Procedure SCI-PRO-001. This task is dependent upon a favorable purchase recommendation.

- Identify Number/Characteristics of LCEs to be Performed at SNL – This task will utilize the information developed in the previous subtasks and consideration of the validation goals (e.g., number of nuclides) to define the desired number and characteristics of the LCEs to perform under this program. Given SNL's recent experience performing critical experiments with the fission product ^{103}Rh, they have been selected as the location to perform the additional LCEs needed for this burnup credit program.

- Prepare Document Establishing LCE Requirements/Needs & Specifications – **Milestone:** Prepare report consistent with appropriate procedures, e.g., LS-PRO-001, *Technical Reports*; predecessor for several LCE measurement-related tasks.

Determine Cross-Section Measurement Requirements/Needs & Priorities – This task will evaluate the need, justification, and, as appropriate, the prioritization, specification, and requirements for performing new nuclear data measurements. The technical rigor utilized in current fission product cross-section data are deficient relative to that of the major actinides and can impact the uncertainty and credibility of the validation process. Hence, under the DOE OLM burnup credit program, ORNL has been working with the Institute for Reference Materials and Measurement (IRMM) to assess the quality of cross-section data for the key fission product nuclides relevant to that program and performing new cross-section measurements. This work activity, which was being conducted under a DOE-Euratom agreement, will be continued under this project.

- Assess Existing Nuclear Cross-Section Data for Fission Products – This task will continue and extend (to consider the 29 Principal Isotopes) the efforts initiated under the DOE OLM burnup credit project in which available cross section and cross section uncertainty data (via national and international resources) for key fission product nuclides relevant to that program were assessed (Leal et al. n.d.) to identify deficiencies relative to burnup credit. The previous assessment focused on seven primary fission product isotopes (^{103}Rh, ^{133}Cs, ^{143}Nd, ^{149}Sm, ^{151}Sm, ^{152}Sm, and ^{155}Gd) that impact reactivity analyses of transportation packages and two fission product isotopes (^{153}Eu and ^{155}Eu) that impact prediction of ^{155}Gd concentrations. The accuracy of the data will be investigated by using differential and integral data. Measured differential data will be retrieved from the experimental data in the EXFOR (EXchange FORmat) measurements database (National Nuclear Data Center 2005) [EXFOR is the exchange format system designed to allow the sharing of nuclear data among users throughout the world. The EXFOR library contains an extensive compilation of experimental nuclear reaction data. The data bank system is maintained by the National Nuclear Data Center of Brookhaven National Laboratory.] and compared with continuous-energy cross sections obtained from the evaluated nuclear data libraries processed with the NJOY and AMPX code systems (MacFarlane and Muir 2000; Dunn and Greene 2002). To verify the adequacy of the evaluated data in integral benchmark calculations, MCNP and SCALE will be used to investigate the performance of the fission product data in benchmark calculations. Integral benchmark experiments and reactivity worth measurements carried out at the French Atomic Energy Commission at Cadarache will be used, where available. The resonance parameters for a number of the important fission products in the existing cross-section libraries are basically the parameters listed in the Mughabghab compilation (Mughabghab 1984) with minor modifications.

- Prepare a Document Establishing Measurement Requirements/Needs and Priorities – **Milestone:** Prepare report consistent with appropriate procedures, e.g., LS-PRO-001, *Technical Reports*; predecessor for cross-section measurement-related tasks.

<u>Determine Reactor Operating History Data Requirements/Needs & Specifications</u> – This task involves assessing the available operational history data and identifying data needs. The NRC staff guidance on burnup credit for transport [ISG-8, Revision 2 (NRC 2002)] states that calculated spent nuclear fuel (SNF) isotopic compositions "*should be calculated using fuel design and in-reactor operating parameter values that appropriately encompass the range of design and operating conditions for the proposed contents*." Consequently, reactor analysis used to predict the SNF composition for a burnup credit safety evaluation assumes operating history parameters that can be justified as bounding in terms of the impact on the k_{eff} value. Insufficient and/or incomplete operating history data complicate the selection and justification of bounding parameters, often leading to the use of overly conservative parameters. However, the selection and use of overly conservative parameters can have a significant impact on the calculated k_{eff} value (DeHart 1996; DOE 1998) of SNF, and subsequently on loading curves (Wagner and Sanders 2003) and SNF assembly loading acceptance. In an effort to provide a basis for statistically meaningful and realistic bounding values, ORNL and other organizations have

initiated efforts to gather operational parameter data into a usable database. Soluble boron concentrations, maximum fuel temperature, and minimum moderator densities were the initial parameters investigated (Williams and Mueller 2006). Investigation of the range of data values obtained and the mean standard deviations will provide a technical basis for bounding assumption values that should be used in the safety analysis. Given a sufficiently large data base, it is anticipated that there should be a reduction in the conservatism associated with values recommended in earlier reports (Parks et al. 2002). The reduction should allow a larger fraction of SNF assemblies to be considered as acceptable for loading.

- Assess Existing Operational History Data Needs – This task involves assessing the available operational history data and identifying justified data needs with the goal of developing a technical basis for bounding values that should be used in the safety analysis.

- Prepare a Document Establishing Data Requirements/Needs – **Milestone:** Prepare report consistent with appropriate procedures, e.g., LS-PRO-001, *Technical Reports*; predecessor for operating history data collection-related tasks.

Evaluate Cost/Benefit of Data Needs – This task involves a number of activities and studies that will be used to define the ultimate scope of the experimental tasks. Although the experimental tasks are planned in this initial TWP to enable credit for the 29 principal isotopes, preliminary analyses indicate that reducing the number of fission product nuclides will not significantly impact the percentage of the CSNF inventory that would be qualified for acceptance in a burnup credit canister. The activities in this task are intended to enable informed decision-making based on comparison of estimated project costs and benefits (cost savings) associated with obtaining additional measured data. Project costs are costs due to acquiring data, while cost savings are associated with increasing the percentage of the CSNF inventory that would be qualified for acceptance. Given the generally accepted need for credit for the high-worth fission product nuclides (e.g., ^{103}Rh, ^{133}Cs[*], ^{143}Nd, ^{149}Sm, ^{151}Sm/^{151}Eu, ^{152}Sm, and ^{155}Gd), the experimental programs may be initiated prior to the completion of this task; the anticipated outcome of this task is that efforts, such as performance of LCEs and cross-section measurements, to credit a number of the low-worth fission product nuclides may be given a lower priority or even abandoned (e.g., ^{101}Ru, ^{109}Ag, ^{150}Sm, ^{95}Mo). Illustrative results for sensitivity as a function of cooling time for PWR SNF in a representative TAD canister are provided below for actinide (Figure 1) and fission product (Figure 2) isotopes. The sensitivity is defined as the ratio of the change in k_{eff} due to some change in a nuclear data parameter of interest (e.g., total macroscopic cross section) over the change in the nuclear data parameter of interest. The total sensitivity shown in Figures 1 and 2 represents the change in k_{eff} due to the change in the total macroscopic cross section, i.e., the presence of the nuclide.

- Perform Isotope Reactivity Ranking – This task involves S/U analyses to rank the relevant actinide and fission product isotopes for relevant repository conditions and contents of interest for criticality safety. The ranking analysis will consider previous relevant works (e.g., Broadhead et al. 1995) and evaluate relevant parameter variations,

[*] The previous screening out of credit for this high-worth fission product nuclide is to be reevaluated as part of the work scope in this TWP.

including cooling time, assembly characteristics, and waste form. Results similar to those shown below in Figure 1 and Figure 2 will be developed.

- Perform Code Validation with Available/Existing Data – This task will essentially utilize available/existing data to perform baseline validation consistent with the regulatory guidance to support the development of baseline loading curves and enable improved understanding of the needs and benefits of additional validation data.

  - Perform Sensitivity/Uncertainty Analyses with LCE Data – This task will employ the S/U analysis tools in the SCALE code system to identify applicable critical experiment data for use in criticality code/data validation. This task will build on previous efforts under the DOE OLM burnup credit program and consolidate efforts in subtasks in this plan related to the evaluation of the French LCE data. The outcome will be a recommended set of LCE data for use in validation.

  - Calculate Bias and Bias Uncertainty Based on Recommended LCE Data – Utilizing the recommended LCE data from the previous subtask, criticality code/data bias and bias uncertainty will be determined. In support of other projects, ORNL staff have been exploring and evaluating approaches whereby a bias and bias uncertainty may be calculated for each fission product individually using fission product critical experiments. This effort is largely due to the fact that most of the French PF critical experiments (and any new LCEs that are done without plutonium present) do not include any (or significant concentrations of) plutonium and, thus, necessitate alternative approaches to bias determination.[**] Under this task, the approaches under consideration will be applied and evaluated for usage in repository licensing.

[**] Ideally, the bias and bias uncertainty applicable to a burnup credit cask model would be calculated using critical experiments that were similar to the burnup credit cask model, including having similar actinide and fission product compositions. Then the total bias and bias uncertainty calculated from these experiments would include bias and bias uncertainties for all relevant isotopes. This is referred to herein as the "conventional" approach to bias determination. Currently, however, there are only a few critical experiments that include the relevant fission products at levels providing negative reactivity worth similar to that provided by the fission products in CSNF. Unfortunately, the critical experiments containing fission products all suffer from one or more defects (e.g., not including significant plutonium compositions) that reduce their usefulness in a conventional bias determination. Consequently, alternative approaches involving determination of separate biases and uncertainties associated with fission products must be considered and developed.

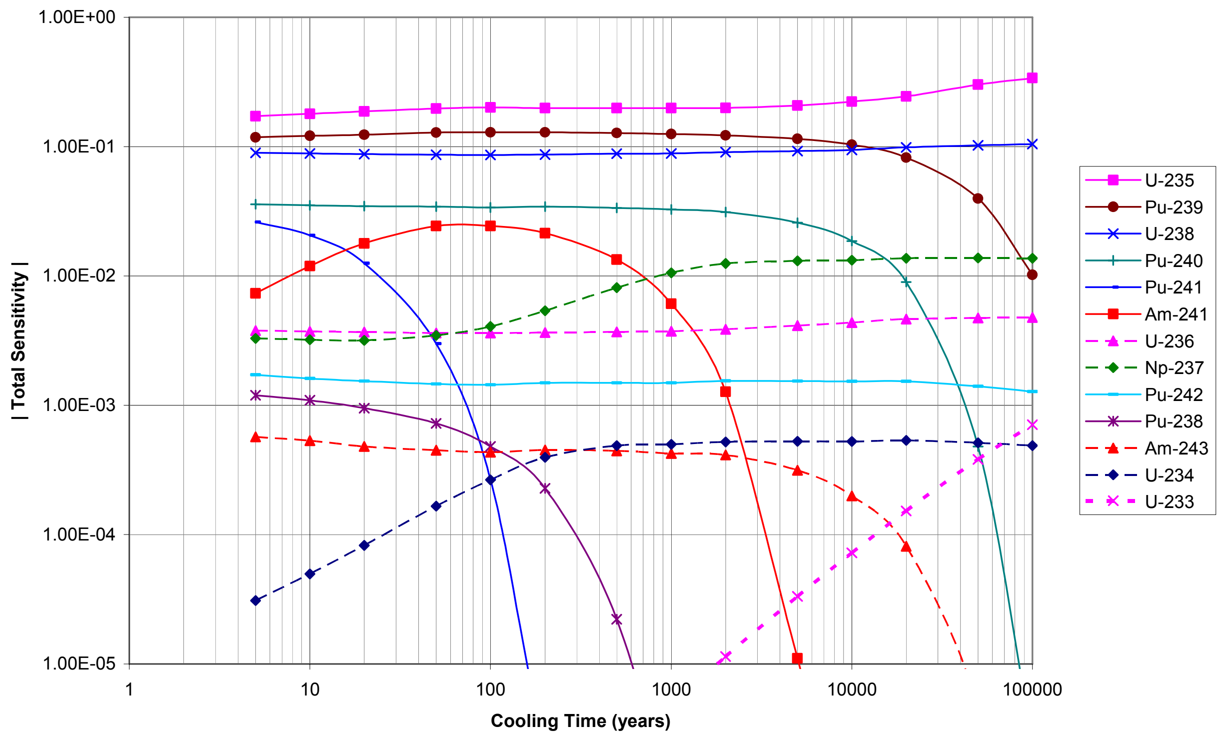


Figure 1. Total Sensitivity of Individual Actinide Isotopes as a Function of Cooling Time for PWR SNF in a Representative TAD Canister

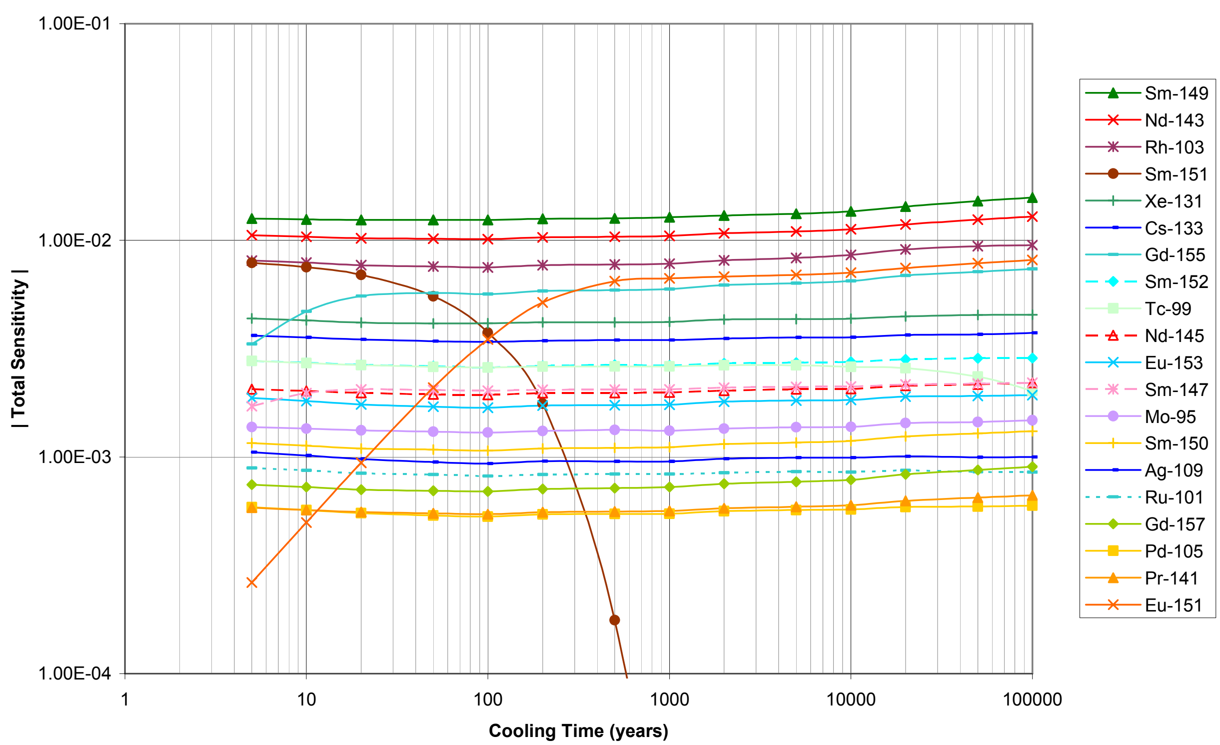


Figure 2. Total Sensitivity of Individual Fission Product Isotopes as a Function of Cooling Time for PWR SNF in a Representative TAD Canister

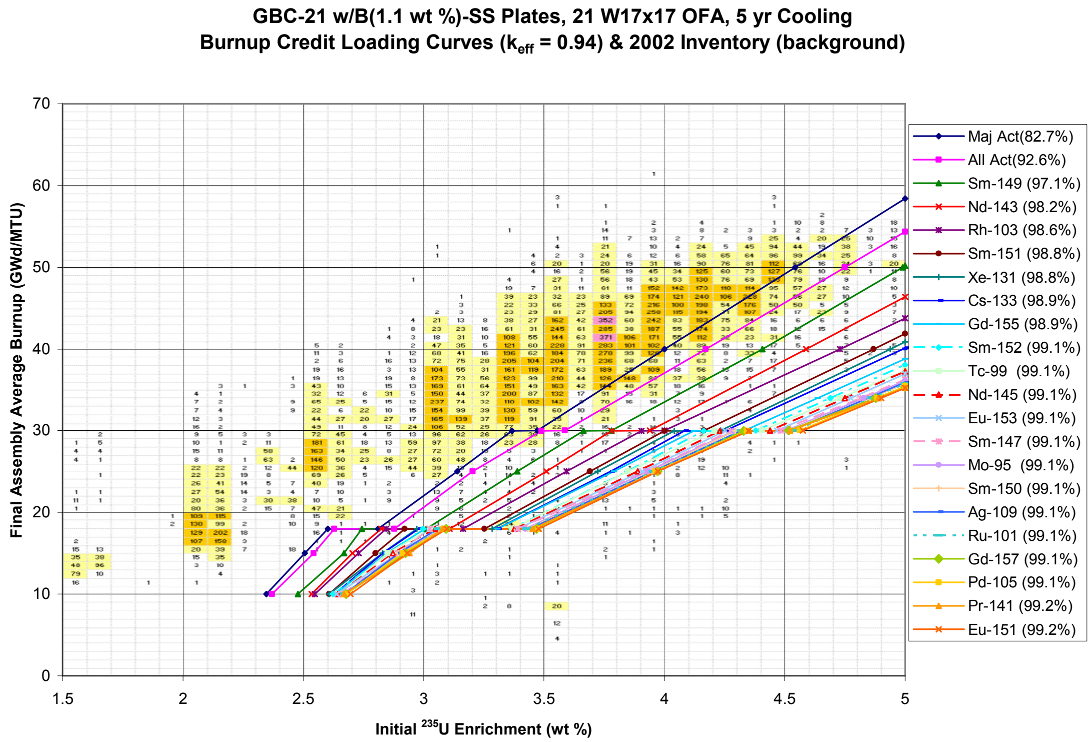
- Calculate C/E Ratios Based on RCA Data – This task will involve calculating the isotopic compositions for comparison to available/existing RCA data, including data from proprietary programs that are available to DOE/ORNL, and subsequently determining the calculated-to-experimental (C/E) ratios. The calculated compositions and C/E ratios are needed for the application of validation approaches in the following subtask. The outcome will also include a recommended set of RCA data to be used for validation purposes. Under this task, the two-dimensional depletion calculational sequence (NEWT/TRITON) in SCALE will be utilized for these calculations.

- Calculate Bias and Bias Uncertainty Based on RCA Data – Utilizing the recommended RCA data from the previous subtask, depletion code/data bias and bias uncertainty will be determined. ORNL and other organizations have evaluated varying approaches for depletion code/data validation based on RCA data. Under this task, these approaches, which are briefly described below, will be applied and evaluated for usage in repository licensing.

  For independent validation of depletion methods and data, calculated isotopic predictions have traditionally been compared to RCA data to determine biases and uncertainties for each isotope considered in the safety evaluation. The calculational bias is defined as the average measured-to-calculated ratio for a number of comparisons for a given isotope. The uncertainty in the bias is the product of the standard deviation of the bias and a tolerance factor corresponding to a desired confidence level. The uncertainty is typically accounted for at a 95% confidence level and reflects the variance of the predicted bias and the number of assay measurements available. For isotopes with relatively few measurements, such as the relevant fission products, the uncertainty can be large. An important consideration is how to properly combine the uncertainties of the individual isotopes. The most conservative approach is to adjust the calculated isotopic concentration of every isotope to its statistical limit in such a way as to always create a more reactive system; concentrations of fissile isotopes are always increased, while the concentrations of absorbing isotopes are always decreased. Each isotopic concentration is multiplied by an isotopic correction factor to adjust for the average bias in the depletion calculation and the uncertainty in the bias. If the concentration of each isotope included in the criticality calculation is adjusted to its statistical limit to account for the nuclide uncertainty, this bounding approach ensures that the predicted reactivity margin due to the uncertainties in the calculated isotopic inventories will be bounding. This approach is conservative but unrealistic, since the nuclear physics governing isotopic generation will not result in concentrations that are predominantly biased to be the most reactive possible.

  More recently developed best-estimate methods (see, for example, DeHart 2001 and Gauld 2003) have been shown to provide a more accurate, yet bounding, estimate of the effects of nuclide uncertainty by combining the uncertainties in a more realistic manner. These approaches evaluate the aggregate effect of isotopic uncertainties on k_{eff} rather than the separate effects from individual isotopes, and as a result, the approach credits compensating uncertainties in the calculated isotopic concentrations. The net uncertainty is derived directly from experimental radiochemical assay data, providing a realistic and meaningful measure of the effects of such uncertainties. With these approaches, calculated isotopic concentrations are adjusted for the average bias in the depletion calculation, while the aggregate effect of isotopic uncertainties is accounted for by reduction in the upper subcritical limit. However, these approaches necessitate numerous RCA data sets that include all relevant isotopes to enable the aggregation of the uncertainties. Hence, while these approaches may be readily applied for the principal actinides, since numerous RCA data sets are available that include the principal actinides, the currently available RCA data do not enable such an approach for the fission product isotopes. Hence, until additional RCA data are developed some combination of these best-estimate approaches for the primary actinides and isotope correction factors for the fission products must be used, thus significantly decreasing the benefits of burnup credit.

- Assess Reactivity Margins and Loading Curves – This task involves activities to support an efficient and thorough evaluation of the relevant burnup credit methodology inputs and assumptions in terms of the ultimate product of the burnup credit criticality safety evaluation (i.e., loading curves).
  - Develop Computational Sequence to Automate Loading Curve/Impact Studies – Under this task, the SCALE sequence for automated loading curve generation will be updated and expanded to utilize the MCNP Monte Carlo code (in addition to the SCALE KENO Monte Carlo code that it currently uses). The expansion to include MCNP is useful because the post-closure criticality analysis methodology is based on the MCNP code.
  - Determine Baseline Loading Curves – This task will build on the activities in the above subtask (Perform Code Validation with Available/Existing Data) to develop baseline loading curves for comparison purposes.
  - Evaluate Impact of Including Individual Fission Products and Minor Actinides – This task will evaluate/estimate the potential benefits to be gained (i.e., increase in percentage of SNF that is acceptable for loading) via the inclusion of individual fission products and minor actinides for which data are not currently available and/or sufficient for validation. Results such as those illustrated in Figure 3 will be generated for relevant configurations.



NOTE: Each curve represents credit for the nuclide(s) indicated in the legend, in addition to credit for all nuclides listed above it within the legend. These curves are for illustrative purposes only; attention should focus on comparison of the individual loading curves, as opposed to where the actual loading curves lie relative to the discharged fuel data.

Figure 3. Illustrative Loading Curves for Westinghouse 17×17 Fuel Loaded in a Representative 21-PWR Assembly Canister Overlaid on the Westinghouse 17×17 Discharge Data from the RW-859 Database (DOE 2004)

- Evaluate Impact of Other Relevant Calculational Inputs – This task will evaluate/estimate the potential benefits to be gained (i.e., increase in percentage of SNF that is acceptable for loading) via improvements in other calculational inputs (e.g., improved estimates of bounding reactor operating history parameters). Studies similar to those conducted for a high-capacity transportation cask (Wagner and Sanders 2003) will be performed for the TAD canister.

- Evaluate Benefits of Performing Cross-Section Measurements on Selected Fission Products – This task will evaluate the impact of fission product cross section uncertainties on loading curves and evaluate/estimate the potential benefits to be gained via improvements. The product of this task will be an improved understanding of the influence of cross section uncertainties on loading curves.

- Perform Cost/Benefit Analysis of Including Individual Fission Products and Minor Actinides – Utilizing loading curves generated in the above tasks, projected discharge data from the RW-859 database (DOE 2004), estimated costs for data measurement activities, and estimated costs for handling SNF that cannot be accommodated in TADs without other means (e.g., reduced capacity and/or rod inserts), the cost benefits of including the individual fission products will be evaluated.

- Document Supporting Studies, Findings, and Recommendations – **Milestone:** Prepare document consistent with appropriate procedures, e.g., LS-PRO-001, *Technical Reports*.

Technical Oversight – Monitor Data Programs and Adjust Course, As Needed – This task is included to ensure appropriate integration, guidance, and technical oversight are applied to the data collection and measurement tasks such that they remain focused on addressing the priority data needs essential to justify implementation of burnup credit, to the extent needed, in the transport, aging, and disposal of CSNF. A primary objective is to manage the risks associated with misalignment of data collection needs and actions, and applicability of the results. A secondary objective is to maintain awareness and, as appropriate, engage other programs that may provide benefits to this project.

- Oversee Technical Work Progress – Evaluate progress of all tasks on a monthly basis.

- Determine Deficiencies/Recommend Changes – Identify technical and/or programmatic deficiencies and work with respective parties to correct.

- Monitor and Evaluate Other Domestic/International Programs for Potential Benefit – Maintain awareness and engage, as appropriate, with other domestic and/or international programs (e.g., MALIBU), organizations such as the International Atomic Energy Agency, Japan Atomic Energy Agency, and Cogema, and activities (e.g., the Organization for Economic Cooperation and Development/Nuclear Energy Agency Working Party on Nuclear Criticality Safety), where opportunities that benefit this program are identified.

- Ensure Consistency Between Data Collection & BUC Methodology – Facilitate communication and coordination between experimentalists and computational analysts to manage risks associated with experiments.

2.1.3 Radiochemical Analysis Measurements

The main elements comprising this primary task are: identification and prioritization of candidate fuel for RCA measurement, selection of primary and confirmatory laboratories for performing measurements, transportation of CSNF rods and samples to laboratories, and measurements on CSNF samples, as discussed in Section 1.2.3. Three staggered campaigns of full-length rod shipments and RCA measurements are planned to generate new data for 72 samples (three campaigns of six rods with four samples/rod [3×6×4=72]; 48 PWR samples, 24 BWR samples). Additionally, RCA measurements are planned for ~10 ATM samples at PNNL. The end result will be a set of nearly 100 new RCA measurements for the full set of nuclides listed in Table 1.

The following is a list of the major subtasks within this primary task. The technical approaches and governing procedures for these activities will be established, as appropriate, in task-specific planning documents to be developed for this element of the experimental program.

Identify and Prioritize Candidate Fuel for Measurement – This task will review options for obtaining fuel for measurement with the goal of balancing cost and schedule objectives, while ensuring selected fuel is consistent with the project needs (as determined in the technical integration subtask *Determine RCA Measurement Requirements/Needs & Specifications)*. This task will take advantage of existing fuel samples, where possible, to reduce costs associated with handling and transportation. The following activities are planned:

- Perform an Assessment of Available Fuel Samples – This activity will evaluate samples that are currently on site or are scheduled for post-irradiation examinations as part of another program for suitability to the YMP program.

- Prepare Prioritized List of Recommended Fuel Samples for Measurement – This task considers utility SNF inventory, readiness, and willingness to participate. In addition, this task also involves assessing that detailed assembly-specific design/operating history information is available and that the selected assemblies experienced normal operations.

- Recommendations for Review – Provide a report of the recommendations.

- Review/Acceptance of Recommendations on Fuel Samples for Measurements – **Milestone.**

Select Laboratories for Performing RCAs – This task is to evaluate the radiochemical assay capabilities of the different national laboratories for assaying new fuel samples. Due to the complexity and difficulty in performing assay measurements for some isotopes, multiple laboratories will be utilized for the purposes of performing independent cross-check measurements on duplicate fuel samples to verify the accuracy and reliability of the reported data. Factors that will be considered include but are not limited to past experience, hot-cell capabilities, isotope separation processes in place for principal isotopes, standing on the Qualified Suppliers List (QSL), and effort required to be approved for this activity. The following actions are planned for the selection process:

- Site visits to assess facilities & capabilities [e.g., PNNL, Idaho National Laboratory, ORNL, and the Argonne National Laboratory]

- Review and evaluation of site capabilities and readiness.

- Recommendation for review – Provide a report including the decision criteria for review

- Review/acceptance of sites for RCA – **Milestone.**

Funding Available to Start Measurements – **Milestone.** This task involves the placement of contracts between Lead Lab and the selected facilities to perform the RCAs, and the allocation of required funds.

Perform Measurements at PNNL with ATM Samples – PNNL currently has ATM samples in a hot cell that are ready for assay (Arm et al. 2006). This task provides for the possibility of performing measurements with these samples, but is contingent on a thorough assessment of the issues, including capabilities to measure all nuclides of interest, experience performing the measurements, availability of ATM material and facilities, and material disposition. An initial campaign of five ATM samples will be assayed and evaluated; pending acceptance of the results of this first campaign (based on comparisons with pre- and post-test predictions to ensure uncertainties are within predetermined criteria), a second campaign of five ATM samples will follow. The work activities for this task involve the following:

- Measurement Planning – PNNL will provide a detailed test plan to Lead Lab which must be approved prior to any work beginning. The test plan requirements will be provided by Lead Lab but at a minimum will require (1) a listing of PNNL approved procedures for each isotope being measured, (2) plans for establishing PNNL's status on the QSL for this work, (3) the working solution, preparation, dissolution, and storage technique(s), (4) procurement/testing/installation requirements, (5) a detailed schedule, and (6) cost estimates.

- QSL Requirements – PNNL's QA program description must be evaluated/modified for RCA services to be added to the QSL.

- Document Measured Data – Data analysis and documentation will be performed in accordance with appropriate procedures.

Plan for Fuel Rod Transfers from Utilities to Primary Laboratory – This task involves the arrangement and coordination of the activities necessary for transporting full-length spent fuel rods from a commercial nuclear power plant to the primary laboratory for RCA where they will be destructively assayed for isotopic composition. Replicate fuel segments will be cut at the primary laboratory and repackaged for transportation to a secondary laboratory where cross check measurements will be performed. This activity will be accomplished through the development of a detailed planning report that includes the following: arrangements for spent fuel transfer cask rental, coordination with utility(ies) for fuel bundle disassembly, transfer and receipt of spent fuel rods, identification of applicable NRC requirements, emplacement of state agreements, as necessary, and arrangements for material disposition. The detailed activity plan must include cost and schedule, and be approved by Lead Lab. A separate plan is required for each shipping campaign.

QSL Requirements for Primary and Secondary Laboratories – This activity will be implemented for laboratories selected to perform RCA. The initial objective is to have a minimum of two separate laboratories listed on the QSL for performing RCA. This activity will be accomplished by the selected laboratories working with the Lead Lab QA department to ensure that the appropriate QARD (DOE 2006b) elements are available in or added to the laboratory QA program so that RCA items/services are qualified.

Plan for Fuel Rod Segment Transfers to Confirmatory Laboratory – This task involves the arrangement and coordination of the activities necessary for transporting spent fuel rod segments from the primary lab to the second lab for confirmatory analyses. The primary lab will have the responsibility for this activity and will be required to develop a detailed planning document that includes the following: arrangements for spent fuel transfer/shipping cask rental if needed, identification of applicable NRC requirements, coordination between the laboratories for transfer and receipt of spent fuel rod samples, emplacement of state agreements, as necessary, and arrangements for material disposition. The detailed activity plan must include cost and schedule, and be approved by Lead Lab.

The following activities will be performed for each set of the spent fuel sample sets. The plan is to have three separate, staggered shipping campaigns. Each campaign will involve shipments of full-length fuel rods from the utility to the primary laboratory, and shipments of smaller fuel segments cut from the rods at the primary laboratory to the secondary laboratories for the purposes of cross check analyses. Two campaigns for PWR CSNF (to obtain fuel from the most prevalent 15×15 and 17×17 lattice designs) and one campaign involving BWR CSNF.

Fuel Shipment Campaign – This activity involves the implementation of the fuel rod transfer plan developed for each of the three campaigns. The actions that will be implemented to accomplish this activity include the following: placement of utility/vendor agreements; shipping cask identification, reservation, and approvals; emplacement of state agreements as necessary; coordination of utility and transportation interface activities; fuel assembly rod removal and shipment preparations; and transport and receipt at the primary laboratory.

Perform RCA Measurements (Primary Lab) – This task will be accomplished through the following:

- Measurement Planning – The primary lab will provide Lead Lab with a detailed project plan that must be approved prior to any work beginning. The detailed project plan requirements will be provided by Lead Lab but at a minimum will require (1) a listing of approved procedures for each isotope being measured, (2) plans for establishing QSL status for this work (if not already in place), (2) the working solution, preparation, dissolution, and storage technique(s), (3) procurement/testing/installation of the instrumentation and control system, (4) mock up testing, (5) coordination with the secondary lab for rod section transfer, and (6) schedule.

- Perform Measurements – This activity is the implementation of the measurement plan. This activity will perform measurements in batches for an anticipated total of 24 measurements per campaign.

- Document Measured Data – Perform data analysis and document in accordance with appropriate procedures.

Perform RCA Measurements (Secondary Lab) – This task will be accomplished through the following:

- Measurement Planning – The secondary lab will provide Lead Lab with a detailed project plan that must be approved prior to any work beginning. The detailed project plan requirements will be provided by Lead Lab but at a minimum will require (1) a listing of approved procedures for each isotope being measured, (2) the working solution, preparation, dissolution, and storage technique(s), (3) procurement/testing/installation of the instrumentation and control system, (4) mock-up testing, and (5) schedule.

- Perform Measurements – This activity involves the implementation of the measurement plan. This activity will perform measurements for an initial suite of samples, potentially followed by an additional suite of samples.

- Document Measured Data – Under this subtask, data analysis and documentation will be performed in accordance with appropriate procedures.

2.1.4 Laboratory Critical Experiments

The main elements and/or strategy for this Primary Task are: obtain needed safety basis approvals to conduct the experiments; prepare relevant QA plans and procedures; design and plan a series of experiments that are applicable to the design basis configurations of the CSNF to be disposed of in Yucca Mountain; re-perform critical experiments (Harms et al. 2004) for ^{103}Rh in order to establish quality objectives for subsequent LCEs; perform critical experiments for additional fission product nuclides in order of prioritization and material availability (prioritization developed in Technical Integration task *Evaluate Cost/Benefit of Data Needs*); and analysis and documentation of measured data. Due to significant issues related to using plutonium and obtaining facility approvals, as well as the planned purchase of the HTC experiment data for actinide validation, the planned critical experiments will not include plutonium.

Even though this plan includes tasks to purchase the previously performed French HTC critical experiments for actinide validation and to evaluate, with the intent to purchase, the French PF critical experiments for validation of selected fission products (^{103}Rh, ^{133}Cs, ^{nat}Nd, ^{149}Sm, ^{152}Sm, and ^{155}Gd), needs remain for additional critical experiments to support validation of the fission products in the list of 29 principal isotopes (see Table 1) that are not covered by the French PF experiment data. Also, in the event that the French PF data are not recommended for purchase, new critical experiments will need to be performed to address those fission product nuclides as well. The potential need for additional LCE data, either to expand or to supplement the French data, was also recognized in the OLM burnup credit project for transportation. Hence, under that program ORNL sought to obtain and assess critical experiment data from all known potential sources, including: (1) critical experiments within the IHECSBE (NEA 2005); (2) proprietary critical experiment data (e.g., French data and data from the REBUS program); (3) commercial reactor criticals, i.e., critical state points from operating reactors; and (4) critical experiments on-going in other countries (e.g., those performed recently at the Japan Atomic Energy Agency in support of reprocessing activities). Relevant critical experiment data identified from that assessment will be incorporated and utilized, where appropriate.

The applicability and value of the available critical experiments was assessed with the aid of S/U analysis tools developed at ORNL and incorporated within Version 5 of the SCALE code system (ORNL 2006b; Broadhead et al. 2004). The TSUNAMI-3D sequence within SCALE uses first-order linear perturbation theory (Rearden 2004) to calculate the sensitivity of k_{eff} for systems (e.g., SNF casks) and/or critical experiments to variations in nuclear data. Energy-, nuclide-, reaction-, and position-dependent sensitivity profiles are generated and saved in sensitivity data files. The TSUNAMI-IP module of SCALE uses the sensitivity data file information and cross-section uncertainty data to evaluate the similarity of different systems.

These S/U tools were used to evaluate the set of experiments performed in 2003 at SNL as part of a DOE Nuclear Energy Research Initiative, which were designed and performed to support taking credit for the presence of ^{103}Rh in CSNF during transport and storage in casks. The experiments involved placement of one of three thicknesses of ^{103}Rh foils between low-enrichment UO_2 fuel pellets in selected fuel rods in a roughly cylindrical, water moderated and water-reflected triangular-pitched array. Figures 4 and 5 show the experimental apparatus used in these experiments. This set of critical experiments was included in the 2005 edition of the IHECSBE (NEA 2005).

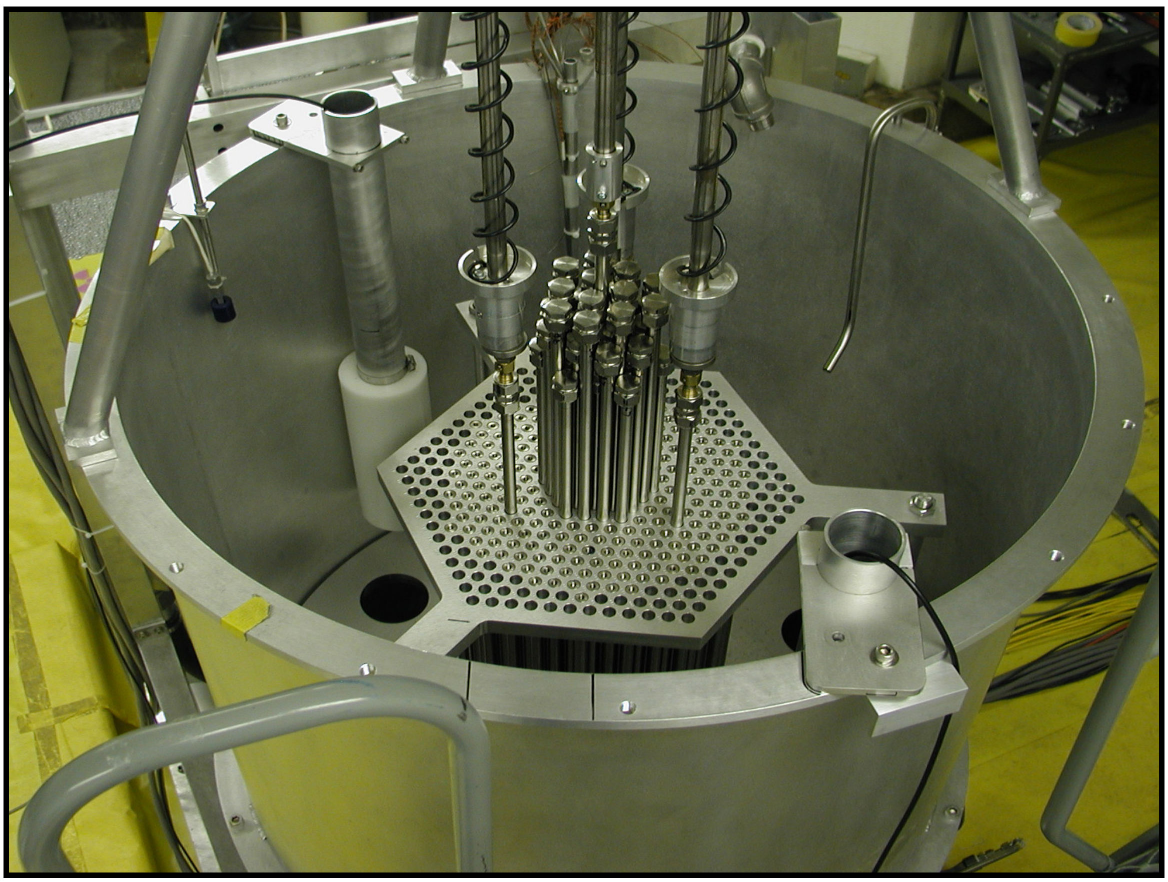


Figure 4. Photograph of the SNL ^{103}Rh Experimental Apparatus

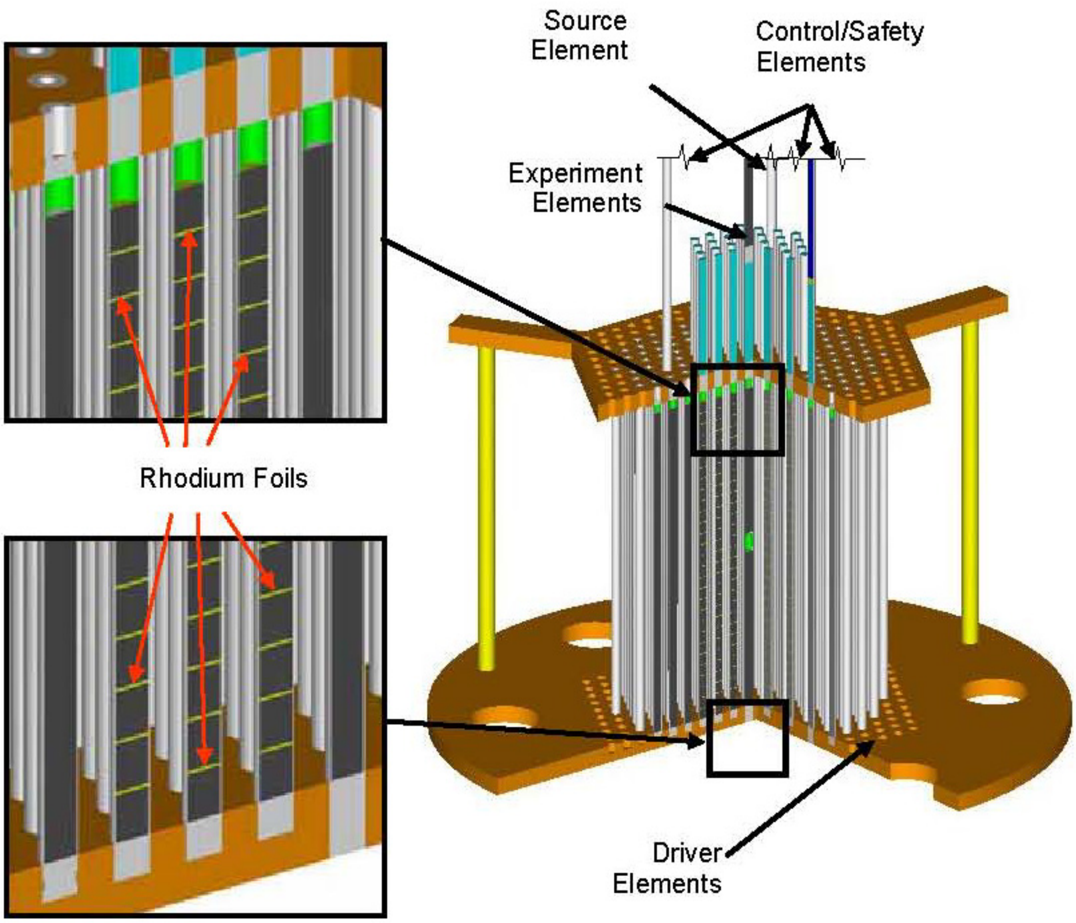


Figure 5. Illustration of the SNL ^{103}Rh Experimental Apparatus Showing the Rods and ^{103}Rh Foils

S/U analyses have been performed for the SNL ^{103}Rh critical experiments, and the results have been compared with S/U analyses results for a high-capacity transport and storage cask model. A comparison of the energy-dependent sensitivity profiles shows reasonably good agreement over most of the neutron energy range. Studies were also performed to show how a modified experiment design (use of thinner foils) could improve the applicability of the experiments. The S/U tools will be employed in the designing and planning of the new LCE experiments to ensure maximum applicability (Mueller and Harms 2005).

The following is a list of the major subtasks within this primary task. The technical approaches and governing procedures for these activities will be established, as appropriate, in task-specific planning documents to be developed for this element of the experimental program.

Funding Available to Start – **Milestone**: the schedule for all subsequent activities in this task is dependent on this milestone.

Obtain Required NEPA Approvals – The purpose of this task is to have the SNL site office obtain the required National Environmental Policy Act (NEPA) approvals to enable the work.

NEPA analyses will be performed to show that the LCEs can be done within the boundaries of the existing SNL Site-Wide Environmental Impact Statement.

Obtain Safety Basis Approvals – The purpose of this task is to obtain the required safety basis approvals to enable the work. The authorization basis (AB) documents used by the National Nuclear Security Administration/Sandia Site Office to assess the risks associated with the activities in nuclear facilities are updated annually. The AB documents will be updated to (1) accommodate the burnup credit program experiments and (2) incorporate changes necessitated by an evolving regulatory environment. The AB documents are subjected to an extensive review process both inside SNL and at the DOE.

Design Experiments and Procure Materials – The purpose of this task is to plan and prepare for performing the burnup credit critical experiments. The products of this activity are (1) training and use of appropriate Lead Lab procedures that implement QARD requirements, (2) specification of the number of critical experiments for each material, (3) definition of the fission product material concentrations/geometries in the experiments, (4) a global AB analysis that shows that the experiments fit within the AB envelope of the facility. Procurement of the fission product material will be started. Preparations will be made to incorporate the fission product material in the experiments.

Prepare Hardware – The existing critical experiment hardware and the instrumentation and control system will be upgraded to improve the efficiency and reliability of operations. The hardware and instrumentation and control system will be assembled and installed in the reactor building.

Prepare for Experiments – The experiment plan for the initial set of experiments will be prepared and submitted for safety review. Operating procedures necessary to perform the experiments will be updated as necessary. All procedures will need to be integrated as Lead Lab "technical procedures." The training of the operating crew will be completed.

Perform Readiness Assessment – The readiness of the project team to proceed with the critical experiments will be assessed in reviews by (1) facility management, (2) SNL corporate personnel, (3) Lead Lab staff (TCO, Engineered Barrier Systems, QA) and (4) DOE. The reviews cover all aspects of experiment operations including the AB, the hardware, operating procedures, and training.

Authorization Received to Perform Experiments – **Milestone**: facility authorized to commence critical experiments.

Perform Critical Experiments – The first set of critical experiments will be performed with the existing ^{103}Rh sample materials to reestablish the capability and ensure satisfactory results. An initial load-to-critical will be done without the experiment material to demonstrate the operability of the experiment process. Critical experiments with the Rh material will then be done. The experiments will be analyzed and documented for publication. Details describing the critical assembly design, hardware, experimental procedures for approach to critical, analysis of results, and estimation of experimental uncertainties are provided in Harms et al. (2004).

Perform Material 2 Critical Experiments – The experiments for this material will be designed, the required AB analysis will be done, experiment samples will be procured, the experiment material will be incorporated in experiment elements, the critical experiments will be performed, and the documentation of the experiments will be prepared.

Perform Material 3-15 Critical Experiments – The process for completing the experiments for this and succeeding materials follow the process for the Material 2 critical experiments.

Complete All Critical Experiments – **Milestone**: completion of all critical experiments; facility available for decontamination and decommissioning.

Decontaminate and Decommission Assembly – The experiment hardware will be decontaminated and placed in storage. Plans for disposition of all radioactive materials and the experiment fuel will be developed and these materials will be removed from the facility. Decontamination and decommissioning are budgeted as part of this TWP.

2.1.5 Cross-Section Measurements

The following is a list of the major subtasks within this primary task. The technical approaches and governing procedures for these activities will be established, as appropriate, in task-specific planning documents to be developed for this element of the experimental program.

Funding Available to Start – **Milestone**: the schedule for all subsequent activities in this task is dependent on this milestone.

Establish QA Procedures and Requirements – The goal of this task is to ensure the cross-section data developed under this program is qualified for use by YMP. This task involves implementing QA requirements applicable to cross section measurements, performance of cross section evaluations, and generation of cross section libraries for use to support postclosure criticality safety analyses. The QA program will be evaluated with appropriate Lead Lab procedures for inclusion on the OCRWM QSL. The cross-section evaluated data will be submitted for inclusion into ENDF All evaluated nuclear data in ENDF undergo testing and peer review prior to inclusion. Hence, any data developed under this program and submitted for inclusion in ENDF would undergo this testing and peer review.

Perform Cross-Section Measurements – This task involves performing cross-section measurements consistent with approved procedures. As part of this task, it will be necessary to procure target samples suitable for cross section measurements. Following measurement of the ^{155}Gd and ^{133}Cs cross sections, which were initiated under the DOE OLM burnup credit program via the DOE-Euratom agreement, the order of new/additional fission product cross section measurements will be determined by target material availability and prioritized ranking determined in the technical integration subtask, *Determine Cross-Section Measurement Requirements/Needs & Specifications*. A task to develop a detailed plan for performing the new cross-section measurements, which will address issues such as methods for data collection, data reduction, recording, measurement specifications, criteria, and calibration, and provisions for handling unexpected measurement results, is included. Lead Lab staff will review and approve this plan prior to authorization of new measurements. The sample preparation groups at ORNL and IRMM will prepare and characterize transmission and capture samples for measurement of stable fission products. ORNL will perform the cross-section evaluations of the measured data with assistance from IRMM as needed. ORNL and IRMM have complementary measurement facilities that can be used to measure data in the thermal, resolved and unresolved resonance regions. ORNL will perform the total and capture cross-section measurements at the Oak Ridge Electron Linear Accelerator facility, with additional cross-section measurements to be performed at the GELINA TOF facility at IRMM as needed. Consistent with the DOE-Euratom agreement, it is anticipated that ORNL and IRMM will carry out the work interactively by exchanging ideas, documents, and consultants as the task progresses.

Perform Cross-Section Evaluations & Generate Libraries for SCALE – This task involves evaluation of the cross-section measurement data and generation of cross-section data libraries for use in depletion and criticality safety calculations. Evaluation of the measured cross-section data produces the nuclear data in the ENDF format. Cross-section libraries, suitable for use in the SCALE and MCNP code systems, will be generated. The ^{103}Rh evaluation will be performed first because the cross sections have recently been measured under the DOE OLM burnup credit program. Evaluation and library generation for the other fission products will be performed as the data measurement tasks are completed.

Interactions with Cross-Section Evaluation Working Group for Testing/Inclusion into ENDF Release – This task involves interacting with the Cross-Section Evaluation Working Group to ensure that the cross-section evaluations are properly performed and tested to facilitate inclusion into a future ENDF release.

2.1.6 Reactor Operating History Data

The following is a list of the major subtasks within this primary task. The technical approaches and governing procedures for calculations will be established, as appropriate, in task-specific planning documents to be developed for this element of the program.

Provide EPRI with Data Requirement/Needs to Facilitate Cooperation – This task involves providing EPRI with the reactor operating history data specifications developed in the Technical Integration task *Determine Reactor Operating History Data Requirements/Needs & Specifications*. Useful reactor operating data typically include data like soluble boron concentrations, core average power densities, maximum power densities, fuel and moderator temperatures, moderator densities, exposure to burnable poisons, and burnup profile data. A document will be prepared and provided to EPRI describing the needed reactor operations data and the reporting format.

Interact with EPRI and/or Utilities to Acquire Data – This task involves working with EPRI and/or the utilities to answer questions that may arise concerning the data to be collected and the reporting format.

Receive Data from EPRI – This task involves receiving and performing an initial evaluation of the data to determine that the correct data was transmitted in a usable format. As necessary, requests for information and corrected or additional data will be generated.

Analyze, Evaluate, and Package Data – This task involves sorting, analyzing and evaluating the reactor operations data and preparing usable summaries of the data. Evaluation of the data will yield recommendations for bounding parameters to be used in fuel depletion calculations.

Prepare Data Package and Report – This task involves preparing a report containing the collected data, summaries of the data, technical evaluation of the data, and recommendations for bounding parameters to be used in fuel depletion calculations.

Complete Data Package and Report – **Milestone:** Prepare report consistent with appropriate procedures, e.g., LS-PRO-001, *Technical Reports*.

2.1.7 Features, Events, and Processes

Although this activity does not directly address FEPs, output from this activity will be used to further support the exclusion justifications made in *Screening Analysis of Criticality Features, Events, and Processes for License Application* (BSC 2004, Sections 6.8.2, 6.8.6, 6.8.10, and 6.8.14) for the in-package criticality FEPs listed in Table 3.

Table 3. In-Package Criticality FEPs for License Application

FEP Number and Section in BSC 2004	Name
2.1.14.16.0A	In-package criticality (degraded configurations)
2.1.14.19.0A	In-package criticality resulting from a seismic event (degraded configurations)
2.1.14.22.0A	In-package criticality resulting from rockfall (degraded configurations)
2.1.14.25.0A	In-package criticality resulting from an igneous event (degraded configurations)

2.2 ADDITIONAL STEPS FOR PERFORMANCE CONFIRMATION TEST PLANS

Activities in this TWP are not for the purpose of performance confirmation, and hence, requirements related to planning for performance confirmation activities are not applicable.

2.3 ADDITIONAL STEPS FOR MODELING ACTIVITIES

Although calculations, analyses, and other modeling activities may be involved as part of this overall burnup credit data program, this TWP does not generate a model or scientific analysis or calculations in accordance with procedures SCI-PRO-005, *Scientific Analyses and Calculations*, and SCI-PRO-006, *Models*. However, task-specific planning documents for activities specified in this TWP will include modeling and scientific analyses that will be performed in accordance with the appropriate procedures (SCI-PRO-005 and SCI-PRO-006).

3. INDUSTRY STANDARDS, FEDERAL REGULATIONS, DOE ORDERS, REQUIREMENTS, AND ACCEPTANCE/COMPLETION CRITERIA

This section lists the applicable industry standards, federal regulations, DOE orders, requirements, and acceptance/completion criteria.

3.1 LIST OF DIRECTLY APPLICABLE STANDARDS

The following is a list of industry and technical standards that are directly applicable to activities or products in this work plan:

ANSI/ANS-8.1-1998. *Nuclear Criticality Safety in Operations with Fissionable Material Outside Reactors*

ANSI/ANS-8.7-1998. *American National Standard for Nuclear Criticality Safety in the Storage of Fissile Materials*

ANSI/ANS-8.17-2004. *American National Standard, Criticality Safety Criteria for the Handling, Storage and Transportation of LWR Fuel Outside Reactors*

ANSI/ANS-8.19-2005. *American National Standard, Administrative Practices for Nuclear Criticality Safety*.

3.2 LIST OF CODE OF FEDERAL REGULATIONS, U.S. DEPARTMENT OF ENERGY ORDERS, AND/OR REGULATORY REQUIREMENTS

Fuel transportation will be in accordance with quality assurance provisions of 10 CFR Part 71, Packaging and Transportation of Radioactive Material and U.S. Department of Transportation rules in 49 CFR Part 173, Shippers--General Requirements for Shipments and Packaging. Transportation will also be subject to requirements of DOE Directive DOE M 460.2-1, *Implementation Guide for Use with DOE O 460.2 Departmental Materials Transportation and Packaging Management.*

The activities in this plan will be used to address the following *Yucca Mountain Review Plan, Final Report* (NRC 2003) acceptance criteria:

- Section 2.2.1.2.2.3, Scenario Analysis and Event Probability – Identification of Events with Probabilities Greater than 10^{-8} Per Year – Acceptance Criteria (AC 1 [2], and 2)

- Section 2.2.1.3.1.3, Model Abstraction – Degradation of Engineered Barriers – Acceptance Criteria(AC 1 [6])

- Section 2.2.1.3.3.3, Model Abstraction – Quantity and Chemistry of Water Contacting Engineered Barriers and Waste Forms – Acceptance Criteria (AC 1 [11] and 3 [5])

- Section 2.2.1.3.4.3, Model Abstraction – Radionuclide Release Rates and Solubility Limits – Acceptance Criteria (AC 1 [7] and 3 [6])

- Section 2.2.1.3.7.3, Model Abstraction – Radionuclide Transport in the Unsaturated Zone – Acceptance Criteria (AC 3 [3])

- Section 2.2.1.3.9.3, Model Abstraction – Radionuclide Transport in the Saturated Zone – Acceptance Criteria (AC 3 [3]).

Nuclear Regulatory Commission key technical issues and additional information needs are not applicable because none is directly applicable to the work described in this TWP.

The following is a list of other regulatory requirements and guidance that are to be directly addressed (as applicable and consistent with 10 CFR Part 63) by activities or products in this work plan:

> "Safety Evaluation Report for Disposal Criticality Analysis Methodology Topical Report, Revision 0" (Reamer 2000).
>
> > Open Item 5 – "The DOE must include a criticality margin when comparing k_{eff} values from regression analyses to CL values."
> >
> > Open Item 6 – "The DOE must present an approach for developing the criticality margin."
> >
> > Open Item 8 – "The DOE needs to use the cross-section data corresponding to the temperature for the WP or critical benchmarks."
> >
> > Open Item 9 – "The DOE must include the cross-dependency of configuration parameters for k_{eff} regression equations."
> >
> > Open Item 11 – "The DOE is required to develop an acceptable methodology for establishing bias and uncertainties for the isotopic depletion model."
> >
> > Open Item 13 – "The DOE should address the types of criticality uncertainties and biases, which is based on ANSI/ANS-8.17, presented by the staff in this SER."
> >
> > Open Item 15 – "The DOE is required to include the isotopic bias and uncertainties as part of Δk_c if not included as isotopic correction factors."

3.3 PROVISIONS FOR DETERMINING THE LEVEL OF ACCURACY, PRECISION, AND REPRESENTATIVENESS OF RESULTS

The accuracy, precision, and representativeness of the testing and analysis work performed are assessed as part of the uncertainty analyses for each of the products developed. Initial estimates of RCA isotopic composition accuracy are listed in Section 2.1.1. The precision of the testing results is to be controlled by using appropriate instrument calibrations and reference standards. The accuracy of individual measurements is to be assessed based on use of replicate measurements and/or the established precision of the measuring and test equipment used. Representativeness of test samples and conditions is to be discussed in the test planning documents, as discussed in Section 2.1.3 under subtask *Identify and Prioritize Candidate Fuel for (RCA) Measurement*. Test results will be documented in the technical products. The activities covered by this TWP will meet the level of detail and accuracy needed to support the probability screening analyses for LA. Technical products will be considered acceptable if they are developed, checked, reviewed, and approved in accordance with the appropriate implementing procedures (Section 4), or comparable procedures for suppliers on the QSL. Each technical product developed for the activities in this work plan will be technically checked in accordance with the appropriate procedure.

The specific provisions for determining the level of accuracy, precision, and representativeness of results for each activity will be provided in activity-specific planning reports approved by the Lead Lab technical manager.

3.4 ACCEPTANCE CRITERIA FROM HIGHER LEVEL PLANNING DOCUMENTS

No higher-level planning acceptance and/or completion criteria (including DOE acceptance criteria and contractor completion criteria) have been identified for any of the listed activities or products.

None of the technical products identified in this TWP has been identified as deliverables. Technical products from subsequent, specific test activities (via pending individual TWPs) will likely include deliverables as specified by DOE.

3.5 LIST OF REQUIREMENTS

No additional requirements apply to the activities covered by this TWP.

4. IMPLEMENTING DOCUMENTS

Current revisions of the following procedures will be used by Lead Laboratory to review/assess testing work or test results, as appropriate to individual activities within the scope of this TWP:

- DM-PRO-002, *Records Management*
- IM-PRO-002, *Control of the Electronic Management of Information*
- IM-PRO-003, *Software Management*
- IM-PRO-004, *Qualification of Software*
- IM-PRO-005, *Software Independent Verification and Validation*
- LP-7.5Q-OCRWM, *Establishing Deliverable Acceptance Criteria and Reviewing Deliverables*
- LS-PRO-001, *Technical Reports*
- QA-PRO-004, *Supplier Evaluation and Qualified Supplier List Maintenance*
- QA-PRO-009, *Acceptance of Services*
- PI-PRO-004, *Management Self-Assessments and Organizational Self-Assessments*

- PM PRO 001, *Procurement Documents*
- SCI-PRO-001, *Qualification of Unqualified Data*
- SCI-PRO-002, *Planning for Science Activities*
- SCI-PRO-005, Scientific Analyses and Calculations
- TST-PRO-001, *Submittal and Incorporation of Data to the Technical Data Management System*
- TST-PRO-002, *Control of Measuring and Test Equipment*
- TST-PRO-003, *Scientific Notebooks*
- TST-PRO-006, *Testing Work Implementation and Control*
- TST-PRO-007, *Preparing and Approving Technical Procedures*
- TST-PRO-008, *Sample Control*.

All work will comply with the quality requirements as implemented by the QA program described in the QSL for qualified suppliers, or be in accordance with the procedures listed above. The qualified supplier-implementing documents will be identified in the lower-tier test plans discussed in Section 2.1.

Non-Q pre- and post-testing activities will be controlled by sub-tier planning documents that will cover the detail planning of activities coordinated by this TWP such as RCA measurements and LCEs and pre-test and post-test predictions.

5. EQUIPMENT

Measuring and test equipment necessary to conduct testing is controlled and calibrated at the facilities performing the work in accordance with TST-PRO-002, *Control of Measuring and Test Equipment*. For work activities performed by qualified suppliers listed on the QSL, their respective quality assurance programs listed on the QSL that have been evaluated and found to comply with QARD (DOE 2006b) requirements, will be used. The equipment needed will be specified in task-specific planning documents that are to be developed for each measurement element of this program.

6. RECORDS

Users of this TWP are to collect and submit all required records generated as a result of the implementing procedures in accordance with DM-PRO-002, *Records Management*. The records that are required will be specified by the implementing procedure(s). Records to be generated, maintained, and submitted include the following:

1. Test plans
2. QA program document
3. Technical procedures and implementing documents
4. Calibration of standards records
5. Measuring and test equipment calibration records
6. Personnel training records
7. Personnel qualification records
8. Internal and external audit reports
9. Nonconformance reports
10. Corrective action records
11. Software validation results
12. Data sheets containing raw data and calculations
13. Q Procurement documents (such as purchase orders, subcontract documents)
14. Sub-tier supplier evaluation/qualification documents
15. Sub-tier supplier documentation and records
16. Drawings, sketches
17. Scientific notebooks
18. Technical products.

Records generated as a result of performing the above-described activities shall be collected and submitted to the Records Processing Center (RPC) in accordance with DM-PRO-002, and shall be readily retrievable. Data collected shall be submitted to the TDMS in accordance with TST-PRO-001, *Submittal and Incorporation of Data to the Technical Data Management System*. Prior to submittal of records and data, controls to protect data and verify electronic transfers of data shall be made as discussed in Section 8, below.

7. QUALITY VERIFICATIONS

Data collected or procured under this work plan will be qualified and will have completed a technical review process before it is submitted to the TDMS consistent with TST-PRO-001. Work on the YMP subject to QARD (DOE 2006b) requirements will comply with the latest revisions of the OCRWM-qualified Quality Assurance Program at each laboratory for qualified suppliers, or with the implementing documents listed in Section 4. For future sub-tiered planning documents, analysis work will be performed to the appropriate procedure, SCI-PRO-005, *Scientific Analyses and Calculations,* or equivalent for qualified suppliers. This TWP describes quality affecting activities subject to audits/surveillances by the OCRWM Office of Quality Assurance and the Lead Lab Quality Assurance Department. Management and self-assessments may be performed per PI-PRO-004, *Management Self-Assessments and Organizational Self-Assessments*.

Specific hold points have been identified:

- Prior to commencement of Q testing, all experimental test plans shall be reviewed and approved by TCO and Engineered Systems
- Concurrent with the above review, a formal management assessment will be documented (per details in Section 8)
- Prior to submission of data to records, the data package will be submitted to the Engineered Systems principal investigator for review and approval.

8. PREREQUISITES, SPECIAL CONTROLS, ENVIRONMENTAL CONDITIONS, PROCESSES, OR SKILLS

All testing and analysis activities planned under this TWP will be subject to QARD (DOE 2006b) requirements because they are associated with the characterization of waste forms in support of performance assessment. All quality affecting testing will be conducted in accordance with the supplier's Quality Assurance Program as described on the OCRWM QSL or Lead Laboratory's Quality Assurance, as appropriate. A qualified procedure to adequately verify consumable standards from non-QSL suppliers for use in qualified work must be developed in collaboration with TCO. All QSL suppliers must remain in good standing on the OCRWM QSL in order to perform the qualified tests.

Readiness assessments will occur annually at a minimum and at various times throughout the work implementation and will be documented as defined in PI-PRO-004. The assessments will be planned to monitor significant activities or activities, determined by management or staff, that carry risks associated with quality, safety, environmental compliance, or work schedule. These assessments will involve appropriate staff from TCO, supplier and customer organizations.

Formal readiness assessments shall occur in parallel to the experimental testing plan review/approval prior to initiating Q work. As part of Lead Lab's commitment to performing due diligence inspections, test plan controls need to be examined prior to starting work. Review shall include technical or implementing procedures for measuring and test equipment control, data collection software, and Q equipment; safety readiness; approved data inputs; training requirements; test/experimental plan and approved work scope, as appropriate.

Prior to Q work beginning in any laboratory facility, an on-site pre-job check will be conducted by Lead Lab to ensure the following:

1. The work scope is adequately documented and approved.
2. Approved technical implementing procedures exist to conduct the work.
3. Lab technicians have been properly trained and the training documentation is available for inclusion in the YMP RPC.

4. Provisions are in place to procure and control consumable standards consistent with QARD (DOE 2006b) requirements.

5. Data collection software has been controlled in accordance with IM-PRO-003, *Software Management*, or appropriate QSL approved procedures.

6. Scientific notebooks, if appropriate, have been established to document relevant laboratory activities.

7. Measuring and test equipment are properly installed and calibrated and documentation exists to demonstrate operational readiness.

An evaluation in accordance with IM-PRO-002, *Control of the Electronic Management of Information,* has been conducted, and this work is subject to requirements to manage and control electronic data. The process control evaluation is provided in Appendix E. As a result the following methods will be used for the control of electronic management of information:

1. Upon completion of work activities, QA records will be submitted to the RPC in accordance with applicable implementing procedures. These records will be retained, protected, and dispositioned in accordance with the requirements of DM-PRO-002.

2. During the conduct of work activities, electronic information will be backed up and readily available on network drives. Electronic information on personal computers and on network drives can be retrieved instantly.

3. The technical reports, data, and software are retained on network drives. Electronic information that may be stored on password-protected personal computers during the conduct of work activities will be retained until the information associated with the work activity becomes part of the record system. Information on personal computers will be backed up on network drives.

4. Electronic information that may be stored on hard drives on password-protected personal computers will be transferred to the RPC on compact discs or other suitable media. Discs and all other removable backup media will be labeled with the following: generating program, originator, date, document number, and content description. This information will be retained on the password-protected personal computers until confirmation by the RPC that the information has become part of the record system.

5. Completeness and accuracy of the input information are assured through compliance with checking, quality compliance review, and technical review requirements of the applicable procedure controlling the work activity. Changes to this information will be made in accordance with the revision requirements of the controlling procedure.

6. Security and integrity of the electronic information developed during the work activity is maintained by storing the information on network drives and on hard drives of password-protected personal computers, and by limiting write access. After transfer to the RPC and to the TDMS, integrity is maintained by RPC access controls.

7. When electronic information is transferred, its accuracy and completeness will be verified in accordance with IM-PRO-002 or equivalent procedure for qualified suppliers working to the QA program described in the QSL.

Special controls and processes are expected for the handling of spent nuclear fuel during operations involving loading, transport, sample acquisition, and radio-chemical assay. Some of these activities will take place in hot cells to enable worker safety and preclude environmental contamination. Some will occur in a radiation protection area to enable worker safety. Technical training and skills for specialized laboratory processes of radiochemical assay and laboratory criticality experiments are required for these tasks. Supplier personnel need to be trained, and appropriate education and experience must be ensured by supplier QA requirements approved by Lead Lab. Quality of work products will be ensured by performance of the work, including checking and review as applicable, in accordance with approved implementing procedures or equivalent qualified supplier approved QA program descriptions in the QSL.

Training requirements for Lead Lab employees will be established in a training matrix and administered for compliance. If the staff member is affiliated with one of the national laboratories currently working on the Yucca Mountain Project, his or her training requirements are established by the national laboratory in accordance with the laboratory's contract to SNL. Compliance with the training requirements will be met through the contractual mechanisms associated with the contract.

No further special QA controls, beyond applicable procedures and each laboratory's approved QA program, apply to this work.

Testing may require special environmental conditions that will be described in the task-specific test plans. Prerequisites for the performance of this work, such as those related to laboratory operations (such as Q-procurements, software qualification, and calibration of test equipment) will be covered by task specific test plans and implementing procedures that have been evaluated and approved through the QSL approval system and found to comply with QARD (DOE 2006b) requirements. Any inputs required to satisfy prerequisites will be provided by the Engineered Systems organization.

Non-Q work, specifically pretest predictions and calculations to enable optimal test set-up, will be controlled by planning documents prepared according to SCI-PRO-002 and these planning documents will be implemented accordingly.

9. SOFTWARE

All software used during testing at the facilities is subject to the QARD (DOE 2006b, Supplement I) requirements.

Controlled unqualified software can be used for pretest predictions of experimental results/conditions to facilitate process efficiency and safety precautions.

Any software used will be listed in the applicable test plans. Commercially available off-the-shelf software to complete tasks directed by this TWP may include Microsoft Office (Word, Excel, PowerPoint, Access), Internet browsers (Explorer, Netscape) and associated applications (e.g., Adobe Photoshop). Spreadsheets calculations will be verified either by hand calculations or by comparison with appropriate published examples, or both. This software is exempt from qualification per IM-PRO-003, Section 2.

Controlled software that will be the basis of comparisons against laboratory results include those listed in Table 4. These software applications will be qualified following IM-PRO-003 and IM-PRO-004, *Qualification of Software*, prior to conducting Q calculations.

Table 4. List of Software

Software	Software Tracking Number	Qualification Status
MCNP5	N/A	Unqualified
SCALE 5.1 (including all modules)	N/A	Unqualified

NOTE: Software qualification will be completed prior to any Q-work performed in accordance with the process described in TWP-EBS-MD-000018 REV 000.

10. ORGANIZATIONAL INTERFACES

The Lead Lab Postclosure Criticality team is responsible for the execution and oversight of the work identified in this TWP. The work will be performed by Lead Lab personnel at the Summerlin campus, as well as by personnel at the SNL, ORNL, PNNL, and other, yet to be determined, DOE national laboratories. The TCO will have responsibility for implementing task-specific test plans and experimental operations. These plans will be prepared by the Lead Lab Postclosure Criticality team. Many of the task-specific test plans will be prepared by labs on the OCRWM QSL. Interactions with project licensing, design, OCRWM, and NRC are anticipated. Interactions with EPRI will be advantageous for accessing fuel assembly records of nuclear utilities and obtaining CSNF for RCA measurements

11. PROCUREMENT

Procurement of items and services shall be in accordance with processes identified, in PM-PRO-001, *Procurement Documents*, or the OCRWM-approved supplier QA program as appropriate for the activity identified. Contracts will be placed with the QSL vendors prior to beginning testing at their facilities. Procurement controls need to be specified in each supplier’s test/experimental plan to control all Q procurements.

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APPENDIX A

DECISION ON APPROACH TO BURNUP CREDIT, MEMORANDUM FROM M.H. WILLIAMS TO E.F. SPROAT, DATED DECEMBER 8, 2006

Department of Energy
Office of Civilian Radioactive Waste Management
1551 Hillshire Drive
Las Vegas, NV 89134-6321

QA: N/A

DEC 18 2006

MEMORANDUM FOR: Edward F. Sproat, III, Director
Office of Civilian Radioactive
Waste Management

FROM: Mark H. Williams, Director
Regulatory Authority Office

SUBJECT: Decision on Approach to Burnup Credit

Enclosed for your signature is a decision paper on the issue identified in Monthly Program Review – 01, entitled "Establish path forward for dealing with Burn-Up Credit including Transportation and NNPP." The paper recommends purchase of the French actinide data, further evaluation of the French fission product data, and the development of a domestic data gathering program. These actions will support the benchmarking and validation of codes that will allow a criticality event to be screened out of the repository analysis. Please sign the enclosed decision paper.

RAO:JRW-0304

Enclosure:
Commercial SNF Burnup Credit for Disposal,
Transportation, and Storage

cc w/encl:
W. J. Boyle, DOE (RW-6) NV
J. R. Dyer, DOE (RW-4) NV
P. M. Golan, DOE (RW-1) FORS
G. J. Lanthrum, DOE (RW-10) FORS
J. O. Low, DOE (RW-5) NV
P. R.Z. Russell, DOE (RW-4) NV
J. M. Thompson, DOE (RW-15) FORS

cc w/encl: (continued)
J. R. Williams, DOE (RW-6) FORS
M. H. Williams, DOE (RW-6) NV
D. E. Dei, Department of the Navy, Washington Navy Yard, DC
J. M. McKenzie, Department of the Navy, Washington Navy Yard, DC
T. C. Feigenbaum, BSC, Las Vegas, NV
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C. V. Parks, ORNL, Oak Ridge, TN
John Wagoner, ORNL, Oak Ridge, TN
M. C. Brady Raap, PNNL, Richland, WA
C. L. Howard, SNL, Las Vegas, NV
S. A. Orrell, SNL, Las Vegas, NV
RAO Records Coordinator, NV
Records Processing Center = "11"

Commercial SNF Burnup Credit for Disposal, Transportation, and Storage

1. Issue/Action Title:

Issue #13 from the design review meeting (*Reconcile Burn-Up Credit approaches between transportation and disposal. Present a single RW regulatory approach for management approval and implementation.*) Also, the issue is closely related to MPR-01, Action #14 (*Establish path forward for dealing with Burn-up Credit including Transportation and NNPP.*)

2. Assigned To/Date:

This action was assigned to OCRWM Regulatory Authority Office on September 19, 2006.

3. Scheduled Closure Date:

This action was planned to be closed on October 30, 2006.

4. Issue:

NRC has maintained that, to credit burnup for transportation, storage and disposal of Commercial Spent Nuclear Fuel (SNF), sufficient quantity of experiment data would be needed to validate a two-step analysis process. The first step of the analysis process is to benchmark the computational tools to validate the isotopic concentration predictions in irradiated commercial spent nuclear fuel. The second step is to validate the cross sections and reactivity contribution of credited isotopes. In order to perform this validation process, the acquisition of extensive data on the credited actinides and fission product isotopes concentrations and reactivity effects (potentially including neutron cross-section data) would be essential since the data available today are extremely limited. Once the computational tools have been validated, the criticality potential of irradiated commercial SNF in expected transportation and postclosure configurations can be properly evaluated. This position has been reflected in published NRC guidance, the project's postclosure criticality Topical Report, and the associated NRC SER. Although the project proposed such a process to the NRC, acquisition of the necessary data has not been funded. Current data availability, future data sources, and data needs for the 29 Principal Isotopes (identified for burnup credit for postclosure criticality) have been reviewed at a meeting with DOE, Sandia, Pacific-Northwest, and Oak Ridge National Laboratories, Naval Reactors, and BSC on October 25, 2006. The discussion at this meeting enabled the Department to make an informed decision on the merit of purchasing foreign data and the use of this data to complement a domestic data acquisition program. More extensive background discussion is provided in Attachment 1.

5. Options/Discussion:

Other options for addressing postclosure criticality have been considered, such as using only Commercial Reactor Critical (CRC) data in the benchmarking of burnup credit or shifting from screening postclosure criticality on probability (which relies on burnup credit) to a consequence-based analysis. Several approaches to obtaining actinide and fission product isotopic data have also been evaluated. The recommended approach to optimize the integral needs of transportation, storage, and disposal is presented below.

6. Impacts/Risks/Sensitivities:

The NRC has repeatedly indicated that the current project approach which uses CRCs as integral benchmark data to simultaneously validate both the isotopic calculation and the reactivity calculation in lieu of the two-step process is insufficient. While NRC staff has verbally, in informal discussions, expressed some interest in a consequence analysis approach as opposed to probabilistic screening, the political, public and consequential licensing risks are considered too high for such an approach to be successful. In addition, the phenomenological analysis that the NRC would most likely expect to be included in such a consequence analysis approach is not supported by available data.

7. Recommendation

The following actions are necessary in order to complete the burnup credit related analyses and support LA submittal and NRC licensing reviews:

1. Develop detailed plans for acquisition of Radiochemical Assays (RCAs) and laboratory critical experiments (LCEs) to complete data suite needed for burnup credit validation of the credited isotopes. The plan will include how acquired data (foreign and domestic) will be used in the burnup credit validation methodology.

2. Purchase the rights to use the French HTC actinide critical experiments ($1.25 million) for partial satisfaction of repository burnup credit validation and complete the actinide benchmark analysis by LA submittal. Remaining actinide and fission product benchmark analyses will be completed pending availability of additional data.

3. Complete evaluation of the French fission product data to ensure project applicability as well as financial and regulatory benefit. Make purchase decisions and negotiate data acquisition as determined appropriate. Use data to support the LA as it becomes available.

4. Perform analyses to identify the cost/benefit of maintaining the position that 29 Principal Isotopes are required. Preliminary calculations have shown that reducing the number of fission product nuclides may not significantly impact the percentage of the commercial SNF inventory that would be qualified for packaging in a burnup credit waste package.

5. Complete a postclosure criticality LA analysis compliant with 10 CFR 63 based on available data. Provide a commitment in the LA that validation consistent with the LA results will be performed in the post-LA timeframe based upon the expected availability of additional actinide and fission product data.

6. Propose appropriate license conditions for the Construction Authorization and the approach for their removal prior to the LA amendment to Receive and Possess CSNF. These conditions may include limiting the range of applicability of the granted level of burnup credit until the needed additional data is collected and analyzed. This approach could mitigate licensing risks for an initial SER because the burnup credit validation would be consistent with the submitted LA results.

8. Decision:

1. Develop detailed plans for acquisition of RCAs and LCEs, and their implementation in the burnup credit methodology to complete data suite needed for burnup credit validation of the credited isotopes.
2. Proceed with French data acquisition as described above. Acquire the actinide LCE data and evaluate, with the intent to purchase, the LCE data for the limited set of fission products. The French RCA data will not be acquired.
3. Include the approach in the YMP Licensing Strategy and implement in the LA and relevant NRC interactions.

9. Implementation Action:

SNL and BSC develop and execute task plans reflecting the above decision.

10. Appropriate Concurrences Received OR Dissenting Views:

11. Approval: [signature] Date: 1/8/07

12. Closure Concurrence: ____________________________ Date: _____________

11/21/2006 Page 3 of 6

Attachment 1

BACKGROUND

COMMERCIAL SNF BURNUP CREDIT FOR DISPOSAL, TRANSPORTATION, AND STORAGE

Criticality events in the repository during the first 10,000 years of the postclosure period have the potential for adversely affecting the repository performance objectives. However, analyses thus far have shown that under both nominal and disruptive conditions, these events can be excluded from performance considerations on the basis of their low probability of occurrence; therefore, criticality consequences and their impact on system performance are not further evaluated. The bases for the current analyses include use of burnup credit for commercial spent nuclear fuel (CSNF) and corrosion resistant neutron absorbers.

Unirradiated fuel has a well-specified nuclide composition that provides a straightforward and bounding approach to the criticality safety analysis. As the fuel is irradiated in the reactor, the nuclide composition changes and this composition change causes the reactivity of the fuel (its criticality potential) to decrease. Allowance in the criticality safety analysis for the decrease in fuel reactivity resulting from irradiation is termed "Burnup Credit."

Each commercial SNF assembly is defined by its as-manufactured enrichment (U-235 to total uranium ratio) and burnup (energy released from the assembly due to irradiation). Loading curves are the application tool for burnup credit. These curves are generated by determining the acceptable enrichment/burnup pairs to be loaded in a particular canister/waste package design. The repository loading curves are based on the most limiting configuration that has an estimated probability of occurrence greater than the screening criterion for inclusion in system performance evaluations (1 chance in 10,000 for the first 10,000 years). The limiting configuration is a tightly packed geometry of intact fuel assemblies separated by neutron absorber plates (plate thickness is based on minimum residual amount required after 10,000 years of corrosion).

Without Burnup Credit, 97% of all PWR SNF assemblies (i.e. 91,231 assemblies), and 7% of all BWR SNF assemblies (i.e. 8,897 assemblies) will require disposal in an alternate waste package design in order to ensure that postclosure criticality is a very unlikely event and excluded from system performance evaluations. The alternate waste package design could include control rods to be inserted in the guide tubes of PWR SNF assemblies, and a derated configuration for BWR SNF assemblies as well as PWR SNF assemblies without guide tubes. With an estimated cost of $2M a waste package (including drift and operational costs) and a very low estimate of control rods cost at $88K per waste package, the repository cost would increase by over $2B.

In the mid-80s, SNL and ORNL started formulating the approach for attaining burnup credit, but it was not aggressively pursued due to the slow down of the nuclear industry in the early 1990s. OCRWM submitted the Actinide-Only Topical Report for transportation burnup credit to the NRC in May 1995, but the NRC did not issue a Safety Evaluation Report (SER). In May 1999 Actinide-only burnup credit was endorsed by the NRC in SFPO-ISG-8 *Burnup Credit in the Criticality Safety Analyses of PWR Spent Fuel in Transport and Storage Casks.* SFPO-ISG-8 was last revised in September 2002.

OCRWM Submitted *Disposal Criticality Analysis Methodology Topical Report,* Rev. 0 to the NRC in January, 1999. The NRC issued a SER in June 2000 accepting the burnup credit methodology. The *Disposal Criticality Analysis Methodology Topical Report* included burnup credit for 29 Principal Isotopes (14 Actinides and 15 Fission Products). The validation for the computational tools for burnup credit is to be performed through Commercial Reactor Criticals (CRCs), Radiochemical Assays (RCAs), and Laboratory Critical Experiments (LCEs).

Due to project funding decisions, a few RCAs and no LCEs have either been acquired or performed with principal emphasis on relatively inexpensive CRCs (which allow for integral benchmarking.) The few RCAs were performed on available samples for other applications. Directly applicable RCAs were not performed due to higher priority work consuming available funding and the high upfront cost of establishing an RCA program (including shipping of irradiated SNF). LCEs were not performed due to the high upfront cost of configuring a critical facility to neutronically simulate a waste package loaded with commercial SNF.

NRC has maintained, and recently reinforced, that CRCs are inadequate as a primary analysis and model validation basis for transportation and disposal applications. Based on the NRC's SER and revision 2 of SFPO-ISG-8 (*Burnup Credit in the Criticality Safety Analyses of PWR Spent Fuel in Transport and Storage Casks)*, as well as recent interactions with the NRC, the NRC will not accept CRCs as the primary basis and requires a "two step" validation process: (a) use RCAs to benchmark the depletion computational tools and validate the isotopic concentration predictions in commercial spent nuclear fuel, (b) use LCEs to benchmark the cross sections and reactivity contribution of credited isotopes, and limit the use of CRCs as confirmatory benchmarks rather than primary validation experiments.

The YMP Transportation organizations have also sought funding since the early-90s, to establish a burnup credit program to perform RCAs and LCEs on domestic SNF with partial success. Foreign sources of data were pursued in lieu of a domestic program that would be more expensive and require at least a four-year completion time frame.

With regard to the actinide data, Cogema has sponsored a series of simulated HTC (Haut Taux de Combustion [high rate of combustion or burnup]) experiments in order to address burnup credit experimental needs. The experiments were designed to obtain an estimate of the uncertainty associated with the major uranium and plutonium nuclides. It is important to note that these experiments do not include Np-237, Am-242 and Am-243, which are part of the 29 Prinicpal Isotopes for which the repository is currently seeking burnup credit. The HTC fuel was fabricated to replicate the uranium to plutonium ratio found in commercial SNF with a burnup of 37.5 GWd/MTU and an initial enrichment of 4.5 wt%. Four phases of HTC experiments were performed from 1988 to 1991 with a total of 156 experiments.

This set of critical experiments represents the most usable of a very limited set of international data available and can provide initial technical basis for code validation. This basis is necessary to justify the uncertainties associated with actinide-only burnup credit consistent with the NRC position. These French HTC data have been purchased by YMP Transportation, are directly applicable to repository disposal, and provide a foundation for validation of the plutonium and uranium nuclides in a canister geometry. Its significance to the repository program is even higher if the domestic repository LCE program is limited to SNL critical experiments that may not be able to include plutonium concentrations representative of expected repository conditions.

Limited French RCA data are available, but are based on slightly different fuel design, and the reactors are operated much differently (e.g., routine use of control rods to control reactivity) than domestic reactors. These differences could introduce a basis for questions from the NRC staff which might be difficult to resolve.

French LCE data for a limited number of fission products have been evaluated for transportation needs, but the number of fission product nuclides is more limited than currently pursued for the repository. Some important details of the French experiments necessary for interpretation of the data for fission product validation have not been made available to the transportation program, thus the confirmation of applicability to transportation and disposal has not been completed. One LCE set for one fission product nuclide has been evaluated and provides acceptable results. Evaluation of the available sets (still less than that pursued for the repository) would have to be made prior to purchase.

As the current position and path forward are being re-assessed, foreign sources of data continue to have potential value to support burnup credit validation, but cannot serve as the primary source of validation data because 1) the available LCEs do not address the number of nuclides that the repository currently needs to consider, 2) the different operating conditions of non-domestic reactors may create uncertainty regarding applicability of the RCA data, and 3) additional RCA data will be needed even if the foreign assay data is acquired.

Continuing with the current repository burnup credit validation approach without purchasing foreign data and/or implementing the repository data acquisition program, will likely result in NRC rejecting the burnup credit argument and disallowing any burnup credit for transportation or disposal. Actinide-only burnup credit which is expected to be granted by the NRC after the purchase of the French HTC actinide critical benchmarks is insufficient to cover an acceptable fraction of the commercial SNF inventory resulting in the need for costly (financial and operational) additional neutron absorbers and potential impact on the repository size and number of waste packages needed.

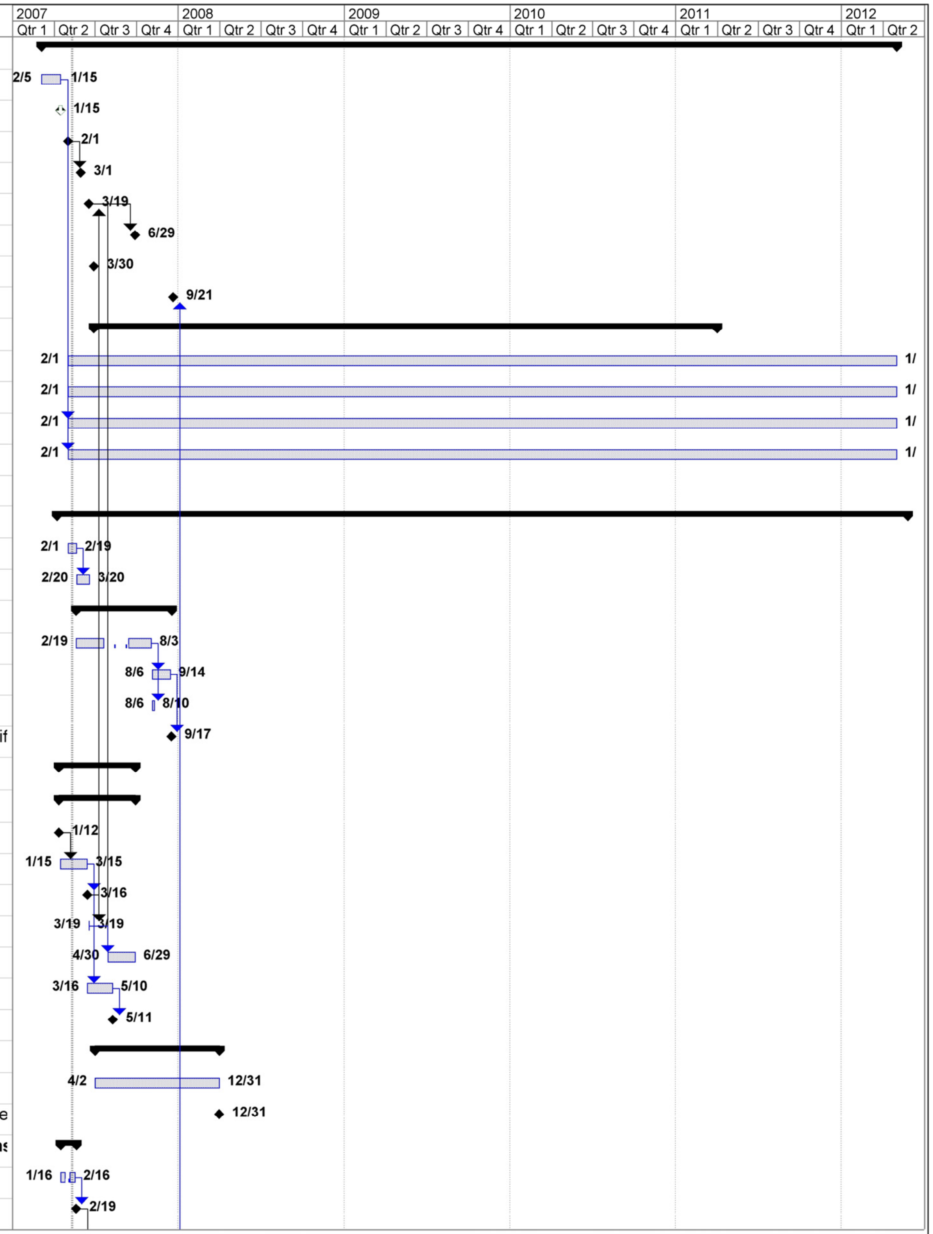
Other concerns include applicability of the RCAs (as part of the domestic data acquisition program) to the entire commercial SNF inventory not just the sampled assembly types. The expectation is that this risk can be managed by careful selection of samples and proper extrapolation of the validation to demonstrate conservatism to less reactive assembly designs. Proper design of the critical facility will ensure applicability of the LCEs for their intended validation use. Similar to any experimental program, there are risks associated with intractable measurement error and usability of the results. Some of these risks can be managed with careful and frequent pre- and post-experiment analyses as well as frequent communication and coordination between experimentalists and computational analysts.

The methodology and the process for validating burnup credit will be described in the LA Safety Analysis Report (SAR) to support the 2008 LA submittal. In addition, with the purchase of the French HTC actinide critical benchmarks, the validation for crediting some actinides is also expected to be completed by LA submittal. The validation work for the fission products will continue through the NRC LA review period and it is expected to be completed by construction authorization given a successful data acquisition program. The results of the burnup credit data acquisition plan will not impact the TAD/Waste Package design; they will, however, limit the number of needed waste packages with additional criticality control (control rods or derated waste packages).

APPENDIX B

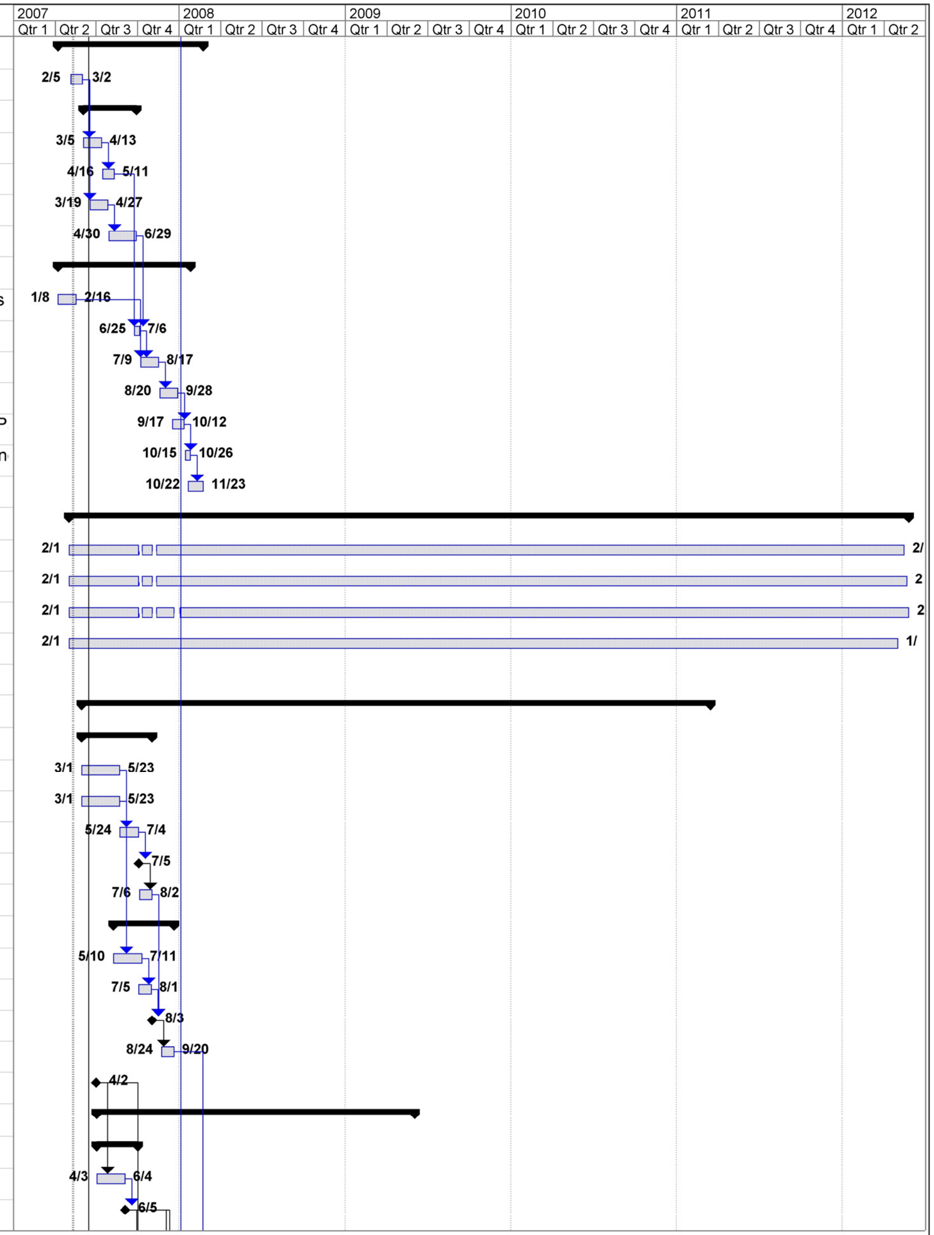
PROJECT PLAN GANTT CHART

ID	WBS	Task Name
1	**1**	**Management**
2	1.1	Develop Project Plan
3	1.2	Communicate Proposed Project Plan to Customer (DOE)
4	1.3	Initiate purchase of French HTC LCE data
5	1.4	Complete purchase of French HTC LCE data ($1.25M)
6	1.5	If recommend, initiate purchase of French PF LCE data
7	1.6	Complete purchase of PF data
8	1.7	Purchase RCA Data from International "MALIBU" Program
9	1.8	Finalize Site Selections to Perform RCAs
10	**1.9**	**Development of Detailed Task-Specific Plans**
20	1.10	RCA Authorizations
21	1.11	LCE Authorizations
22	1.12	XS Authorizations
23	1.13	Management Oversight
24		
25	**2**	**Technical Integration**
26	2.1	Define Specifics of BUC Methodology Implementation
27	2.2	Develop Data Requirements/Needs for Implementing BUC Methodology
28	**2.3**	**Determine RCA Measurement Requirements/Needs & Specifications**
29	2.3.1	Assess Existing RCA Measurement Data from Other Programs
30	2.3.2	Identify Number/Characteristics of CSNF Samples to be Measured
31	2.3.3	Identify Nuclides for Measurement and Target Measurement Accuracies
32	2.3.4	Prepare Document Establishing RCA Measurement Requirements/Needs & Specif
33	**2.4**	**Determine LCE Measurement Requirements/Needs & Specifications**
34	**2.4.1**	**Assess Existing LCE Data From Other Programs**
35	2.4.1.1	Receive Complete French PF LCE Data for Evaluation
36	2.4.1.2	Evaluate French PF LCE Data
37	2.4.1.3	Provide Recommendation on Purchasing French PF Data
38	2.4.1.4	QA Qualify HTC Data
39	2.4.1.5	If Recommendation Favorable, QA Qualify PF Data
40	2.4.1.6	Identify Number/Characteristics of LCEs to be Performed at SNL
41	2.4.1.7	Prepare Document Establishing LCE Requirements/Needs & Specifications
42	**2.5**	**Determine Cross-Section Measurement Requirements/Needs & Specifications**
43	2.5.1	Assess Existing Nuclear Cross-Section Data for FPs
44	2.5.2	Prepare a Document Establishing Measurement Requirements/Needs and Prioritie
45	**2.6**	**Determine Reactor Operating History Data Requirements/Needs & Specifications**
46	2.6.1	Assess Existing Operational History Data Needs
47	2.6.2	Prepare a Document Establishing Data Requirements/Needs



Note: This Gantt chart represents an initial working schedule that is subject to change. The actual schedule is controlled by the AWP.

ID	WBS	Task Name
48	**2.7**	**Evaluate Cost/Benefit of Data Needs**
49	2.7.1	Perform Isotope Reactivity Ranking
50	**2.7.2**	**Perform Code Validation with Available/Existing Data**
51	2.7.2.1	Perform Sensitivity/Uncertainty Analyses with LCE Data
52	2.7.2.2	Calculate Bias and Bias Uncertainty Based on Recommended LCE Data
53	2.7.2.3	Calculate C/E Ratios Based on RCA Data
54	2.7.2.4	Calculate Bias and Bias Uncertainty Based on RCA Data
55	**2.7.3**	**Assess Reactivity Margins and Loading Curves**
56	2.7.3.1	Develop Computational Sequence to Automate Loading Curve/Impact Studies
57	2.7.3.2	Determine Baseline Loading Curves
58	2.7.3.3	Evaluate Impact of Individual Fission Products & Minor Actinides
59	2.7.3.4	Evaluate Impact of Other Relevant Calculational Inputs
60	2.7.3.5	Evaluate Benefits of Performing Cross-Section Measurements on Selected FP
61	2.7.3.6	Perform Cost/Benefit Analysis of Including Individual Fission Products and Min
62	2.7.4	Document Supporting Studies, Findings, and Recommendations
63	**2.8**	**Technical Oversight - Monitor Data Programs and Adjust Course, As Needed**
64	2.8.1	Oversee Technical Work Progress
65	2.8.2	Determine Deficiencies / Recommend Changes
66	2.8.3	Monitor and Evaluate Other domestic/International Programs for Potential Benefit
67	2.8.4	Ensure Consistency Between Data Collection & BUC Methodology
68		
69	**3**	**Radiochemical Analyses (RCA) Measurements**
70	**3.1**	**Identify and Prioritize Candidate Fuel for Measurement**
71	4.4.1	Review Available Fuel Samples at Various Locations to Evaluate Suitability
72	3.1.2	Review Utility SNF Inventory, Readiness, and Willingness to Participate
73	3.1.3	Prepare Prioritized List of Recommended Fuel Samples for Measurement
74	3.1.4	Provide Recommendations for Review
75	3.1.5	Review/Acceptance of Recommendations on Fuel Samples for Measurements
76	**3.2**	**Select Laboratories for Performing RCAs (assumes primary & confirmatory)**
77	3.2.1	Site visits to assess facilities & capabilities (PNNL, INL, ORNL, ANL)
78	3.2.2	Review & Evaluate Site Capabilities/Risks
79	3.2.3	Provide Recommendation on Sites for Performing RCAs
80	3.2.4	Internal Review of Recommendation/Finalization of Sites
81	3.3	Funding Available to Start Measurements
82	**3.4**	**Perform Measurements at PNNL with ATM Samples**
83	**3.4.1**	**Measurement Planning**
84	3.4.1.1	Prepare Detailed Project Plan
85	3.4.1.2	Submit Project Plan to LL for Review

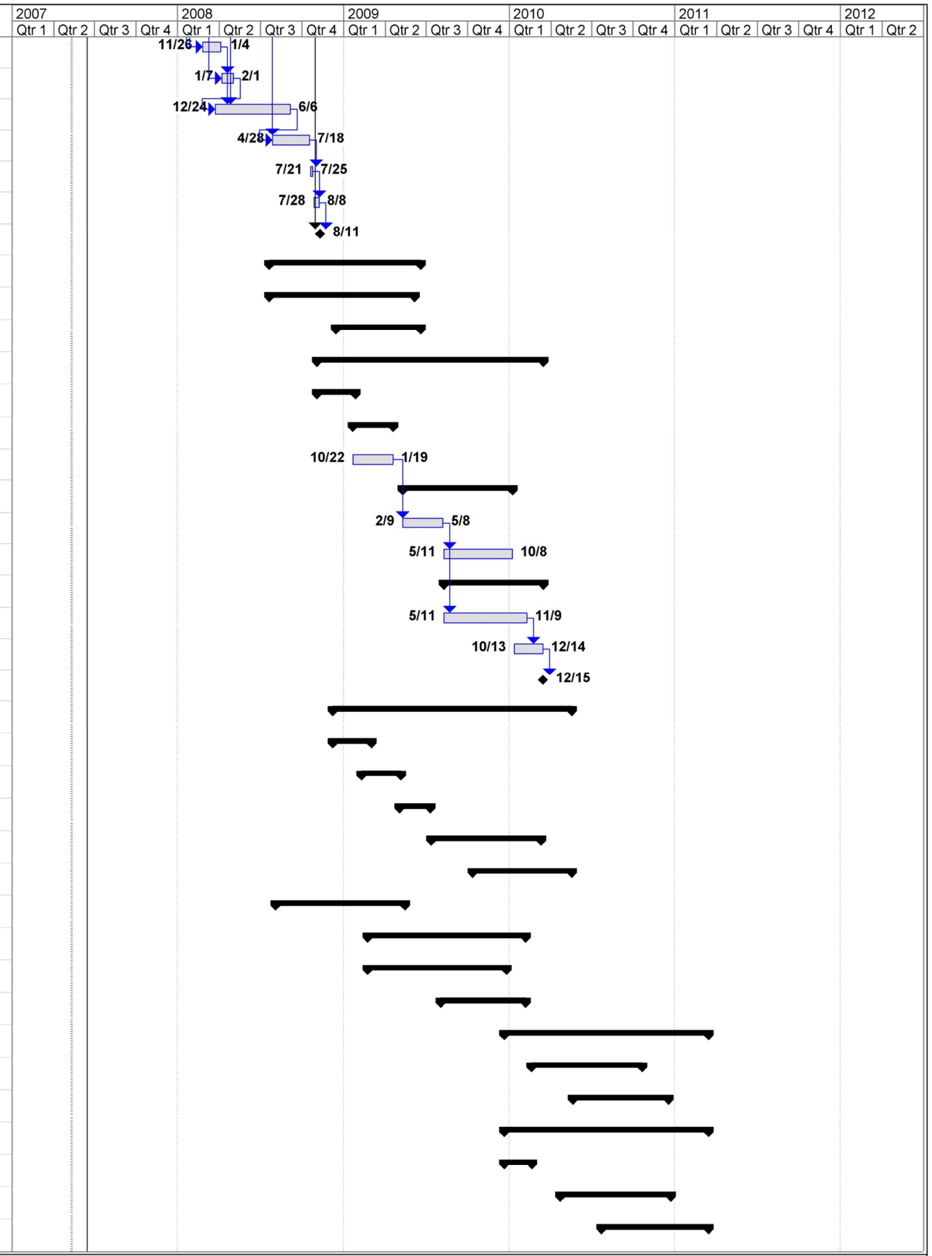


Note: This Gantt chart represents an initial working schedule that is subject to change. The actual schedule is controlled by the AWP.

ID	WBS	Task Name	Start	Finish
86	3.4.1.3	LL Review of Project Plan	6/6	6/25
87	3.4.1.4	LL Acceptance or Rejection of Project Plan		6/29
88	3.4.1.5	Decision on Performing ATM Measurements at PNNL	7/2	7/2
89	**3.4.2**	**Determine and Accommodate QA Requirements**		
90	3.4.2.1	Evaluate Need for Revision to PNNL QAPD	7/3	7/9
91	3.4.2.2	Make Any Necessary Revisions	7/10	9/10
92	3.4.2.3	PNNL on OCRWM QSL for RCA Measurement Work		9/11
93	**3.4.3**	**Measurement Preparation**		
94	3.4.3.1	Develop/Test Procedures for Dissolution/Analysis	9/11	12/6
95	3.4.3.2	Procure/Test/Install Any Needed Equipment	9/4	12/11
96	**3.4.4**	**Perform Measurements**		
97	3.4.4.1	Initial Measurements (~5 ATM samples)	12/7	3/6
98	3.4.4.2	Additional Measurements (~5 ATM samples)	3/7	8/6
99	**3.4.5**	**Document Measured Data**		
100	3.4.5.1	Analyze Results/Compare to Calculations	3/7	9/5
101	3.4.5.2	Write & Publish Document	8/11	12/8
102	3.4.5.3	Document Published		12/9
103	3.4.6	Material Disposition (as needed)	12/10	3/3
104	**3.5**	**Plan for Fuel Rod Transfers from Utilities to Primary Lab**		
105	3.5.1	Prepare Fuel Transfer Plan	9/21	11/15
106	3.5.2	Submit Project Plan to LL for Review		11/16
107	3.5.3	LL Review of Project Plan	11/19	12/7
108	3.5.4	LL Acceptance of Project Plan	12/10	12/14
109	**3.6**	**Determine and Accommodate QA Requirements for Primary & Secondary Labs**		
110	3.6.1	Evaluate Need for Revision to Primary Lab QAPD	10/5	10/25
111	3.6.2	Make Any Necessary Revisions	10/26	4/10
112	3.6.3	Primary Lab on OCRWM QSL for RCA Measurement Work		4/11
113	**3.7**	**Plan for Fuel Rod Transfers from Primary Lab to Confirmatory Lab**		
114	3.7.1	Prepare Fuel Transfer Plan	11/23	1/17
115	3.7.2	Submit Project Plan to LL for Review		1/18
116	3.7.3	LL Review of Project Plan	1/21	2/8
117	3.7.4	LL Acceptance of Project Plan	2/11	2/15
118	**3.7.5**	**Determine and Accommodate QA Requirements for Secondary Lab**		
119	3.7.5.1	Evaluate Need for Revision to Primary Lab QAPD	10/5	10/25
120	3.7.5.2	Make Any Necessary Revisions	10/26	4/10
121	3.7.5.3	Secondary Lab on OCRWM QSL for RCA Measurement Work		4/11
122	**3.8**	**Fuel Shipment Campaign 1**		
123	3.8.1	Utility/Vendor Arrangements	11/5	1/11

Note: This Gantt chart represents an initial working schedule that is subject to change. The actual schedule is controlled by the AWP.

ID	WBS	Task Name
124	3.8.2	Shipping Cask Approval for Usage
125	3.8.3	Shipping Cask Identification and Reservation
126	3.8.4	Organize Utility and Transportation Interfaces
127	3.8.5	Fuel Assembly Handling and Rod Removal
128	3.8.6	Rod Removal from Assembly and Preparation for Shipment
129	3.8.7	Transport to Lab
130	3.8.8	Receipt
131	**3.9**	**Receipt & Handling - Campaign 1**
132	**3.9.1**	**Receipt/Scanning/Segmenting/Sample Prep**
143	**3.9.2**	**Ship Sectioned Fuel Rods to Confirmatory Lab**
149	**3.10**	**Perform RCA Measurements - Primary Lab/Campaign 1**
150	**3.10.1**	**Measurement Planning**
155	**3.10.2**	**Measurement Preparation**
156	3.10.2.1	Develop/Test Procedures for Dissolution/Analysis
157	**3.10.3**	**Perform Measurements**
158	3.10.3.1	Initial Measurements (12 samples)
159	3.10.3.2	Additional Measurements (12 samples)
160	**3.10.4**	**Document Measured Data**
161	3.10.4.1	Analyze Results/Compare to Calculations
162	3.10.4.2	Write & Publish Document
163	3.10.4.3	Document Published
164	**3.11**	**Perform RCA Measurements - Secondary Lab/Campaign 1**
165	**3.11.1**	**Measurement Planning**
170	**3.11.2**	**Measurement Preparation**
172	**3.11.3**	**Receipt & Handling**
176	**3.11.4**	**Perform Measurements**
179	**3.11.5**	**Document Measured Data**
183	**3.12**	**Fuel Shipment Campaign 2**
192	**3.13**	**Receipt & Handling - Campaign 2**
193	**3.13.1**	**Receipt/Scanning/Segmenting/Sample Prep**
203	**3.13.2**	**Ship Sectioned Fuel Rods to Confirmatory Lab**
209	**3.14**	**Perform RCA Measurements - Primary Lab/Campaign 2**
210	**3.14.1**	**Perform Measurements**
213	**3.14.2**	**Document Measured Data**
217	**3.14.3**	**Perform RCA Measurements - Secondary Lab/Campaign 2**
218	**3.14.3.1**	**Receipt & Handling**
222	**3.14.3.2**	**Perform Measurements**
225	**3.14.3.3**	**Document Measured Data**



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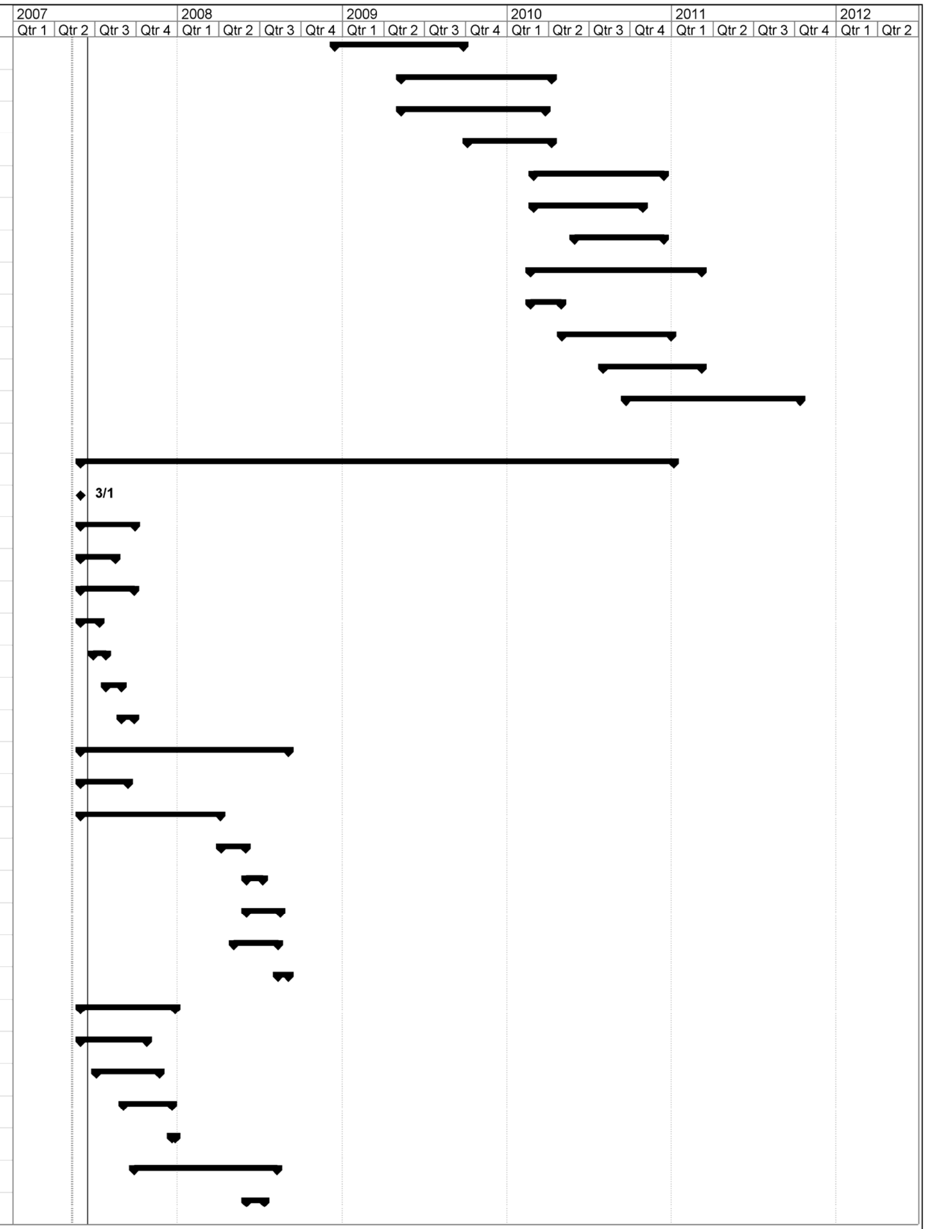
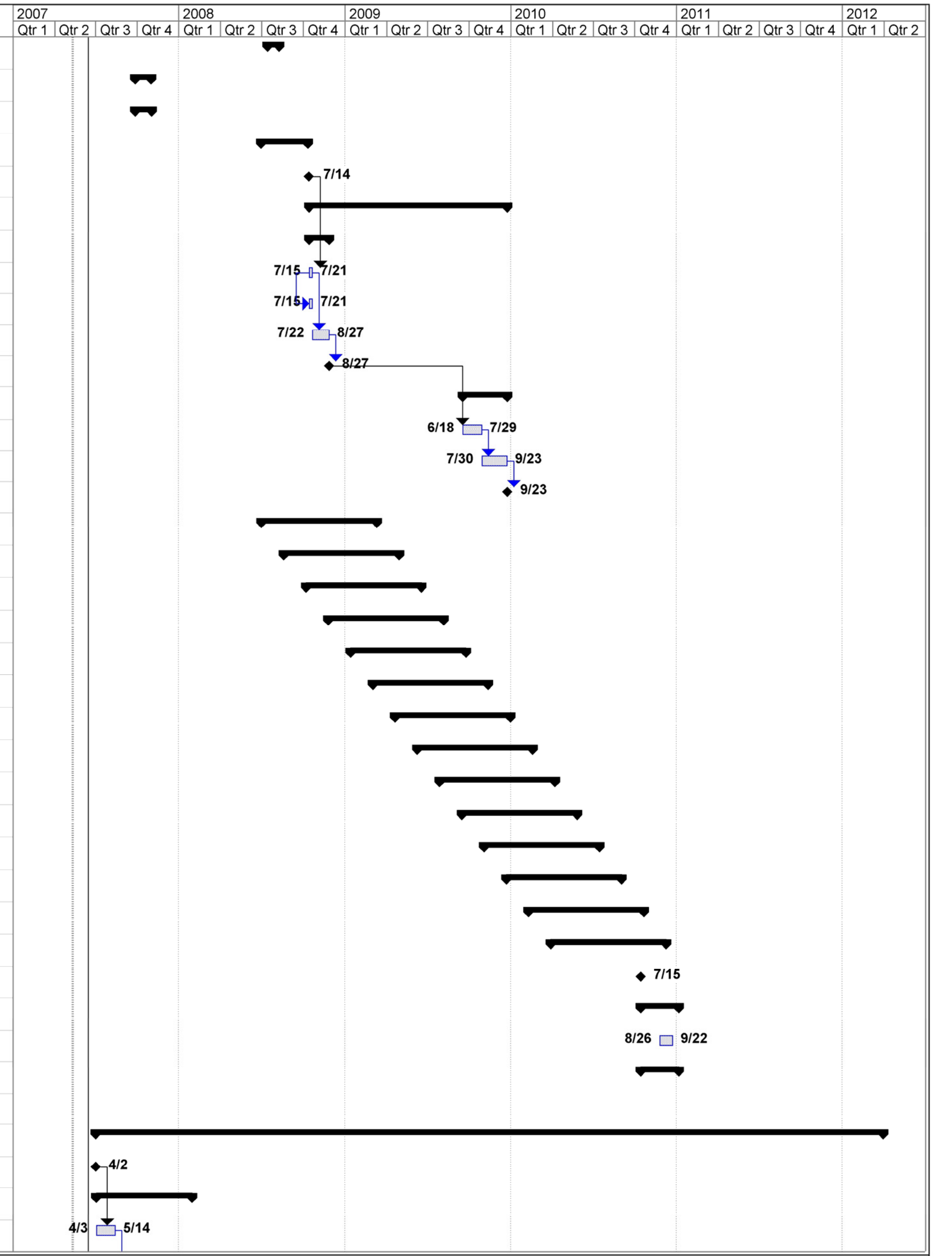
ID	WBS	Task Name
229	3.15	**Fuel Shipment Campaign 3**
238	3.16	**Receipt & Handling - Campaign 3**
239	3.16.1	**Receipt/Scanning/Segmenting/Sample Prep**
250	3.16.2	**Ship Sectioned Fuel Rods to Confirmatory Lab**
256	3.17	**Perform RCA Measurements - Primary Lab/Campaign 3**
257	3.17.1	**Perform Measurements**
260	3.17.2	**Document Measured Data**
264	3.18	**Perform RCA Measurements - Secondary Lab/Campaign 3**
265	3.18.1	**Receipt & Handling**
269	3.18.2	**Perform Measurements**
272	3.18.3	**Document Measured Data**
276	4	**Material Disposition**
281		
282	5	**Laboratory Critical Experiments (LCE)**
283	5.1	Funding Available to Start
284	5.2	**Measurement Planning**
289	5.3	**Obtain Required NEPA Approvals**
293	5.4	**Obtain Safety Basis Approvals**
294	5.4.1	**Update SPRF/CX SAR**
298	5.4.2	**Update TSRs**
300	5.4.3	**Submit SAR/TSR to SNL for Approval**
304	5.4.4	**Submit SAR/TSR to DOE for Approval**
307	5.5	**Design Experiments & Procure Materials**
308	5.5.1	**Determine and Accommodate QA Requirements**
312	5.5.2	**Determine FP Materials to be Investigated**
316	5.5.3	**Design Experiments**
320	5.5.4	**Perform AB Analysis of Experiment**
326	5.5.5	**Procure Sample Materials**
331	5.5.6	**Prepare Glove Box Lab**
335	5.5.7	**Assemble Experiment Elements**
339	5.6	**Prepare Hardware**
340	5.6.1	**Design Hardware Updates**
346	5.6.2	**Fabricate Hardware Updates**
352	5.6.3	**Assemble CX Hardware**
355	5.6.4	**Interface Hardware with I&C System**
357	5.7	**Prepare for Experiments**
358	5.7.1	**Prepare Experiment Plan**



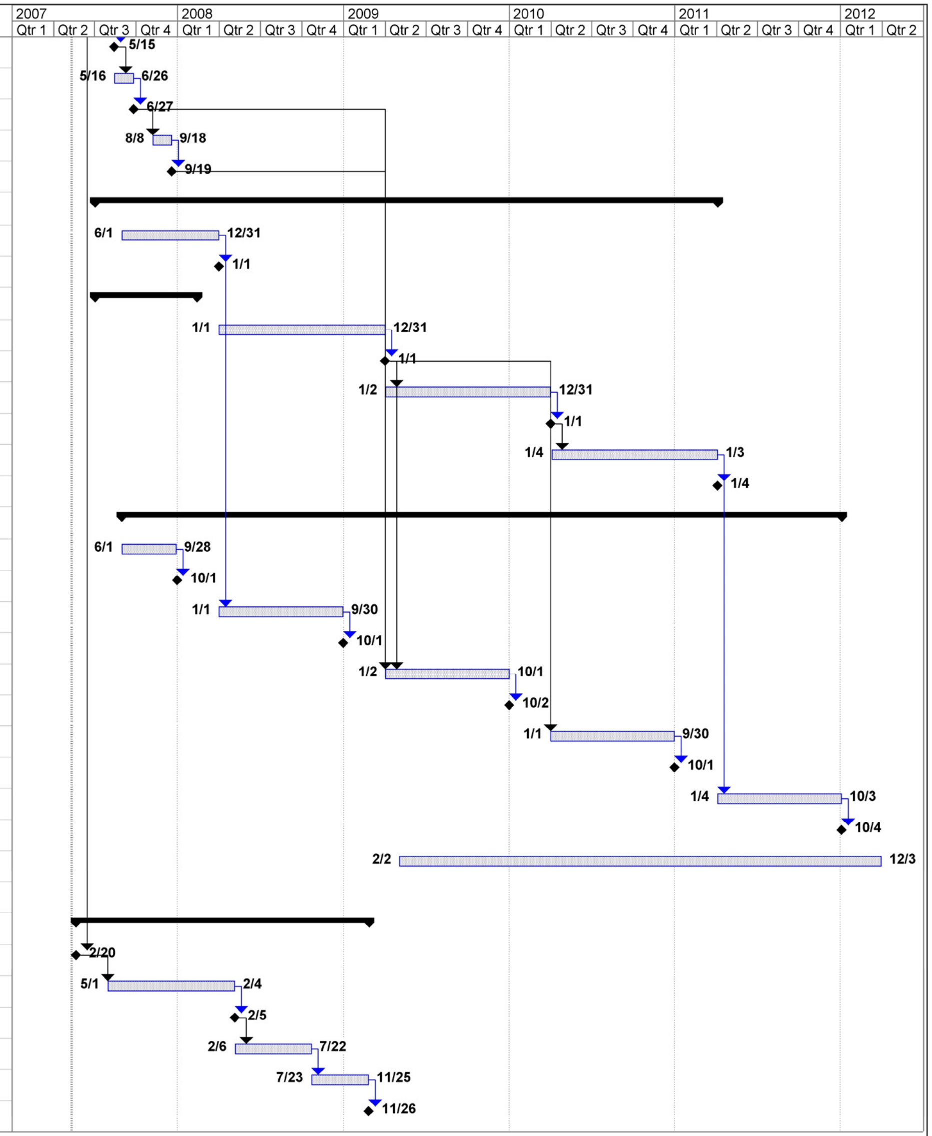
Note: This Gantt chart represents an initial working schedule that is subject to change. The actual schedule is controlled by the AWP.

ID	WBS	Task Name
362	**5.7.2**	**Obtain Approvals for Experiment Plan**
365	**5.7.3**	**Write Operating Procedures**
371	**5.7.4**	**Train Personnel**
377	**5.8**	**Perform Readiness Assessment**
387	5.9	Authorization Received to Perform Experiments
388	**5.10**	**Perform Critical Experiments**
389	**5.10.1**	**Perform Initial Criticals (redo Rh-103 Experiments)**
390	5.10.1.1	Perform Initial Fuel Load
391	5.10.1.2	Perform Instrumentation Checkout
392	5.10.1.3	Perform Criticals
393	5.10.1.4	Criticals Complete
394	**5.10.2**	**Document Experiments**
395	5.10.2.1	Analyze Results
396	5.10.2.2	Write & Publish Document
397	5.10.2.3	Document Published
398	**5.11**	**Material 2 Critical Experiments**
426	**5.12**	**Material 3 Critical Experiments**
454	**5.13**	**Material 4 Critical Experiments**
482	**5.14**	**Material 5 Critical Experiments**
510	**5.15**	**Material 6 Critical Experiments**
538	**5.16**	**Material 7 Critical Experiments**
566	**5.17**	**Material 8 Critical Experiments**
594	**5.18**	**Material 9 Critical Experiments**
622	**5.19**	**Material 10 Critical Experiments**
650	**5.20**	**Material 11 Critical Experiments**
678	**5.21**	**Material 12 Critical Experiments**
706	**5.22**	**Material 13 Critical Experiments**
734	**5.23**	**Material 14 Critical Experiments**
762	**5.24**	**Material 15 Critical Experiments**
790	5.25	All Criticals Complete
791	**5.26**	**Decontaminate & Decommission Assembly**
792	5.26.1	Return Driver Fuel to LANL
793	**5.26.2**	**Decon & Dispose of Rad Hardware**
797		
798	**6**	**Cross-Section Measurements (XS)**
799	6.1	Funding Available to Start
800	**6.2**	**Establish QA Procedures & Requirements**
801	6.2.1	Develop QA Procedures for XS Measurements



Note: This Gantt chart represents an initial working schedule that is subject to change. The actual schedule is controlled by the AWP.

ID	WBS	Task Name
802	6.2.2	Complete QA Procedures for XS Measurements
803	6.2.3	Develop QA Procedures for XS Evaluations
804	6.2.4	Complete QA Procedures for XS Evaluations
805	6.2.5	Develop Establish QA Procedures for XS Library Generation Codes
806	6.2.6	Complete QA Procedures for XS Library Generation Codes
807	**6.3**	**Perform Cross-Section Measurements**
808	6.3.1	Perform Gd-155 & Cs-133 Measurements
809	6.3.2	Complete Gd-155 & Cs-133 Measurements
810	**6.3.3**	**Measurement Planning**
815	6.3.4	Perform 4 New FP XS Measurements
816	6.3.5	Complete 4 New FP XS Measurements
817	6.3.6	Perform 4 New FP XS Measurements
818	6.3.7	Complete 4 New FP XS Measurements
819	6.3.8	Perform 4 New FP XS Measurements
820	6.3.9	Complete 4 New FP XS Measurements
821	**6.4**	**Perform Cross-Section Evaluations & Generate Libraries for SCALE and MCNP**
822	6.4.1	Perform Rh-103 Evaluation
823	6.4.2	Complete Rh-103 Evaluation & Library
824	6.4.3	Perform Gd-155 & Cs-133 Evaluations
825	6.4.4	Complete Gd-155 & Cs-133 Evaluations/Libraries
826	6.4.5	Perform 4 FP XS Evaluations
827	6.4.6	Complete 4 FP XS Evaluations/Libraries
828	6.4.7	Perform 4 FP XS Evaluations
829	6.4.8	Complete 4 FP XS Evaluations/Libraries
830	6.4.9	Perform 4 FP XS Evaluations
831	6.4.10	Complete 4 FP XS Evaluations/Libraries
832	6.5	Interactions with CSEWG for Testing/Inclusion into ENDF Release
833		
834	**7**	**Reactor Operating History Data**
835	7.1	Provide EPRI with Data Requirement/Needs to Facilitate Cooperation
836	7.2	Interact with EPRI and/or Utilities to Acquire Data
837	7.3	Receive Data from EPRI
838	7.4	Analyze, Evaluate, and Package Data
839	7.5	Prepare Data Package and Report
840	7.6	Complete Data Package and Report



Note: This Gantt chart represents an initial working schedule that is subject to change. The actual schedule is controlled by the AWP.

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APPENDIX C

PROJECT BUDGET

Table C-1. Project Budget ($K)

Task	FY07	FY08	FY09	FY10	FY11	FY12	Total
Management[a]	175	184	193	203	213	106	1,073
Purchase rights to French HTC data	1,250[b]	—	—	—	—	—	1,250
Purchase rights to French PF data	6,000[b]	—	—	—	—	—	6,000
Purchase rights to MALIBU data	350[b]	—	—	—	—	—	350
Technical Integration[c]	1,510	1,335	850	650	425	80	4,850
Radiochemical Analysis Measurements[d]	1,132	3,092	4,747	2,527	1,156	—	12,654
Laboratory Critical Experiments[e]	2,345	5,166	5,912	6,436	3,646	735	24,240
Fission Product Cross-Section Measurements[f]	700	1,000	1,000	1,000	1,000	500	5,200
Reactor Operational History Data[g]	45	215	30	—	—	—	290
Total	13,507	10,992	12,732	10,816	6,440	1,421	55,907[h]

[a] Basis of cost: cost for time of staff expected to participate, cost of data from procurement documents.

[b] The purchase of this data was not budgeted in FY07 or FY08 because the decision to purchase was not made prior to the annual work planning process. Therefore, a BCP or other appropriate funding mechanism will be utilized to enable these data purchases.

[c] Basis of cost: cost for time of staff expected to participate.

[d] Basis of cost: (1) interactions with EPRI and national laboratories related to costs and engineering shipment for utility preparation/operations and fuel shipments; cost for time of staff expected to participate in pre-test and post-test analyses; interactions with national laboratories related to costs for QA, project management, start-up operations and laboratory set-up, receipt & handling, RCA measurements, post-measurement laboratory clean-up, and disposition costs. Cost numbers have large uncertainties, but should be bounding; more accurate numbers will become available in the detailed planning documents. Although preliminary analyses indicate that data will not be needed for all 15 fission products in the 29 Principal Isotopes, reduction in the number of isotopes of interest will result in a relatively inconsequential reduction in these costs.

[e] Basis of cost: interactions with SNL staff that have performed similar experiments in recent years. Cost numbers are for 15 materials and 10 critical experiments/material. Costs for actual materials were approximated, but have large uncertainty; more accurate numbers will become available during the preparation of the detailed planning documents. Preliminary analyses indicate that data will not be needed for all 15 fission products in the 29 Principal Isotopes, while this cost estimate is for obtaining data to support all 15 fission products. Purchase of the French data and/or reduction in the number of isotopes of interest will result in a very significant reduction in the costs for this activity.

[f] Basis of cost: interactions with ORNL staff that have experience with performing similar measurements in recent years. Cost numbers are for measurements with 14 materials. Costs for actual materials were approximated, but have large uncertainty; more accurate numbers will become available during the preparation of the detailed planning documents. Preliminary analyses indicate that data will not be needed for all 15 fission products in the 29 Principal Isotopes, while this cost estimate is for obtaining data to support all 15 fission products. A reduction in the number of isotopes of interest could result in a significant reduction in the costs for this activity.

[g] Basis of cost: cost for time of staff expected to participate.

[h] This cost estimate includes a provision for options that will not all be exercised (e.g., if the French PF experiment data are purchased, critical experiments will not be performed for the fission products covered by that data). Also, preliminary analyses indicate that data will not be needed for all 15 fission products in the 29 Principal Isotopes, while this cost estimate is for obtaining data to support all 15 fission products. Reduction of the number of isotopes, will have a significant reduction in the total cost.

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APPENDIX D

PROJECT MILESTONES

Table D-1. List of Milestones

Milestone Description
Management
Communicate Proposed Project Plan to Customer (DOE)
Complete Purchase of French HTC LCE data
Complete Purchase of PF Data
Finalize Site Selections to Perform RCAs
Technical Integration
Prepare Document Establishing RCA Measurement Requirements/Needs and Specifications
Provide Recommendation on Purchasing French PF Data
Prepare Document Establishing LCE Requirements/Needs & Specifications
Prepare a Document Establishing Measurement Requirements/Needs and Priorities (for cross-section measurements)
Prepare a Document Establishing Data Requirements/Needs (for operating history data)
Document Supporting Studies, Findings, and Recommendations (related to cost/benefit analyses and studies)
Radiochemical Analysis Measurements
Review/Acceptance of Recommendations on Fuel Samples for Measurements
Review/acceptance of sites for RCA
Funding Available to Start Measurements
Decision on Performing ATM Measurements at PNNL
Approval of Plan for Fuel Rod Transfers from Utilities to Primary Lab
Primary & Secondary Lab on QSL for RCA Measurements
Approval of Plan for Performing RCA Measurements (Primary Lab)
Approval of Plan for Performing RCA Measurements (Secondary Lab)
Fuel Receipt at Primary Lab – shipment campaign 1
Measurements Complete & Documented (Primary Lab) – campaign 1
Measurements Complete & Documented (Secondary Lab) – campaign 1
Fuel Receipt at Primary Lab – shipment campaign 2
Measurements Complete & Documented (Primary Lab) – campaign 2
Measurements Complete & Documented (Secondary Lab) – campaign 2
Fuel Receipt at Primary Lab – shipment campaign 3
Measurements Complete & Documented (Primary Lab) – campaign 3
Measurements Complete & Documented (Secondary Lab) – campaign 3
All Material Dispositioned
Activity Complete
Laboratory Critical Experiments
Funding Available to Start
Approval of Plan to Perform Measurements
Obtain NEPA Approvals
Obtain Safety Basis Approvals
Authorization Received to Perform Experiments
Procure All Needed Materials & Equipment to Perform Experiments
Complete ^{103}Rh Critical Experiments

Table D-1. List of Milestones (Continued)

Milestone Description
Laboratory Critical Experiments (Continued)
Complete Critical Experiment for Material 2; repeating milestones for subsequent materials
Complete All Critical Experiments
Facility Decontamination/Decommission Complete
Activity Complete
Cross-Section Measurements
Funding Available to Start
Complete QA Procedures for Measurements, Evaluations, and Software
Complete ^{155}Gd & ^{133}Cs Measurements
Approval of Plan to Perform New Measurements
Complete XS Measurements; repeats for subsequent materials
Complete ^{103}Rh Evaluation & Library
Complete ^{155}Gd & ^{133}Cs Evaluations & Libraries
Complete XS Evaluations/Libraries; repeats for subsequent materials
Inclusion of XS Evaluations in ENDF
Activity Complete
Reactor Operating History Data
Provide EPRI with Data Requirement/Needs to Facilitate Cooperation
Receive Data from EPRI
Complete Data Package and Report
Activity Complete

APPENDIX E

PROCESS CONTROL EVALUATION FOR THE ELECTRONIC MANAGEMENT OF INFORMATION

Sandia National Laboratories

Process Control Evaluation for the Electronic Management of Information

Complete only applicable items.

QA: QA
Page 1 of 1

A. Procedure/Work Activity Identification (check one)

☐ Procedure (identify process procedure number, title, revision and ICN level being evaluated), or

☒ Work Activity (identify by work package number, Technical Work Plan, technical product, etc., including title and revision)

Technical work plan for: Development of Technical Data Needed to Justify Full Burnup Credit in Criticality Safety Licensing Analyses Involving Commercial Spent Nuclear Fuel, Revision 0

B1. Processes/Process Functions/Work Activities Evaluation

		Yes	No
1.	Will, or does, the process/process function/work activity depend on a form of electronic media to store, maintain, retrieve, modify, update, or transmit information?	☒	☐
2.	Will, or does, the process/process function/work activity manage, control, or use an electronic database, spreadsheet, set of files, or other holding system for information?	☒	☐
3.	Will, or does, the process/process function/work activity transfer information electronically from one location to another? (The method may be File Transfer Protocol, electronic download, tape to tape, disk to disk, etc.)	☒	☐
4.	Will, or does, the process/process function/work activity produce any Sensitive Unclassified electronic information?	☒	☐

If the answers to Section B1 are all "No", process in accordance with Step 6.1.2G.

B2. Processes/Process Functions/Work Activities Compliance Evaluation

		Yes	No	N/A
1.	If any Sensitive Unclassified electronic information is produced, are the process controls in accordance with Sandia Corporate processes	☒	☐	☐
2.	Does the procedure or work activity document provide adequate controls to protect information from damage and destruction for its prescribed lifetime?	☒	☐	☐
3.	Does the procedure or work activity document provide adequate controls to ensure that information is readily retrievable?	☒	☐	☐
4.	Does the procedure or work activity document provide adequate controls to describe how information will be stored with respect to media, conditions, location, retention time, security, and access?	☒	☐	☐
5.	Does the procedure or work activity document provide adequate controls to properly identify storage and transfer media as to source, physical and logical format, and relevant date?	☒	☐	☐
6.	Does the procedure or work activity document provide adequate controls to ensure completeness and accuracy of the information input and any subsequent changes?	☒	☐	☐
7.	Does the procedure or work activity document provide adequate access to controls to maintain the security and integrity of the information?	☒	☐	☐
8.	Does the procedure or work activity document provide adequate controls to ensure that transfers are error free or within a defined permissible error rate? (e.g., copying raw information from notebook to electronic information form, electronic media to another electronic media, or File Transfer Protocols)	☒	☐	☐

If the answers to Section B2 are all "Yes", process in accordance with Step 6.1.2G. Mark "N/A" for those items that are not applicable to the specific process or work activity.

C. Results of Evaluation

Provide a summary of the "as-is condition," proposed remedial actions, and expected completion date of document revision, for each item in Section B2 that was indicated as "No."

Responsible Manager	Date
Cliff Howard	1-10-07

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