UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

September 19, 2011

Dr. Brian Sheron, Director
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: ACRS ASSESSMENT OF THE QUALITY OF SELECTED NRC RESEARCH PROJECTS- FY 2011

Dear Dr. Sheron:

Enclosed is our report on the quality assessment of the following research projects:

- Degradation of LWR Core Internal Materials Due to Neutron Irradiation, NUREG/CR-7027
  - This project was found to be more than satisfactory, a professional work that satisfies research objectives.
- Analysis of Experimental Data for High Burnup PWR Spent Fuel Isotopic Validation—ARIANE and REBUS Programs (UO_2 Fuel), NUREG/CR-6969
  - This project was found to be satisfactory, a professional work that satisfies research objectives

These projects were selected from a list of candidate projects suggested by the Office of Nuclear Regulatory Research (RES).

We anticipate receiving a list of candidate projects for quality assessment in FY-2012 prior to our November 3-5, 2011 meeting.

Sincerely,

/RA/

Said Abdel-Khalik
Chairman

Enclosure: As stated

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Office of Nuclear Regulatory Research
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Accession No: **ML11262A210** **Publicly Available** **Y** **Sensitive** **N**
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Assessment of the Quality of Selected NRC Research Projects by the Advisory Committee on Reactor Safeguards - FY 2011

September 2011

U.S. Nuclear Regulatory Commission
Advisory Committee on Reactor Safeguards
Washington, DC 20555-0001

ABOUT THE ACRS

The Advisory Committee on Reactor Safeguards (ACRS) was established as a statutory Committee of the Atomic Energy Commission (AEC) by a 1957 amendment to the *Atomic Energy Act* of 1954. The functions of the Committee are described in Sections 29 and 182b of the Act. The *Energy Reorganization Act* of 1974 transferred the AEC's licensing functions to the U.S. Nuclear Regulatory Commission (NRC), and the Committee has continued serving the same advisory role to the NRC.

The ACRS provides independent reviews of, and advice on, the safety of proposed or existing NRC-licensed reactor facilities and the adequacy of proposed safety standards. The ACRS reviews power reactor and fuel cycle facility license applications for which the NRC is responsible, as well as the safety-significant NRC regulations and guidance related to these facilities. The ACRS also provides advice on radiation protection, radioactive waste management and earth sciences in the agency's licensing reviews for fuel fabrication and enrichment facilities and waste disposal facilities. On its own initiative, the ACRS may review certain generic matters or safety-significant nuclear facility items. The Committee also advises the Commission on safety-significant policy issues, and performs other duties as the Commission may request. Upon request from the U.S. Department of Energy (DOE), the ACRS provides advice on U.S. Naval reactor designs and hazards associated with the DOE's nuclear activities and facilities. In addition, upon request, the ACRS provides technical advice to the Defense Nuclear Facilities Safety Board.

ACRS operations are governed by the *Federal Advisory Committee Act* (FACA), which is implemented through NRC regulations at Title 10, Part 7, of the *Code of Federal Regulations* (10 CFR Part 7). ACRS operational practices encourage the public, industry, State and local governments, and other stakeholders to express their views on regulatory matters.

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Mr. Gordon (Dick) Skillman, Principal, Skillman Technical Resources Inc., Hershey, Pennsylvania

Mr. John W. Stetkar (Member-at-Large), Principal, Stetkar & Associates, Lake Forest, California

ABSTRACT

In this report, the Advisory Committee on Reactor Safeguards (ACRS) presents the results of its assessment of the quality of selected research projects sponsored by the Office of Nuclear Regulatory Research (RES) of the NRC. An analytic/deliberative methodology was adopted by the Committee to guide its review of research projects. The methods of multi-attribute utility theory were utilized to structure the objectives of the review and develop numerical scales for rating the project with respect to each objective. The results of the evaluations of the quality of the two research projects are summarized as follows:

- Degradation of LWR Core Internal Materials Due to Neutron Irradiation, NUREG/CR-7027

  - This project was found to be more than satisfactory, a professional work that satisfies research objectives.

- Analysis of Experimental Data for High Burnup PWR Spent Fuel Isotopic Validation—ARIANE and REBUS Programs (UO_2 Fuel), NUREG/CR-6969

  - This project was found to be satisfactory, a professional work that satisfies research objectives.

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ABBREVIATIONS

ACRS	Advisory Committee on Reactor Safeguards
AEC	Atomic Energy Commission
ANL	Argonne National Laboratory
BWR	Boiling Water Reactor
CFR	Code of Federal Regulation
CGR	Crack Growth Rate
dpa	Displacements Per Atom
FACA	Federal Advisory Committee Act
FY	Fiscal Year
GPRA	Government Performance and Results Act
IASCC	Irradiation Assisted Stress Corrosion Cracking
ISG	Interim Staff Guidance
LWR	Light Water Reactor
MAUT	Multi-Attribute Utility Theory
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
PWR	Pressurized Water Reactor
RES	Office of Nuclear Regulatory Research
SOW	Statement of Work
U.S.	United States

1 INTRODUCTION

The Nuclear Regulatory Commission (NRC) maintains a safety research program to ensure that the agency's regulations have sound technical bases. The research effort is needed to support regulatory activities and agency initiatives while maintaining an infrastructure of expertise, facilities, analytical tools, and data to support regulatory decisions.

The Office of Nuclear Regulatory Research (RES) is required to have an independent evaluation of the effectiveness (quality) and utility of its research programs. This evaluation is required by the NRC Strategic Plan that was developed as mandated by the Government Performance and Results Act (GPRA). Since fiscal year (FY) 2004, the Advisory Committee on Reactor Safeguards (ACRS) has been assisting RES by performing independent assessments of the quality of selected research projects [1-7]. The Committee established the following process for conducting the review of the quality of research projects:

- RES submits to the ACRS a list of candidate research projects for review because they have reached sufficient maturity that meaningful technical review can be conducted

- The ACRS selects a maximum of four projects for detailed review during the fiscal year.

- A panel of three to four ACRS members is established to assess the quality of each research project.

- The panel follows the guidance developed by the ACRS full Committee in conducting the technical review. This guidance is discussed further below.

- Each panel assesses the quality of the assigned research project and presents an oral and a written report to the ACRS full Committee for review. This review is to ensure uniformity in the evaluations by the various panels.

- The Committee submits an annual summary report to the RES Director.

Based on discussions with RES in 2010, the ACRS made the following enhancements to its quality assessment process:

- After familiarizing itself with the research projects selected for quality assessment, each panel holds an informal meeting with the RES project manager and representatives of the User Office to obtain an overview of the project and the User Office's insights on the expectations for the project with regard to their needs.

- In addition, if needed, an additional informal meeting would be held with the project manager to obtain further clarification of information prior to completing the quality assessment.

The purposes of these enhancements were to ensure greater involvement of the RES project managers and their program office counterparts during the review process and to identify objectives, user office needs, and perspectives on the research projects.

An analytic/deliberative decisionmaking framework was adopted for evaluating the quality of NRC research projects. The definition of quality research adopted by the Committee includes two major characteristics:

- Results meet the objectives
- The results and methods are adequately documented

Within the first characteristic, the ACRS considered the following general attributes in evaluating the NRC research projects:

- Soundness of technical approach and results
  - Has execution of the work used available expertise in appropriate disciplines?

- Justification of major assumptions
  - Have assumptions key to the technical approach and the results been tested or otherwise justified?

- Treatment of uncertainties/sensitivities
  - Have significant uncertainties been characterized?
  - Have important sensitivities been identified?

Within the general category of documentation, the projects were evaluated in terms of the following measures:

- Clarity of presentation
- Identification of major assumptions

In this report, the ACRS presents the results of its assessment of the quality of the research projects associated with:

- Degradation of LWR Core Internal Materials Due to Neutron Irradiation
- Analysis of Experimental Data for High Burnup PWR Spent Fuel Isotopic Validation—ARIANE and REBUS Programs (UO_2 Fuel)

These two projects were selected from a list of candidate projects suggested by RES.

The methodology for developing the quantitative metrics (numerical grades) for evaluating the quality of NRC research projects is presented in Section 2 of this report. The results of the assessment and ratings for the selected projects are discussed in Section 3.

2 METHODOLOGY FOR EVALUATING THE QUALITY OF RESEARCH PROJECTS

To guide its review of research projects, the ACRS has adopted an analytic/deliberative methodology [8-9]. The analytical part utilizes methods of multi-attribute utility theory (MAUT) [10-11] to structure the objectives of the review and develop numerical scales for rating the project with respect to each objective. The objectives were developed in a hierarchical manner (in the form of a "value tree"), and weights reflecting their relative importance were developed. The value tree and the relative weights developed by the full Committee are shown in Figure 1.

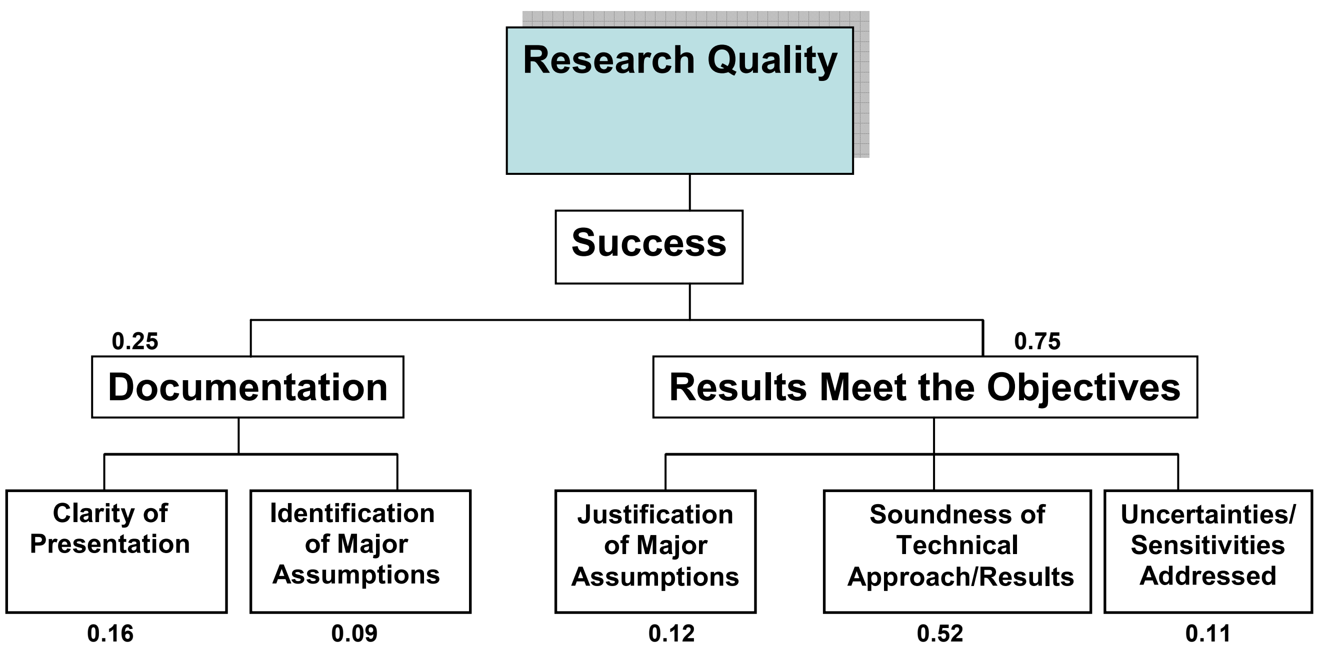

Figure 1 The value tree used for evaluating the quality of research projects

The quality of projects is evaluated in terms of the degree to which the results meet the objectives of the research and of the adequacy of the documentation of the research. It is the consensus of the ACRS that meeting the objectives of the research should have a weight of 0.75 in the overall evaluation of the research project. Adequacy of the documentation was assigned a weight of 0.25. Within these two broad categories, research projects were evaluated in terms of subsidiary "performance measures":

- justification of major assumptions (weight: 0.12)
- soundness of the technical approach and reliability of results (weight: 0.52)
- treatment of uncertainties and characterization of sensitivities (weight: 0.11)

Documentation of the research was evaluated in terms of the following performance measures:

- clarity of presentation (weight: 0.16)
- identification of major assumptions (weight: 0.09)

To evaluate how well the research project performed with respect to each performance measure, constructed scales were developed as shown in Table 1. The starting point is a rating of 5, Satisfactory (professional work that satisfies the research objectives). Often in evaluations of this nature, a grade that is less than excellent is interpreted as pejorative. In this ACRS evaluation, a grade of 5 should be interpreted literally as satisfactory. Although innovation and excellent work are to be encouraged, the ACRS realizes that time and cost place constraints on innovation. Furthermore, research projects are constrained by the work scope that has been agreed upon. The score was, then, increased or decreased according to the attributes shown in the table. The overall score of the project was produced by multiplying each score by the corresponding weight of the performance measure and adding all the weighted scores.

The value tree, weights, and constructed scales were the result of extensive deliberations of the whole ACRS. As discussed in Section 1, a panel of three ACRS members was formed to review each selected research project. Each member of the review panel independently evaluated the project in terms of the performance measures shown in the value tree. The panel deliberated the assigned scores and developed a consensus score, which was not necessarily the arithmetic average of individual scores. The panel's consensus score was discussed by the full Committee and adjusted in response to ACRS members' comments. The final consensus scores were multiplied by the appropriate weights, the weighted scores of all the categories were summed, and an overall score for the project was produced. A set of comments justifying the ratings was also produced.

Table 1. Constructed Scales for the Performance Measures

SCORE	RANKING	INTERPRETATION
10	Outstanding	Creative and uniformly excellent
8	Excellent	Important elements of innovation or insight
5	Satisfactory	Professional work that satisfies research objectives
3	Marginal	Some deficiencies identified; marginally satisfies research objectives
0	Unacceptable	Results do not satisfy the objectives or are not reliable

3. RESULTS OF QUALITY ASSESSMENT

3.1 Degradation of LWR Core Internal Materials Due to Neutron Irradiation

Structural materials used in the core regions of nuclear power plants face a daunting array of environmental challenges. Unlike materials used in the balance of plant, core materials operate under intense neutron irradiation in which both the material and the coolant are profoundly affected. Neutron irradiation permanently changes the microstructure and microchemistry of core materials by displacement of individual atoms, radiation-induced segregation of certain alloying elements, and formation of numerous defects in the crystalline lattice. The extent to which a core material is damaged by neutron irradiation is quantified by the "dpa" (displacements per atom) parameter. This parameter is a measure of the number of times that each atom in the material has been displaced from its equilibrium lattice position during service. During the 60 year licensed life of a high power density light water reactor (LWR), dpa of the order of 10 can be achieved. The defects produced by these displacements result in large increases in the strength of irradiated materials and corresponding decreases in ductility and fracture toughness, making these materials more susceptible to mechanical failure or to stress corrosion cracking.

Concurrently, neutron irradiation also dissociates the reactor coolant and creates highly oxidizing (transient and stable) chemical species. This further increases the potential for a unique form of stress corrosion known as IASCC (irradiation assisted stress corrosion cracking). IASCC is the most aggressive damage mechanism affecting the integrity of austenitic stainless steel core internals in operating LWRs, and is the NRC's major concern regarding the structural and functional integrity of these components.

To address IASCC and other radiation induced degradation phenomena unique to core internals, the staff initiated a broad literature review [12] at the Argonne National Laboratory (ANL). The scope of work was divided into two main tasks.

Task 1

- Review the existing open literature on IASCC susceptibility of austenitic stainless steels and identify knowledge gaps that need to be addressed

- Document important conclusions from earlier studies on materials and environmental conditions to:
    - identify the materials and environmental conditions that lead to significant neutron irradiation damage,
    - establish crack growth rates (CGR) for core internal materials,
    - evaluate the synergistic effects of radiation and thermal embrittlement under BWR and PWR operating conditions
    - evaluate the effects of void swelling and its effect on fracture toughness, and
    - evaluate the effectiveness of methods proposed by industry to mitigate radiation effects and identify deficiencies and knowledge gaps

- Propose a research plan that addresses the identified issues and knowledge gaps

Task 2

- Review two industry documents (MRP 227/175 and AMP on PWR internals)
- Prepare a report assessing these industry programs and provide recommendations regarding their sufficiency
- If insufficient, identify knowledge gaps and data needed for proper certification of the industry documents

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The results of Task 1 research are documented in NUREG/CR-7027, “Degradation of LWR Core Internal Materials Due to Neutron Irradiation” [13]. The scope of this quality review is limited to this report.

General Observations

The literature review prepared by Dr. O.K. Chopra of ANL and documented in NUREG/CR-7027 fully met the requirements in the Task 1 of the statement of work (SOW). The consensus scores for this project are shown in Table 2. The score for the overall assessment of this work was found to be 6.1 (more than satisfactory, a professional work that satisfies research objectives).

Table 2. Summary Results of ACRS Assessment of the Quality of the Project NUREG/CR-7027, “Degradation of LWR Core Internal Materials Due to Neutron Irradiation”

Performance Measures	**Consensus Scores**	**Weights**	**Weighted Scores**
Clarity of presentation	7	0.20	1.4
Identification of major assumptions	N/A	--	--
Justification of major assumptions	N/A	--	--
Soundness of technical approach/results	6	0.66	3.9
Treatment of uncertainties/sensitivities	5	0.14	0.7
		Overall Score	6.1

Comments and conclusions within the evaluation categories are provided below.

Clarity of Presentation (Score = 7.0)

The report is very well organized and well written. The Abstract, Forward, Executive Summary and Topical Summary are clear and concise. The objectives of the work are clearly stated, as are the major findings and conclusions. Gaps in available data are discussed in sufficient detail to be of value in assessing the adequacy of industry research and formulation of NRC research plans and regulatory guidance. With few exceptions, figures in the report are very readable and not overly busy.

The report addresses the major radiation damage phenomena: Irradiation Assisted Stress Corrosion Cracking, Neutron Embrittlement, Void Swelling and Stress Relaxation and Creep. For each phenomenon, key material properties and mechanisms affecting structural properties are critically reviewed. Consistent with the statement of work, the major issue of IASCC is thoroughly covered and constitutes approximately half of the 122 page report. Overall, the report presents a wealth of data and analyses which should be of great value to the NRC staff in the formulation of regulatory guidance and evaluation of operating plant issues.

Identification of Major Assumptions (Consensus Score –N/A)

This assessment category is not applicable for a literature review project. Weighting factors for the applicable categories used in the assessment have been normalized to account for this fact.

Justification of Major Assumptions (Consensus Score – N/A)

This assessment category is not applicable for a literature review project. Weighting factors for the applicable categories used in the assessment have been normalized to account for this fact.

Soundness of Technical Approach and Results (Consensus Score – 6.0)

This report provides an excellent review and analysis of 148 reports and publications from peer reviewed papers spanning the period from the late 1970s to the present. Papers and reports reviewed were authored by internationally recognized engineers and materials scientists active in the field of materials degradation research.

The approach taken by the author is sound and comprehensive. It incorporates materials science theory, laboratory data, and field experience to quantify to the extent possible, the influence of the many variables affecting the properties of core internals in operating LWR environments. While there are many variables in play, and many conflicting observations, the fundamental influence of the key variables have been assessed, and the limitations of the supporting research identified. These analyses have been used to:

- Identify the key material and environmental parameters that influence irradiation induced degradation of reactor core internal materials.

- Provide an improved understanding of the threshold fluence above which irradiation effects on IASCC susceptibility and mechanical properties are significant.

- Develop disposition curves for the cyclic and stress corrosion crack growth rates as a function of stress intensity for stainless steels and nickel based alloys used in LWR core internals.

- Evaluate the potential for radiation embrittlement of materials in wrought core materials as well as the synergistic effects of thermal and neutron embrittlement on cast austenitic stainless steels.

- Assess the effects of void swelling and its effect on fracture toughness.

- Evaluate the significance of stress relaxation due to irradiation creep on the functional integrity of core internal components.

Overall, this is a fine piece of work.

Treatment of Uncertainties/Sensitivities (Consensus Score – 5)

While this category is not strictly applicable to a literature review, the Committee has chosen to evaluate the "gaps in available data" identified in the ANL report as an equivalent category. These gaps are the source of uncertainties in the quantification of the effects of neutron irradiation on material properties. In the ANL report, major gaps are identified and discussed. For example, a significant amount of materials irradiation damage research has been, and continues to be, performed in fast reactors. The higher fluxes available in fast reactors allow materials irradiations to be performed in months rather than years. However, these higher neutron dose rates and harder spectrums produce differences in microstructure and microchemistry than observed in LWR irradiations. The report describes how these effects could significantly affect both neutron embrittlement and susceptibility to IASCC and lead to misleading conclusions when assessing the effects of neutron irradiation on the materials degradation in light water reactors. Similar discussions and insights are provided for each of the following major gaps:

1. Applicability of Fast Reactor Data to LWRs,
2. Microstructure and Microchemistry Characterization of PWR-Irradiated Materials,
3. Effect of Si Segregation on IASCC Susceptibility,
4. Validity of Proposed K/Size Criteria,
5. IASCC Crack Growth Rate Disposition Curve for PWR Core Internals,
6. Fatigue Crack Growth Rate,
7. IASCC Initiation,
8. Effect of Irradiation Temperature on Fracture Toughness,
9. Lower Bound Fracture Toughness of Irradiated Austenitic Stainless Steels,
10. Void Swelling and its effect on Fracture Toughness, and
11. Effect of Coolant Environment on Fracture Toughness.

Overall, this gap analysis is a valuable contribution to the understanding of the limitations of available data and provides a solid basis for planning future research.

3.2 Analysis of Experimental Data for High Burnup PWR Spent Fuel Isotopic Validation—ARIANE and REBUS Programs

The nuclear fuel currently discharged from U.S. commercial reactors is achieving progressively higher burnups by using higher initial fuel enrichments, improved fuel assembly designs, and more efficient fuel management schemes. The current trend is toward extended initial enrichments up to approximately 5.0 wt %, with extended irradiation cycles achieving around 70-80 GWd/MTU.

Many of the limits in the existing regulatory guidance related to spent fuel transport and storage have not kept pace with changing characteristics of spent fuel being discharged by the industry. For instance, most transport and storage casks in the United States are licensed for fuel up to 45 GWd/MTU. The NRC Regulatory Guide 3.54 on decay heat in independent spent fuel storage installations also has a burnup limit of 50 GWd/MTU for PWR fuel and 45 GWd/MTU for BWR fuel. The Interim Staff Guidance ISG-8 for burnup credit was only recently extended in 2003 to allow burnup credit up to 50 GWd/MTU. These limits are based on the very limited experimental data available for validating computer predictions of the isotopic composition of high burnup spent fuel.

Access to new experimental data is seen as a key prerequisite to understanding and reducing the uncertainties associated with high burnup fuel characterization. The NRC has sponsored a research project at the Oak Ridge National Laboratory (ORNL) through which ORNL will participate in international programs designed to acquire new experimental assay data; analyze the data using domestic computational tools; and evaluate the data to quantity the uncertainties in predicted decay heat, radiation source terms, and nuclide concentrations used in burnup credit.

The NUREG/CR-6969 report, "Analysis of Experimental Data for High Burnup PWR Spent Fuel Isotopic Validation—ARIANE and REBUS Programs," [14] is part of a series that documents high-quality radiochemical assay data against which computer code predictions of the isotopic composition in high burnup fuel can be validated. The scope of this quality review is limited to this report. The report documents the analysis of experimental data acquired by ORNL through participation in two international programs: (1) ARIANE (Actinides Research In A Nuclear Element) and (2) REBUS (Reactivity Tests for a Direct Evaluation of the Burnup Credit on Selected Irradiated LWR Fuel Bundles). Evaluating the computer model predictions in these new domains of increased burnup is fundamental for understanding and reducing the uncertainties associated with predicting the high burnup fuel characteristics for spent fuel transportation and storage applications involving decay heat, radiation sources, and criticality safety evaluations with burnup credit, as well as for reactor safety studies and accident consequence analyses.

General Observations

The consensus scores for this project are shown in Table 3. The score for the overall assessment of this work was found to be 5.1 (satisfactory, a professional work that satisfies research objectives). Comments and conclusions within the evaluation categories are provided below.

Table 3. Summary Results of ACRS Assessment of the Quality of the Project, "Analysis of Experimental Data for High Burnup PWR Spent Fuel Isotopic Validation—ARIANE and REBUS Programs"

Performance Measures	Consensus Scores	Weights	Weighted Scores
Clarity of presentation	6.3	0.16	1.01
Identification of major assumptions	5.0	0.09	0.45
Justification of major assumptions	4.7	0.12	0.56
Soundness of technical approach/results	5.0	0.52	2.6
Treatment of uncertainties/sensitivities	4.7	0.11	0.52
		Overall Score	5.1

Clarity of Presentation (Consensus Score – 6.3)

The report is well organized and well-written. A primary purpose of the document is to archive experimental data and sufficient detail on assembly and irradiation history to permit independent calculation and comparison of results. This purpose is achieved. A comparison of computed results with experiments is presented, but no systematic assessment of the codes is presented. That presumably will be done in a subsequent report when additional experimental results are available.

Identification of Major Assumptions (Consensus Score – 5)

Many assumptions are not identified. For example, the most critical assumption that the selected data are appropriate for the evaluation of high burnup effects is unstated and is outside the scope of the report. The accuracy of the experimental measurements is that reported by the experimenters. There is an implicit assumption, presumably based on prior experience, that the measurements are indeed reliable. The identification of the assumptions in the sections on fuel assembly and irradiation history data and computational models is good.

Justification of Major Assumptions (Consensus Score – 4.7)

The justification of many assumptions is purely qualitative and judgmental, e.g., arguments of the sort “the replacement rods were indicated to have burnup similar to that of the original rods and not modeling the fuel rods reconfiguration was deemed to be of minor importance” without a supporting sensitivity calculation.

Soundness of Technical Approach/Results (Consensus Score – 5.0)

The report is straightforward. The data, as reported by the primary experimenters, are presented. The necessary information on assembly and irradiation history is presented along with any additional assumptions that must be made in order to carry out a computational estimate of the results. The results of the computations are presented and compared to the experimental results. The experimental uncertainties are those reported by the primary experimenters. For one sample, measurements were made at two laboratories. However, the only results reported for this sample are consensus results developed by a team of experts. It would have been very helpful to have the actual results from the two laboratories so that the differences could be compared with the uncertainties in the experimental measured reported by the laboratories. Similarly even when the two laboratories are using the same experimental technique, there are surprisingly large differences in the uncertainties reported by the laboratories. For example, the 95% uncertainty in the measurement of U-234 by one laboratory is 5.02%, and for the other laboratory, it is 0.02%. The report should discuss the reasons for such large differences.

The comparison of the experimental results is reported strictly in terms of the relative difference between the computed values and the reported experimental values. This is a good measure of the difference between the computed value and the true value only when experimental errors are small. It would have been helpful to also have tables where the relative difference in the computed and experimental results is compared with the reported experimental error.

The TRITON module of the SCALE code was used for the code-to-data comparisons. The report should provide more background information about the adequacy of the computational tools used in this effort and how they compare with other tools for such applications. It is noted that the authors did provide some insights when they note in Section 6.1, “...results of the comparison in the case of samples GU3 and GU4 are consistent with the results of a previous analysis using the HELIOS code.”

No criteria for the adequacy of the comparisons between the computed results and the experiments are cited. The authors should provide some perspective about the cited results, which range from 1 to 6% for uranium and plutonium nuclides and from 1 to 30% for other nuclides.

Treatment of Uncertainties/Sensitivities (Consensus Score – 4.7)

The cited experimental uncertainties are those reported by the primary experimenters. These are assumed to be accurate by the authors. Inclusion of the two sets of results for the one specimen examined by two laboratories would have provided insight into the adequacy of this assumption.

As noted previously, in a number of cases assumptions are made in the analysis that certain effects are small without supporting analytical sensitivity analysis.

While the difference between the computed and observed results are reported, no uncertainty analysis was performed using the model to assess how much of the differences could be attributed to uncertainties in the input parameters and how much was actual model error.

4. REFERENCES

1. Letter Dated November 18, 2004, from Mario V. Bonaca, Chairman, ACRS, to Carl J. Paperiello, Director, Office of Nuclear Regulatory Research, NRC, Subject: ACRS Assessment of the Quality of Selected NRC Research Projects.

2. Letter Dated November 5, 2005, from William J. Shack, Acting Chairman, ACRS, to Carl J. Paperiello, Director, Office of Nuclear Regulatory Research, NRC, Subject: ACRS Assessment of the Quality of Selected NRC Research Projects - FY 2005.

3. Letter Dated October 17, 2006, from Graham B. Wallis, Chairman, ACRS, to Brian Sheron, Director, Office of Nuclear Regulatory Research, NRC, Subject: ACRS Assessment of the Quality of Selected NRC Research Projects - FY 2006.

4. Letter Dated October 19, 2007, from William J. Shack, Chairman, ACRS, to Brian Sheron, Director, Office of Nuclear Regulatory Research, NRC, Subject: ACRS Assessment of the Quality of Selected NRC Research Projects - FY 2007.

5. Letter Dated October 22, 2008, from William J. Shack, Chairman, ACRS, to Brian Sheron, Director, Office of Nuclear Regulatory Research, NRC, Subject: ACRS Assessment of the Quality of Selected NRC Research Projects - FY 2008.

6. Letter Dated September 16, 2009, from Mario V. Bonaca, Chairman, ACRS, to Brian Sheron, Director, Office of Nuclear Regulatory Research, NRC, Subject: ACRS Assessment of the Quality of Selected NRC Research Projects - FY 2009.

7. Letter Dated November 15, 2010, from Said Abdel-Khalik, Chairman, ACRS, to Brian Sheron, Director, Office of Nuclear Regulatory Research, NRC, Subject: ACRS Assessment of the Quality of Selected NRC Research Projects - FY 2010.

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Letter to Dr. Brian Sheron, Director, RES, from S. Abdel-Khalik, ACRS Chairman, dated September 19, 2011

SUBJECT: ACRS ASSESSMENT OF THE QUALITY OF SELECTED NRC RESEARCH PROJECTS- FY 2011

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