UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 8, 2016

Dr. Dennis C. Bley, Chairman
Advisory Committee on Reactor Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: REVIEW AND EVALUATION OF THE NUCLEAR REGULATORY COMMISSION SAFETY RESEARCH PROGRAM

Dear Dr. Bley:

On behalf of the U.S. Nuclear Regulatory Commission (NRC), I am responding to your letter dated April 28, 2016, enclosing Volume 12 of NUREG-1635, "Review and Evaluation of the Nuclear Regulatory Commission Safety Research Program."

I want to express my appreciation to the Advisory Committee on Reactor Safeguards (ACRS) for its valuable review and evaluation of NRC's safety research program. Throughout the years, the ACRS's evaluations and suggestions have helped to improve the program.

The agency appreciates your affirmation that the strategy for prioritizing research subjects through the User Need process has worked well and that the process has generated useful products in a timely manner. I also appreciate the ACRS's emphasis of the importance of collaborative research activities to leverage agency resources and to share knowledge and experience that contribute to intermediate and long-term research objectives. The agency will continue to use the Committee's review in guiding our research program.

The ACRS review highlights the importance of careful consideration of the potential impacts of Project Aim reduction to NRC research activities. The agency plans to maintain the NRC core competencies in key technical areas as reflected in the agency's strategic workforce plan. I want to assure you that the staff thoroughly evaluated the impacts of rebaselining to preserve our technical competency and also to ensure the effectiveness and efficiency of the agency's program.

The enclosure contains the NRC staff responses to the ACRS's specific observations and recommendations. We will consider your recommendations as we execute the research program and develop research plans and budgets for upcoming fiscal years.

I look forward to continued interactions with the ACRS and thank the Committee for its review and recommendations.

Sincerely,

Victor M. McCree
Executive Director
for Operations

Enclosure:
As stated

cc: Chairman Burns
Commissioner Svinicki
Commissioner Baran

NRC STAFF RESPONSES TO RECOMMENDATIONS
ON SPECIFIC RESEARCH ACTIVITIES CONTAINED IN
NUREG-1635, VOL. 12, "REVIEW AND EVALUATION OF THE NUCLEAR
REGULATORY COMMISSION SAFETY RESEARCH PROGRAM"

On April 28, 2016, the Advisory Committee on Reactor Safeguards (ACRS) submitted a letter to Chairman Burns enclosing Volume 12 of NUREG-1635, "Review and Evaluation of the Nuclear Regulatory Commission Safety Research Program." That report contains a number of observations and recommendations about the U.S. Nuclear Regulatory Commission's (NRC's) safety research program. The NRC staff responses follow below.

CHAPTER 3 – DIGITAL INSTRUMENTATION AND CONTROL SYSTEMS

The staff will evaluate ACRS's recommendation to initiate a research program on software and hardware based voting units in the NRC Instrumentation and Controls (I&C) Systems Research Plan currently under development. If this research program is incorporated into the Research Plan, the staff will coordinate with the Digital I&C Steering Committee and other stakeholders as to how the results from the research should inform the agency's regulatory infrastructure modernization activities in accordance with the Integrated Action Plan transmitted to the Commission in SECY-16-0070.

The staff will evaluate ACRS's recommendation to initiate a research program that evaluates completion of diagnostics in the NRC I&C Systems Research Plan currently under development. If this research program is incorporated into the Research Plan, the staff will coordinate with the Digital I&C Steering Committee and other stakeholders as to how the results from the research program should inform the agency's regulatory infrastructure modernization activities in accordance with the Integrated Action Plan.

The staff will evaluate ACRS's recommendation to develop a research program to evaluate one-way hardware based data transmission in the NRC I&C Systems Research Plan currently under development. If this research program is incorporated into the Research Plan, the staff will coordinate with the Digital I&C Steering Committee and other stakeholders as to how the results from the research program should inform the agency's regulatory infrastructure modernization activities in accordance with the Integrated Action Plan.

CHAPTER 4 – FIRE SAFETY

The staff agrees with the ACRS's recommendation to continue support for research on the High Energy Arc Faults (HEAF) project, also known as Joint Analysis of Arc Faults. The Commission in Staff Requirements Memorandum (SRM) for SECY-16-0009 directed the staff to continue this work. This item is currently being reviewed for applicability as a generic issue.

Through SRM-SECY-16-0009, "Recommendations Resulting from the Integrated Prioritization and Re-Baselining of Agency Activities" (ML16104A158), the staff recommended and the Commission agreed to shed further research activities in number of fire safety areas effective in

FY 2017. Therefore, many efforts, including testing and experimentation, fire prediction model development, issues related to the effects from fire, heat, and smoke on digital equipment, performance of fire detection systems under complex geometries, performance of incipient detection systems, performance of fire sprinkler systems under highly obstructed conditions, and performance of fire sprinkler systems against a large oil pool fire are not planned for the foreseeable future. The staff will continue collaborative efforts with U.S. industry and international organizations as resources allow.

CHAPTER 5 – REACTOR FUEL

The staff agrees with the ACRS's observation that fuel failures during normal operation or anticipated operational occurrences (AOOs) do not present a safety concern. With regard to design basis accidents, the staff clarifies that the "allowed" equivalent cladding reacted (ECR) for loss-of-coolant accidents (LOCAs) has not been decreased and remains at 17 percent pending the Commission consideration of the 10 CFR 50.46c draft final rulemaking.

The staff agrees with the ACRS position that experimental work on pellet cladding interaction (PCI) can be terminated. The NRC considers its experimental work effectively completed. The staff notes that international interest continues in computing the PCI phenomenon. Residual work on PCI is being championed by other international organizations, not NRC, and does not constitute a significant portion of the program's budget.

The staff agrees with the ACRS's observation and prior recommendations on 10 CFR 50.46c rulemaking. The research effort started with the issuance in 1998 of the Agency Program Plan for High-Burnup Fuel (ADAMS: ML011380085) and, as noted by the ACRS, has provided a solution to an important safety-related issue.

CHAPTER 6 – HUMAN FACTORS AND HUMAN RELIABILITY

The NRC staff agrees with the ACRS's recommendation to better understand human performance under extreme conditions to support human reliability analysis (HRA) for severe accidents that go beyond the emergency operating procedures (EOPs), severe earthquakes that damage the plant, and severe fire and smoke condition. The staff has undertaken several projects to better understand extreme conditions and to provide tools for the regulatory staff to handle these conditions. We have a project underway that is looking into human performance issues associated with extreme weather phenomena and are evaluating and characterizing human actions in these situations. The staff is developing the IDHEAS General Methodology to model human responses including those in extreme conditions. In December 2015, the staff modeled human performance actions for Fukushima Unit 1 using a draft of the IDHEAS-G methodology. For severe fire and smoke conditions, the staff is currently updating NUREG-1921, Fire Human Reliability Analysis (HRA) guidance to add information on modeling main control room abandonment. In addition, the staff has used the draft IDHEAS-G method to expand upon the work done on seismically induced spent fuel pool accidents to support work on decommissioning rulemaking activities. With this work, the staff modeled severe earthquakes as well as other credible extreme condition events. Finally, the staff supports the international efforts under the Organization for Economic Cooperation and Development/Nuclear Energy Agency/Committee on the Safety of Nuclear Installations (OECD/NEA/CSNI) Working Group on Human and Organizational Factors task proposals that are being developed to (1) gather human performance lessons-learned from Fukushima and (2) show how to develop organizational resilience to handle severe accidents and extreme conditions.

The staff agrees that more human factors and human performance work should be done in medical applications, activities that support vulnerability assessments, and digital instrumentation and control, as funding allows. The staff is currently looking for creative, low-cost methods of expanding in these areas, while implementing the agency's decision on rebaselining. Moreover, with respect to safety culture, the staff supports international efforts to monitor and track safety culture and supports outreach to licensees in the implementation of the NRC's safety culture policy statement. The staff also plans to update NUREG-2114 cognitive basis report for HRA to include safety culture, teamwork, and distributed decision-making research. This could allow for the potential inclusion of safety culture aspects into HRA modeling if the agency sees a need for this capability.

CHAPTER 7 – MATERIALS AND METALLURGY

The staff agrees with the ACRS's recommendation for the NRC to participate actively in International Cooperative Group on Environmentally Assisted Cracking (ICG-EAC). The staff recognizes the value of the ICG-EAC and understands that it provides unique opportunities for engagement with domestic and international counterparts performing research in the field of environmentally assisted cracking. The staff and contractors typically attend the annual meeting to provide updates on the status of NRC-sponsored programs and to seek opportunities for mutually beneficial information exchanges with other organizations. The cognizant staff will continue to actively participate in this group. However, in absence of attendance at the meetings, the staff may seek lower-cost alternatives.

The staff agrees with the ACRS's recommendation to complete the Extremely Low Probability of Rupture (xLPR) and pressurized thermal shock (PTS) efforts as expeditiously as possible. The PTS effort is expected to conclude in the next couple of months. The staff briefed the ACRS materials subcommittee on May 3, 2016, on the PTS regulatory guide public comment resolution. A full committee brief is expected in the next several months. The staff will publish the final Regulatory Guide and supporting NUREG after that meeting. The xLPR Version 2.0 developmental effort is scheduled to conclude in September of this year with the release of the Version 2.0 code. Current staff efforts are focused on verification and validation testing and the development of a maintenance, support, distribution, and Users Group structure for the Version 2.0 code. The goal is to have this structure in place by the Version 2.0 release date.

The ACRS noted that there is little justification for further research in the steam generator area with the exception of special cases that may arise in the future. The staff agrees. The staff sees the current on-going research coming to completion in the 2019 timeframe. Any future research, consistent with the on-going research, will be focused on special cases (e.g. research associated with emerging NDE technology). The ACRS report also indicated that all mill-annealed steam generators have been replaced. Based on the latest information, there are 3 units operating with mill-annealed Alloy 600 tubes. Although Alloy 690 has not shown indications of cracking in field use, several key areas of uncertainty remain in steam generator operation as a whole. The current research program includes evaluation of eddy current software and automated analysis, validation of the equivalent rectangular crack method and the effectiveness of eddy current inspection due to probe wear, and the ability of eddy current testing to identify and characterize cracks. These tasks are important to the technical basis and may impact the inspection criteria. The staff's recently completed research on cracking near volumetric indications resulted in the industry changing their guidelines to state that if cracking could be occurring near volumetric indications, then rotating probe examinations (or equivalent) should be performed.

SGTIP has also resulted in industry changing protocols for inspecting loose parts near the top of the tubesheet. It was determined that bobbin coil inspections were not reliable in detecting loose parts or loose part wear near the top of the tubesheet, which led to inspection changes at several sites. In addition, as part of this program, TIP-5, the fifth generation of the international collaboration on steam generators, has provided international Operating Experience, identification of existing and current research related to NRC interests, and collaborative discussion among world experts in tube integrity. As part of TIP-5, both the NRC and the Electric Power Research Institute (EPRI) participate and share information with industry either directly or through the semi-annual meeting of the Steam Generator Task Force to ensure that licensees and NRC stay abreast of emergent issues. SGTIP is currently reducing scope as tasks are completed and closed out. However, research still remains to be completed and it will provide valuable input into the technical basis during 2017-2019.

The staff agrees with the ACRS's recommendation that going forward, long-term efforts should be focused on issues that are related to license extensions and, more importantly, subsequent license renewal (SLR). The staff is addressing the following long-term issues:

- The NRC is working closely with EPRI and their ongoing efforts to obtain high-fluence reactor pressure vessel (RPV) material data. It is expected this data will be pulled from capsules around 2025 and will be used to validate the current embrittlement trend curves. In the meantime, the staff is continually adding surveillance data to the Reactor Embrittlement Archive Project (REAP) database as it becomes available and is conducting a review of the technical adequacy of Regulatory Guide 1.99. The staff will publish a report by the end of calendar year 2016.

- The staff is actively performing experimental research through both cooperative research with EPRI, Halden and other stakeholders as well as limited independent NRC testing to characterize and test high fluence ex-plant materials including plates and welds. The staff expects final results from these programs in 2017 (plate up to 50 displacements per atom (dpa)) and 2018 (welds up to 2 dpa).

- The staff is actively performing experimental research on cast stainless steels (CASS) to determine the effect of neutron dose (3.5 dpa) on the mechanical strength and fracture toughness of CASS. Argonne National Laboratory is conducting the experimental work and expects a 2017 completion date. The staff will develop an approach to applying probabilistic risk assessment (PRA) for the evaluation of cask systems and to identify issues for which additional research is needed, recognizing that the risks associated with dry cask storage are relatively low.

- The staff is participating in assessing the public health risks from dry cask storage. For example, the Level 3 PRA project directed by SRM-SECY-11-0089 includes specific consideration of the risk arising from dry cask storage. In addition, the staff plans to further define potential areas of future collaboration in this area.

CHAPTER 8 – NEUTRONICS AND CRITICALITY SAFETY

The staff appreciates the continued support of the ACRS for the staff's ongoing activities in the neutronics and criticality safety areas and the recognition that the staff conducting research in these areas constitute critical agency core capability. The staff supports the ACRS's conclusion that this capability should not erode due to limited resources and staff retirement and that baseline funding is therefore needed. In addition to providing licensing and confirmatory analyses tools in the areas of reactor physics and spent nuclear fuel management, this research area supports several important research programs including the fuel cycle planning, fuel rod mechanical and thermal analysis, and high-burnup fuel performance and safety evaluations. By maintaining competency with the current state-of-the-art tools, consisting primarily of the SCALE suite and the PARCS computer codes and the staff experts who use the codes, the agency is able to influence the prioritization of new features in its state-of-the-art computational tools. Expanded application capability for existing and advanced reactors and improved computational efficiency and accuracy are among the highest priorities.

The staff concurs with the ACRS's assessment of current research activities. For example that additional sensitivity and uncertainty analyses would help facilitate the staff's understanding and assessment of the impact of the licensees' continued optimization of core and fuel designs and their supporting methodology and analyses. The SCALE code suite includes the TSUNAMI and SAMPLER sensitivity and uncertainty modules that have been used to gain a better understanding of the impact of the various materials and features on safety analysis results and to provide a quantified and defensible penalty estimate to cover validation gaps and deficiencies. This is especially important for applications for which measurements or experimental data are lacking such as small modular reactors, new light-water reactors (LWRs), as well as Mo-99 production facilities and non-LWR advanced reactors. Ongoing and planned updates to the existing uncertainty and sensitivity analysis capability will ensure continued improvement of NRC's review of licensee calculation results.

The staff appreciates the ACRS's assessment that the burnup credit methodology developed for PWRs to improve isotopic composition analyses and criticality predictions represents a key success. This success was due in part to our access to measurements and experimental data and benchmarks from the OECD/NEA International Criticality Safety Benchmark Evaluation Project (ICSBEP) and the International Reactor Physics Experiment Evaluation Project (IRPhE). The staff supports the ACRS's recommendation that participation in the international groups should continue as the NRC develops a similar burnup credit methodology for boiling-water reactors (BWRs).

The staff also appreciates the ACRS's assessment of the importance of confirmatory coupled neutronic/thermal hydraulic calculations to inform staff technical review of BWR power extended power uprates (EPUs) in the MELLLA+ operating domain. Staff were able to develop sophisticated simulations and visualizations with TRACE/PARCS that informed complex BWR operating behavior during ATWS scenarios in the MELLLA+ domain. These types of calculations will become more important as fuel vendors, licensees, and reactor designers move towards more complex, optimized, and heterogeneous fuel designs. In addition, core physics analysis (PARCS), with the use of SCALE/TRITON and SCALE/Polaris, is used to separately initiate exposure-specific coupled neutronics/thermal-hydraulic analysis. PARCS models are used to inform staff review of core designs and operating regimes with respect to shutdown margin and reactivity control at all points in cycle (10 CFR Part 50 Appendix A, GDC Criteria 26 through 28). It is important for RES to maintain staff and contractor resources to enable staff to review both Small Modular Reactor (SMR) and large PWR designs (APR-1400 design certification). This is a critical competency.

Finally, the staff is pleased with the ACRS's support of its ongoing and planned activities to modify and extend the existing NRC codes and methods.

CHAPTER 9 – OPERATIONAL EXPERIENCE

The ACRS recommended that staff examine the impact of uncertainty in success data in their applications and analyses, and noted that the previous volume of NUREG-1635 (volume 11) also recommended this. ACRS also noted that NUREG/CR-5500, Volumes 1-11, provided industrywide failure rate estimates for a variety of equipment, and further recommended that this previous work be expanded to fully incorporate these uncertainties. The NRC staff notes that limitations in the reporting of primary performance data cannot be completely overcome. For example, uncounted demands results, along with more accurate reporting of failures, tends to result in an overestimate of the probability of failure-on-demand. Conversely, an overly optimistic estimate of run times could result in underestimated failure frequency for normally operating equipment. As long as these reporting issues do not result in too unrealistic failure frequencies, it is not considered to be an impediment to successful risk analyses by the NRC staff. Uncertainty in failure rate estimates need to be considered, acknowledged, and managed within the framework of risk-informed decision-making, but the staff believes that formal efforts to assess uncertainties in this area would not lead to a significant improvement in regulatory oversight.

CHAPTER 10 – PROBABILISTIC RISK ASSESSMENT

Probabilistic Risk Assessment (PRA) was a primary focus of the ACRS review and, consequently, of the staff's response to that review. The staff recognizes the usefulness and potential benefits of performing a pilot application of a risk-informed licensing framework for new reactor designs. Such a pilot of the guidance developed under NUREG-1860 was described in SECY-11-0024, "Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews," dated February 11, 2011 (ML110110688). However, in a January 30, 2014, memo to the Commission (ML13212A222), the staff concluded that it "cannot justify further efforts to develop a technology-neutral regulatory structure as an agency priority" and "will not conduct pilot studies in which a technology-neutral regulatory structure will be considered for iPWR and non-LWR application-related activities." As a result, the staff terminated efforts to further develop a risk-informed, technology-neutral framework for new reactor licensing and ceased activities related to performance of a pilot application. Therefore, pending a change in agency priorities in this regard, further work to develop and pilot a risk-informed, technology-neutral, licensing framework has been suspended. However, the staff documented lessons learned from preparatory work for an iPWR pilot application in a gap study (ML13224A338) that could support future work should licensing office needs change in the future.

The staff appreciates ACRS's support of collaborative research programs with external organizations such as EPRI, the National Oceanic National Oceanic and Atmospheric Administration (NOAA), and the National Aeronautics and Space Administration (NASA), as well as university programs. These programs, particularly university research, provide a unique opportunity to gain access to state-of-the-art research and beneficial research results for the agency's PRA programs. The staff will continue to support these programs in a manner consistent with budget priorities. The specific recommendation of continued coordination with EPRI on digital I&C PRA methods is covered under the NRC-EPRI Memorandum of Understanding (MOU), and the staff has supported joint NRC-EPRI ACRS briefings on digital I&C research in the past. The staff agrees that a pilot application would be an efficient way to test and further refine potential digital I&C PRA methods in the future. However, through SRM-SECY-16-0009, "Recommendations Resulting from the Integrated Prioritization and Re-Baselining of Agency Activities" (ML16104A158), the staff recommended and the Commission agreed to terminate further research activities in the digital I&C PRA area effective in FY 2017. Therefore, such a pilot activity is not planned for the foreseeable future.

The staff agrees to explore ways to increase the engagement of regional and headquarters staff in Standardized Plant Analysis Risk (SPAR) model maintenance and related Reactor Oversight Process (ROP) support activities. The staff also appreciates ACRS's support of research projects that would advance the state-of-the-art in risk assessment methods and practices. However, the regional and headquarters offices currently lack the necessary PRA staff and resources to fully share these technical support activities. Moreover, developing this capability would likely divert resources from higher priority tasks in support of the ROP and licensing activities. In addition, sharing of this work among a number of regional and headquarters offices would result in increased inefficiencies and would significantly increase overall program costs. Advantages of the current centralized approach for SPAR model maintenance and development include: (1) minimizing the number of highly skilled staff needed to support the program, (2) increased consistency across the SPAR models, (3) better version and configuration control, and (4) the ability to more fully integrate the SPAR models with other PRA-related activities such as data collection, system studies, and new modeling improvements (e.g., support system initiators and enhanced loss of offsite power modeling).

The staff appreciates the ACRS recommendation to increase the priority for SPAR-AHZ and low power and shutdown model development. The staff continues to prioritize SPAR activities consistent with the priorities established by NRR to ensure the SPAR models can meet mission-related needs. Although the staff plans on continuing SPAR-AHZ development in future years, in addition to limited low-power and shutdown work, the resources associated with this work have been reduced as a result of staff recommendations and Commission decisions made in SRM-SECY-16-0009, "Recommendation Resulting from the Integrated Prioritization and Re-baselining of Agency Activities." The staff will continue to look for opportunities to improve SPAR modeling in areas beyond internal events, at power.

The staff appreciates that the ACRS has noted the value of developing new reactor SPAR models. The staff prioritizes the development of new reactor SPAR models in close coordination with NRO based on available agency resources and future regulatory needs. At the current time, development of an ESBWR SPAR model has been prioritized at a lower effort than SPAR activities supporting the startup of the AP1000 reactors at the V.C. Summer Units 2 and 3 and Vogtle Units 2 and 3 sites, which are actively being constructed. The staff will continue to identify future new reactor SPAR model needs and appropriately prioritize this work in the future.

As noted, the staff recently completed a major update to NUREG-1855 (i.e., Revision 1). This revision included additional guidance on identifying and characterizing the uncertainties associated with PRA, performing uncertainty analyses to understand the impact of the uncertainty on the PRA results and, most importantly, how to factor the results of the uncertainty analyses into risk-informed decision-making. Moreover, EPRI has developed companion reports to NUREG-1855. These EPRI reports provide guidance on detailed and approximate methods for parameter uncertainties, particularly with regard to the state-of-knowledge correlation. In addition, the reports provide specific methods for identifying key sources of uncertainties (associated with both internal and external hazards) within the context of significant contributors to the various risk metrics that are relevant to a particular application. To support the use of this guidance, training is being developed to assist decision makers in understanding the sources of uncertainty and how to factor uncertainty into regulatory decision-making for risk-informed activities.

The staff is working to better understand current security-related regulatory needs and currently available tools (including vulnerability assessment tools being used by the nuclear power industry and the Department of Energy) that may be used in assessing risk for nuclear security. As needs are identified, this may lead to the development of research projects that start applying the fundamental risk assessment framework and analysis techniques used for nuclear safety issues to the risk assessment of nuclear security issues (both physical and cyber). Recognizing some fundamental differences exist in the availability of information, the nature of the hazard/threat (e.g., the adaptability of the security threat to the facility protection scheme), and stakeholder viewpoints regarding the usefulness of risk assessment results in support of decision-making, it is clear that safety-oriented approaches will need to be adapted for security applications and that significant challenges remain in developing appropriate adaptations. The magnitude and specific nature of these challenges will vary with application; it is anticipated that future work will pursue application-specific solutions before the development of a more generic framework.

The staff agrees that a potential role exists for risk-informed approaches in the decommissioning of licensed facilities and waste disposal. The staff will continue to discuss needs in this area with the program offices and will engage in research activities consistent with priorities and resources. In addition, the staff agrees that this research area may constitute an additional strategic goal in the PRA research arena, and such an identification would highlight the need to consider future research activities in this area.

The staff agrees that the results of the Level 3 PRA project will be a valuable input to the general decision-making on future work for areas that are informed by the project. This usage is consistent with the objectives of the project, which include extraction of new risk insights to enhance regulatory decision-making and help focus limited agency resources (see SECY 12 0123, "Update on Staff Plans to Apply the Full-Scope Site Level 3 PRA Project Results to the NRC's Regulatory Framework").

CHAPTER 11 – RADIATION PROTECTION

The staff appreciates the ACRS endorsement of the current NRC research activities in the area of radiation protection. These activities include development and maintenance of health effect/dose calculation tools, emerging health effects and dosimetry research, and participation in a number of national and international collaborative radiation protection activities.

In addition, the staff released a new version of the Radionuclide Transport, Removal and Dose Estimate code (RADTRAD) in March 2015 under the Symbolic Nuclear Analysis Package

(SNAP) Model Editor graphical user interface. This newer version of the RADTRAD code is now called SNAP/RADTRAD and was developed by RES in close collaboration and under a User Need Request from NRR. All the components of SNAP/RADTRAD are written in the modern computer language of Java. In addition, with SNAP/RADTRAD's incorporation into the Radiation Protection Code Analysis and Maintenance Program (RAMP), new developments in the science of radionuclide behavior and transport from both international and domestic members will be supported by the services offered to SNAP/RADTRAD users by RAMP.

CHAPTER 12 – NUCLEAR MATERIALS AND WASTE

The staff is participating in limited research activities to better understand the public health risks from dry cask storage. For example, the Level 3 PRA project directed by SRM-SECY-11-0089 includes specific consideration of the risk arising from dry cask storage. In addition, the staff plans to continue to define potential areas of future collaboration in this area, although these efforts will be limited.

CHAPTER 13 – SEISMIC AND STRUCTURAL ENGINEERING

The staff appreciates the feedback on the seismic research plan and agrees with the assessment that this program will adequately support the NRC staff's capabilities to evaluate potential risks to U.S. nuclear power plants due to events such as earthquakes and tsunamis. The staff is involved in efforts to improve assessment of the seismic hazard at new and existing nuclear power plants. Collaborative efforts have resulted in a new seismic source characterization (SSC) model for the Central and Eastern United States (CEUS) and ongoing development of a ground motion attenuation model for the CEUS (NGA-East). Selected ongoing activities include enhancing the capability of probabilistic seismic hazard assessment (PSHA) software to perform seismic hazard calculations using the CEUS-SSC model and the latest ground motion attenuation relationships; developing software to improve modeling of local site amplification effects; further developing guidance on the treatment of uncertainty and the use of experts in hazard assessment; understanding the phenomenon of paleo-liquefaction as an aid in predicting large, but rare, earthquakes in the CEUS region; and developing probabilistic methods to evaluate landslide-based tsunami sources to support a new regulatory guide on tsunami hazard assessment.

The staff anticipates a renewed emphasis on the research related to seismic fragility assessment of structures, systems, and components of nuclear power plants to support review guidance for the seismic reevaluations of operating reactors as well as licensing of new reactors. To inform and support subsequent license renewal guidance, the staff is updating and revising aspects of its structural engineering program to improve understanding of containment degradation. This includes loss of tendon pre-stress, irradiation effects on concrete structures, and alkali silica reaction (ASR) degradation of concrete structures. In addition, RES plans to continue confirmatory assessments of analysis methods and software that inform the review of impact loads on spent nuclear fuel transportation casks, security-related regulatory activities, and structural aspects of severe accident studies.

The staff is working with the partner offices updating the Seismic and Structural Research Plan to reflect the completion of certain projects and the basis and framework for new projects.

CHAPTER 14 – SEVERE ACCIDENTS AND SOURCE TERM

The staff concurs with the ACRS's observation that severe accident research is an essential component of the agency's research and investment to develop the computational tools and experimental databases used to support code development and validation. The staff also concurs with the ACRS's recommendation that research activities be maintained to meet the agency's current and anticipated needs. To this end, the staff is working closely to best use available resources to enhance the code capabilities to provide the technical basis for safety and security applications.

The staff agrees with the ACRS's view that the effort to preserve the agency's severe accident competency is a challenge. A research plan is currently in development and once finalized, this plan should help maintain future core competency in this area. The staff acknowledges the ACRS's encouragement that the agency continue to address succession planning concerns related to maintaining severe accident expertise. The staff appreciates the ACRS's recognition of knowledge management efforts to preserve and provide to others the insights gained from severe accident research. To address this, the staff is conducting seminars and will continue to identify additional knowledge management efforts in the future.

The staff recognizes that severe accident calculation methodologies are subject to uncertainties due to limitations in understanding phenomena or calculation limitations. These uncertainties are addressed by performing uncertainty analyses or sensitivity calculations to quantify the effect of uncertainty on the results. This uncertainty can be reduced by further experimental data for calculation validation or the incorporation of more advanced calculation methodologies. The staff intends to use insights gained from the events that occurred at the Fukushima Dai-ichi Nuclear Power Plant as they become available to address uncertainties associated with BWR-specific in-vessel and ex-vessel severe accident phenomena and uncertainties attributed to the impact of the use of salt-water addition, along with providing data for offsite consequence analysis validation.

The staff agrees with the ACRS's recommendation to modernize severe accident analysis software and will continue efforts to implement improved models as budget priorities allow to increase calculation robustness and incorporate further experimental results. Software developed through severe accident research is used by the agency to perform confirmatory analyses and provides the technical basis for regulatory decisions; therefore, maintaining severe accident codes and technical expertise is important to address current and future user needs. The staff also supports the ACRS's recommendation to revise the severe accident baseline research program to actively engage in efforts to obtain the required data to enhance and validate models that are found to be deficient. The staff appreciates the ACRS's support for the NRC's approach in leveraging resources in severe accident research through international and domestic collaboration. The staff continues to evaluate international projects for their value in providing experimental data for reducing uncertainties in code predictions and to ensure collaborations are worth the investment. The staff continues to participate in selected international projects under bilateral and/or cooperative agreements and to organize user meetings that act as forums to facilitate a common understanding of severe accident issues among domestic and international counterparts.

CHAPTER 15 – THERMAL HYDRAULICS

The staff agrees with the ACRS's recommendation to continue to develop the capability to perform uncertainty analyses with TRACE. TRACE currently has uncertainty multipliers that are applied globally in the model. Current planned improvements include:

- Adding uncertainty multipliers on a component by component basis;

- Increasing the number of code physical models to which uncertainty multipliers can be applied; and,

- Developing standard uncertainty multiplier distributions for different types of accidents.

The staff has enough computing capability for the development of uncertainty methodologies. However, this capability will need to be expanded as uncertainty methodologies are used for production calculations. The current plan for high performance computing capabilities is to move to cloud computing. Cloud computing services such as the Amazon EC2 could provide a flexible way to quickly ramp up computing resources as needed for production use of uncertainty calculations.

The staff agrees with the ACRS's recommendation to couple TRACE to other codes and, through the exterior communications interface (ECI) and other custom interfaces, TRACE has previously demonstrated this ability. However, in some cases such as improved fuel rod models, a better approach may be to implement the improved models directly into TRACE. Related efforts include:

- The University of Michigan, under a grant from the NRC, demonstrated successful coupling of TRACE to STAR-CCM+ computational fluid dynamics code. The final report for the research grant is documented in a report titled, "Multi-scale Thermal-Hydraulic Tool for Nuclear Power Plant Safety Analyses," which is available in ADAMS (ML15274A057).

- PARCS/PATHS has been developed to provide the capability to calculate core-wide burnup distributions and history effects that can be used to obtain three-dimensional nodal kinetics cross sections and point kinetics parameters from SCALE cross sections for use in LWR transient analysis. PhD research by an NRC employee has shown that the results may be improved by using more realistic fuel rod models like FRAPCON. Implementation of a realistic fuel rod model into PARCS/PATHS or coupling PARCS/PATHS to FRAPCON will be explored as funding allows.

The staff agrees with the ACRS's thermal-hydraulic experimental research recommendations with a minor exception. The staff believes that interfacial area transport may be of some use in TRACE for low-pressure subcooled boiling flows found in some test reactors. The staff will maintain a low-level effort in this area if resources allow. The staff will also compare the modeling approach with those used by the nuclear industry to determine the most effective approach to represent multiphase phenomena.

I look forward to continued interactions with the ACRS and thank the Committee for its review and recommendations.

Sincerely,

/RA by Michael R. Johnson for/

Victor M. McCree
Executive Director
for Operations

Enclosure: As stated

cc: Chairman Burns
Commissioner Svinicki
Commissioner Baran

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