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Risk Management Activities at the DOE Class A Reactor Facilities

by

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ABSTRACT

The PRA and risk management group of AERO develops risk management initiatives and standards to improve operation and increase safety of the DOE Class A reactor facilities. Principal risk management applications that have been implemented at each facility are reviewed. The status of a program to develop guidelines for risk management programs at reactor facilities is presented.

INTRODUCTION

The operating contractors of Department of Energy (DOE) Class A nuclear reactors have developed probabilistic risk assessments (PRA) which define the risk for severe fuel-damaging accidents for these facilities. These PRA provide a powerful capability to assist decision making by addressing the incremental effect on plant risk of operating decisions and facility changes. They provide a means for ranking competing actions according to risk, help in the management of limited resources for the most cost-effective safety improvements, and allow the safety significance of review questions, concerns and proposals to be directly addressed.

This is Risk Management, the use of risk models and information to provide facility management the means to incorporate knowledge of the safety significance of their options into their decision making processes. Risk Management also provides the information needed to manage the operations so as to maintain severe accident risks as low as reasonably achievable.

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The AERO PRA Subgroup

The Association for Excellence in Reactor Operation (AERO) is an organization of DOE contractors that are operators of Class A nuclear reactors. The PRA and risk management subgroup of AERO provides a forum for discussion of issues related to PRA and risk management that are common to these reactor facilities.

Heretofore, risk management activities at DOE reactors have been implemented separately as the PRA were developed by the operating contractors. Now, consideration is being given to development of formal procedures and programs for facility risk management at several reactors and for non-reactor operations at DOE sites. In keeping with its charter, the AERO PRA subgroup seeks to develop guidelines for risk management procedures and programs in a way that insures that risk management concepts are applied in a consistent and uniform fashion at the various reactor sites. Such guidelines will improve both the quality and credibility of risk-based decision making by facility operators and DOE.

STATUS OF RISK MANAGEMENT ACTIVITIES

Probabilistic risk assessments have been performed for all currently operating DOE Class A reactors. The results are being used to identify and prioritize safety issues and to implement cost effective safety programs. The scope of these efforts spans the following areas:

Operations and Training

- Training of operators and support personnel in risk-significant accident sequences, failures, human responses, and general risk awareness.

- Development, upgrading, and reviewing of emergency procedures and risk-sensitive operating procedures.

• Development of accident management systems, procedures, actions, and instrumentation including Safety Parameter Display Systems.

• Assistance to emergency planning by provision of probable accident scenarios, realistic protective actions, dose projections, and bases for emergency planning zones.

• Simulator and simulator training improvements for accident responses.

• Identification of risk-significant system dependencies, common cause failure vulnerabilities, and human error vulnerabilities.

• Safety evaluations of experimental or other temporary operating conditions or configurations.

• Review and guidance for the acceptance or rejection of new programs which may involve incremental risk.

Facility Modifications and Changes

• Definition and design optimization of significant risk reduction facility upgrades.

• Review of proposed facility modifications, backfits and upgrades for safety impact, risk/benefit, and/or safety design optimization.

• Risk-based prioritization of proposed facility upgrade projects and changes for project planning.

Issue Management

• Evaluations for safety reviews, questions, potential concerns, and the safety significance of operational occurrences.

• Evaluations of degraded equipment performance, partial system failures, extended equipment outages, and alternate or temporary operations configurations.

• Evaluations for potential Unreviewed Safety Questions and for Justifications for Continued Operation.

• Safety/risk significance and resolution, prioritization and/or ranking of restart issues and input to Operational Readiness Reviews.

SARs and Technical Specifications

• Risk based improvements in Technical specifications or Technical Safety Requirements for Allowable Outage Times, surveillance requirements, and Limiting Conditions for Operation.

• Improvements to reactor safety analysis reports through provision of comprehensive accident lists with defined probability categories and including probable multiple failure accident sequences, guidance for exclusion of very low probability events from the design basis, definitions of safety/risk significant systems and components, and single failure vulnerability or risk significance guidance.

Risk assessments are being applied in many ways at the Class A reactor facilities for the management and control of facility risks. A summary of key risk management activities at these facilities is provided below.

Advanced Test Reactor (ATR)

A formal risk management program and process is being developed for the ATR. The results, insights, and risk models of the ATR PRA are being used to address reactor operations issues. Some of the most significant risk management applications of the ATR PRA have been:

• Identification of the most risk-significant and cost effective facility upgrades to reduce the fuel damage risk for external events. The most significant upgrades, which reduce the fuel damage frequency by about 70%, are to provide drains and seal penetrations for the diesel generator pit and to relocate the safety significant Utility Battery-Backed Power System. These actions prevent events possibly leading to a station blackout from diesel pit fires and diesel pit flooding.

• Application of the human reliability analysis from the PRA to facilitate parallel development of new symptom-based emergency procedures.

• Elimination of a $2.5 million diesel generator electrical system upgrade shown to not be risk-significant and reduction in scope of a battery-backed power system relocation project based on what was risk-important.

• Evaluation of the fuel damage risk implications of component failures and outages as ATR equipment reaches end-of-life. Risk-based guidance is being provided on alternate operational configurations, acceptable outage times, surveillance, and possible Technical Specifications changes.

• Evaluation of proposed operational upgrades and operational incidents to provide management guidance regarding their risk-significance.

• Definition of the most risk-significant components and subsystems, based on their importance to the PRA for use in aging, maintenance improvement, and environmental qualification programs. The confinement analyses for severe accidents performed for the Level 2 PRA are also providing important environmental qualification program input.

ATR risk management activities including a review of operational incidents and facility operating data are compiled and reported to management at least annually in an ATR Risk Management Report.

Experimental Breeder Reactor-II (EBR-II)

Risk management applications for the EBR-II PRA include both the identification of situations that contribute to increasing risk but that can be relatively easily amended, and the use of PRA tools and models to support plant modifications or safety evaluations.

An example of the first class of applications is correction of deficiencies detected during plant seismic walkdowns. Inadequacies were observed in the anchorage of some electric panels and battery racks. Even though these did not affect significantly the seismic risk of core damage, corrective actions were implemented in order to increase the post-seismic availability of electrical systems.

Power to the two EBR-II primary pumps is supplied from a motor generator set with a clutch coupling. Failure of these clutches would result in a fast pump coastdown. The PRA systems analysis identified a dependency in the clutch control power for the EBR-II primary pumps. Because of a lack of effective separation between the two clutch control circuits, a single failure could result in the simultaneous loss of both primary pumps. Work to reverse this situation started soon after it had been identified, and the PRA models and tools were used in the design of a separated control system.

As an example of the second class of applications, a procedure revision and an engineering design task were supported with PRA methodology. The procedure revision involved the reactor scram system. Previously, the control rods in EBR-II were tested on a daily basis to verify that rod sticking due to bowing or binding was not occurring. A revised procedure with less frequent and shorter rod movements was desirable to ease operator burden. The PRA had made use of the daily rod movements to estimate the common cause failure of the rods to drop under demand, due to rod sticking. The test interval of 24 hours yielded a relatively low failure probability.

Alternative rod test procedures were analyzed with the PRA model. Increasing the test interval reduced the scram reliability, but fewer rod movement up-demands reduced the probability of a reactivity insertion initiator. The study of several alternative control rod test procedures indicated that a rotational test of fewer rods every day would have a negligible effect on the scram reliability and a weekly test of all the rods would affect reliability only marginally.

High Flux Beam Reactor (HFBR)

Risk management activities at the HFBR utilize results and insights from the Level 1 PRA, which was completed in 1989. Several plant modifications to improve accident mitigation potential have been implemented, based on the PRA. In addition, projects have been implemented in the areas of accident management and post-accident dose reduction to operations personnel.

A formalized program of risk management has been proposed for the HFBR. There are several elements to this program, including prioritization of plant upgrades based on PRA results, assessment of the risk-significance of recent modifications to HFBR systems and administrative controls, reevaluation of the PRA results themselves resulting from these upgrades, and enhanced efforts to communicate the results and implications of risk assessment activities both onsite and offsite. A risk management advisory committee has been proposed to oversee the risk management program and to review safety related issues associated with the HFBR, as well as to assess the effectiveness of the risk management program in issue resolution. Additionally, several plant improvement projects have been implemented based on risk reduction insights from the HFBR PRA.

High Flux Isotope Reactor (HFIR)

With the publishing of the PRA for the HFIR, a significant step toward a comprehensive and cost-effective program for managing risk at the HFIR has been completed. A program is in progress to apply the results of the PRA to manage risks attending the HFIR design and operation. This program includes

• Use of the results of the PRA to enhance operator training and emergency response for the HFIR;

• Provision of input to HFIR safety requirements programs such as equipment qualification and safety analyses, to ensure information important to risk is included in those programs;

• Obtaining an improved understanding of how the HFIR plant responds to normal and abnormal conditions;

• Balancing competing risks in the design and operation of the plant.

Several improvements to the HFIR design and operation have been implemented based on the PRA results. The principal improvements are listed below.

• Reduction in sources of core flow blockage;

• Implementation of a direct trip of the primary pumps on high bearing temperature to reduce dependence on rapid operator actions for pump protection;

• Modifications to improve the capability of equipment and structures to resist seismic and high wind events;

• Purchase of portable diesel generators to reduce vulnerability to long-term loss of electric power;

• Reduction in the susceptibility to loss-of-coolant events by having the emergency depressurization valves fail in a closed position on loss of instrument air.

The HFIR PRA will be periodically updated and improved, with the goal of having it become a "living" document and thereby provide a significant contribution to the safe and effective management of the HFIR facility.

K Reactor

Since the baseline Level 1 PRA was completed, the K Reactor PRA staff has been supporting risk management activities associated with reactor restart decision making. These activities have included:

• Development of risk perspectives for K Reactor restart issues;

• Review and recommendations for modifications to reactor emergency procedures proposed for restart;

• Assessment of risk reductions afforded by proposed plant upgrades;

• Development and application of a risk-based methodology to screen candidates for SAR analyses for inclusion in the design basis;

• Characterization of the risk to the public and to site workers posed by K Reactor operation;

• Education of the DOE management and government review bodies responsible for reactor restart decisionmaking regarding these risks.

The PRA has been upgraded to the restart configuration, and has been simplified and implemented in PC-based software to facilitate easy use. The PRA is also being used to review and evaluate modifications proposed to the plant safety envelope.

Ongoing risk management activities for K

Reactor will be conducted in the areas of operational and training improvements, safety issue evaluation, safety document modification guidance, evaluation of proposed facility modifications, and maintainability improvements.

Operational and training improvements promote training of operators and support personnel in risk-significant accident sequences, likely failures, the role of human response, and general risk awareness. Work will also continue in the area of review and upgrading of emergency procedures as well as in identification of risk-sensitive operating procedures and in simulator training support.

Risk management techniques will continue to be used in the evaluation and resolution of issues concerning K Reactor operation, upgrades, and layup. Additionally, safety reviews, potential concerns, and the safety significance of operational occurrences will be addressed.

Risk-based guidance will be provided to improve Technical Specifications, including Allowable Outage Times, surveillance requirements, and Limiting Conditions for Operation. This area of risk management will also assist in the maintenance and upgrading of the K Reactor SAR.

The application of risk assessment techniques to review, rank, and prioritize major projects and programs affecting the reactor status will continue. In addition, risk assessments of reactor maintainability issues will be employed to provide guidance for cost-effective spares/parts inventory management. A Risk-Centered Maintenance Program will be implemented, to identify key components and systems for maintenance improvements.

PROPOSED RISK MANAGEMENT PROGRAM GUIDELINES

The AERO PRA subgroup is seeking to develop uniform guidelines for risk management at the Class A reactors. Such guidelines can improve the quality and credibility of risk - based decision making by plant staff and DOE by insuring that risk management concepts are applied in a consistent fashion. Guidelines are being formulated regarding the elements of an effective risk management program, and recommended practices for effective risk management.

Recommended Risk Management Practices

It is appropriate that a graded approach to implementation of risk management practices be followed in accordance with the magnitude of the hazards associated with a particular facility. The practices recommended below are most appropriately applied to the higher hazard facilities, in the opinion of the subgroup.

Risk assessments should be quantitative whenever practical and should be performed by qualified risk analysts and human reliability analysts. The best foundation for quality risk management is a current, high quality, peer reviewed PRA including a comprehensive external events analysis. A Level 3 PRA is recommended to support decisionmaking based upon public risk criteria.

Qualitative screening analyses may be performed to assess whether an activity or decision being reviewed needs further risk assessment. Guidelines and criteria should be developed for the use of such qualitative analyses.

Risk assessments supporting risk management decisions should include an assessment and indication of the risk uncertainties. Sensitivity analyses should also be used to identify the important contributors and assumptions of the risk assessment or to identify the risks.

It is suggested that risk management is most cost-effective when all risk management activities related to the operation are consolidated whether or not they are directly related to the nuclear reactor risk. Then all site risk issues concerned with reactor operation and safety, worker safety, environmental issues, and waste management and cleanup can be evaluated, reviewed, and managed on an equal basis with site-wide priorities better defined and resources better managed.

New projects or proposed significant changes in the facilities or reactor operation should have a risk management review. Risk review of projects or facility changes should begin with the conceptual design to incorporate risk insights and risk management at a most cost-effective stage.

Good risk management requires good

communication of the significant risks and risk insights identified by the PRA, uses of the results and insights of the PRA, and risk management practices and applications to all operations and reactor support personnel. This communication provides a general risk awareness that will improve safe operation and will involve more of the personnel in risk management. Workshops or seminars are an effective way to achieve this level of communication. It is important that such communication reach all levels of the reactor operations management, and that it be extended to the elements within DOE with authority and responsibility for reactor operations and safety.

Risk management programs should emphasize early identification, assessment, and control of potential risk issues.

Risk management programs should also include continued development of efficient, effective risk management strategies and practices and the continued development and application of advanced and innovative methodologies for risk assessment.

Elements of an Effective Risk Management Program

To practice consistent, quality risk management for all risk-significant decisions regarding facility operations and support, several elements are needed in a risk management program.

A formal program with set goals, objectives, and standards should be established within the organization responsible for operation of the facility. Groups providing analytical support for risk management and risk assessment should be identified along with their responsibilities, their interfaces with the reactor operating and support organizations, and their implementing procedures and practices. The implementing procedures and practices need to specify the conditions, situations, and types of decisions for which risk evaluation is required. Guidelines and examples need to be provided in the implementing procedures and practices by which the need for or advisability of risk-based decisionmaking can be determined.

Standards are needed for the risk assessments and their applications to the decisionmaking process. The standards should include requirements for the review of the risk assessments and of their applications.

Criteria are needed for screening risks for acceptability. The screening criteria need to have a basis that is defendable on technical and regulatory grounds, and that will achieve the goals and objectives of the risk management program. The criteria should address not only public safety but also facility and worker safety. Criteria also should be established for the performance of risk/benefit analysis in support of risk-based decisionmaking.

A risk management program should establish standards for the documentation of the risk assessments and risk-based decisionmaking used as the basis for risk management actions.

The program should include the collection and analysis of facility operations data to establish a plant-specific data base for the reliability and availability of risk-significant facility systems and components. The data collection and analysis effort should include the tracking and identification of trends or changes in the data. Facility risk assessments should be based as much as is practical on plant-specific data or data from similar facilities and equipment.

The program should also include a provision for periodic self-assessment for appropriate application of risk-based technology within the program as well as for overall program effectiveness.

SUMMARY

Risk management programs founded on the results and insights of PRA are being implemented at the Class A reactor facilities. These programs have been strengthened by the communications and information transfer activities of the AERO PRA subgroup. The guidelines for consistent implementation of risk management being developed by AERO promise to further enhance the effectiveness of these programs.

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