2.0 Risk-Informed Decision Making

The regulatory framework proposed in this report for decommissioning plants is based on a risk-informed process. In 1995, the NRC published its PRA Policy Statement [Ref 1], which stated that the use of PRA technology should be increased in all regulatory matters to the extent supported by the state-of-the-art of the methods. Probabilistic risk assessment provides a structured analytical method to assess the various combinations of failures and events that result in undesirable consequences, such as core damage in an operating reactor. The end points of PRAs can be extended to include public health effects by modeling the timing and mode of containment failure and radioactive releases to the environment.

Subsequent to issuance of the PRA Policy Statement, the agency published Regulatory Guide (RG) 1.174 [Ref.2] which contained general guidance for application of PRA insights to the regulation of nuclear reactors. The guidelines in RG 1.174 pertain to the frequency of core damage accidents (CDF) and large early releases (LERF). For both CDF and LERF, RG 1.174 contains guidance on acceptable values for the changes that can be allowed due to regulatory decisions as a function of the baseline frequencies. For example, if the baseline CDF for a plant is below $1x10^{-4}$ per year, plant changes can be approved that increase CDF by up to $1x10^{-5}$ per year. If the baseline LERF is less than $1x10^{-5}$ per year, plant changes can be approved which increase LERF by $1x10^{-6}$ per year.

For decommissioning plants, the risk is primarily due to the possibility of a zirconium fire associated with the spent fuel rod cladding[1]. The consequences of such an event do not equate exactly to either a core damage accident or a large early release[2]. Zirconium fires in spent fuel pools potentially have more severe long term consequences than an operating reactor core damage accident, because there may be multiple cores involved, and because there is no containment surrounding the SFP to mitigate the consequences. On the other hand, they are different from a large early release, because the postulated accidents progress very slowly (allowing time for protective actions to be taken to significantly reduce early fatalities), and the absence of short lived isotopes in the release (e.g., iodine isotopes will have decayed away though early health effects are still possible from Cesium isotopes). As a result, the criteria of RG 1.174 cannot be applied directly to the risk of a decommissioning plant.

Even though the event progresses more slowly than an operating reactor large early release event and the isotopic make-up is somewhat different, the risk assessment consequence calculations performed by the staff[3] (assuming multiple cores) show that large inventories of radioisotopes could be released that could have significant late health effects (latent cancers) for the population at some distance from the plant, as well as the potential for a small number of early fatalities. The staff has therefore decided that the end state and consequences of a spent fuel pool fire are sufficiently severe that the RG 1.174 LERF baseline guideline of $1x10^{-5}$ per

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[1]See section 3 for more complete discussion of fuel pool risk scenarios

[2]RG 1.174 describes LERF as the frequency of unmitigated releases that have the potential for early health effects, in a time frame prior to effective evacuation of close-in population

[3]See Appendix 4 for consequence and health impact assessment

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year (the value of baseline risk above which the staff will only consider very small increases in risk) provides an appropriate frequency guideline for a decommissioning plant SFP risk, and a useful tool to be used in combination with other factors such as accident progression timing, to assess features, systems and operator performance needs of a spent fuel pool in a decommissioning plant. The staff therefore proposes 1×10^{-5} per year as the recommended pool performance guideline (PPG) for baseline zirconium fire frequency. In its letter of November 12, 1999 [Ref. 3], the Advisory Committee on Reactor Safeguards (ACRS) recommended that application of the LERF guideline as discussed above be utilized. The staff agrees with this recommendation.

2.1 Principles of Regulatory Guide 1.174

As discussed in RG 1.174, quantitative risk assessment is only one tool utilized in risk-informed decision making. RG 1.174 articulates the following safety principles which should be applied to the decommissioning case:

- "The proposed change meets the current regulations unless it is explicitly related to a requested exemption or rule change, i.e., a "specific exemption" under 10 CFR 50.12 or a "petition for rulemaking" under 10 CFR 2.802.
- The proposed change is consistent with the defense-in-depth philosophy.
- The proposed change maintains sufficient safety margins.
- When proposed changes result in an increase in core damage frequency and/or risk, the increases should be small and consistent with the intent of the Commission's Safety Goal Policy Statement
- The impact of the proposed change should be monitored using performance measurement strategies."

While the focus of RG 1.174 was decision-making regarding changes to the licensing basis of an operating plant, the same risk-informed philosophy can be applied to rulemaking for decommissioning plants or to consider potential exemptions to current requirements. The intent and scope of these safety principles are discussed below. However, since the application of this study specifically relates to exemptions to a rule or a rule change for decommissioning plants, a discussion of the first principle regarding current regulations is not necessary nor is it provided. A discussion on how the rest of these principles are satisfied, as demonstrated by the staff's safety assessment, is provided in Section 4.

2.1.1 Defense-in-Depth

Defense-in-depth describes a multi-layered design and operational philosophy whose goal is to prevent the initiation of accidents or to prevent their progression to serious consequences. The defense-in-depth philosophy applies to the operation of the spent fuel pool, whether at an operating plant or in a decommissioning plant. In accordance with the Commission White Paper on Risk-Informed Regulation (March 11, 1999), "Defense-in-depth is an element of the NRC's Safety Philosophy that employs successive compensatory measures to prevent accidents or mitigate damage if a malfunction, accident, or naturally caused event occurs at a nuclear facility. The defense-in-depth philosophy ensures that safety will not be wholly dependent on any single element of the design, construction, maintenance, or operation of a nuclear facility. The net effect of incorporating defense-in-depth into design, construction, maintenance and operation is that the facility or system in question tends to be more tolerant of failures and external challenges."

Therefore, application of defense-in-depth could mean in part that there is more than one source of cooling water or that pump make-up can be provided by both electric as well as direct drive diesel pumps. Additionally, defense-in-depth can mean that even if a serious outcome (such as fuel damage) occurs, there is further protection such as containment to prevent radionuclide releases to the public. However, implementation of defense-in-depth for SFPs is different from that applied to nuclear reactors because of the different nature of the hazards. The robust structural design of a fuel pool, coupled with the simple nature of the pool support systems, goes far toward preventing accidents associated with loss of water inventory or pool heat removal. Additionally, because the essentially quiescent (low temperature, low pressure) initial state of the spent fuel pool and the long time available for taking corrective action associated with most release scenarios provide significant safety margin, a containment structure is not considered necessary as an additional barrier to provide an adequate level of protection to the public. Likewise, the slow evolution of most SFP accident scenarios allows for reasonable human recovery actions to respond to system failures. Section 4 summarizes the specific design and operational features of the SFP, industry commitments and the additional staff assumptions that ensure that SFP defense-in-depth is maintained. This level of defense is achieved through preventative measures, appropriate mitigating systems, and an appropriate level of emergency planning.

2.1.2 Safety Margins

A safety margin can relate to the difference between the expected value of some physical parameter (e.g., temperature, pressure, stress, reactivity) and the point at which adequate performance is no longer assured. An example of this would be a containment pressure calculation which may show a peak accident pressure of 40 psig is reached for a structure which has a design capability of 60 psig and an actual ultimate capability of 110 psig. In this case there is margin from the accident calculation of 20 psig to the design limit as well as a large margin of 70 psig to the actual expected failure limit.

The safety margins associated with fuel in the spent fuel pool for many physical processes and parameters are much greater than those associated with an operating reactor. The spent fuel pool is in a quiescent state, at or near ambient temperature and pressure. The decay heat levels are much lower than those of the fuel in an operating reactor. This allows much greater time for heating and boil off of the coolant water, and for heat up of the fuel itself, once uncovered. The fuel is covered with approximately 23 feet of water at or near ambient temperature. The pool is designed with ample margin to criticality, using both passive (geometry) and active (poisons) means of reactivity control. Section 4 describes the provisions that ensure the SFP maintains adequate safety margins in a decommissioning plant.

2.1.3 Impact of Proposed Changes

The impact of the proposed change should be small. As discussed above, the staff is applying the pool performance guideline (PPG) of 1×10^{-5} per year frequency for a zirconium fire, which was developed from the treatment for LERF in RG 1.174 and a change guideline of $1\text{X}10^{-6}$ per year (assuming that the $1X10^{-5}$ per year PPG is already met). This PPG is used to assess the impact and acceptability of SFP risk in decommissioning plants. Sections 3 and 4 discuss the design and operational characteristics of the SFP that are relied upon to produce the low baseline risk results. These are identified in the context of industry commitments as well as additional staff assumptions needed to produce the low SFP risk conclusions.

2.1.4 Implementation and Monitoring Program

RG 1.174 states that an implementation and monitoring plan should be developed to ensure that the engineering evaluation conducted to examine the impact of the proposed changes continues to reflect the actual reliability and availability of structures, systems, and components (SSCs) that have been evaluated. This will ensure that the conclusions that have been drawn will remain valid.

Therefore, with respect to all the above safety principles, implementation and monitoring of important considerations could include such actions as: comparing a check list against the spent fuel pool seismic design and construction; control of heavy load movements; development and implementation of procedures and other provisions to ensure human reliability; monitoring the capability, reliability, and availability of important equipment; and checking the effectiveness of on-site emergency response and plans for communication with off-site authorities. In many areas the implementation and monitoring may already be accomplished by utility programs such as those developed under the maintenance rule [Ref. 4].