Prior to 2/28/99

- I. Risk and Safety Level at decommissioned plants
  - A. Current level of protection for operating plants
  - B. Time for decay since shutdown/ time period of concern
  - C. Possibility of beyond design basis seismic event and damage to pool
  - D. Credit for mitigative features

- II. Types of accidents for SFPs
  - A. Loss of SFP cooling
  - B. Reduction in SFP level (siphon or site-specific design break)
  - C. SFP structural failure

- III. Credibility of structural failure
  - A. Failure of structure dominates risk
    - 1. 2.6E-4 to 1.6E-10 PWR and 6.5E-5 to 4E-11 BWR (NUREG/CR-4982 (BNL))
  - B. SFPs generically can withstand larger than SSE
    - 1. 4 - 19 times stronger than design SSE (source?)

- IV. Type of structural failure
  - A. Full Draindown
    - 1. Air cooling only
    - 2. Fuel assembly geometry intact
    - 3. Ventilation?
  - B. Partial Draindown
    - 1. Could be a more conservative accident (NUREG/CR-0649 (SNL))
    - 2. Possible PNNL work supporting partial draindown is temporary situation
    - 3. Could starve itself of oxygen and therefore not create self-sustaining oxidation

- V. Maximum temperature of fuel for air cooling
  - A. 565 °C limit
    - 1. Predictable geometry of fuel bundle; no blistering of clad
    - 2. Onset of gap release

- VI. Critical decay time
  - A. Previous studies provide general insights but are deficient for bounding values
    - 1. NUREG/CR-0649 (SNL)
      - a. General Insights informative
      - b. Specific values not directly applicable due to use of low burnup fuel; lack of ventilation
    - 2. NUREG/CR-6451 (new BNL)
      - a. Used insights from NUREG/CR-0649
      - b. Specific values not directly applicable due to use of code that is in question
  - B. Current studies to define generic values
    - 1. FLUENT calculation of generic BWR and PWR (RES)
    - 2. COBRA calculation of generic BWR and PWR (PNNL)

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VII. ~~Mitigative~~ Features

A. SFP level indicators and alarms

1. During periods of no fuel movement (TS)
2. During and in preparation of fuel movement (TS)

B. Radiation monitors (DSAR)

C. SFP temperature (TS) and cooling system (DSAR)

D. SFP makeup source (TS)

E. Power sources (TS?)

F. SFP Leakage detection (DSAR)

G. SFP coolant chemistry (TS program)

VIII. Radiation Protection (EP rule only)

A. Type of radiological release

IX. Allowance for ad hoc EP actions (EP rule only)

Operating power plant have a margin of safety commensurate with the risk to provide assurance that undue risk to public health and safety does not occur.

Permanently defueled plants do not produce the short-lived radioisotopes that area a concern for operating reactors. Therefore, they have a reduced risk and do not require the same controls to maintain the same margin of safety. Further, as the time period since final shutdown increases, the radiological risk continues to decrease as the radioisotopes decay. The same controls for an operating reactor are unnecessary for permanently defueled plants and place an undue burden on the licensee.

While looking at the decreased risks for a permanently shutdown plant and the decreasing risk with time, the staff needs balance the reduced risk with the assure that sufficient margin of safety continues to exist to protect public health and safety.

Anticipatory and mitigative features regarding the spent fuel pool can provide that margin to assure that actions can be taken to prevent or mitigate radiological releases. The major feature is to have SFP makeup capability available. Also, indication of the loss of coolant by monitoring level, temperature, and area radiation levels may provide additional time early in an event to take mitigative actions to prevent a release.

During operation, the quality of the spent fuel pool coolant was maintained at a standard similar to the reactor coolant system because the environments joined for refueling operations. This need is no longer applicable for defueled plants. The staff believes that spent fuel environment needs to be maintained at a high standard to minimize corrosion of the fuel and radiation exposure to personnel. Proper care of the spent fuel and structure are important in the defueled condition. The cleaning and chemistry monitoring of the coolant assures that the fuel is in a high quality environment and ensures that failed fuel will be detected. If a weaknesses in the pool structure occurred it may cause the pool to be outside of the design analysis. Structural weakness can be indicated through SFP leakage detection system.

These features are generally not new systems or features for plants but are more important to safety in the defueled condition. New controls on these systems are merited to provide the needed assurance that the margin of safety is compensated for due to the reduction in off-site emergency planning and reduction in staffing.

The staff looked at severe accidents associated with the spent fuel pool. One of the worst case scenarios would be the complete or nearly complete drain down of the coolant.

SPLB/DSSA has become increasingly involved in the review and approval of license amendments and exemptions regarding the spent fuel pool for decommissioned plants. Of particular concern is the methods used to approve the reduction in regulation for emergency planning, safeguards, and insurance indeminity. These three areas have rule making efforts in progress. The staff intent is to have all three rules depend on the same criteria to reduce the regulations. The first reduction would be allowed when offsite radiological consequences are no longer significant as demonstrate that a release would not exceed the EPA PAGs. For DSSA, the technical issue involves the potential for a radiological release from the spent fuel. This will not occur if the fuel is sufficiently cooled by water or of the fuel has decayed usch that sufficient decay heat does not exist to

Past studies were intended to gain insights into representative values.

Several issues remain in question on this subject and will be discussed.

Credibility of accident

Limited work has been performed on the effects of a partial drain down event as opposed to a full drain down.

SPLB believes that the loss of all or nearly all coolant is a credible accident for a period of time following the permanent shut down of a plant. The length of the of time is specific to the unique configuration of the fuel and the racks, and the design of the spent fuel pool and building. The issue of air cooling spent fuel was briefly addressed in Generic Issues 82, "Severe Accident in Spent Fuel Pools." Several studies evaluated the issues but no extensive work was performed. However, given the reduced controls on defueled plants, the loss of all or nearly all coolant is a concern to the staff.

In AEOD/S96-02 report, "Assessment of SF Cooling," October 23, 1996, the staff states that risk estimates for SFP accidents is dominated by the uncertainty in the frequency for loss of pool integrity events (seismic event contributes over 90% for PWRs and 95% for BWRs for SF damage probability) and capacity of the SFP to survive (expressed as fragility).

In NUREG/CR-5176, "Seismic Failure and Cask Drop Analyses of the Spent Fuel Pools at Two Representative Nuclear Power Plants," stated that the loss of the liner integrity due to gross structural failure of the structure was the dominate failure mode of the spent fuel pool

Maximum Temperature of Fuel

Several different temperatures have been used as the safety limit for the maximum temperature that the air-cooled fuel is allowed to reach. Although the exact temperature is dependent on the fuel configuration, the following temperatures are general values:

900 °C	Self-sustained oxidation
650 °C	Inadequate cooling; fuel clad damage certain; distortion in assembly geometry
565 °C	Onset of clad failure

In the AEOD/S96-02 report, "Assessment of SF Cooling," October 23, 1996, the staff stated that due to the "large uncertainties" in the thermal behavior, temperatures in excess of 650 °C should not be viewed as successful cooling. At these temperatures, cladding failure and fission product release is "very likely" and the potential for cladding fire is "high"

Evaluations have identified several parameters as Important parameters in determining the maximum temperature including the following:

- Decay heat level
- Spent fuel pool configuration (unfilled cells and downcomer width)
- Building ventilation
- Storage rack geometry (baseplate hole size)

The oxidation reaction is exothermic and therefore, once begun, the temperature rises rapidly. Additionally, once cladding damage begins, the clad will blister and the fuel configuration will change. This increases the difficulty in predicting air flow through the assembly. Therefore, lower, conservative values such as 565 °C and 650 °C have been used in analyses.

<u>Generic critical decay time</u>

Several reports have discussed general or generic critical decay times. These times have been suggested by licensees to as comparative sources for the basis of an exemption. DSSA has reviewed these reports and finds deincies in the report or in the applicability for current plants.

In NUREG/CR-0649, "Spent Fuel Heatup Following Loss of Water During Storage," critical decay times listed below were calculated. This highest burnup was 33,000 MWD/MTU for PWRs and 30,600 MWD/MTU for BWRs. Perfect ventilation or chimney effect was assumed.

700 days	PWR, 6 kW/MTU decay power, high density rack, 10.25" pitch, 5" orifice, 1-inch from wall storage
280 days	PWR, 6 kW/MTU decay power, high density rack, 10.25" pitch, 5" orifice; 1-ft from wall storage
180 days	BWR, 14 kW/MTU decay power, cylindrical baskets, 8.5" pitch, 1.5" orifice
unknown	BWR, high density rack, SFUEL1W code limited for computation of BWR high density racks.

This NUREG provided significiant and useful insights to air-cooled spent fuel assemblies. It was written to address the possibility of an identified an issue and its consequences. However, it is the opinion of DSSA that the NUREG alone is not a basis for exemption to regulation. The time limits provide a general conclusion of approxiametly how long a plant may have to wait if it has a similar configuration that was used in the strudy. However, the NUREG was not meant to establish criteria for a acceptable calculation. As such, the NUREG lacks sufficient information on all of the parameters that could affect the necessary decay time. Additionally, the NUREG is based on burnup values that were used at the time. Since then, burnups values have increased, so the results are not directly applicable to today's spent fuel. The general conclusions and the phenomena described in the study may be valid and assist in the assessment of issue. However, the specific values do not bound the operation of plants today and, therefore, the values can not be directly applied to today's decisions due to changes in plant operation and spent fuel storage configuration.

In NUREG/CR-6451, "A Safety and Regulatory Assessment of Generic BWR and PWR Permanently Shutdown NPPs," August 1997, the critical decay times listed below were calculated. Perfect ventilation or chimney effect was assumed.

17 months	PWR, high density rack, 60,000 MWD/MTU burnup; 10.4" pitch; 5" orifice
7 months	BWR, high density rack, 40,000 MWD/MTU burnup; 6.25" pitch; 4" orifice

The NUREG was meant as an assessment to support rulemaking activities. The NUREG was not intended nor was it structured to be a regulatory guide to be followed for adherence or in this case an exemption from regulation. NUREG/CR-6451 used burnups that are representative, but not bounding, for today operating plants. DSSA is concerned that for generic rulemaking this is still insufficient.

The analysis results from actual permanently defueled plants are as follows::

8.3 months	BWR - Big Rock Point (licensee calc)
14 months	PWR - Haddam Neck (NRC calc)
18 months	PWR - Haddam Neck (licensee calc)

Shortfalls in the available generic evaluations

- Perfect ventilation or the chimney effects probably will not occur.
- Flow resistance (grid spacer losses) as air flowed through the assembly was not included.
- Higher burnup is used today and is expected to be increased in the future.
- The spent fuel rack pitch or orifice hole in the base plate can be smaller than the analyses.

Mitigative Features

The licensee shall control the following items through TSs:

SFP level indicators (TS) provides assurance of adequate shielding to protect personnel, ensures a large heat sink in case of loss of cooling; and increases time to uncovery of fuel. Level specifications are applicable any time fuel is located in the spent fuel pool. Two different coolant levels may be used for periods of no fuel movement and for periods during and in preparation of fuel movement. Maintains initial conditions for DSAR accident anaylsis of loss of cooling accident.

SFP temperature (TS) ensures indication of loss of coolant and ensures no excessive thermal stresses on pool structure

SFP makeup source (TS) ensures dedicated means to replace coolant to pool

SFP coolant chemistry (TS program) ensures high quality environment for spent fuel to reduce corrosion.

The licensee shall describe In DSAR:

SFP level alarms (DSAR) provides notification to plant personnel,

SFP cooling and cleaning system (DSAR) provides a quality coolant environment for spent fuel to reduce corrosion and provide visibility of pool. Maintains initial conditions of DSAR accident analysis for loss of cooling accident.

Radiation monitors and alarms (DSAR) provides indication of loss of shielding to protect personnel

? Power sources (DSAR) provides assurance that level and temperature indicators, radiation monitors, pumps for cooling and makeup systems will be able to function when needed.

SFP leakage detection (DSAR) provides early indication of structure weakness