NUREG–1353

Regulatory Analysis for the Resolution of Generic Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools"

U.S. Nuclear Regulatory Commission

Office of Nuclear Regulatory Research

E. D. Throm

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Manuscript Completed: February 1989
Date Published: April 1989

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ABSTRACT

Generic Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools," addresses the concerns with the use of high density storage racks for the storage of spent fuel, and is applicable to all Light Water Reactor spent fuel pools.

This report presents the regulatory analysis for Generic Issue 82. It includes (1) a summary of the issue, (2) a summary of the technical findings, (3) the proposed technical resolution, (4) alternative resolutions considered by the Nuclear Regulatory Commission, (5) an assessment of the benefits and cost of the alternatives considered, (6) the decision rationale, and (7) the relationships between Generic Issue 82 and other NRC programs and requirements.

Based on this evaluation, the NRC staff concludes that no new regulatory requirements are warranted concerning the use of high density storage racks.

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ABBREVIATIONS AND ACRONYMS

ALARA	As Low As Reasonable Achievable
AR	At-Reactor
ASCE	American Society of Civil Engineers
BNL	Brookhaven National Laboratory
BWR(s)	Boiling Water Reactor(s)
CDF	Core Damage Frequency
CFR	Code of Federal Regulations
DBE	Design Basis Earthquake
DF	Decontamination Factor
DOE	Department of Energy
EPRI	Electric Power Research Institute
FSAR	Final Safety Evaluation Report
GDC(s)	General Design Criterion (Criteria)
GI	Generic Issue
GL	Generic Letter
GSI	Generic Safety Issue
HCLPF	High Confidence of Low Probability of Failure
HEP(s)	Human Error Probability(ies)
IE	Inspection and Enforcement
IEB	Inspection and Enforcement Bulletin
kgm	kilogram
KgU	kilogram of uranium
kw	kilowatt
LLNL	Lawrence Livermore National Laboratory
LPCI	Low Pressure Coolant Injection
LWR(s)	Light Water Reactor(S)
MTIHM	Metric Tons of Initial Heavy Metal
MTHM	Metric Tons of Heavy Metal
MTU	Metric Tons of Uranium
Mw(t)	Megawatts-thermal
NERC	National Electric Reliability Council
NRC	Nuclear Regulatory Commission
NRR	Office of Nuclear Reactor Regulation, NRC
ORNL	Oak Ridge National Laboratory
PRA(s)	Probabilistic Risk Assessment(s)
PWR(s)	Pressurized Water Reactor(s)
RES	Office of Nuclear Regluatory Research, NRC
RHR	Residual Heat Removal
RWST	Refueling Water Storage Tank
SFDF	Spent Fuel Damage Frequency
SFP	Spent Fuel Pool
SNL	Sandia National Laboratory
SRP	Standard Review Plan
SSE	Safe Shutdown Earthquake
SSMRP	Seismic Safety Margins Research Program

PREFACE

This report presents the regulatory analysis, including the decision rationale, for the resolution of Generic Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools." The objective of this regulatory analysis is to determine whether the use of high density storage racks for the storage of spent fuel poses an unacceptable risk to the health and safety of the public. As part of this effort, the seismic hazards for two older spent fuel pools were evaluated. The risk change estimates, value/impact and cost-benefit analyses, and other insights gained during this effort, have shown that no new regulatory requirements are warranted in relation to this generic issue.

Edward D. Throm

EXECUTIVE SUMMARY

The risk of beyond design basis accidents in spent fuel storage pools was examined in WASH-1400. It was concluded that these risks were orders of magnitude below those involving the reactor core because of the simplicity of the spent fuel storage pool design: (1) the coolant is at atmospheric pressure, (2) the spent fuel is always subcritical and the heat source is low, (3) there is no piping which can drain the pool and (4) there are no anticipated operational transients that could interrupt cooling or cause criticality.

The reasons for the re-examination of spent fuel storage pool accidents are twofold. First, spent fuel is being stored instead of reprocessed. This has led to the expansion of onsite fuel storage by means of high density storage racks, which results in a larger inventory of fission products in the pool, a greater heat load on the pool cooling system, and less distance between adjacent fuel assemblies. Second, some laboratory studies have provided evidence of the possibility of fire propagation between assemblies in an air cooled environment. Together, these two reasons provide the basis for an accident scenario which was not previously considered.

In addition, in recent years, increasing knowledge in the geosciences has led to a better understanding that, although still highly unlikely, it is more likely that nuclear power plants in the Eastern United States (i.e., east of the Rocky Mountains) could be subjected to earthquake ground motion greater than for which the plants were designed. For this reason, interest has developed in demonstrating that nuclear power plant structures and safety-related systems can safely withstand earthquake ground motion larger than their design earthquake ground motions (post-1973 safe-shutdown earthquake, SSE, or pre-1973 design-basis earthquake, DBE).

Nuclear reactor plants include storage facilities for the wet storage of spent fuel assemblies. The safety function of the spent fuel pool (SFP) and storage racks is to cool the spent fuel assemblies and maintain them in a subcritical array during all credible storage conditions and to provide a safe means of loading the assemblies into shipping casks.

The SFP and components are reviewed to assure conformance with the requirements of 10 CFR Part 50 Appendix A General Design Criteria (GDC) 2, 4, 5, 61, 62, and 63. The review is performed under Section 9.1.2, "Spent Fuel Storage," of the Standard Review Plan (SRP). The SFP water level control system, cleanup system and cooling system are reviewed to assure conformance with the requirements of GDCs 2, 4, 5, 44, 45, 46, 61 and 63 under Section 9.1.3, "Spent Fuel Pool Cooling and Cleanup," of the SRP. In addition, a finding related to 10 CFR Part 20, paragraph 20.1(c) is made as it relates to radiation doses being kept as low as is reasonably achievable (ALARA).

The methods used to provide cooling for the removal of decay heat from the stored assemblies vary from plant to plant depending upon the individual design. The safety function to be performed remains the same: the spent fuel assemblies must be cooled and must remain covered with water during all storage conditions. Assuming that the water is drained, or boiled off, from the spent fuel pool, the fuel rods will heat up until the buoyancy-driven air flow is sufficient to prevent further heatup. If the decay heat level is high enough to heat the fuel rod cladding to about 900 ^{o}C (1650 ^{o}F) the oxidation becomes self-sustaining, resulting in a Zircaloy cladding fire. Propagation of the Zircaloy cladding fire to older adjacent assemblies is likely if the decay heat level in an older adjacent assembly is high enough to heat that assembly to within 100 to

200 °C (200 to 400 °F) of the self-sustaining oxidation temperature. Although propagation of a Zircaloy cladding fire to one to two year old fuel by only thermal radiation can occur, the older fuel would have to be next to the hottest assemblies.

The conditional probability of a Zircaloy cladding fire given a complete loss of water was found to be 1.0 for PWRs and 0.25 for BWRs. The PWR value is based on the use of high density storage racks and the BWR value is selected based on the use of directional storage racks, with the channel box in place. The conditional probability of a Zircaloy cladding fire given a complete loss of water in low density storage racks is estimated to be at least a factor of five less than for the high density configurations. The PWR conditional probability of a Zircaloy fire would be reduced to 0.2 and the BWR conditional probability would be reduced to 0.05. The actual risk reduction achievable may be greater. Open frame racks or cylindrical racks with large inlet holes could result in an greater reduction in risk. The cooling time to preclude a Zircaloy cladding fire could be reduced to less than 20 days, for a conditional probability of 0.05 of a Zircaloy fire for both fuel types.

In addition to implementing the requirements contained in 10 CFR Part 50 Appendix A of the "General Design Criteria," and 10 CFR Part 20, concerning radiation doses being kept as low as is reasonably achievable, licensees should have implemented additional or corrective actions based on the following guidance:

1. IE Bulletin 84-03, "Refueling Cavity Water Seals," issued August 24, 1984.

2. IE Information Notice 84-93, "Potential for Loss of Water From the Refueling Cavity," issued December 17, 1984.

3. Generic Letter 85-11, "Completion of Phase II of 'Control of Heavy Loads at Nuclear Power Plants' NUREG-0612," issued June 28, 1985.

4. IE Information Notice 87-13, "Potential for High Radiation Fields Following Loss of Water from Fuel Pool," issued February 24, 1987.

5. IE Information Notice 87-43, "Gaps in Neutron-Absorbing Material in High-Density Spent Fuel Storage Racks," issued September 8, 1987.

6. IE Information Notice 88-65, "Inadvertent Drainages of Spent Fuel Pools," issued August 18, 1988.

7. IE Information Notice 88-92, "Potential For Spent Fuel Pool Draindown," issued November 22, 1988.

The risk from the storage of spent fuel in the spent fuel storage pool at light water reactors is dominated by the beyond design basis earthquake accident scenario. The seismic capacities, or fragility, of two older spent fuel pools indicate that the high confidence of low probability of failure (HCLPF) is about three times the safe shutdown earthquake (SSE) design level. The HCLPF values are estimated to be in the 0.5 to 0.65 g range. The median peak ground

acceleration needed to fail these pools is estimated to be in the 1.4 to 2.0 g range, nearly a factor of ten higher than the SSE design value. A report prepared by the American Society of Civil Engineers also concluded that, in general, the seismic design of nuclear facility structures result in median factors of safety on the order of 4 to 19 based on post-1973 design criteria.

The structural capacity of the elevated BWR pool is lower than that for the PWR pool located at the ground level, however the lower conditional probability of a Zircaloy fire for the BWR fuel assembly design offsets the higher seismic failure frequency. The probability of a Zircaloy cladding fire, resulting from the loss of water from the spent fuel pool, is estimated to have a mean value of $2x10^{-6}$ per reactor year for either the PWR or the BWR spent fuel pool. The seismic event contributes over 90% of the PWR spent fuel damage probability, and nearly 95% for the BWR.

The source term for the spent fuel pool accident is not the same as the source term associated with core damage accidents. The consequences of a spent fuel pool accident which results in the complete loss of water are dominated by the long lived isotopes, such as cesium and strontium. The health consequences are dominated by the risk of latent cancer fatalities due to long term exposures.

The best estimate of the consequences of a spent fuel pool accident which results in spent fuel damage to approximately one-third of an equivalent reactor core is $8x10^{6}$ person-rem. This total dose translate to a public health risk from a spent fuel pool accident of 480 person-rem over an average remaining lifetime of 30 years, based on a Zircaloy cladding fire probability of $2x10^{-6}$ per reactor year. The best estimate offsite property damage cost is $4,000 million (1988 $s). The best estimate values are based on a population density of 340 people per square mile within a 50 mile radius from the site and result from the release of radionuclides from the last fuel discharge, 90 days after being discharged. The best estimate of the onsite costs for a SFP accident is $1,180 million (1988 $s), including five years of replacement power to replace the damaged spent fuel pool. Based on an average remaining lifetime of 30 years and a 5% discount rate, the present value of the offsite property damage is estimated to be $124,300 and the present value of the onsite property damage is estimated to be $32,400, based on a Zircaloy cladding fire probability of $2x10^{-6}$ per reactor year.

The value/impact and cost-benefit evaluations for the proposed alternatives for Generic Issue 82 do not indicate that cost effective options are available to mitigate the risk of beyond design basis accidents in spent fuel pools. The option to use low density storage racks for recently discharged fuel has a best estimate value/impact ratio of $32,000 per averted person-rem based on a reduction in spent fuel damage frequency of $2x10^{-6}$ per reactor year. Low density racks would decrease the consequences by a factor of five to ten, but the value/impact ratio is based on 100% reduction in public dose.

The use of post-accident spray systems to mitigate the consequences of a spent fuel pool accident has a best estimate value/impact ratio of $3,300 per averted person rem. This assumes that a post-accident spray system can be designed to withstand the beyond design basis earthquake which causes gross failure of the spent fuel pool structure and has a decontamination factor (DF) of at least 45.

The risks associated with a severe accident in the spent fuel pool are also compared to the objectives and guidance in the Safety Goal Policy Statement. The estimated frequency of a spent fuel pool accident, $2x10^{-6}$ per reactor year, resulting in spent fuel damage meets a target

objective of a few percent of a $1x10^{-4}$ to $5x10^{-5}$ per reactor year value for overall core damage frequency. The target objective for a "large release" of $1x10^{-6}$ per reactor year is marginally met, within a best estimate factor of two, but subject to interpretation since the definition of "large release" is still under development. In meeting the societal risk objective of 0.1% of the normally occurring risk to the public given the release frequency of $2x10^{-6}$ per reactor year, the latent cancer fatality rate from spent fuel pool accidents is estimated to be less than 3% of the target value for the operation of a nuclear power plant.

Therefore, the backfit criteria (10 CFR 50.109) that (1) a substantial increase in the overall protection of the public health and safety is achieved, and (2) the direct and indirect costs of implementation are justified are not met, and Alternative 1 - "No Action" is recommended for the resolution of GI-82.

The risk and consequences of a spent fuel pool accident appear to meet the Safety Goal Policy Statement objectives. They would also meet the proposed $1x10^{-6}$ per reactor year large-release frequency guideline, at least pending definition of a "large release" by the Commission. Therefore the recommended resolution, Alternative 1 - "No Action," is justified.

Although these studies conclude that most of the spent fuel pool risk is derived from beyond design basis earthquakes, this risk is no greater than the risk from core damage accidents due to seismic events beyond the safe-shutdown earthquake. Therefore, reducing the risk from spent fuel pools due to events beyond the safe-shutdown earthquake would still leave at least a comparable risk due to core damage accidents. Because of the large inherent safety margins in the design and construction of the spent fuel pool, Alternative 1 - "No Action" is justified.

REGULATORY ANALYSIS FOR THE RESOLUTION OF

GENERIC ISSUE 82

"BEYOND DESIGN BASIS ACCIDENTS IN SPENT FUEL POOLS"

1. STATEMENT OF THE PROBLEM

1.1 Historical Background

The risk of beyond design basis accidents in spent fuel storage pools was examined in WASH-1400 (Ref. 1). It was concluded that these risks were orders of magnitude below those involving the reactor core because of the simplicity of the spent fuel storage pool: (1) the coolant is at atmospheric pressure, (2) the spent fuel is always subcritical and the heat source is low, (3) there is no piping which can drain the pool and (4) there are no anticipated operational transients that could interrupt cooling or cause criticality.

The reasons for the re-examination of spent fuel storage pool accidents are twofold. First, spent fuel is being stored instead of reprocessed. This has led to the expansion of onsite fuel storage by means of high density storage racks, which results in a larger inventory of fission products in the pool, a greater heat load on the pool cooling system, and less distance between adjacent fuel assemblies. Second, some laboratory studies have provided evidence of the possibility of fire propagation between assemblies in an air-cooled environment. Together, these two reasons provide the basis for an accident scenario which was not previously considered.

In addition, in recent years, increasing knowledge in the geosciences has led to a better understanding that, although still highly unlikely, it is more likely that nuclear power plants in the Eastern United States (i.e., east of the Rocky Mountains) could be subjected to earthquake ground motion greater than for which the plants were designed. For this reason, interest has developed in demonstrating that nuclear power plant structures and safety-related systems can safely withstand earthquake ground motion larger than their design earthquake ground motions (post-1973 safe-shutdown earthquake, SSE, or pre-1973 design-basis earthquake, DBE).

1.2 Safety Significance

A typical spent fuel storage pool with high density storage racks can hold roughly five times the fuel in the core. However, since reloads typically discharge one third of the core, much of the spent fuel stored in the pool will have had considerable decay time. This reduces the radioactive inventory somewhat. More importantly, after roughly three years of storage, spent fuel can be air-cooled. The spent fuel need not be submerged to prevent melting, although submersion is still desirable for shielding and to reduce airborne activity.

If the spent fuel storage pool were to be drained of water the discharged fuel from the last one or two refuelings, stored in high density storage racks, could still be "fresh" enough to melt under decay heat. The Zircaloy cladding of this fuel could be ignited during heatup. The resulting fire, in a spent fuel storage pool equipped with high density storage racks, might spread to other fuel in the pool.

The heat of combustion, in combination with decay heat, would certainly release considerable gap activity from the fuel and would probably drive "borderline aged" fuel into a molten condition. Moreover, if the fire becomes oxygen-starved (quite probable for a fire located in the bottom of a pit such as the spent fuel storage pool), the hot zirconium would rob oxygen from the uranium dioxide fuel, forming a liquid mixture of metallic uranium, zirconium, oxidized zirconium, and dissolved uranium dioxide. This liquid mixture would allow a release of fission products from the fuel matrix. In addition, although confined, spent fuel storage pools are almost always located outside of the primary containment. Thus, a release to the atmosphere is more likely relative to a release inside primary containment.

The safety significance of "Beyond Design Basis Accidents in Spent Fuel Pools" has been designated as a medium priority issue (Ref. 2), Generic Issue 82. GI-82 applies to all light-water reactor spent fuel storage pools.

2. OBJECTIVES

The general objective of GI-82 is to evaluate the need for additional protective measures for the safe storage of spent fuel in high density storage racks in the spent fuel storage pool at light-water reactor sites.

Both prevention and mitigation are considered. A preventive option is one intended to reduce the frequency of accident sequences potentially conducive to the release of fission products from the spent fuel assemblies. A mitigative option is one intended to reduce the magnitude of the consequences that would result from an accident (environmental radiological releases).

Given the diversity of plant-specific design and construction of spent fuel storage pools, the applicability of any generic analysis of risk reduction measures is limited both with respect to the characterization of risk, and to the cost of implementation for any one plant. The analysis performed for GI-82 is intended to provide a broad evaluation of the value/impact attributes of a given proposed alternative. Plant specific analyses are used for the seismic risk evaluations. In this case, older plants have been selected for the analyses. In general the older plants are more vulnerable to seismic induced failures.

The risk from the storage of spent fuel in spent fuel pools should be a small contributor to the overall risk associated with the operation of a light-water reactor (LWR). On the core damage frequency (CDF) risk level, or more specifically in this case spent fuel damage frequency (SFDF), a target for the resolution of Generic Issue 82, based on the Commission's Safety Goal Policy Statement, is that the contribution from spent fuel pool accidents be a small part (a few percent) of an overall CDF target of $1x10^{-4}$ per reactor year.* Since spent fuel pools are not within the primary containment structure, a target SFDF for spent fuel pool accidents on the order of $1x10^{-6}$ per reactor year may be considered to be compatible with the proposed general performance guidelines given in the Commission's Safety Goal Policy Statement, that is, that the probability of a large release from an operating nuclear power plant should be no greater than $1x10^{-6}$ per reactor year. A more direct comparison of a SFDF target with the policy guidelines requires a definition of a "large release" in the policy statement.

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* More recently, a core damage frequency goal of $5x10^{-5}$ per reactor year has been proposed under the safety goal implementation program. This is a factor of two (2) lower than the $1x10^{-4}$ value used herein, but is within the uncertainty inherent in calculations and assumptions made assessing compliance with either goal, and its adoption in lieu of the $1x10^{-4}$ goal would not affect the recommendations made in this Regulatory Analysis.

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3. ALTERNATIVE RESOLUTIONS

In reaching its proposed resolution of GI-82, the staff considered seven specific alternative courses of action. These are discussed below. The requirements would be applicable to all light-water reactor (LWR) spent fuel storage pools, both in the operating or planned construction stage of licensing. There are 108 spent fuel pools for the 119 operating or planned LWRs at 75 reactor sites in the U.S. The three shutdown units, Dresden 1, Indian Point 1 and Humboldt Bay, are excluded from this accounting.

3.1 Alternative 1 - No Action

This proposed alternative assumes that no additional requirements for the safe storage of spent fuel in the primary spent fuel storage pool are needed. It also assumes that all applicable requirements and guidance to date have been implemented, but no implementation is assumed for related generic issues or other staff requirements or guidance that are still unresolved or still under review.

3.2 Alternative 2 - Require Use of Low Density Racks

This proposed alternative would require the use of low density storage racks for the storage of recently discharged fuel. Also, some reracking from high density to low density racks would be required. As a result, it is expected that additional at-reactor storage of spent fuel would be required to accommodate the lost capacity in the spent fuel storage pool. The use of low density racks shortens the cooling time to preclude a Zircaloy cladding fire by promoting air cooling if water is lost from the spent fuel. The likelihood and the amount of fuel damage would both decrease. This alternative is directed primarily towards prevention of a large release from the spent fuel pool.

3.3 Alternative 3 - Improve Cooling/Make-up Systems

This proposed alternative would require improvements in the spent fuel pool cooling and/or make-up systems, beyond the requirements currently used to license the spent fuel storage pools. Improvements in these systems would reduce the likelihood of fuel damage from loss of cooling events. This alternative is primarily directed towards prevention.

3.4 Alternative 4 - Install Spray Systems

This proposed alternative would require licensees to install post accident spray headers to mitigate the consequences of a Zircaloy cladding fire if the spent fuel storage pool is drained and cannot be reflooded. The likelihood of fuel damage would not change, but the spray systems would remove fission products and lower the consequences of a spent fuel pool accident. This alternative is primarily directed towards risk mitigation.

3.5 Alternative 5 - Modify Spent Fuel Storage Rack Designs

This proposed alternative would require the licensee to compartmentalize the spent fuel storage pool by installing partitions (and individual coolant supply diffusers for each compartment) to limit the extent of the accident, or modify the storage racks to improve air circulation, should the spent fuel storage pool drain. This alternative is directed both towards risk mitigation and prevention.

3.6 Alternative 6 - Cover Fuel Debris With Solid Materials

This proposed alternative would require the development of a contingency plan to dump massive amount of solid materials into a drained spent fuel pool to cover the rubble bed to a depth of several feet. The materials would not be necessarily stockpiled on site, but could also be obtained in a timely manner on an ad hoc basis. The materials (sand, clay, dolomite, boron compounds, lead, etc.) are commonly available in all parts of the country. This alternative would be directed at risk mitigation.

3.7 Alternative 7 - Improve Ventilation Gas Treatment System

This proposed alternative would require the installation of a building ventilation and filter system capable of reducing the concentration of airborne radioactivity before discharge to the environment. This alternative would be directed at risk mitigation.

4. TECHNICAL FINDINGS

4.1 Spent Fuel Pool (SFP) Review Guidelines and Requirements

Nuclear reactor plants include storage facilities for the wet storage of spent fuel assemblies. The safety function of the spent fuel pool (SFP) and storage racks is to cool the spent fuel assemblies and maintain them in a subcritical array during all credible storage conditions and to provide a safe means of loading the assemblies into shipping casks.

The SFP and components are reviewed to assure conformance with the requirements of 10 CFR Part 50 Appendix A General Design Criteria (GDC) 2, 4, 5, 61, 62, and 63. The review is performed under Section 9.1.2, "Spent Fuel Storage," of the Standard Review Plan (SRP) (Ref. 3). The facility and components are reviewed with respect to the following:

(a) The quantity of fuel being stored.

(b) The design and arrangement of the storage racks for maintaining a subcritical array during all conditions.

(c) The degree of subcriticality provided along with the analysis and associated assumptions.

(d) The effects of external loads and forces on the spent fuel storage racks, pool, and liner plate (for example, safe shutdown earthquake, crane uplift forces, missiles, and dropped objects).

(e) Design codes, material compatibility, and shielding requirements.

The SFP water level control system, cleanup system and cooling system are reviewed to assure conformance with the requirements of GDCs 2, 4, 5, 44, 45, 46, 61 and 63 under Section 9.1.3, "Spent Fuel Pool Cooling and Cleanup," of the SRP. In addition, a finding related to 10 CFR Part 20, paragraph 20.1(c) is made as it relates to radiation doses being kept as low as is reasonably achievable (ALARA).

The methods used to provide cooling for the removal of decay heat from the stored assemblies vary from plant to plant depending upon the individual design. The safety function to be performed remains the same: the spent fuel assemblies must be cooled and must remain covered with water during all storage conditions. The capability of the spent fuel pool cooling and cleanup system to provide adequate cooling to the spent fuel during all operating conditions is reviewed on one of two bases. The first basis requires the cooling portion of the system to be designed to seismic Category I, Quality Group C requirements. The second basis allows a non-seismic Category I, Quality Group C spent fuel pool cooling system provided that the following systems are designed to seismic Category I requirements and are protected against tornadoes: the fuel pool make-up water system and its sources; and, the fuel pool building and its ventilation and filtration system. The make-up, ventilation and filtration systems must also withstand a single active failure. The systems are reviewed with respect to the following:

(a) The quantity of fuel being cooled, including the corresponding requirements for continuous cooling during normal, abnormal and accident conditions.

(b) The ability of the system to maintain pool water level.

(c) The ability to provide alternative cooling capability and the associated time required for operation.

(d) Provisions to provide adequate make-up to the pool.

(e) Provisions to preclude loss of function resulting from single active failures or failures of non-safety related components or systems.

(f) The means provided for the detection and isolation of system components that could develop leaks or failures.

(g) The instrumentation provided for initiating appropriate safety actions.

(h) The ability of the system to maintain uniform pool water temperature conditions.

Other functions performed by the system, not related to safety, include water cleanup for the SFP, refueling canal, refueling water storage tank and other equipment storage pools; means for filling and draining the refueling canal and other storage pools; and surface skimming to provide clear water in the SFP.

Load handling in the SFP area is reviewed to assure conformance with GDCs 2, 5, 61 and 62 under Section 9.1.4, "Light Load Handling System (Related to Refueling)," and with GDCs 2, 4, 5 and 61 under Section 9.1.5, "Overhead Heavy Load Handling Systems," of the SRP. In addition the requirements identified in the resolution of GSI A-36, "Control of Heavy Loads Near Spent Fuel," as specified in Generic Letter 85-11 (Ref. 4), "Completion of Phase II of Control of Heavy Loads at Nuclear Power Plants (NUREG-0612)," are reviewed to assure that the implementation of Phase I of NUREG-0612 (Ref. 5) "has provided sufficient protection such that the risk associated with potential heavy load drops is acceptably small." Adequate justification is provided by means of (1) a single-failure proof crane, (2) operator training and procedures, maintenance and inspection procedures, safe load paths and mechanical or electrical stops to prevent movement of heavy loads over irradiated fuel, and/or (3) load drop analyses. The staff concluded, in GL 85-11, "that satisfaction of the Phase I guidelines assures that the potential for a heavy load drop is extremely small."

For reference, the titles of the various review and acceptance criteria are provided in Tables 4.1.1, 4.1.2 and 4.1.3.

Table 4.1.1
10 CFR Part 50 Appendix A, "General Design Criteria"

2	-	"Design Bases for Protection Against Natural Phenomena."
4	-	"Environmental and Missile Design Bases."
5	-	"Sharing of Structures, Systems, and Components."
44	-	"Cooling Water."
45	-	"Inspection of Cooling Water System."
46	-	"Testing of Cooling Water System."
61	-	"Fuel Storage and Handling and Radioactivity Control."
62	-	"Prevention of Criticality in Fuel Storage and Handling."
63	-	"Monitoring Fuel and Waste Storage."

Table 4.1.2
Regulatory Guides

1.13	-	"Design Objectives for Light-Water Reactor Spent Fuel Storage Facilities at Nuclear Power Stations."
1.26	-	"Quality Group Classification and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components at Nuclear Power Plants."
1.29	-	"Seismic Design Classification."
1.52	-	"Design, Testing, and Maintenance Criteria for Engineering-Safety-Feature Atmospheric Cleanup System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants."
1.115	-	"Protection Against Low-Trajectory Turbine Missiles."
1.117	-	"Tornado Design Classification."
8.8	-	"Information Relevant to Ensuring That Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable."

Table 4.1.3
Other Guidelines/References

ANS 57.1/ANSI N208,	"Design Requirements for Light Water Reactor Fuel Handling System."
ANS 57.2/ANSI N210-1976,	"Design Objectives for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Stations."
NUREG-0554,	"Single-Failure-Proof Cranes for Nuclear Power Plants."
NUREG-0612,	"Control of Heavy Loads at Nuclear Power Plants."

4.2 Spent Fuel Storage Pool Design Features

At some multi-unit sites a single pool is used for both units. Table A.1 of Appendix A identifies 11 dual unit pools, eight sites which have transfer canals between pools and three sites which can use transfer casks to move fuel between pools. The estimated maximum storage capacities (allowing for a full core reserve and other non-fuel reserve areas) and other plant specific information for all spent fuel pools in operation or planned are also provided in Table A.1. There are 108 spent fuel pools for the 119 operating or planned plants at 75 reactor sites in the U.S. (excluding Dresden 1, Humboldt Bay and Indian Point 1, which are now shutdown; and the Ft. St. Vrain HTGR).

The spent fuel pool floor and walls are lined with 1/8 to 1/4 inch thick stainless steel liner plates. The plates are welded to each other by seam welds. Under the seam welds, leak detection (control) channels are provided.

The design features of spent fuel storage pools keep the likelihood of loss of pool water and recriticality small. These features are:

(a) The fuel building concrete structure, the spent fuel storage pool, the spent fuel storage racks, the SFP cooling system, and the supports for the spent fuel handling trolley are designed to withstand seismic forces so that an earthquake as large as the safe shutdown earthquake will not cause loss of water or recriticality.

(b) Fuel storage racks are designed to keep the fuel widely enough separated so that stored fuel will not achieve criticality or, in high density storage racks, poison material is added to the rack structure for criticality control.

(c) The SFP is designed to prevent inadvertent loss of water from the fuel region by drainage through connected piping systems. Although a pool cooling system is connected to the pool for decay heat removal, it is designed to prevent siphoning of the water. A connection exists between the SFP and the reactor pressure vessel head region through the fuel transfer pathway (refueling canal) which is provided with physical barriers to prevent SFP drainage when not in use. The pools are generally sized so that the fuel remains nearly completed covered if the transfer pathway is inadvertently opened.

(d) Should the water inventory in the pool fall below a pre-set level or increase in temperature, multiple water level, water temperature and radioactivity monitors would actuate alarms in the control room. A make-up water system is provided to keep up with small leaks.

(e) Procedures and interlocks are provided to keep the crane from passing over the pool with heavy loads.

(f) The fuel building and the SFP are designed to accommodate the forces which might result from winds and missiles that might be generated by a tornado. Further, the spent fuel storage racks and the SFP cooling system are protected by structures designed to withstand these forces.

For reference, the physical parameters and crane capacities of some typical PWR and BWR spent fuel pools are provided in Table 4.2.1 (from Ref. 6). Some sites share a single pool for multiple units, such as North Anna 1 and 2, Surry 1 and 2, and Oconee 1 and 2. At other sites a transfer canal exists between pools to allow for spent fuel movement, such as Browns Ferry 1 and 2, Calvert Cliffs 1 and 2, and Hatch 1 and 2. At a few sites, a spent fuel shipping cask is used, or available, to transfer spent fuel between pools (San Onofre 1,2, and 3, and Turkey Point 3 and 4).

Table 4.2.1
Typical Pool Dimensions

Plant	Pool Dimensions L(ft)	W(ft)	H(ft)	Cask Area (sq. ft.)	Other Areas (sq.ft.)	Crane Capacity	Minimum Clearance (ft)
PWRs							
Ginna	43	22.2	41.7	116	29	25 T	32
Indian Point 3	33	27	37	n/a	n/a	40 T	n/a
Maine Yankee	41	37	38	100	230	125 T	24
North Anna 1 & 2	56.5	29.3	46.5	12 x 12	96	125 T	29
Oconee 1 & 2	71.3	15	38	131	0	100 T	29
Oconee 3	47.1	13.9	39	192	117	105 T	28
Palisades	38.8	14.7	38	9 x 9	8	100 T	28
Robinson 2	31	33.5	38.3	8.8x8.8	0	125 T	32
San Onofre 1	14	39	39	n/a	n/a	100 T	n/a
San Onofre 2	44	23	46	n/a	n/a	100 T	n/a
St. Lucie 1	33	37	40.5	10 x 12	0	105 T	28
Surry 1 & 2	72.5	27.3	38.5	12 x 12	0	125 T	29
Turkey Point 3	41.3	25.3	40	n/a	n/a	105 T	28
Turkey Point 4	41.3	25.3	40	n/a	n/a	105 T	28
BWRs							
Brunswick 1	56	34	38.8	160	200	125 T	28
Brunswick 2	56	34	38.8	160	200	125 T	28
Fitzpatrick	40	31	37.8	15 x 12	0	125 T	27
Millstone 1	30.5	40.3	38.8	53	310	110 T	22
Monticello	40	26	38	50	20	85 T	23
Oyster Creek	39	27	40	153	21	100 T	24
Peach Bottom 2	40	35.3	40	10 x 10	0	125 T	32
Peach Bottom 3	40	35.3	40	10 x 10	0	125 T	32
Pilgrim 1	32.8	26.1	38.8	77	0	100 T	26
Vermont Yankee	40	26	37.8	49	0	110 T	18

4.3 Spent Fuel Pool Structures

4.3.1 BWR Mark I and Mark II Plants

The spent fuel pool is located at the operating floor level, about 100 to 150 feet above grade. The pool floor and wall are designed for dead load and live load, hydrostatic pressure load, seismic load, thermal loads and loads resulting from the accidental drop of heavy objects. The thickness of the pool walls and floor is on the order of 4 to 6 feet. The horizontal and vertical loads from the pool floor are transmitted to the two longitudinal walls which are designed as deep girders supported at the peripheral wall of the reactor building.

4.3.2 PWR and BWR Mark III Plants

The spent fuel pool is located at the ground level. The physical dimensions and design loads of the the pool are similar to the BWR Mark I and Mark II designs. Due to the lower elevation, the seismic response is relatively low in comparison to the elevated pools in the BWR Mark I and Mark II plants. The vertical and horizontal loads from the pool floor are transmitted to the ground for plants with free standing or floor mounted fuel storage racks. For plants with laterally braced racks, the horizontal seismic loads from the fuel storage racks are transmitted to the pool wall at either the base level or at the base and upper seismic bracing level (about 14 feet above the base level).

4.4 Spent Fuel Storage Rack Descriptions

The following descriptions of spent fuel storage rack configurations are provided:

4.4.1 Low Density Racks (Cell Pitches 20 to 30 Inches)

The subcritical configuration is achieved by the physical separation of the assemblies in an open-frame aluminum or steel structure. Structurally the racks can be laterally braced at the upper and lower levels or they could be bolted to the floor at four corners with the upper and lower grids connected by cross bracing.

4.4.2 Medium Density Racks (Cell Pitches 9 Inches (BWR) to 13 Inches (PWR))

The subcritical configuration is achieved by the flux trap principle. The assemblies are surrounded by stainless steel cans or cells which prevent the neutrons in the water region between the cells from returning to the fuel assemblies. The typical wall thickness is 1/8 inch. Structurally the racks can be laterally braced at the upper and lower grid levels, bolted to the floor at the four corners with the upper and lower grids connected by cross-bracing, or they can be cantilever cells (2x2 or 4x4 modules to reduce flexibility) welded to a base structure.

4.4.3 High Density Racks (Cell Pitches 6 Inches (BWR) to 9 Inches (PWR))

Subcriticality is achieved by the addition of neutron absorbing poison material between the fuel assemblies. The poison is in the form of boron containing material such as boron-carbide, borated stainless steel, or borated aluminum. The storage cell walls have poison containing pockets. Structurally the racks are mostly free standing or laterally braced at the lower level. The honeycomb construction provides structural integrity. The cell walls are typical 0.09 inches thick. The cells are attached to each other by fusion or spot welds.

BWR high density configuration can also be in the form of directional storage racks. In this configuration the BWR assemblies are stored in 6 inch center-to-center racks, with a 5.3 inch open space between rows. No additional neutron absorber material is required in the rack structure for criticality control.

4.4.4 Consolidated Fuel Racks

The fuel assembly is disassembled and stored in a fuel canister. The canister is then stored in high density racks. The consolidation ratio can be 2 to 1. Two fuel assemblies can be compacted into the same physical dimensions of a single assembly. The non-fuel bearing material (such as grid spacers, guide tubes, etc.) is also compacted and stored. The compaction ratios for the non-fuel bearing material are estimated to be 10:1 for PWRs and 20:1 for BWRs (Ref. 7). Since the non-fuel bearing material can take up room in the spent fuel pool, the consolidation ratio may be as low as 1.5 with a weighted average consolidation ratio of 1.63.

4.5 Evaluation of Spent Fuel Cladding Failure

The results of work performed by Sandia (Ref. 8, Ref. 9) suggested that in certain fuel racking configurations (a) a self-sustaining zirconium-air oxidation reaction can be initiated, and (b) this self-sustaining reaction can propagate from one region of the pool to another.

These results were based on both experimental simulation and computer modeling. A computer program was developed by Sandia, called SFUEL1W, to evaluate conditions under which a self-sustaining Zircaloy reaction would occur and under what condition the Zircaloy fire would propagate to older stored fuel assemblies. Large uncertainties, associated with the phenomenology of Zircaloy oxidation and its propagation in spent fuel assemblies, were identified in the Sandia studies.

The SFUEL1W computer program was partially validated by Sandia (Ref. 9) and was also further validated by BNL (Ref. 10). The calculated results of the SFUEL1W models were compared with existing Sandia National Laboratory (SNL) small-scale experimental results. The CLAD computer program, a modified version of SFUEL (an early version of SFUEL1W), was used. CLAD was developed by Sandia to model the experimental test results (Ref. 9). Sandia had performed some verification studies against the experimental tests, but did not complete the work before funding ended. The BNL calculations with CLAD tended to result in an over-prediction of the peak cladding temperatures.

The NRC staff performed an independent verification of SFUEL1W using the CLAD computer program (Ref. 11). The BNL verification program included some modifications to CLAD. These modifications included the addition of helium properties to model the initial test conditions and a switch from helium to air flow, and an energy balance model to force conservation of energy on each gas control model. In the staff program, additional modifications were made to CLAD. The most significant modification was the inclusion of the SFUEL1W gas heatup model.

This NRC staff modified version of CLAD was verified against two of the Sandia air tests and the results compared favorable with the available experimental data. The peak cladding temperatures calculations were in good agreement with the data. It was concluded that the SFUEL1W fuel, cladding and gas heatup models are satisfactory.

The reaction rate equation for the oxidation of Zircaloy cladding in air used in the SFUEL1W computer program was also subject to uncertainties. BNL (NUREG/CR-4982) performed a literature search related to the oxidation rate of Zircaloy in air. Based upon the current state-of-the-art understanding of the associated phenomena and by performing sensitivity studies on the Zircaloy-air reaction rate correlation, it was concluded by BNL that the oxidation rate model used by Sandia in the SFUEL1W computer program is acceptable for the evaluation of spent fuel damage. For temperatures in the 800-1150 °C range (1470-2100 °F) the available data indicates that the Sandia correlation is valid, for exposure periods of 30 minutes. For longer periods the correlation may be non-conservative. At a constant temperature the rate of oxidation may increase with exposure time. This does not alter the findings concerning the initiation and/or propagation of a self-sustaining Zircaloy fire. Initiation is not influenced by the oxidation rate equation, and propagation can occur before cladding failure and relocation of the fuel rods occurs.

The uncertainties in the Zircaloy oxidation propagation calculations under inadequate room ventilation conditions (most typical of the spent fuel storage pool structures) were further studied by BNL (Ref. 10) using the SFUEL1W computer program. A sensitivity study covering hot spent fuel decay power in the 20 to 90 Kw/MTU range was performed. For reference, 90 Kw/MTU is the decay heat generation rate of fuel five to seven days following shutdown of a 3000 Mw(t) reactor. After one year the decay power level for a BWR is about 6 Kw/MTU and 11 Kw/MTU for a PWR. After two years, the decay power levels are estimated to be 4 Kw/MTU and 6 Kw/MTU respectively.

The SFUEL1W computer program is a finite difference solution of the transient equation for heating of the fuel rods considering:

- The heat generation rate from the decay heat and oxidation of the cladding,
- Radiation to adjacent assemblies and pool walls, and
- Convection to buoyancy-driven air flows.

The key assumptions and limitations of SFUEL1W are:

- The water drains instantaneously from the pool,
- The geometry of the fuel assemblies and racks remains undistorted,
- Temperature variations across the fuel rods are neglected,
- The air flow patterns are one-dimensional, and
- The spaces between adjacent holders are assumed to be closed to air flow.

With respect to the limitation concerning instantaneous draining of the pool, this assumption simplifies the heatup model in the SFUWL1W computer program and is not intended to be representative of any accident sequence other than perhaps the catastrophic failure of the spent fuel structure from a beyond design base seismic event.

After the water is drained from the spent fuel pool, the rods heat up until the buoyancy-driven air flow is sufficient to prevent further heatup. If the decay heat level is sufficient to heat the rods to about 900 °C (1650 °F) the oxidation becomes self-sustaining.

BNL has concluded (Ref. 10) that:

- The likelihood of cladding fire initiation is not very sensitive to the oxidation rate equation,

- The oxidation rate equation in SFUEL1W is a reasonable representation of the available data, and

- The likelihood of cladding fire initiation is most sensitive to the decay heat level and the storage rack configuration (which controls the extent of natural convection cooling).

It was also concluded that the oxidation propagation to older adjacent assemblies is likely if the decay heat level of the older adjacent assembly is high enough to heat that assembly to within 100 to 200 °C (200 to 400 °F) of the self-sustaining oxidation temperature. The radiation heat transfer from the burning assemblies then could be sufficient to raise the temperature of the older adjacent assembly to the self-sustained oxidation limit.

The following descriptions of spent fuel storage rack configurations are provided and are representative of the geometries used by both Sandia (Ref. 8) and BNL (Ref. 10) to determine spent fuel storage configuration which can result in Zircaloy fires and propagation of the fire to older stored fuel:

(1) High density PWR configuration: In this configuration, the fuel assemblies are tightly packed with neutron absorber material used in the rack structure to replace the reduced water moderator for criticality control. The center-to-center assembly spacing is 10.25 inches, the open gap between assemblies is 0.7 inches. This configuration is in use in nearly all PWRs, and is referred to as high density storage.

(2) Cylindrical PWR configuration: This configuration is typical of the early rack designs, used before at-reactor storage of spent fuel was required. The center-to-center assembly spacing is 12.75 inches, in a closed cylindrical stainless steel rack. The typical cross sectional area of a PWR assembly is 8.4 by 8.4 inches. This is referred to as low density storage.

(3) Cylindrical BWR configuration: This configuration is typical of early BWR spent fuel storage rack designs. The center-to-center assembly spacing is 8.5 inches. The typical cross sectional area of a BWR assembly is 5.3 inches. This is referred to as low density storage.

(4) Directional BWR configuration: In this configuration the BWR assemblies are stored in 6 inch center-to-center racks, with a 5.3 inch open space between rows. No additional neutron absorber material is required in the rack structure for criticality control. This is considered to be a high density storage configuration for BWRs.

Because of limitations in the SFUEL1W computer program, BNL limited the BWR spent fuel analyses to the low density cylindrical configuration. The SFUEL1W computer program does not account for air flow between adjacent holders, an assumption which was based on the storage rack design. The self-sustaining oxidation analysis is governed by the BWR channel box design, the air flow through the assembly. The SFUEL1W results are not significantly influenced by the BWR rack design.

The estimated likelihood of self-sustaining oxidation for various spent fuel rack configurations is provided in Table 4.5.1, based on a 12 month fuel cycle which is typical for most PWRs. BWRs typically operate on an 18 month fuel cycle. Additional calculated results from the earlier Sandia work (Ref. 8) are also provided. In Table 4.5.1 the Critical Cooling Time is defined as the decay time to reduce the internal heat generation rate to a low enough value, the Minimum Decay Power, to preclude the Zircaloy cladding temperature from exceeding the self-sustained oxidation limit under air cooling. Considering a fuel cycle of not less than one year, the cooling time can be converted to a conditional probability of fire initiation.

The conditional probability of propagation of the Zircaloy fire to older stored spent fuel was evaluated by BNL (Ref. 10). The results are provided in Table 4.5.2. In Table 4.5.2 the High Power Level is the decay heat generation of the recently discharged fuel and the Adjacent Power Level is the decay heat generation rate of the older fuel at the Approximate Decay Time. Perfect ventilation is assumed for these two studies. The impact of no ventilation, which would result in the depletion of the oxygen from the air, is summarized in Table 4.5.3. The High Power Level and Adjacent Power Level are the same as described for Table 4.5.2.

After an extensive review of the SFUEL1W computer code and comparison to the SNL small scale experiments, BNL concluded that the code provides a valuable tool for assessing the likelihood of self-sustaining clad oxidation for a variety of spent fuel storage configurations (Ref. 10). Additional studies performed by the staff supported the BNL conclusion.

For the purpose of evaluating the risk from beyond design basic accidents in spent fuel pools, the conditional probability of a Zircaloy cladding fire given a complete loss of water will be assumed to be 1.0 for PWRs and 0.25 for BWRs. The PWR value is based on the use of high density storage racks. The BWR value is selected based on the use of directional storage racks, with the channel box in place.

For the proposed alternative to require recently discharged spent fuel be stored in low density storage racks, the risk reduction is estimated to be a factor of five (Ref. 10). This level of risk reduction, resulting from the decrease in the cooling time needed to preclude a Zircaloy fire, is seen to be equivalent to the use of low density cylindrical storage racks with three inch inlet holes. The PWR conditional probability of a Zircaloy fire is reduced to 0.2 and the BWR conditional probability is reduced to 0.05. The actual risk reduction achievable may be greater than assumed. Open frame racks or cylindrical racks with larger inlet holes would result in an increased reduction in risk. The cooling decay time could be reduced to less than 20 days, for a conditional probability of 0.05 for both fuel types.

Table 4.5.1
Estimated Likelihood of Self-Sustaining Zircaloy Clad Oxidation for Various Spent Fuel Rack Configurations and Decay Heat Levels

Spent Fuel Rack Configuration	Inlet Orifice Diameter (inches)	Minimum Decay Power (Kw/MTU)	Critical Cooling Time (days)	Conditional Probability (per year)
BNL (Ref. 10) Last Discharge Only				
High Density PWR	10	11	360	1.0
	5	6	700	1.0
Cylindrical PWR	5	90	10	~0.0
	3	45	50	0.14
	1.5	15	250	0.7
Cylindrical BWR	3	30	30	0.08
	1.5	14	180	0.5
SNL (Ref. 8) Full Core Discharge				
Directional BWR with channel box	5	n/a	90	0.25
Directional BWR without channel box	5	n/a	30	0.08
PWR Open Frame	-	n/a	10	~0.0
Cylindrical PWR	5	n/a	20	0.05
	3	n/a	120	0.33
	1.5	n/a	250	0.7

Notes: Conditional probability estimated from NUREG/CR-0649 for maximum peak cladding temperatures less than 600 °C. Self-sustaining Zircaloy oxidation onset is approximately 900 °C.

n/a - Not Available. In the Sandia studies, the decay power level was not reported, however these analyses were performed for a full core discharge situation.

Table 4.5.2
Estimated Likelihood of Propagation of Zircaloy Fire to Older Spent Fuel for Various Spent Fuel Rack Configurations and Decay Heat Levels

Results for High Density PWR Racks With Large Inlet Holes (10" Diameter) and Perfect Ventilation

High Power Level (kw/MTU)	Adjacent Power Level (kw/MTU)	Approximate Decay Time (Days)	Propagation (Yes/No)
11.0	5.9	365	Yes
19.2	5.9	365	Yes
90	5.9	365	Yes
90	4.0	730	No

Results for Cylindrical PWR Racks With 3" Diameter Inlet Holes and Perfect Ventilation

High Power Level (kw/MTU)	Adjacent Power Level (kw/MTU)	Approximate Decay Time (Days)	Propagation (Yes/No)
90	11	365	No
90	19	180	Yes(1)

Results for Cylindrical PWR Racks With 1.5" Diameter Inlet Holes and Perfect Ventilation

High Power Level (kw/MTU)	Adjacent Power Level (kw/MTU)	Approximate Decay Time (Days)	Propagation (Yes/No)
90	11	365	Yes
90	5.9	730	Yes
90	3	1100	No
15	11	365	Yes
15	5.9	730	No

Note: (1) This is unlikely situation, assumes recent spent fuel discharge six months after previous discharge. Fuel cycles are typically 12 to 18 months.

Table 4.5.3
Summary of Radial Oxidation Propagation Results
for Various PWR Spent Fuel Rack Configurations and No Ventilation

Spent Fuel Rack Configuration	High Power Level (kw/MTU)	Adjacent Power Level (kw/MTU)	Propagation (Yes/No)
Cylindrical			
1.5" hole	90	5.9	Yes
	90	3	No(1)
Cylindrical			
3.0" hole	90	5.9	No
	19.2	11	Yes
High Density			
10" hole	90	4	No(1)

Note: (1) Without ventilation the fire becomes oxygen starved. Oxygen depletion prevents propagation.

4.6 Quantification of Accident Sequences in Spent Fuel Pools

4.6.1 Structural Failure Due to Missiles

High energy missiles which might impact with the spent fuel pool might result in sufficient structural damage to prevent cooling of the spent fuel. Missiles generated by tornadoes or from a turbine failure are considered during plant licensing. As indicated in Section 4.1, these accident sequences are reviewed by the NRC staff to assure compliance with the General Design Criteria.

In WASH-1400, the probability of a turbine failure and missile generation has been estimated to be on the order of 1×10^{-4} per reactor year, and the limiting strike probability for the spent fuel pool has been estimated to be 4.1×10^{-3}, given an energetic missile. The probability of a turbine missile hitting the spent fuel pool is therefore estimated to be 4.1×10^{-7} per reactor year.

The probability of a beyond design basis tornado striking a reactor site has been estimated to have a mean value of about 5×10^{-6} per reactor year (WASH-1400, Ref. 1), with a mean probability for all tornadoes of 5×10^{-4} per reactor year. A typical reactor site is estimated to be about 620 acres (one square mile), or greater (Ref. 6). The plan area of a spent fuel pool (50 feet wide by 60 feet long) is 1×10^{-4} square miles. The probability of a beyond design basis tornado striking the spent fuel pool is therefore on the order of 5×10^{-10} per reactor year. The probability of a tornado missile striking the spent fuel pool has been estimated based on the Zion site to be on the order of 1×10^{-6} per reactor year (Ref. 16).

The likelihood of a missile, turbine or tornado generated, damaging the spent fuel pool and resulting in an unrecoverable loss of water is estimated to be less than 0.01 per demand (Ref. 16). The missile would have to cause sufficient damage to prevent filling or repair of the spent fuel pool. Given the estimated combined likelihood of a missile strike on the order of $1x10^{-6}$ per reactor year, the estimated probability of the structural failure of the spent fuel pool from a missile resulting in a loss of cooling of the spent fuel is less than $1x10^{-7}$ per reactor year, on the order of $1x10^{-8}$ per reactor year.

4.6.2 Structural Failure Due to Aircraft Crashes

The probability of an aircraft striking the spent fuel pool is proportional to the vulnerable area of the structure, the aerial crash density of an aircraft and the number of operations on applicable runways. SRP Section 3.5.1.6 is used to derive the hit frequency for a reactor site.

The probability of structural failure of the spent fuel pool as a result of an aircraft crash has been estimated using Zion PRA results (Ref. 16). The mean hit frequency is estimated to be $6x10^{-9}$ per reactor year with 5% and 95% confidence bounds of $5x10^{-9}$ to $2x10^{-8}$ per reactor year. The probability of structural failure of the spent fuel pool resulting in significant spent fuel damage was estimated to be less than $1x10^{-10}$ per reactor year in NUREG/CR-4982 (Ref.10) and in EPRI NP-3365 (Ref.16).

4.6.3 Structural Failure Due to Heavy Loads Drop (Shipping Cask)

Load handling in the SFP area is reviewed to assure conformance with GDCs 2, 5, 61 and 62 under Section 9.1.4, "Light Load Handling System (Related to Refueling)," and with GDCs 2, 4, 5 and 61 under Section 9.1.5, "Overhead Heavy Load Handling Systems," of the SRP. In addition, the requirements identified in the resolution of GSI A-36, "Control of Heavy Loads Near Spent Fuel," as specified in Generic Letter 85-11 (Ref. 4), "Completion of Phase II of Control of Heavy Loads at Nuclear Power Plants (NUREG-0612)," are reviewed to assure that the implementation of Phase I of NUREG-0612 (Ref. 5) "has provided sufficient protection such that the risk associated with potential heavy load drops is acceptably small." Adequate justification is provided by means of (1) a single-failure proof crane, (2) operator training and procedures, maintenance and inspection procedures, safe load paths and mechanical or electrical stops to prevent movement of heavy loads over irradiated fuel, and/or (3) load drop analyses. The staff concluded, in GL 85-11, "that satisfaction of the Phase I guidelines assures that the potential for a heavy load drop is extremely small."

The estimated probability of structural failure of the spent fuel from a shipping cask drop was estimated by BNL based on a cask handling assumption of two fuel shipments per week, similar to that used in WASH-1400. The estimated probability of a shipping cask being dropped on the spent fuel pool wall, without consideration of the requirements from GSI A-36, was estimated by BNL to be $3.1x10^{-4}$ per reactor year (Ref. 10). The likelihood of pool damage was estimated by BNL (Ref. 10) to be 0.1 per demand, one-in-ten drops causing sufficient damage to completely drain the pool, with an uncertainty range of 0.01 to 1.0. The estimated reduction in the probability of a shipping cask drop for a plant which complies with the resolution of GSI A-36 (Ref. 4) has been estimated by BNL to be a factor of 0.001, for a revised probability of $3.1x10^{-8}$ per reactor year, including the 0.1 conditional probability of failure given a shipping cask drop.

A more detailed analysis of the resultant damage to a spent fuel pool structure as a result of a shipping cask drop was performed by LLNL (Ref. 17). A BWR and PWR spent fuel pool were analyzed for a variety of cask weights and drop heights. The results of the LLNL analysis indicate that the pool wall could suffer severe damage as a result of a cask drop. The indicated regions of potential reinforcing steel yield are quite extensive and while the integrity of the pool liner is difficult to predict, it was concluded by LLNL that it seems likely that the liner would be severely damaged. The estimated probability of the structural failure of a spent fuel pool resulting from a dropped shipping cask is therefore considered to be equivalent to the probability of dropping the cask, 3.1×10^{-7} per reactor year, given a cask handling rate of twice per week (104 per reactor year).

At the present time, spent fuel is mostly being accumulated in spent fuel pools. At a few facilities, the older fuel assemblies are being transferred to dry storage areas on site. To estimate the probable number of cask handling operations per year the following assumptions are made:

(1) The spent fuel pool capacity, with a full core reserve, has reached a licensing limit (either structurally or due to cooling capacity restrictions).

(2) The capacity, maximum number of allowable assemblies, is maintained and excess assemblies are transferred to either an onsite dry storage area or the DOE repository.

(3) Based on a 12 month fuel cycle in PWRs with 200 assemblies in the core, about 70 assemblies would have to be removed annually from the spent fuel pool to accommodate reloads.

(4) Based on a 18 month fuel cycle in BWRs with 800 assemblies in the core, about 130 assemblies would have to be removed annually from the spent fuel pool.

(5) The weight of a PWR assembly is approximately twice that of a BWR assembly, 657.9 kg (1450 lbs) versus 319.9 kg (700 lbs).

(6) Based on TN-24P (Ref. 18) and MC-10 (Ref. 19) dry storage cask designs, twenty-four PWR, or 48 BWR, assemblies can be moved per cask. The cask weight is in the 100 ton range.

The estimated number of transfers per reactor year is therefore estimated to be about a factor of ten lower as compared to the WASH-1400 rate of 104. The probability of structural damage to the spent fuel pool as a result of a dropped shipping cask is estimated to be 3.1×10^{-8} per reactor year (best estimate) for a reasonable cask handing rate. The upper bound estimate is taken from NUREG/CR-4982 (Ref. 10) as 3.1×10^{-7} per reactor year.

4.6.4 Reactor Cavity and Transfer Gate Pneumatic Seal Failures

Inflatable, pneumatic seals are used during refueling operations in PWRs to seal the gap between the reactor pressure vessel flange area and the biological shield walls. This permits flooding of the reactor pressure vessel cavity above the core to allow for the safe handing of the

fuel. In BWRs, the reactor cavity seals are typically permanent stainless steel expansion bellows, and not subject to the failure modes associated with the pneumatic designs. Pneumatic seals are also used to partition areas of the spent fuel pool, for example, between the shipping cask handling area or fuel transfer tube and the main spent fuel storage area. Ten reported cases of pneumatic seal failures resulting in actual or potential loss of water from spent fuel pools are listed in Table 4.6.1, three involving the refueling cavity seal and seven involving other pneumatic seals.

Three of the ten reported events involved the failure of the refueling cavity seal. In one case, no fuel was in the spent fuel pool and the failure occurred during installation and testing. In the other two events, the fuel transfer canal was closed at the time and no actual drainage from the spent fuel pool would have occurred.

At Surry 1 in May 1988 following the water loss from the refueling cavity seal failure, the plant operator opened the fuel transfer canal path to aid in reflooding the reactor cavity. Personnel inside containment, on the fuel crane bridge, had to leave containment as a result of high radiation levels. Operators did not enter appropriate procedures for a loss of refueling cavity level, and the existing procedures provided inadequate guidance to operations personnel on a rapid loss of cavity water (Ref. 20). Procedures had been developed at Surry to address cavity water loss in response to IEB 84-03 (Ref. 21), but were inadvertently omitted from revised procedures in 1987. A review of the design by the seal vendor (Presray), who has stated that they manufacture and continue to supply most of the refueling cavity seals used throughout the industry, determined that the design at Surry is unique and inadequate. A seal backup plate should have been provided to prevent movement of the seal. The IEB 84-03 review by the licensee failed to identify the weakness in the seal design, although procedures were developed to address seal failure.

In the remaining seven reported instances, pneumatic seal failures have occurred which could result in the draining of the spent fuel pool. The event at Hatch (see Table 4.6.1) is considered to be unique, and in two of these seven cases there was no spent fuel in the pool at the time of the event.

For the purpose of evaluating the potential for spent fuel damage from pneumatic seal failures, the event frequency was initially estimated by BNL to be 0.01 per reactor year and is generally applicable to PWRs. Based on advances in seal designs, increased awareness and surveillance resulting from IEB 84-03, BNL estimated the present failure rate to be an order of magnitude less, 0.001 per reactor year. In addition to the seven events identified in NUREG/CR-4892, two more events related to seal failures where identified (Ref. 22) for a total of nine events in about 900 years of experience. The Surry 1 event, which occurred after NUREG/CR-4982 was published, would not alter the event frequency (ten events in 1,000 years of experience).

Not all seal failures will lead to loss of water from the spent fuel pool. A failure of the refueling cavity seal must occur coincident with an open fuel transfer canal. Even under this assumption, the spent fuel pools are designed to preclude significant (a few inches) fuel uncovery due to the leakage. The transfer canal is either located above the top of the storage racks or a weir is used to prevent lowering the level below the top of the fuel.

Seal failures coincident with fuel handling operations are being addressed as a separate issue, Generic Issue 137, as discussed in Section 4.9.3.

Table 4.6.1
Events in Which Pneumatic Inflated Seals Have Failed

Date	Plant	Seal Location	Cause	Result
9/72	Pt. Beach 1[1]	Transfer gate	Failure of air supply	11,689 gal leak
10/76	Brunswick 2	Inner pool gate	Air leak in seals an compressor power supply failure	5" level drop
6/80	Trojan	Transfer gate	Not inflated prior to draining refueling cavity, level alarm also failed	10" below T.S.
2/81	Davis-Besse	Transfer gate	Low seal pressure	15" level drop
5/81	ANO-2	Transfer gate	Maintenance error air supply shutoff	1000 gpm leak
8/84	Haddam Neck[2]	Cavity seal	Design weakness in 20 minutes	200,000 gal leak
10/84	San Onofre 2[1]	Gate seal	Air compressor fails	20,000 gal leak
11/84	San Onofre 2[1]	Cavity seal[3]	Manufacturing defect seal ruptured	19.5" level drop
12/86	Hatch[4]	Pool canal flexible joint	Air supply valve closed	141,000 gal leak
5/88	Surry 1[5]	Cavity seal	Maintenance error and design weakness	30,000 gal leak

Notes: (1) No spent fuel in pool at time of event.
(2) Fuel transfer canal closed. No water loss from pool.
(3) Failure during installation and leak testing
(4) Make-up system cycled to maintain level, undetected for about 7.5 hours. Hatch has interconnected transfer canal between two pools. Seal required for SSE considerations. Unique design.
(5) Licensee had reviewed seal design following Haddam Neck event, and determined design to be adequate. Procedures developed to address seal failure subsequently omitted. Maintenance error isolated air supply to seal, combined with low backup nitrogen accumulator resulted in seal failure. Passive backup seal failed due to improper installation and design. Design determined to be unique to Surry. Maximum leakage 6,500 gpm for 4 minutes.

In response to IEB 84-03, the analyses supplied by licensees indicated that the failure of a pneumatic refueling cavity seal in most PWR plants would not result in massive leakage because of the relatively narrow gap to be sealed and the geometric shape of the seal (the Haddam Neck design was determined to be unique because of the large gap sealed). Also, leaks from seal failures in the transfer canal gates would be limited, in most cases, because the leakage would be into a confined volume, for example from the pool into a drained up-ender sump. This volume is small in comparison to the spent fuel pool volume and the level in the spent fuel pool would decrease slightly.

Licensee responses to IEB 84-03 have been reviewed by the NRC staff to determine the credible leakage that could result from pneumatic seal failures, in particular the refueling cavity seal. Although BWRs do not generally use pneumatic seals (permanent stainless steel bellows are used), some licensees did provide estimates for credible leakage in the highly unlikely case these seals were to fail. The seal failure leakage rates provided by licensees are listed in Table 4.6.2, and are representative of the maximum flow rates achieved for a fully flooded refueling cavity. As the water level drops, the hydrostatic pressure decreases and the flow rate will also decrease. For example, in the Summer submittal (Virgil C. Summer response to IEB 84-03, October 16, 1984, Docket No. 50-395), even though the maximum flow rate is 5,500 gpm, it was estimated that it would require 160 minutes to drain the cavity to the level of the seal ring with the transfer tube open. If the transfer tube is closed, the spent fuel pool will not drain. The Watts Bar submittal (Watts Bar response to IEB 84-03, December 6, 1984, Docket No. 50-390) estimated the time to drain to the reactor vessel flange region was about 95 minutes. The Catawba/McGuire submittal (William B. McGuire 1 and 2 and Catawba 1 and 2 responses to IEB 84-03, November 11, 1984, Docket Nos. 50-369, -370, -413, and -414) provided the most comprehensive assessment of postulated leak rates. The times to drain the refueling cavity, considering the hydrostatic pressure changes as level decreases, ranged from 12 minutes for 100% gross failure to 414 minutes for a 1/16 inch gap around the entire seal circumference. For the 25% gross seal failure, the time was estimated to be 65 minutes. This case was reported to be identical to the Haddam Neck seal failure event.

The catastrophic complete failure of the refueling cavity seal is not considered to be credible. The Haddam Neck seal failure is considered to the most limiting case. Even if a catastrophic failure occurred, with one to two feet of water remaining above the fuel in the spent fuel pool, there would be at least two hours available for the operator to take emergency actions to provide cooling for the spent fuel before the water covering the spent fuel boils off. This time estimate is based on Table 4.6.3, which shows that the maximum rate of boiling following a full core discharge five days after shutdown is equivalent to one foot every two hours (based on 49 hours to boil off 23 feet of water). For a normal refueling, assuming 1/3 core discharge, the recovery time would be five hours. An example of a procedure developed to address this highly unlikely situation was provided in the Catawba/McGuire response to IEB 84-03. The alternate cooling method is to recirculate water from the containment sump to the refueling water storage tank and then to the spent fuel pool using a residual heat removal pump.

The fuel transfer canal structure, located between the fuel transfer canal in the reactor vessel refueling pool and the fuel storage pool in the fuel storage building, is typically equipped with a metal expansion joint to accommodate flexure. In the event the fuel transfer tube tube expansion joint failed, the outer sleeve slip joints would limit the leakage flow. The maximum calculated leakage through a slip joint was estimated to be 400 gpm (Indian Point 2 supplemental response to IEB 84-03, March 31, 1987, Docket No. 50-247).

BNL estimated (Ref. 10) that the frequency of a serious loss of pool water inventory resulting from a pneumatic seal failure would be on the order of one in one hundred events (0.01). The combined probability estimate was $1x10^{-5}$ per reactor year for a serious loss of pool water event (Ref. 10). This estimate does not include credit for recovery actions to mitigate or stop the draining event from resulting in spent fuel damage. A conditional probability of failure to recovery of 0.05 was used by BNL, based on previous studies (Ref. 27), resulting in a frequency estimate of $5x10^{-7}$ per reactor year for the seal failure accident sequence.

To assure that the BNL estimate is appropriate for this event, the NRC staff examined the human error probability (HEP) of failure to diagnose this event in sufficient time to take mitigative action. As discussed above, licensee responses to IEB 84-03 demonstrate that there is considerable time to respond to a seal failure event, even for postulated leakage on the order of several thousand of gallons per minute. The refueling cavity seal would have to fail while the transfer canal was open. For the protection of the spent fuel, the transfer canal gate valves can be closed and make-up water provided to restore the pool level if the level in the refueling cavity falls below the reactor pressure vessel flange region. Using the nominal HEP screening model (Ref. 21) to estimate the HEP for failure to diagnose the event, the median joint HEP for a one to four hour time period is $1x10^{-4}$ to $5x10^{-5}$. The error factor on the median HEP is 30, therefore the HEP value for failure to diagnose a serious seal failure is estimated to be in the $3x10^{-3}$ to $1.5x10^{-4}$ range.

On December 17, 1984 an IE Information Notice, IN 84-93, "Potential for Loss of Water From the Refueling Cavity," was issued (Ref. 24). In this notice the staff concluded that "Adequate emergency procedures and properly calibrated refueling cavity water level instrumentation are considered to be important in the mitigation of any loss-of-cavity-water accident."

Based on the heightened awareness to refueling cavity seal designs, installation, testing and maintenance of the seals, and to the need for adequate procedures to address seal failures, as identified in IEB 84-03 and in IN 84-93, and considering the time available to diagnose a serious seal failure on the order of one hour, the staff updated the estimate of the frequency of loss of spent fuel pool water resulting in fuel damage. Given a serious seal failure frequency estimate of $1x10^{-5}$ per reactor year with an HEP conditional failure probability of $3x10^{-3}$ (median value for one hour with error factor) to diagnose the seal failure, the best estimated frequency is $3x10^{-8}$ per reactor year of a seal failure resulting in spent fuel damage. The upper estimate for this event is $5x10^{-7}$ per reactor year, based on the BNL evaluation in NUREG/CR-4982 (Ref. 10).

Table 4.6.2
Refueling Cavity Seal Leak Rates Following Seal Failure

Plant	Type	Leak Rate (gpm)	Assumptions
Point Beach 1/2	PWR	62	break area of 0.5 square inches
Turkey Pt. 3/4	PWR	50	
Comanche Peak	PWR	100	break area of 1.0" diameter
Oconee	PWR	50	total dislodged inner seal
TMI	PWR	4,700	maximum, major gasket failure
Vogtle	PWR	175	8" section of gasket
Watts Bar	PWR	3,176	1/16" gap around seal
Summer	PWR	5,500	60 mil gap around seal
Prairie Island 1/2	PWR	4,200	2" gap
Watts Bar	PWR	3,200	
Haddam Neck	PWR	10,000	actual seal failure data
Catawba/McGuire	PWR	103,642	gross failure, 100% of seal
		20,467	gross failure, 25% of seal
		3,210	1/16" gap around seal
LaSalle	BWR	185	
Vermont Yankee	BWR	500	
FitzPatrick	BWR	370	inner bellow seal
		7,100	outer bellow seal

Note: Leak rates are maximum flows with full refueling cavity water level. As level decreases, flow rates will decrease.

4.6.5 Inadvertent Draining of the Spent Fuel Pool

There are other mechanism for draining the spent fuel, in addition to the seal failures discussed previously. Pipe breaks in the cooling system or heat exchangers, or siphoning paths could result in loss of water. There have been a number of recent events resulting in partial draining of spent fuel pools. These have been identified in IE Information Notice 88-65, "Inadvertent Drainages of Spent Fuel Pools." (Ref. 25)

At Wolf Creek (12/22/87) a valve in a return line to the refueling water storage tank (RWST) was left open following use of the spent fuel pool cleanup system to clean the RWST. The spent fuel pool level indicator and low level alarm were both inoperable in the control room. Successive tripping of the spent fuel pool cooling system pump alerted the operators to a problem. The minimum level in the spent fuel pool was 22 feet above the fuel.

At River Bend (9/20/87) an antisiphoning device in the purification system suction line was plugged in the upper spent fuel pool. River Bend is a Mark III BWR with an upper spent fuel pool near the reactor pressure vessel. Fuel movement to the primary spent fuel pool is not necessary unless the spent fuel is being completely discharged from the reactor. The upper pool was intentionally drained below the level indicator range to accommodate placement of the steam dryer in the pool. When using the condensate storage tank (CST) to refill the upper pool, valve misalignment result in a siphoning effect. High radiation alarms and a level increase in the CST alerted the operators to the problem. The manual valves in the purification line were closed to stop the drainage.

At San Onofre 2 (6/22/88) a siphoning path was present in the purification system, and approximately 9,000 gallons were siphoned. Although siphon breakers, check valves, and locked valves were installed, the administrative controls were not established allowing alignment of the system which led to the siphoning event.

Operating procedures for the interconnected systems associated with the spent fuel pools either were not sufficiently detailed or were incorrect and failed to prevent alignments causing unintentional drainage. At Wolf Creek procedures did not exist. Also surveillance procedures were not implemented to ensure the operability of all instrumentation and control equipment at Wolf Creek.

At Turkey Point 4 (8/16/88) approximately 3,100 gallons of water was released from the spent fuel pool through a vent valve on a failed pump. This event occurred after IE Information Notice 88-65 was issued.

At Surry Unit 1 (10/2/88) a small leak developed in a pneumatic seal in the fuel transfer system as a result of the an accidental pinhole puncture in the single air supply line. The leak was promptly detected and stopped before seal integrity was lost. The reactor cavity seal was not installed at the time and if the seal failed, the loss of water could have lowered the spent fuel pool level to within 13 inches above the top of the stored fuel. IE Information Notice 88-92, "Potential for Spent Fuel Pool Draindown," was issued on November 22, 1988 (Ref. 26) to alert licensees to potential problems resulting from failure of the fuel transfer canal door seal.

The inadvertent draining of a spent fuel pool should be precluded by design or administrative procedures. Antisiphoning devices, or approved system alignment procedures should be in place to assure that the primary safety function of the spent fuel pool is not compromised. To this end, instrumentation to alert operators to potential problems should be operable. IE Information Notice 88-65 identified these issues and all holders of OLs and CPs are expected to review the information and consider appropriate actions to avoid similar problems.

The frequency of a siphoning event was estimated (Ref. 27) to be 0.001 per reactor year, based on a break in the cooling system. An 0.01 conditional failure probability of the cooling system to isolate was assumed. Further it was assumed that the conditional failure probability of the backup make-up system was 0.015. The frequency of a siphoning event was estimated to be 1.5×10^{-7} per reactor year (Ref. 27). Based on a conditional probability of an anti-siphoning check valve failure of 0.08 (Ref. 27), the frequency of this scenario resulting in spent fuel damage is estimated to be 1.2×10^{-8} per reactor year.

The operational experiences concerning spent fuel pool component performance indicates that partial pool draining resulting from non-seal failure related causes, such as inadvertent siphoning, do not result in a significant loss of water from the spent fuel pool (Ref. 28). At San Onofre 2, for example, the 9,000 gallons is equivalent to about 19.5 inches of water. At Davis-Besse, on June 6,1980, an improperly calibrated level alarm did not actuate until the level was 10.25 inches below the Technical Specification limit. At Trojan, June 10,1982, misalignment of the spent fuel pool purification system as a result of not closing the door between the spent fuel pool and the fuel transfer canal resulted in a lowering of the level to 21 feet 9 inches above the top of the stored fuel. The Technical Specification limit is 23 feet. The rate of draining was 132 gpm.

As a result of increased awareness concerning the development and use of proper administrative procedures for system alignments and the use of anti-siphoning devices and the need for spent fuel pool level indication through the issuance of IE Information Notice 88-65, the staff concludes that the frequency of spent fuel damage from inadvertent draining of the spent fuel pool is less than $1x10^{-7}$ per reactor year, and the best estimate value is $1.2x10^{-8}$ per reactor year based on previous estimates (Ref. 27).

4.6.6 Loss of Cooling/Make-Up

The acceptance criteria associated with the general design and operation of the spent fuel pool and it's related support systems, primarily the cooling and make-up systems, are based on the long time interval available to the plant operators to diagnose and correct failures in these systems. In WASH-1400, for example, it was assumed that the likelihood of failure to recover from loss of cooling was $1x10^{-6}$ per event. With an assumed loss of cooling event frequency of 0.1 per reactor year, the probability of damage to the spent fuel was judged to be extremely small, $1x10^{-7}$ per reactor year.

In WASH-1400 the assumed spent fuel pool inventory was limited to about 2/3 of a full core. A pool loading of 1/3 of a core with 150 days decay and 1/3 with three days decay was assumed for the limiting condition. Approximately nine days (216 hours) would be available before the 50,000 cubic feet of water in the spent fuel pool would be completely boiled off. The average pool loading assumption resulted in 3.8 weeks (640 hours) available for the repair of the cooling system and/or water make-up to be accomplished. In WASH-1400 it was believed that spent fuel shipping would be occurring on a weekly basis and the likelihood of failure to recover was estimated to be $1x10^{-6}$.

However, spent fuel is not being shipped within the United States and the spent fuel pool inventories are larger than assumed in WASH-1400. To determine the available time for recovery, a simplified calculation was performed. A 3000 Mw thermal plant is assumed to have discharged 1/3 of a full core annually for a period of 20 years, for a spent fuel pool heat load of 3.5 million BTU/hr of decay heat. Older fuel would not increase the heat load significantly. Based on the pool data provided in Table 4.2.1, it is assumed that there is 32,000 cubic feet of water covering the spent fuel, a 30 foot by 40 foot surface with a depth of 23 feet over the spent fuel. Heatup of only the water is assumed. The results of the calculation are provided in Table 4.6.3 for the case when 1/3 of the core is recently discharged or the case when the full core is discharged. Also provided in the table is the needed make-up rate, in gallons per minute, to match the boil off rate.

Based on Table 4.6.3, the time available to recovery from loss of cooling can be estimated as at least 24 hours for the most limiting case - full core discharge five days following reactor shutdown. At this time the water level covering the spent fuel (approximately ten feet) is adequate to provide shielding to maintain the radiation levels in the spent fuel storage area to a low enough value to permit limited operator access to the SFP area as required to establish make-up. The make-up capacity is less than 100 gpm and the assumption that the fire system can be used to provide make-up appears to be reasonable. It is also noted that the frequency of this limiting condition is estimated to be less than 5% of the lifetime of the facility. Full core offloading is an unusual occurrence, except during ten year inservice inspections of the reactor pressure vessel. Assuming four inspections per life, and eight additional unanticipated offloads, the estimated frequency of having a full core in the spent fuel pool (assuming the full core is in the pool for a period of 30 days) is 1 year per 40 year life or 2.5% of the time. For the typical expected condition of a 1/3 core discharge five days after shutdown, the time available to restore cooling and/or establish make-up is three days. For recovery actions which would not require operators to enter the potentially high radiation area, the available time to recovery cooling would be between two days, the most limiting case, and five days, for a normal refueling case. If the loss of cooling event occurs 30 days after discharge, the recover time intervals nearly double.

The spent fuel pool is equipped with temperature and level instrumentation to warn the operator of a degrading condition. Although these instruments are not safety grade, they do alarm in the control room. The spent fuel pool storage area also contains radiation monitors to alert the operator to degrading situations. These instruments provide the operator with the information necessary to initiate appropriate safety actions to assure that the safety function of the spent fuel pool, to maintain the spent fuel assemblies in a safe and subcritical array during all credible storage conditions, is not compromised. The issuance of IE Information Notice 88-65 (see Section 4.6.5) has emphasized the importance of assuring that the spent fuel pool level instrumentation is operable and that surveillance procedures are in place to assure the the instrumentation is properly maintained.

Operator performance, the human error probability (HEP), is estimated from NUREG/CR-1278 Chapter 12, "Diagnosis of Abnormal Events." (Ref. 23) The nominal screening model is used. Table 4.6.4 lists the median joint HEPs and the error factors for a variety of assumptions for failure to diagnose a loss of cooling event. Typical repair time estimates, as well as failure rates, for the components of the cooling system are provided in Table 4.6.5.

The failure rates in Table 4.6.5 are for all failure modes. For a series system which has one pump, one heat exchanger, one level indicator and four valves, the estimated failure rate of the system is 0.15 per reactor year. The mean time to repair the system is about 34 hours. This is representative of the minimum cooling system allowed under current requirements, and supports the estimated failure rate of a single cooling system of 0.1 per reactor year previously used in WASH-1400 and in NUREG-0933 (Ref. 27). Based on the mean time to repair the spent fuel pool cooling system, 34 hours, it is seen that there is adequate time to repair the cooling system before the spent fuel pool level decrease to a level where spent fuel damage would occur and the make-up rates needed to match the boil off rates are not excessive.

Four "generic" fuel pool cooling and make-up systems have been examined to estimate the possible range of failure frequencies for these systems. The four representative systems, based on current SRP acceptance criteria, are:

System A: Minimum cooling and make-up system requirements. One full capacity cooling train with redundant active components (i.e., valves, pumps, etc.). One Category I make-up system and one backup pump or system (not required to be Category I) which can be aligned to a Category I water supply.

System B: Minimum cooling and make-up system requirements (System A) with credit for make-up from the fire system for recovery.

System C: Typical older system. One cooling train with backup active components (but the backup components are required to supplement cooling about 30% of the time); and, one safety grade make-up system and one non-safety grade make-up system.

System D: Typical older system (System C) with a third make-up train available for recovery (i.e., the fire system).

Systems A and B are not intended to represent actual systems. Rather, they are representative of the minimum requirements in the current SRP.

The failure rates and systems failure frequencies are based on data from WASH-1400 and assumptions used in NUREG-0933 (Ref. 27). Specifically:

1. A 0.1 per reactor year frequency for the initiating event, loss of cooling, is based on WASH-1400 estimates. As discussed above, this is the expected failure frequency for a typical single train system based on typical component failure rates.

2. The conditional failure probability of 0.05 for the second cooling train (Systems A and B) represents a relatively high common mode failure probability. This value was used in NUREG-0933 to assist in the prioritization of this generic issue.

3. The conditional failure probability of 0.3 for the second cooling train (Systems C and D) represents the assumption that both cooling pumps are necessary 30% of the time. Thus a failure of either pump represents a failure of the system.

4. Train 1 of the make-up system is assumed to be independent of the cooling system and is assigned a low common cause contribution. The likelihood of a prolonged station blackout events is assumed to be low. This assumption is supported by a recent study completed by Sandia (Ref. 28). For 63 recorded incidents of loss of off-site power, the longest recovery time reported was about nine hours (for severe weather related losses), with the sample mean recovery time for all causes of 1.2 hours. The conditional probability of 0.015 is used, based on RHR reliability in the LPCI mode (WASH-1400).

5. Train 2 of the make-up system is assigned a conditional failure probability of 0.05. This system is not powered by emergency power buses and may be put out of service by a common mode failure of the spent fuel pool cooling system.

The estimated failure frequency of the spent fuel pool cooling and make-up systems resulting in a heatup of the spent fuel without recovery is summarized in Table 4.6.6 for each of the four systems.

Table 4.6.3
Heatup and Boil Dry Times for a Typical Spent Fuel Pool

	Based on 1/3 Core Discharge				Based on Full Core Discharge			
Days After Shut Down	Q-decay 1/3 core Discharge (BTU/hr)	Heat 125 F - 212F (hrs)	Boil Off Water (hrs)	Make-Up Boil Off (gpm)	Q-decay Full Core Discharge (BTU/hr)	Heat 150F - 212F (hrs)	Boil Off Water (hrs)	Make-Up Boil Off (gpm)
5	1.51×10^7	11.2	125.0	31.9	3.82×10^7	3.1	49.3	81.0
10	1.22×10^7	13.9	154.9	25.8	2.95×10^7	4.1	63.8	62.6
30	8.87×10^6	19.0	212.2	18.8	1.97×10^7	6.1	95.8	41.7
45	7.75×10^6	21.8	242.8	16.4	1.63×10^7	7.4	115.5	34.5
65	6.96×10^6	24.3	270.4	14.8	1.39×10^7	8.6	135.2	29.5
100	6.14×10^6	27.5	306.5	13.0	1.15×10^7	10.5	164.2	24.3
150	5.27×10^6	32.0	357.1	11.2	8.58×10^6	13.6	212.6	18.8
200	4.81×10^6	35.1	391.2	10.2	7.47×10^6	16.1	251.9	15.8
250	4.54×10^6	37.2	414.5	9.6	6.66×10^6	18.1	282.6	14.1
300	4.39×10^6	38.4	428.3	9.3	6.22×10^6	19.3	302.4	13.2
350	4.30×10^6	39.2	437.5	9.1	5.94×10^6	20.2	316.6	12.6
365	4.29×10^6	39.3	438.6	9.1	5.91×10^6	20.4	318.4	12.5

Note: Q-decay includes 3.5×10^6 BTU/hr from 20 years of accumulated discharges.

Table 4.6.4
Nominal HEP Model Estimates for Failure to Diagnose Loss of Cooling

	Following 1/3 Core Discharge			Following Full Core Discharge		
	Time Min	Mean Joint HEP	Error Factor	Time Min	Median Joint HEP	Error Factor
Failure to Diagnosis Loss of Cooling Before Boiling Occurs	600	0.00002	30	180	0.00005	30
Failure to Recovery Before High Radiation Field in SFP Area	>1440	0.00001	30	1440	0.00001	30

Note: The HEP probabilities are based on the nominal HEP model (Ref. 23). Previous estimates of failure to recovery (NUREG-0933, for example) have used a HEP value of 0.05 considering the high temperature and high radiation fields following loss of water from the spent fuel pool, and considering the location of the spent fuel pool in a BWR. Make-up was assumed to be from a fire hose.

Table 4.6.5
Typical Failure Rates and Repair Times for Cooling System Components (Taken from EPRI NP-3365)

Component	Failure Rate (per hour)	Range (per hour)	Average Repair Time (hours)
Piping (per 10 ft section)	3×10^{-10}	1×10^{-11} to 3×10^{-8}	30
Pump	1×10^{-5}	3×10^{-6} to 3×10^{-5}	40
Heat Exchanger	3×10^{-6}	1×10^{-7} to 1×10^{-4}	30
Valves (per valve)	1×10^{-6}	3×10^{-7} to 3×10^{-6}	24
Instrumentation (per channel)	1×10^{-6}	3×10^{-7} to 1×10^{-5}	6

Table 4.6.6
Failure Frequency of Generic SFP Cooling and Make-Up Systems Without Recovery

System	Cooling Train 1 (per R-y)	Cooling Train 2 (per demand)	Make-up Train 1 (per demand)	Make-up Train 2 (per demand)	Frequency of Heatup (per R-y)
A/B	0.1	0.05	0.015	0.05	3.8×10^{-6}
C/D	0.1	0.3	0.015	0.05	2.2×10^{-5}

The probability of the complete loss of the cooling and the make-up systems resulting in spent fuel damage is dependent on actions taken by the plant operators to either restore the cooling and/or make-up system or provide an alternative method for make-up or cooling, for example use of the station fire fighting system or use of a portable backup pump. In NUREG-0933, a conditional failure probability of 0.05 was assigned to the operator failure to accomplish recovery actions. The resulting frequency of fuel damage was estimated to be 1.9×10^{-7} per reactor year for System B (System A with recovery) and 1.1×10^{-6} per reactor year for System D (System C with recovery). The 0.05 conditional failure probability of recovery before fuel damage was based on the assumption that the spent fuel pool area environmental conditions would eventually become severe enough to make it difficult to setup the fire hose for make-up. The NUREG-0933 (Ref. 27) evaluation did not consider the time available to diagnose and take corrective or recovery actions.

Based on the time available to diagnose a loss of cooling event, at least three hours before boiling occurs, the HEP value for failure to diagnose is 0.0015 (median value for full core discharge with error factor). For the 1/3 core discharge case, these values are lower by a factor of about two. The probability of a pool heatup event resulting in boiling of the water in the spent fuel pool is therefore estimated to be 5.7×10^{-9} per reactor year for System A ($3.8 \times 10^{-6} \times 1.5 \times 10^{-3}$) and 3.5×10^{-8} per reactor year for System C ($2.2 \times 10^{-5} \times 1.5 \times 10^{-3}$).

The spent fuel pool cooling and make-up systems are designed to meet one of two basic sets of requirements. The first basis requires the cooling portion of the system to be designed to seismic Category I, Quality Group C requirements. The second basis allows a non-seismic Category I, Quality Group C spent fuel pool cooling system provided that the following systems are designed to seismic Category I requirements and are protected against tornadoes: the fuel pool make-up water system and its sources; and, the fuel pool building and its ventilation and filtration system. The make-up, ventilation and filtration systems must also withstand a single active failure.

Since Generic Issue 82 is concerned with risk from beyond design basis events, LLNL evaluated the probability of a beyond design basis seismic event resulting in a loss of cooling event and subsequent pool heatup transient (Ref. 17).

The cooling and make-up water systems for two pools were reviewed, one for a BWR system and one for a PWR system. Event and fault tress were constructed by LLNL to identify the accident sequences that result from failure of these systems. For components appearing in these accident sequences, seismic fragilities were estimated based on design information and plant walkdowns. Boolean equations developed from the fault tree analysis were quantified using the seismic fragilities and preliminary hazard curves for the two sites. The dominant components to spent fuel pool system failures were found to be similar to components that have been found to contribute to seismic risk in several PRAs concerned with reactor core damage; poorly anchored electrical equipment and tanks. The components which contribute significantly to the seismic induced failure of the spent fuel pool support systems are the non-safety electrical systems in the plant; the motor control centers, switchgear and station service transformers which have relatively low seismic capacities.

The estimated mean probability of a beyond design basis seismic event resulting in loss of cooling, combined with operator failure to properly align normal make-up, was found to be on the order of 1.5×10^{-4} per reactor year for both systems. A sensitivity study without operator failure rates or random failures showed little change in the mean probability estimate (Ref. 17). The median (50-th percentile) probability estimate was found to be about an order of magnitude lower than the mean value. For the seismic induced loss of cooling event to result in damage to spent fuel, the previously determined nominal HEP (with error factor) failure to diagnosis and failure of the second make-up train are used. Using the values of 0.0015 for failure to diagnose and 0.05 for failure of the second make-up train to recover, the estimated probability of fuel damage is therefore 1.5×10^{-4} x 0.0015 x 0.05, or 2.1×10^{-8} per reactor year. Based on the estimated failure frequencies used in Table 4.6.6 above, it would appear that common mode failures in the non-safety electrical systems resulting from a beyond design basis seismic event, at least for the two plants studied, may have been underestimated by a factor of two for System A (0.1 x 0.05 x 0.015, or 7.5×10^{-5} per reactor year without credit for make-up train 2 as compared to 1.5×10^{-4} per reactor year). The combined best estimate probability of spent fuel damage from loss of cooling, from component failures and beyond design basis seismic events, is therefore estimated to be 4×10^{-8} plus 2×10^{-8} or 6×10^{-8} per reactor year. Previous estimates, based on a conditional probability of failure to recover from a loss of cooling event value of 0.05 without consideration for event diagnosis and using the systems data in Table 4.6.6, provide an upper bound probability estimate of 1.4×10^{-6} per reactor year.

4.6.7 Structural Failure of SFP From Beyond Design Basis Earthquakes

The probability of failure of a structure is related to the functional relationships between the various physical parameters and the variabilities in the parameters themselves. Two types of variability are considered. The first variability is that which is potentially reducible and is called the uncertainty. The additional component, which cannot be practically reduced, is called randomness.

The seismic analysis of a structure includes two parts. The first is the structural capacity and the response of the structure to a seismic event. This is referred to as fragility. The second is the seismic input and site response to an earthquake, the seismic hazard analysis. The hazard analysis is comprised of two parts. The site response (peak ground acceleration, response spectra, and frequency for both horizontal and vertical ground motions) and the annual frequency of exceeding a given peak ground acceleration, the seismic hazard curve. Because of uncertainty, both the fragility and seismic hazard analyses are described by families of curves. Each curve representing different confidence levels. The resulting combination of these two

sets of curves in the PRA can yield large differences in the estimated probability of structure failure dependent on the confidence level. While the seismic hazard curves and the parameters used to define the fragility are developed and expressed in terms of median values, the mean value is used in PRA applications.

The NRC Seismic Margins Program has developed an additional measure of importance for assessing seismic risk. This measure is the high confidence of low probability of failure (HCLPF), defined in terms of the peak ground acceleration (g value). This value is derived from the fragility analysis and is independent of the site seismic hazard curves, the annual frequency of exceedance of a given g value. The HCLPF value is defined as the peak ground acceleration at which there is a 95% confidence that failure will not occur. This value may be compared to the safe shutdown earthquake peak ground acceleration used in the deterministic analysis to determine the margin in excess of the SSE for which no structural failure is anticipated.

A comprehensive assessment of uncertainty and conservatism in the seismic analysis and design of nuclear facilities has been prepared by the American Society of Civil Engineers (ASCE) (Ref. 29). The objectives of this study were to:

1. Identify sources of uncertainties present in seismic analysis and design,

2. quantify uncertainties, when possible, and recommend actions where data are missing, and

3. Identify the status of current analysis and design methods relative to the scatter of data for known sources of uncertainty.

The current practices employed to determine the seismic input and site response produce conservative (e.g., 84th percentile or greater), not median values, of the design seismic input. Empirical procedures for structural design provide an additional margin of safety across the entire design response spectrum in earthquake-resistant designs. The ASCE (Ref. 29) concluded that a nuclear power plant having a design seismic input value of 0.25 g may actually be able to withstand much larger values of peak ground acceleration.

Some siting procedures differ in the western United State because there is a strong ground motion data base available. Less extrapolation is required and tectonic faults and structures are also much easier to identify. The design seismic input is still conservatively evaluated in comparison to historical data.

The ASCE estimated the median factors of safety and logarithmic standard deviations associated with the safe shutdown earthquake (SSE), based on post 1973 seismic design methods. These factors are provide in Table 4.6.7 (from Table 9.1, Ref. 29).

The probability of gross structural failure of the spent fuel from a beyond design basis earthquake was estimated by LLNL (Ref. 17) for a typical, although older, elevated BWR spent fuel pool and a typical, older PWR spent fuel pool.

In analyzing the failure of the spent fuel pool structures and systems, LLNL considered the following:

(a) Loss of liner integrity precipitated by structural failure of the spent fuel pool.

(b) Loss of function of the fuel pool support systems (e.g. pool cooling and make-up water capacity) resulting in loss of water through boil-off or drainage.

(c) Damage to fuel racks caused by fuel rack motion.

The failure modes of the spent fuel pool structures were determined by LLNL. For the BWR Mark I and Mark II elevated spent fuel pools, the failure mechanisms which need to be considered are:

1. The failure mode of the pool floor is that of a slab fixed at the four edges. The girders supporting the pool are in reality long walls acting as deep girders and are supported by the peripheral walls of the reactor building.

2. Compressive and shear stresses at the reaction points of the girders (onto the reactor building walls) for transmitting vertical and horizontal seismic loads from the storage pool to the foundation needs to be considered for structural adequacy.

3. Due to large concentrated loads (50 to 70 kips) at each foot of the storage rack, bearing and punching shear stress in the pool floor should also be investigated.

4. For laterally braced high density fuel storage racks, large concentrated loads are transmitted to the pool wall at either the base level or at the base level and the upper seismic bracing level. The effect of concentrated load needs to be investigated.

Although thermal loads are important in the design of the spent fuel pools, their influence on the fragility of the pool is judged not significant by LLNL because the thermal loads are self-relieving.

For BWR Mark III and PWR storage pools, which are general on or below grade, the failure modes for the pool floor are:

1. Punching shear stress due to concentrated loads at the foot of the storage racks.

2. Foundation settlements for soil; soil settlement may only be an issue for piping relative displacements.

3. Failure modes for the walls are similar to that described for the BWR Mark I and II designs.

Possible failure modes for the liner plate identified by LLNL are:

1. Tearing of the liner plate or seam welds at the leak channels due to vertical/horizontal loads from fuel storage racks; this is of concern only if the rack slides and the foot bears on the leak channel.
2. Tearing of the liner plate due to sliding of the rack over any floor depression or wrinkles in the liner plate.

3. For a laterally braced rack, puncturing of the liner plate at the knuckle in the vicinity of the pool floor/walls intersection.

The failure modes of free standing or sliding racks, and for laterally braced high density fuel racks were considered by LLNL. Based on information provided to the NRC staff concerning a reracking amendment by a licensee (Ref. 30), LLNL concluded that the peak ground acceleration would have to exceed 1.5 to 2.0 g before failure of the free standing racks would occur. The median acceleration capacity of the racks for incipient impact with the pool wall is estimated to be 1.0 g, and it would require 1.5 to 2.0 times this value to cause impact and damage. Even then, the fuel rack design is such that the assembly cannot be compressed into a critical mass. LLNL therefore concluded that crushing of fuel and assemblies is not a credible failure mode of the spent fuel pool system. Also, the failure of the spent fuel pool liner plate resulting from movement of the spent fuel storage racks, either from sliding or puncturing, is not expected to result in the sudden or rapid drainage of the water from the spent fuel pool.

The actual potential failure modes of the BWR spent fuel pool studied by LLNL included the following:

(a) Out of plane shear failure of the pool floor slab.

(b) Out of plane bending failure of the pool floor slab.

(c) Punching shear failure of the pool floor slab under the fuel rack support pad.

(d) Out of plane bending failure of the south pool wall.

(e) Bending and shear failure of the girder under the south wall.

(f) Bending and shear failure of the girder under the east pool wall.

(g) Overall transfer of N-S and E-W inertial loads to the reactor building.

The controlling failure mode with the lowest seismic capacity was determined to be the out of plane shear failure of the pool floor slab. The slab was evaluated for out of plane loading resulting from dead weight load plus seismic load. Sources of dead loads are the weights of the slab, grout, water, fuel racks, and attached equipment. Sources of seismic loads are (a) vertical seismic response of the slab and attached masses, (b) fluid impulse and convective mode responses induced by horizontal seismic excitation, and (c) horizontal seismic response of the spent fuel racks.

The PWR spent fuel has two features which are not typical. The storage racks are both low density and high density in design. And to accommodate the region of high density racks, a support column was added beneath the spent fuel pool floor, in the waste gas holdup tank room below the spent fuel structure. The pool floor is actually six feet above grade at Robinson.

The actual potential failure modes of the PWR spent fuel pool studied by LLNL included the following:

(a) Out of plane bending of the East or South wall.

(b) Out of plane shear failure of the East or South wall.

(c) Out of plane shear failure of the pool floor slab.

(d) Out of plane bending failure of the pool floor slab.

(e) Overall seismic stability of the spent fuel.

The out of plane bending failure of the east wall was determined to be the failure mode with the lowest seismic capacity. The East or South wall resists the lateral forces of the old fuel racks. It was modeled by LLNL as a slab fixed on three sides and free on top. The loads considered in the evaluation of the seismic capacity of this wall are (a) hydrostatic loads (normal water level), (b) hydrodynamic loads induced by horizontal and vertical accelerations in earthquakes, (c) wall inertia force, and (d) reaction forces from the old fuel racks.

The fragility of a structure, or component, is expressed in terms of its median factors, A_m, β_R, and β_U. A_m is the median ground acceleration at which the probability of failure is 0.5. β_R and β_U are the random variability and the uncertainty in the median capacity based on a lognormal model. β_R and β_U are the logarithmic standard deviations of the median value. Using the lognormal model a high confidence of low probability of failure (HCLPF) capacity factor is defined, HCLPF capacity = $A_m \exp(-1.64 (\beta_R+\beta_U))$. The HCLPF value is defined as the peak ground acceleration at which there is a 95% confidence that failure will not occur. This value may be compared to the safe shutdown earthquake peak ground acceleration used in the deterministic analysis to determine the margin in excess of the SSE for which no structural failure is anticipated. This fragility model and development of fragility parameters have been utilized in over 25 seismic PRAs.

The median factors of safety and variabilities of the spent fuel pool structure for the elevated BWR were found to be $A_m = 1.4$ g, with $\beta_R = 0.26$ and $\beta_U = 0.39$. The HCLPF value is 0.5 g. For the PWR spent fuel pool, $A_m = 2.0$ g, with $\beta_R = 0.28$ and $\beta_U = 0.40$. The HCLPF value is 0.65 g. The HCLPF value shows a design margin of a factor of at least three over the SSE design peak ground acceleration for either pool. Typical SSE design values for LWRs are in the 0.15 to 0.2 g range. The BWR used in this study has an SSE value of 0.14 g, and the PWR has an SSE of 0.2 g.

Preliminary seismic hazard curves for the two sites were used to estimate the probability of failure of the spent fuel pool structures from beyond design basis earthquakes. These preliminary curves have not been finally reviewed by the NRC and were used by LLNL only to obtain a better understanding of the seismic induced spent fuel pool failure. The hazard curves may change after NRC review and guidance for their proper use will be developed. They are

however expected to be a reasonable representation of the seismic characteristics of the sites. A recently published report (NUREG/CR-5042, Supplement 1, Ref. 31) compares the NRC and EPRI preliminary estimates for the annual probability of exceedance at the SSE earthquake level for nine reactor sites. The differences between the NRC and EPRI estimates are reasonable, with no greater than about one order of magnitude difference between the estimates at any confidence level. The median (50%), 85% and 15% confidence levels were compared.

The resulting annual seismic failure frequencies for the two pools are provided in Table 4.6.8. The results are provided for a variety of confidence levels and for a variety of cutoff values. The use of a cutoff value of less than 100% demonstrates the sensitivity of the analysis to the extreme tails in the seismic hazard curves and fragility curves. LLNL recommends use of the 99% cutoff value based on their experiences with seismic PRAs (Ref. 17). The mean failure frequency at the 99% cutoff value is used for this Regulatory Analysis.

The LLNL study used two representative spent fuel pools. These pools have been designed to the seismic design criteria existing in the late 1960s. Their large seismic capacities lead LLNL to conclude that the pools designed to current seismic standards (post 1973) should have higher seismic capacities and should not contribute significantly to seismic risk. Based on the demonstrated relatively high seismic capacity (the HCLPF capacity of the pool structures are estimated to be more than three times the SSE value), LLNL also concluded that the risk contribution from spent fuel pool structural failures is negligibly small (Ref. 17). In addition, the results obtained for the two pools studied also fall within the margins estimated by the ASCE for nuclear power plant seismic structures. The margins, based on median capacities, are about 8 for the BWR and 10 for the PWR which fall within the estimated structural factor range of 4 to 19 (see Table 4.6.8).

Table 4.6.7
Estimated Median Factors of Safety and Logarithmic Standard Deviations Associated With the Safe Shutdown Earthquake (SSE)
(Post 1973 Seismic Design Methods)

Item	Median Factor of Safety	Logarithmic Stnd. Deviation
Structures		
Capacity		
Ultimate Strength vs Code Allowable	1.2 - 2.5	0.16 - 0.20
Inelastic Energy Absorption Capacity	1.8 - 4.0	0.20 - 0.30
Total Capacity Factor (1)	2.5 - 6.0	0.28 - 0.34
Response		
Design Response Spectra	1.2 - 1.6	0.25 - 0.40
Damping Effects	1.2 - 1.4	0.09 - 0.20
Modeling Effects	1.0	0.10 - 0.20
Modal and Component Combination	1.0 - 1.1	0.15 - 0.20
Soil-Structure Interaction	1.1 - 1.5	0.10 - 0.40
Total Response Factor (1)	1.6 - 3.2	0.40 - 0.59
Total Structural Factor (1)	4 - 19	0.52 - 0.65
Mechanical Equipment		
Capacity Factor	1.5 - 8.0	0.28 - 0.34
Building Response Factor	1.6 - 3.2	0.40 - 0.59
Floor Spectra Factor	1.4 - 1.6	0.25 - 0.35
Total Mechanical Equipment Factor	3.5 - 40	0.59 - 0.72

Notes:
(1) These total factors are the product of the preceding individual factors upon which they are based. However, a range is shown for each of the individual factors and it is not reasonable to assume all the individual factors would concurrently be at either their lowest or highest values. Judgment was introduced in establishing the expected range of these factors. For example, the estimated range on the structural median capacity factors of 2.5 to 6.0 is less than would be obtained from concurrently using either the lowest or highest values of the strength and energy absorption which would produce a median capacity factor range of 2.2 to 10.0.

Table 4.6.8
Annual Seismic Failure Frequencies
for Two Representative Spent Fuel Pools

Pool	Fragility Data A_m (g)	β_R (-)	β_U (-)	HCLPF (g)	Cutoff Value (%)	Mean 1/R-y	Failure Frequencies 5% 1/R-y	50% 1/R-y	95% 1/R-y
BWR	1.4	0.26	0.39	0.5	100	3.8×10^{-5}	1.8×10^{-11}	7.7×10^{-8}	3.6×10^{-5}
					99	6.7×10^{-6}	3.1×10^{-11}	8.3×10^{-8}	1.9×10^{-5}
					97	3.8×10^{-6}	3.1×10^{-11}	7.7×10^{-8}	1.4×10^{-5}
PWR	2.0	0.28	0.40	0.65	100	8.6×10^{-6}	6.1×10^{-12}	1.3×10^{-8}	8.6×10^{-6}
					99	1.8×10^{-6}	9.9×10^{-12}	1.5×10^{-8}	5.0×10^{-6}
					97	9.9×10^{-7}	9.5×10^{-12}	1.4×10^{-8}	3.5×10^{-6}

4.7 Summary of Accident Sequence Quantification

The frequency of spent fuel damage resulting from accident sequences which can result in the loss of water from the spent fuel pool through either drainage or through boiling as a result of loss of cooling are summarized in Table 4.7.1. HEP failure to diagnose values, including error factors, based on the nominal HEP model (Ref. 23) have been used to develop the best estimate accident frequencies and are based on the most limiting condition in the spent fuel pool - a full core discharge into a pool containing 20 years of spent fuel. The upper bound frequency values represent previous estimates from WASH-1400, NUREG-0933 and NUREG/CR-4982. In general, these previous studies did not consider the time available for recovery actions but, in general, used intentionally conservative assumptions regarding operator performance.

Table 4.7.1
Summary of SFP Accident Frequencies

Accident Sequence	PWR Frequency		BWR Frequency	
	Best Estimate (per R-year)	Upper Bound (per R-year)	Best Estimate (per R-year)	Upper Bound (per R-year)
Structural Failures				
1. Missiles	1.0×10^{-8}	1.0×10^{-7}	1.0×10^{-8}	1.0×10^{-7}
2. Aircraft crashes	6.0×10^{-9}	2.0×10^{-8}	6.0×10^{-9}	2.0×10^{-8}
3. Heavy Load Drop	3.1×10^{-8}	3.1×10^{-7}	3.1×10^{-8}	3.1×10^{-7}
Pneumatic Seal Failures	3.0×10^{-8}	5.0×10^{-7}	3.0×10^{-8}(1)	5.0×10^{-7}(1)
Inadvertent Drainage	1.2×10^{-8}	1.0×10^{-7}	1.2×10^{-8}	1.0×10^{-7}
Loss of Cooling/Make-up	6.0×10^{-8}(2)	1.4×10^{-6}	6.0×10^{-8}(2)	1.4×10^{-6}
Total	1.5×10^{-7}	2.4×10^{-6}	1.5×10^{-7}	2.4×10^{-6}
Seismic Structural Failure	1.8×10^{-6}		6.7×10^{-6}	
Conditional Probability Of Zircaloy Cladding Fire Given Loss of Water (High Density Storage Racks)	1.0		0.25	

Notes: (1) BWRs do not, in general, use pneumatic refueling cavity seals, but other pneumatic seals are used in the transfer canal.
(2) Includes beyond design basis seismic induced loss of cooling and make-up.

4.8 Radiological Consequences Evaluation

The inventory of radionuclides contained in spent fuel assemblies depends on the operating history and the size of the plant. During refueling, the freshly discharged fuel contains a large inventory of isotopes with short half-lives in the range of approximately one to thirty days. These isotopes decay over the course of a year, until the next refueling outage.

The older fuel contains radionuclides which have longer half-lives. The older fuel approaches a decay rate which is inversely proportion to the decay time. For example, after four years, the spent fuel contains approximately one-forth of the specific activity of one-year old fuel.

During each refueling outage approximately one-third of a PWR core and about one-forth of a BWR core are off-loaded to the spent fuel storage pool. It is noted that releases for an accident involving the reactor core are basically noble gases and halogens, while for a spent fuel storage pool accident the releases are primarily alkali metals (such as cesium, Cs) and alkali earths (such as strontium, Sr). Therefore, it may not be appropriate to directly relate the probability of a spent fuel storage pool accident to a core damage accident because of the different radionuclides involved.

4.8.1 Radionuclide Inventories

The ORIGEN2 computer program (Ref. 12) was used by BNL to determine the radionuclide inventory of the spent fuel as a function of decay time. Separate inventories were calculated for activation products in the fuel assembly hardware and cladding, and for the fissions products and actinides sealed in the fuel elements. The data was obtained for a reference BWR and a reference PWR. Millstone Unit 1 and R. E. Ginna were selected by BNL as the reference plants for the source term evaluation. A comparison of the radionuclide inventory at different decay times, up to the time when the spent fuel storage pool reaches a capacity load, to the equilibrium inventory of a reactor core is provided in NUREG/CR-4982 (Ref. 10).

4.8.2 Radionuclides Potentially Available for Release

The source term for any postulated accident sequence is defined in terms of:

- the amount (curies) of each radionuclide,

- the composition, physical and chemical form of each radionuclide, and,

- the time and the duration of the release of the radioactivity to the environment.

The physical and chemical processes that would take place in a drained spent fuel storage pool are not well characterized at the present time. It was therefore necessary for BNL to use engineering judgment to estimate the source term. The SFUEL1W computer program does not account for relocation of the reaction products (molten un-oxidized cladding, fuel dissolved in molten zirconium, etc). Also the degree to which exposed UO_2 would oxidize to U_3O_8 and reduce the release of less volatile fission products has not been studied. The estimate of the

fraction of each radionuclide release was determined by BNL based on available data and on engineering judgment, and is provided in Table 4.8.1 (from NUREG/CR-4982, Table 4.2, Ref. 10).

Table 4.8.1
Estimated Radionuclide Release Fractions During a Spent Fuel Pool Accident Resulting in Complete Destruction of the Fuel Cladding

Chemical Family	Element or Isotope	Release Fractions[1] Value Used	Uncertainty Range	
Noble gases	Kr, Xe	1.0	0	
Halogens	I-129, I-131	1.0	0.5 -	1.0
Alkali metals	Cs, (Ba-137m) Rb	1.0	0.1 -	1.0
Chalcogens	Te, (I-132)	0.02	.002 -	0.2
Alkali earths	Sr, (Y-90), Ba (in fuel)	2×10^{-3}	1×10^{-4} -	1×10^{-2}
	Sr, Y-91 (in cladding)	1.0	0.5 -	1.0
Transition Elements	Co-58 (assembly hardware)	0.1	0.1 -	1.0
	Co-60 (assembly hardware)[2]	0.12	0.1 -	1.0
	Y-91 (assembly hardware)	0.1	0.1 -	1.0
	Nb-95, Zr-95 (in fuel)	0.01	1×10^{-3} -	1×10^{-1}
	Nb-95, Zr-95 (in cladding)	1.0	0.5 -	1.0
Miscellaneous	Mo-99	1×10^{-6}	1×10^{-8} -	1×10^{-5}
	Ru-106	2×10^{-5}	1×10^{-6} -	1×10^{-4}
	Sb-125	1.0	0.5 -	1.0
Lanthanides	La, Ce, Pr, Nd, Sm, Eu	1×10^{-6}	1×10^{-8} -	1×10^{-5}
Transuranics	Np, Pu , Am , Cm	1×10^{-6}	1×10^{-8} -	1×10^{-5}

Notes: (1) Release fractions of several daughter isotopes are determined by their precursors, e.g., Y-90 by Sr-90, Tc-99m by Mo-99, Rh-106 by Ru-106, I-132 by Te-132, Ba-137m by Cs-137, and La-140 by Ba-140.

(2) Release fraction adjusted to account for 100% release of the small amount of Co-60 contained in the Zircaloy cladding.

4.8.3 Estimated Releases and Consequences for SFP Accidents

The dose equivalent of the release estimates depends on many factors including the location of the spent fuel storage pool and equipment operability (for example, with and without filters in the fuel storage structure). Cesium, for example, is expected to be released as an aerosol and filters may provide an effective removal mechanism. If the fuel storage building structure cracks or if fans fail to function due a seismic event, the release may be substantial. The predicted release to the environment was estimated for each of several accident categories.

The radionuclide inventories for both the BWR and the PWR spent fuel pools were calculated using the ORIGEN2 computer program and the actual operating and discharge histories for a BWR and a PWR. For both plants, the noble gases and halogens in the spent fuel inventory are a small fraction of the inventory in an equilibrium core at shutdown, except for the freshly discharged fuel. The cesium and strontium inventories are more than three times the equilibrium inventory, as a result of the large inventories of spent fuel in the pool (the calculation were based on 11 fuel cycles for the BWR and 16 fuel cycles for the PWR).

A re-evaluation of the cladding fire propagation estimate (given the complete loss of water from the spent fuel pool) indicates that, with the use of high density storage racks, there is a substantial likelihood of propagation to adjacent fuel bundles that have been discharged within the last one or two years. Subsequent propagation to even lower power bundles by thermal radiation is highly unlikely, but with a substantial amount of fuel and cladding debris on the pool floor, the coolability of even these lower power bundles is uncertain.

The fission product release fractions were calculated for two limiting cases in which a Zircaloy cladding fire is assumed to occur. In the first case (1) the cladding combustion is assumed to propagate throughout the entire pool and the entire inventory is involved. In the second case (2) the inventory is limited to only the most recently discharged fuel batch. Parametric studies were performed by BNL to evaluate the consequences as a function of the time of the postulated accident.

In calculating the consequences of a spent fuel pool accident, BNL has assumed no credit for the ventilation and filtration systems in the fuel storage building. While these systems are designed to mitigate the consequences of a fuel handling accident, the design of these systems does not consider the high temperature conditions of a Zircaloy cladding fire (in excess of 2000 ^{o}F). Fission product retention under these conditions is questionable. A sensitivity study with a decontamination factor of 10 was performed by BNL (Ref. 10), to demonstrate the possible affect of fission product retention on structures.

For a Zircaloy cladding fire to occur, the fuel must be recently discharged (between 30 and 180 days in a cylindrical BWR configuration, and between 30 and 250 days in a cylindrical PWR configuration). Since the spent fuel is stored in high density racks, the probability for a Zircaloy fire in a PWR is assumed to be 1.0, given a complete loss of water. For a BWR, which uses directional racks, the probability of a Zircaloy fire is assumed to be 0.25, given a complete loss of water. This value is selected from the full core discharge calculation performed by Sandia (Ref. 8) with the channel box attached (see Table 4.5.1, above), and is also representative of the average values for the cylindrical BWR configuration with different inlet orifice sizes.

For a less severe accident in which the fuel is exposed to air but does not reach temperatures high enough to ignite the Zircaloy cladding, fuel pin failure could occur resulting in a release of the noble gases and halogens. Two cases have been considered by BNL. In the first case the entire pool is assumed to be drained but the decay period is one year since the last discharge and 50% of the pins are assumed to perforate or rupture. In the second case it is assumed that only part of the fuel is uncovered 30 days after the last discharge and all the rods fail. The consequences of either of these two cases are small and result from the release of noble gases.

Sensitivity analyses of the offsite consequences for the Zircaloy fire cases were calculated with the CRAC2 computer program by BNL to study the affect of the source term assumptions on the population dose and interdiction area (Ref.13). The results of this study are provided in Table 4.8.2, along with the results for a case which represents cladding rupture only. The following assumptions were used by BNL (Ref. 10):

- a generalized site surrounded by a constant population density of 100 persons per square mile within a 50 mile radius;

- generalized meteorology (a uniform wind rose, average weather conditions);

- the population in the affected zones are relocated after 24 hours, persons expected to receive more than 25 rem from ground shine in seven days.

There are several unusual characteristics of a severe accident that cause somewhat unexpected results in the radiation exposure calculations. The radiation exposure is relatively insensitive to fairly large variations in the estimated release. This is due principally to the health physics assumptions within CRAC2. This has also been seen in calculation related to fission product releases from core damage accidents. The CRAC2 code assumes that decontamination will limit the exposure of each person to 25 rem. For the long lived isotopes (predominately cesium), the exposure is due mainly to exposure after the area is decontaminated and people return to their homes. Thus, for this type of release the long term whole body dose is limited by the population in the affected sectors (about 0.8 million people in three of the 16 sectors downwind of the release within a 50 mile radius) or about 3,000,000 person-rem (Table 4.8.2).

Another measure of the consequences of a spent fuel pool accident is the interdiction area (the area with such a high level of radiation that it is assumed that it cannot be decontaminated). The interdiction area is sensitive to the source term as shown in Table 4.8.2.

Additional consequences calculations were performed by BNL (Ref. 13) using the MACCS computer program and are provided in Table 4.8.3. The MACCS computer program models are described in NUREG-1150, Appendix O (Ref. 14). The source term data developed by BNL in NUREG/CR-4982 (Ref. 10) was used for these new calculations. These calculations were performed for the value impact studies in Section 5 based on the a site population density of 340 people per square mile, the mean population density around nuclear power plant sites projected for the year 2000 (Ref. 15), Case 1. In addition, the offsite property damage cost for a spent fuel pool accident was also calculated with MACCS for use in the value impact studies in Section 5. A worst case analysis was also performed, assuming the entire spent fuel pool inventory is released at a high population site (Zion, Illinois, 860 people per square mile population density), Case 2.

A direct comparison of the consequences of a severe accident in a spent fuel storage pool to the consequences of a severe core accident can be misleading. For the spent fuel pool accident, there are no "early" fatalities and the risk of early injury is negligible. For a severe core damage accident, early fatalities and early injury are part of the risk due to the presence of the shorter lived isotopes.

Table 4.8.2
Offsite Consequences of Spent Fuel Pool Accidents - CRAC2 Results

Case	Description	Whole Body Dose (person-Rem per-Event)	Interdiction Area (square miles)
1A.	Total inventory 30 days afte last discharge	2.6×10^6	244
1B.	Total inventory 90 days after last discharge	2.6×10^6	215
2A.	Last discharge 90 days after last discharge	2.3×10^6	44
2B.	Last discharge 90 days after last discharge, DF of 10 reduction	1.1×10^6	4
3.	50% of all fuel rods leak 1 year after last discharge	4.0	0

Note: Sensitivity study based on population density of 100 people per square mile within a 50 mile radius of the site, from Reference 10.

Table 4.8.3
Offsite Consequences of Spent Fuel Pool Accidents - MACCS Results

Case	Description	Whole Body Dose (person-Rem per-Event)	Offsite Property Damage (1983 $s)
1.	Best Estimate Consequences Last discharge (1/3 core) 90 days after discharge 50 mile radius Based on 340 people/square mile	8.0×10^6	3.4×10^9
2.	Worst Case Estimate Consequences Total inventory 30 days after discharge, 50 mile radius Based on 860 people/square mile	2.6×10^7	2.6×10^{10}

4.8.4 Summary Conclusions on Fuel Damage and Consequences

The conditional probability of a Zircaloy cladding fire, given a complete loss of water from a spent fuel pool, is estimated to 1.0 for PWRs with high density storage racks and 0.25 for BWRs with directional storage racks (with the channel box in place in the assembly).

The propagation of the fire to older stored spent fuel assemblies is predicted to occur for spent fuel that has been stored less than two years, under some conditions. Propagation can occur as a result of radiative heat transfer from the hottest fuel assemblies to the older assemblies if the decay heat level of the older assemblies is sufficient to heat the cladding to within 100 to 200 °C (200 to 400 °F) of the self-sustaining oxidation temperature of 900 °C (1650 °F).

The best estimate of the consequences of a spent fuel pool accident which results in fuel damage is 8.0×10^6 person-rem with an offsite property damage estimate of $3,400 million (1983 $s). The best estimate is based on a population density of 340 people per square mile within a 50 mile radius from the site and is a result of the release of radionuclides from the last fuel discharge (1/3 of a reactor core), 90 days after being discharged. Although propagation of a Zircaloy cladding fire to one-to-two year old fuel by thermal radiation can occur, the older fuel would have to be next to the hottest assemblies. Subsequent propagation to even lower power assemblies by thermal radiation is highly unlikely, but with a substantial amount of fuel and cladding debris on the pool floor, the coolability of even these lower power bundles is uncertain.

A worst case estimate of the consequences is based on a population density of 860 people per square mile within a 50 mile radius from the site and is a result of the release of radionuclides from the entire pool inventory, with the last fuel discharge being 30 days old. The consequences are estimated to be 2.6×10^7 person-rem with an offsite property damage estimate of $26,000 million (1983 $s).

4.9 Other Issues Concerning Use of High Density Storage Racks

4.9.1 Gaps in Neutron-Absorbing Materials

Board Notification 87-011 (Board Notification Regarding Anomalies in Boraflex Neutron Absorbing Material, June 15, 1987, Ref. 32) and IE Information Notice 87-43 (Gaps in Neutron-Absorbing Material In High-Density Spent Fuel Storage Racks, September 8, 1987, Ref. 33) have been issued by the NRC to alert licensees of anomalies in boraflex neutron absorbing material used in the construction of high density storage racks in the Quad Cities Unit 1 spent fuel pool. The gaps were inferred from anomalies in "blackness" testing results and confirmed by underwater neutron radiography. The material supplier and the Electric Power Research Institute (EPRI) have undertaken research programs to collect data and information on gap formation, including the effects of rack fabrication methods and irradiation damage mechanisms.

Boraflex is also used in the Turkey Point spent fuel pool racks and in the Point Beach spent fuel pools. At Point Beach, some deterioration of the samples inserts were noticed during surveillance testing.

These anomalies do not impact on the finding concerning loss of water from a spent fuel pool.

4.9.2 Potential for High Radiation Fields

IE Information Notice 87-13, "Potential for High Radiation Fields Following Loss of water From Fuel Pool," February 24, 1987 (Ref. 34), was issued to alert licensees of the potential for high radiation fields following the inadvertent loss of water from the spent fuel pool or transfer canal. Following the seal leakage at Hatch, the licensee determined that potentially high radiation fields could exit in the spent fuel area as a result of irradiated control blades being stored in the spent fuel pool on short hanger. Some of the control blades could have been completely uncovered if the water level dropped to the bottom of the transfer canal.

In determining the frequency of loss of cooling events and in evaluating HEP diagnosis and recovery actions, the assumptions concerning loss of water from a spent fuel pool used conservative upper bound failure rates for failure to diagnose prior to pool boiling and therefore address this concern. In the highly unlikely situation of draining the spent fuel pool to the transfer canal level, licensee responses to IEB 84-03 (Ref. 19), concerning pneumatic seal failures, indicate that emergency procedures have been considered which would not require entry into the spent fuel pool area - the high radiation fields from the spent fuel alone would likely restrict access.

4.9.3 Refueling Cavity Seal Failure During Fuel Assembly Handling (GI 137)

Generic Issue 137, titled "Refueling cavity Seal Failure," is considering the issue of spent fuel damage resulting from a reactor cavity seal failure during fuel assembly handling (Ref. 35). The risk of failure of a single fuel assembly and the potential risk to plant personnel, not the general public, is being addressed.

The likelihood of uncovering stored spent fuel as a result of a seal failure and the risk to the general public are addressed in this Regulatory Analysis.

5. VALUE/IMPACT ANALYSIS

5.1 Alternative 1 - No Action

This alternative assumes that no additional action is necessary based on the evaluation of the current risk associated with the use of high density racks for the storage of spent fuel in spent fuel pools at LWRs. It is also assumed that all applicable requirements and guidance approved to date have been implemented.

In addition to implementing the requirements contained in 10 CFR Part 50 Appendix A of the "General Design Criteria," and 10 CFR Part 20, concerning radiation doses being kept as low as is reasonably achievable, licensees should have implemented additional or corrective actions based on the following guidance:

1. IE Bulletin 84-03, "Refueling Cavity Water Seals," issued August 24, 1984. (Ref. 21)

2. IE Information Notice 84-93, "Potential for Loss of Water From the Refueling Cavity," issued December 17, 1984. (Ref. 24)

3. Generic Letter 85-11, "Completion of Phase II of 'Control of Heavy Loads at Nuclear Power Plants' NUREG-0612," issued June 28, 1985. (Ref. 4)

4. IE Information Notice 87-13, "Potential for High Radiation Fields Following Loss of Water from Fuel Pool," issued February 24, 1987. (Ref. 34)

5. IE Information Notice 87-43, "Gaps in Neutron-Absorbing Material in High-Density Spent Fuel Storage Racks," issued September 8, 1987. (Ref. 33)

6. IE Information Notice 88-65, "Inadvertent Drainages of Spent Fuel Pools," issued August 18, 1988. (Ref. 25)

7. IE Information Notice 88-92, "Potential For Spent Fuel Pool Draindown," issued November 22, 1988. (Ref. 26)

No costs are usually attributed to a "No Action" alternative because the future cost of accidents are conventionally counted as benefits or averted costs in the assessment of the alternative actions. However, a spent fuel pool accident would result in cleanup and repair costs. In addition, replacement power costs could occur during the cleanup and repair period. Reactor operations without a safe place to store spent fuel could not continue. If the accident also results in a large release of radioactivity offsite, the costs of relocating people, restricting food and water, cleanup of contamination, and health consequences would add to these costs. Occupational exposure due to a spent fuel pool accident could also be considered on a monetary basis. BNL has evaluated these attributes (Ref. 13). The following paragraphs summarize this assessment of risk and the cost associated with a representative (base case) spent fuel pool accident, based on an estimated probability of spent fuel damage of 2×10^{-6} per reactor year.

5.1.1 Occupational Exposure (Accidental)

Exposure to plant personnel associated with post-accident cleanup of a major spent fuel pool accident is expected to be similar to those associated with the cleanup activities at TMI-2. For this accident, BNL estimates the occupational radiation dose from cleanup is less than 4,580 person-rem (Ref. 13). Since the potential offsite dose impact (per accident) ranges from 8 to 26 million person-rem, further refinement of this estimate is not warranted.

5.1.2 Onsite Property Damage

The spent fuel pool accident sequence involves (1) failure of the pool due to seismic or load drop events resulting in the complete loss of water inventory, or loss of cooling resulting in boiling dry the pool, (2) Zircaloy fire initiation of recently discharged fuel and the potential propagation of the fire to older spent fuel assemblies stored in the pool, and (3) loss of confinement since the spent fuel pool building is assumed to be breached as a result of a seismic event or as a consequence of the highly exothermic Zircaloy fire.

The consequences of these scenarios are expected to be similar to the Category II accident defined in NUREG/CR-3568 (Ref. 36), 50% clad melting and contamination. For this case cleanup and decontamination are estimated to be approximately $192 million (1988 $s). Plant outage times were estimated by BNL based on the time estimates to license, construct and test a replacement pool (Ref. 37), and range from five to seven years. The cost (1988 $s) for a replacement pool, $54 million for a 400 MTU pool, and the cost of permanent disposal of damaged fuel, $30 million, were also estimated from reference 37.

The cost of replacement power is approximated by (from NUREG/CR-3568):

$$C = (0.13 * R + 0.12)10^6\$/\text{MW-year}$$

where R is the fraction of replacement energy by oil fired or non-economical power purchases from a given National Electric Reliability Council (NERC) region. This formula includes credit for the avoided variable fuel cycle cost of a shutdown reactor. An R value of 0.41 was used for the best estimate (national average) and a value of 0.9 (highest NERC region) was used for the worst case estimate for replacement power costs (based on 1981 $s). A plant capacity of 65% is factored into the above equation and a 1,000 MW(t) generic plant size was assumed.

The BNL best estimate replacement power cost (in 1983 $s) for a 1,000 Mw(t) plant for five years is $867 million. For the worst case estimate the seven year replacement power cost is $1,660 million.

Using NUREG/CR-4568 (Ref. 38) data, the cost of replacement power (1984 $) for the national average cost of 0.026 $/Kw-hr is $740 million for the best estimate and, using a high NERC region cost of 0.035 $/Kw-hr, the worst case estimate is $1,400 million. Assuming a constant 5% inflation rate over a four year period (to 1988), the current values would be $900 million and $1,700 million respectively. These values are used in this regulatory analysis, and indicated that replacement power costs are not sensitive to modeling assumptions (2% to 4% uncertainty in comparing BNL 1983 values to staff 1988 values).

The onsite costs are calculated from (NUREG/CR-3568):

$$V_{on} = N \times \Delta F \times U_{on}$$

where:

- V_{on} - value of avoided onsite property damage
- N - number of affected facilitities
- ΔF - change in accident frequency

and

$$U_{on} = \frac{(C_c + C_r + C_{rp})}{m} \frac{e^{-rti}}{r^2} (1 - e^{-r(tf-ti)}) (1 - e^{-rm})$$

where:

- U_{on} - present value of onsite property damage conditional upon release
- C_c - cleanup and decontamination costs
- C_r - repair, replacement of spent fuel pool, disposal of damaged fuel
- C_{rp} - replacement power costs
- tf - average years remaining till end of reactor life, 30 years
- ti - year plant starts operating, taken to be 0 years
- r - discount rate
- m - years plant is out of service

The onsite property damage costs per accident, V_{on}, are summarized in Table 5.1.1, based on a ΔF of 2×10^{-6} per reactor year.

5.1.3 Offsite Health and Property Damage

The offsite health and property damage estimates were obtained by BNL from the MACCS computer program (Section 4.6, Table 4.6.2), and are summarized in Table 5.1.2.

The offsite costs are calculated using the NUREG/CR-3568 methodology and discounting the cost of the 30 year remaining life of a typical facility:

$$V_{off} = N \times \Delta F \times U_{off}$$

where:

- V_{off} - value of avoided offsite property damage
- N - number of affected facilitities
- ΔF - change in accident frequency

and

$$U_{off} = C_{off} \times \frac{e^{(-rti)} - e^{(-rtf)}}{r}$$

where:

- U_{off} - present value of offsite property damage, conditional upon release
- C_{off} - offsite property damage cost
- tf - average years remaining till end of reactor life, 30 years
- ti - year plant starts operating, taken to be 0 years
- r - discount rate

The offsite damage costs per accident, V_{off}, are summarized in Table 5.1.2, based on a ΔF of 2×10^{-6} per reactor year.

Table 5.1.1
Onsite Property Damage Costs Per SFP Accident (1988 $s)

Item	Units	Best Estimate	Worst Estimate
Cleanup and Decontamination	$1,000,000	192	192
Repair Pool and Dispose of Fuel	$1,000,000	84	84
Replacement Power	$1,000,000	900	1,700
Average Number of operating years remaining	years	30	30
Years plant is out of service	years	5	7
Present Value (V_{on}) At 10% Discount rate	1988 $s	17,600	27,000
Present Value (V_{on}) At 5% Discount Rate	1988 $s	32,400	51,800

Table 5.1.2
Offsite Health and Property Damage Estimates (1988 $s) Per SFP Accident

Case Description	Whole Body Dose (person-Rem per-Event)	Offsite Property Damage ($s)	Present Value (V_{off}) At 10% Discount ($s)	Present Value (V_{off}) At 5% Discount ($s)
Best Estimate Consequences Last discharge 90 days after discharge, 50 mile radius Based on 340 people/square mile	8.0×10^6	4.0×10^9	76,000	124,000
Worst Case Estimate Consequences Total inventory 30 days after discharge, 50 mile radius Based on 860 people/square mile	2.6×10^7	3.0×10^{10}	580,000	940,000

5.1.4 Potential Consequences and Cost of SFP Accidents

The probability of a spent fuel pool accident which would result in spent fuel damage is estimated to be 1.5×10^{-7} per reactor year, summed over all accident sequences except for the beyond design basis seismic failure of the spent fuel pool structure. The conditional probability of Zircaloy cladding fire is estimated to be 1.0 for a high density racked PWR and 0.25 for a BWR.

The seismic structural capacity of the spent fuel pool has been shown to have a median ground acceleration in the 1.4 to 2.0 g range. This is a factor of 10 above the typical SSE design values. The high confidence low probability of failure value (0.5 to 0.65 g) shows a margin of safety of three over the SSE design value. That is, there is less than a 5% chance of failure at a confidence level of 95% for a peak ground acceleration three times the SSE design value. The estimated mean seismic probability of a Zircaloy fire in a PWR spent fuel pool is 1.8×10^{-6} per reactor year, and in an elevated BWR spent fuel pool the estimated value is 1.7×10^{-6} per reactor year. The probability of a spent fuel pool accident which would result in spent fuel damage is therefore estimated to be on the order of 2×10^{-6} per reactor year, including the seismic hazard, for a typical LWR spent fuel pool.

For comparison purposes, in a review of the results of seismic core damage and large release frequencies from studies performed as part of USI A-45, "Decay Heat Removal Requirements," the point estimates for seismic core damage frequencies ranged from 1×10^{-5} to 8.3×10^{-5} per reactor year and the seismic release frequencies ranged from 4.6×10^{-6} to 3.7×10^{-5} per reactor year (Ref. 31). The dominant contribution to core damage was found to be from earthquakes in the 0.2 to 0.4 g range (Ref. 31). It is therefore concluded that, in comparison to the probability and consequences of a reactor core damage accident from a seismic event, the likelihood and risk associated with the beyond design basis seismic induced spent fuel pool failure are only a small part of the overall risks associated with the operation of a nuclear power plant.

The best estimate consequences of a spent fuel pool accident are summarized in Table 5.1.3, based on a plant mean probability of a spent fuel pool accident of 2×10^{-6} per reactor year. This value is representative of both the PWR and BWR pool and includes the beyond design basis earthquake accident.

The cost estimate data available is generally based on 1983 values. The offsite property damage from MACCS, the EPRI study on alternative spent fuel storage options, and onsite property damage (cleanup and replacement power) are all monetized to, or represent 1983 costs. These 1983 cost estimates were escalated to 1988 values by using the Gross National Product Price Deflator ratio between 1988 and 1983 (121.4 divide by 104.1, or a factor of 1.17), taken from NUREG/CR-4627 (Ref. 39), Abstract 6.4 "Time-Related Cost Adjustments." As seen in Table 5.1.3, the monetized present value of the offsite health effects, at $1,000 per person-rem, dominates present value estimates when compared to property damage costs at the 5% discount rate. At a 10% discount rate, as recommended in NUREG/BR-0058 (Ref. 40), the onsite and offsite property damage present value cost estimates would be about one-half the values shown in Table 5.1.3. The 5% discount rate is used in this Regulatory Analysis because it is believed to be more representative of the current economical environment than the 10% value. It is therefore concluded that additional refinements in cost estimates concerning onsite and offsite property damage costs are not required and will not affect the value/impact or cost benefit analyses provided. In addition, first order approximation of costs are generally being used in this Regulatory Analysis and any additional adjustment to these estimates is not warranted.

The significance of the potential consequences of this base case spent fuel pool accident evaluation, and the related costs associated with an accident, are discussed in more detail under Section 6, "Decision Rationale." Alternatives actions, other than this "no action" proposal, are considered in the following sections to determine if cost beneficial options are available to reduce the risk or consequences of a spent fuel pool accident.

Table 5.1.3
Best Estimate Consequences of a Spent Fuel Pool Accident

Frequency of Occurrence of Zircaloy Fire (Mean value for PWR or BWR SPF)	2×10^{-6} per reactor year
Consequences, over 30 years based on 340 people per square mile population density within a 50 mile radius of the site	480 person rem
Present Value of Offsite Health Risk Based on $1,000 per person rem	$ 480,000 (1988 $s)
Present Value of Offsite Property Damage 5% discount over 30 years of remaining life	$ 124,300 (1988 $s)
Present Value of Onsite Property Damage 5% discount over a five year repair period	$ 32,400 (1988 $s)
Total Present Value of a SFP Accident	$ 636,700 (1988 $s)

Note: Without the beyond design basis seismic failure, consequences are estimated to be an order of magnitude lower.

5.2 Alternative 2 - Require Use of Low Density Racks

The use of high density storage racks increases the probability of a release of radioactive from stored fuel if water is lost from the spent fuel pool. Studies performed in 1979 (Ref. 8) concluded that the minimum allowable decay time for PWR spent fuel in a well-ventilated room varies from five days, for open-frame storage configurations, to a value of 700 days, for high density, closed-frame configurations with wall-to-wall spent fuel placement. The minimum decay time for BWR fuel varied from five days to 150 days for the configurations studied. In addition, it was determined that the high density storage configuration could allow for the propagation of fuel damage from the recently discharged fuel to older, adjacent stored fuel in the pool. The results of these 1979 studies prompted the identification of Generic Issue 82.

5.2.1 Risk Reduction Estimate

One of the potential means to reduce the risk from loss of water in the spent fuel pool would be to require the use of low density storage racks for the recently discharged fuel. This alternative would reduce the probability of fuel damage, or a Zircaloy fire. The estimated reduction in risk is a result of the decreased decay time required for low density storages racks to preclude spent fuel damage if water is lost, as compared to the high density racks. BNL estimated the reduction in risk to be at least a factor of five, or about an 80% reduction in the consequences (Ref. 10). For the purpose of evaluating this alternative, a 100% reduction in the consequences will be assumed.

5.2.2 Cost of Low Density Storage

Additional storage for spent fuel at reactor sites is required. If the DOE spent fuel repository opens in 2003, it is estimated that the industry will need to provided for between 12,200 MTHM to 20,000 MTHM of additional storage capacity (Ref. 7). If no repository is made available the additional capacity is estimated to be between 32,090 MTHM and 42,450 MTHM (Ref. 7).

The use of low density storage racks would require the need for additional at-reactor-site storage capacity to accommodate the change in the storage configuration, from high density racks. For each PWR low density storage location, three high density assemblies would be displaced. For a BWR, two high density assemblies would be displaced for each low density storage location (Ref. 13).

The evaluation of the amount of additional storage capacity, resulting from a proposal to require low density racks, is provided in reference 13. The fuel cycle information and spent fuel projections where obtained from DOE/RL-87-11, "Spent Fuel Storage Requirements 1987" (Ref. 41). The proposed alternative for low density storage could increase the additional capacity by about 17,000 MTHM.

The cost of additional storage depends on the type of facility to be used. EPRI evaluated four alternative storage facilities in NP-3365 (Ref. 16), "Review of Proposed Dry-Storage Concepts Using Probabilistic Risk Assessment." These concepts are:

1. Additional Pool, separate from existing pool,

2. Cask storage,

3. Caisson, or dry-well, storage, and

4. Vault storage.

The risk associated with these alternative concepts was found to be generally acceptable since the spent fuel would be five years old, or older, and the likelihood of significant fuel damage was found to be low. The consequences were found to be negligible when compared to the operating reactor at the site (Ref. 16).

The costs for alternative storage concepts were evaluated by EPRI in NP-3380, "Cost Comparisons for On-Site Spent-Fuel Storage Options" (Ref. 37). In addition to the primary four alternatives identified above, silo storage, reracking and rod consolidation were addressed in terms of cost. The cost estimates are provided in units of dollars per kilogram of uranium ($/kgU) and vary with the size of the facility. The cost estimates decrease as the storage capacity increases, per unit, because of initial licensing and engineering fees associated with the facility design.

In a recently completed study performed by DOE (Ref. 7), the cost of additional storage for the cask concept and the rod consolidation concept have been reviewed and updated to reflect the limited amount of actual experiences with these methods of providing additional at-reactor-site storage. These methods are considered to be the most practical and represent demonstrated technologies. The costs estimates are provided below, in Table 5.2.1.

The estimated cost (1988 $s) of additional storage by the year 2003 is estimated by DOE to range between $945 million and $1,267 million for 12,200 MTHM, and between $1,545 million and $2,000 million for 20,000 MTHM. If rod consolidation can accommodate the 350 MTHM requirements, the costs estimates would be reduced to $468 million for the 12,200 MTHM case and $793 million for the 20,000 MTHM case. The mean cost estimate for the 17,000 MTHM additional storage which would be needed if low density storage is required is $1580 million, based on the DOE cost estimates. The mean cost (for the 108 pools) is $14.6 million per pool, for a unit cost of $93/Kgm of heavy metal.

The cost estimates for the dry storage concepts were developed assuming that the cost of a low density requirement would be an incremental, additional cost as virtually every spent fuel pool will reach it's capacity limit and out of pool storage will be required before end-of-license if a repository in not available (Ref. 13). Rod consolidation was not considered because it is not known how many pools can accommodate the additional decay heat load and structural loads associated with the in-pool increase and still meet NRC requirements. The unit cost for at-reactor storage decreases with an increase in the total amount, or capacity, of the additional storage required. The total licensing, engineering and fixed facility costs for the initial at-reactor storage facility is estimated to be $0.6 to $1.8 million (1988 $s) per facility, based on metal cask storage (Ref. 7). These one-time costs would not be impacted by this alternative, and are costs which will be incurred by most licensees prior to the availability of the DOE repository. The cost of the additional at-reactor storage which would result from this alternative is also provided, for reference, assuming that the additional storage capacity cost is based on the unit cost estimates for a facility the size of only the additional storage requirement. This is referred to as the lead cost estimate. Table 5.2.2 provides a summary of the incremental capacity increases which would result from this alternative. The associated cost estimates for dry storage alternatives based on these capacities are provided in Table 5.2.3.

The DOE cost estimates based on the incremental cost assumption for the 17,000 MTHM additional storage are $1,510 million, or a mean cost of $14 million per pool (1988 $s). The DOE cost estimates (Ref. 7) level off for capacities in excess of 300 MTHM (see Table 5.2.4 below).

Table 5.2.1
Range of Unit-Cost Estimates for Additional Storage Requirements
(Costs in 1988 $s per kilogram of heavy metal)

Storage Technology	Capacity Increase 100 MTHM	300 MTHM	1000 MTHM
Rod Consolidation(1)	40 - 75	30 - 50	n/a
Metal Cask (10 MTHM)	60 -115	55 -115	55 - 100
Concrete Cask	50 -105	45 - 90	45 - 80
Horizontal Concrete Modules	45 - 65	40 - 55	40 - 55
Modular Vault System	105 -155	70 -105	45 - 70

Notes:

(1) - The unit costs are based on the cost for an additional storage slot created in the storage pool. From 2.6 to 3 spent-fuel assemblies must be consolidated for each storage slot (Ref. 7).

n/a - An increase of 1000 MTHM is not applicable to rod consolidation because at a typical reactor not much more than 300 MTHM of additional spent fuel can be gained through consolidation (Ref. 7).

Table 5.2.2
Additional Incremental Storage Capacity Requirements for Alternative 2

Capacity Range (MTHM)	PWRs Impacted	BWRs Impacted	Total Impacted
0 - 50	0	2	2
50 - 100	8	10	18
100 - 150	15	18	33
150 - 200	23	8	31
200 - 250	15	1	16
250 - 300	3	0	3
300 - 350	4	0	4
350 - 400	1	0	1

Table 5.2.3
Storage Costs Associated With Alternative 2 (1988 $s)

		Cost:	Per Pool		For All 108 Pools		
		Discount Rate: 0%	5%	10%	0%	5%	10%
		($1,000,000)			($1,000,000)		
Pool	(BNL Incremental Costs)	25.3	19.5	14.9	2,720	2,100	1,610
Drywell	(BNL Incremental Costs)	10.6	9.5	8.0	1,150	1,038	863
Vault	(BNL Incremental Costs)	24.1	19.5	14.9	2,612	2,100	1,610
Cask	(BNL Incremental Costs)	14.0	14.2	12.2	1,516	1,539	1,318
Silo	(BNL Incremental Costs)	18.2	14.2	11.2	1,959	1,539	1,178
Cask	(BNL Lead Costs)	19.7	20.1	17.3	2,134	2,169	1,866
Cask	(DOE Incremental Costs)	14.0	14.2	12.3	1,510	1,530	1,330
Cask	(DOE Lead Costs)	14.6	14.9	12.8	1,580	1,610	1,380

Notes:
Zero % discount rate corresponds to the case where additional storage capacity is built now. The 5% and 10% rates reflect discounted costs in delaying the building of additional capacity until needed.

The difference between the estimated costs for cask storage, in comparing the BNL-based and DOE-based estimates, are due to the difference in the $/Kgm costs estimates based on facility capacity. In Table 5.2.4, the BNL point-estimate cost (based on EPRI NP-3380, Ref. 37) is compared to the DOE lower and upper bound estimates.

Table 5.2.4
Cask Storage Cost Estimates as a Function of Facility Capacity

Capacity (MTHM)	BNL Point Estimate ($/Kgm) (1983 $s)	DOE Lower Estimate ($/Kgm) (1988 $s)	DOE Upper Estimate ($/Kgm) (1988 $s)
25	113.2	105	160
50	113.2	95	140
75	113.2	85	120
100	113.2	80	115
125	113.2	80	110
150	113.2	80	110
200	113.2	80	105
300	99.8	80	100
400	93.4	80	100
500	89.	80	100
600	85.8	80	100
700	84.2	80	100
800	82.9	80	100
900	81.6	80	100
1000	81.	80	100
1200	79.4	80	100
1400	78.8	80	100
1600	77.5	80	100
1800	77.2	80	100
2000	77.2	80	100

5.2.3 Value/Impact Summary

The value/impact, cost-benefit analysis is provided in terms of the mean industry risk from spent fuel pool accidents in Table 5.2.5. The best estimate accident frequencies are used and the best estimate consequences, based on fission product release from 1/3 of a reactor core, are used. The conditional probability of the Zircaloy fire, given the loss of water from the spent fuel pool, is 1.0 for the PWRs and 0.25 for the BWRs. Since the amount of spent fuel which could become involved in the release is uncertain, a sensitivity study using the worst case consequences, full spent fuel pool inventory at a high population site, is also provided.

The risk is comprised of 69 PWR spent fuel pools with a spent fuel damage probability of 1.95×10^{-6} per reactor year (including seismic events and conditional Zircaloy fire probability of 1.0 given loss of water) and 39 BWR spent fuel pools with a spent fuel damage probability of 1.71×10^{-6} per reactor year (including seismic events and conditional Zircaloy fire probability of 0.25 given loss of water). The mean remaining lifetime for the PWR spent fuel pool is 29.8 reactor years, and 27.9 years for the BWR spent fuel pool.

Since this alternative addresses dry storage, and because nearly every utility will require some additional dry storage prior to the start-up of the DOE repository, the NRC development and implementation costs concerning the licensing of a 10 CRF Part 72, "Licensing Requirements for the Independent Storage of Nuclear Fuel and High-Level Radioactive Waste," (amended August 19, 1988, 53 FR 31651), facility are not included as additional costs to be included in the value/impact analysis. These costs will be incurred and are not affected by this alternative.

The industry and NRC operational costs associated with dry storage are also costs which will be incurred and are not impacted by this alternative. The additional storage requirements which would result from this alternative would not affect these costs. Industry and NRC costs which could result from a re-racking amendment to replace high density racks with low density racks as part of this proposed alternative are expected to be small in comparison to the dry-storage costs and have not been quantified. Inclusion of these additional costs would result in an even less favorable value/impact or cost benefit assessment.

Sensitivity studies were performed by BNL to test the assumptions used (Ref. 13). The discount rate applied to property damage costs, the monetary conversion factor for health effects, plant site economics and meteorology, and industry implementation costs were evaluated.

The recommended discount rate, NUREG/BR-0058 (Ref. 40), is 10%, which results in a lower estimate of property damages by a factor of two. Public dose reduction is not affected since it is not discounted.

A major difficulty with the net-benefit method is the evaluation of health effects in monetary units. Sensitivity studies of $500 and $2,000 per person-rem are used to demonstrate uncertainty.

The base line calculation adopted by BNL used the economic factors of the Zion plant site as a best estimate. Zion is somewhat higher than the U.S. average. A sensitivity study based on West Virginia was performed by BNL to evaluate the sensitivity to economic factors. The economics of West Virginia are considered to be much below the national average. Zion weathers conditions were also employed in the base line calculations with MACCS. A review of several severe accidents calculation, by BNL, indicated that varying weather models have a small effect on the public health and offsite consequences.

Since the costs associated with spent fuel storage construction costs and overhead and maintenance are well documented in either the EPRI NP-3380 (Ref. 37) study or in the DOE Dry-Storage study (Ref. 7), the industry implementation costs appear to be well defined and no sensitivity study is performed.

The impact of these sensitivity studies are shown in Table 5.2.6. The best case analysis is used as the reference, base line case. The results of the sensitivity study shows that the dominance of the cost of dry-storage in comparison to the potential damage costs is overwhelming and therefore this alternative is not cost effective. A factor of 10 increase in the probability of a Zircaloy fire in a spent fuel pool would not alter this conclusion.

Table 5.2.5
Summary of Industry Wide Value/Impact Analysis for Alternative 2
Based on 100% Risk Reduction (1988 $s)

Attribute	Dose Reduction (person-Rem) Best Est.	Dose Reduction (person-Rem) High Est.[a]	Cost ($1,000) Best Est.	Cost ($1,000) High Est.[a]
Public Health [1]	47,000	153,000	47,000	153,000
Occupational Exposure (Accidental)	negligible	negligible		
Onsite Property Damage (5% discount)	3,500	5,600		
Offsite Property Damage (5% discount)			13,400	101,000
Industry Implementation and Operation Cask Assumption			-1,510,000	-1,510,000
NRC Development/Implementation and Operation			negligible	negligible
Net Benefit			-1,446,000	-1,250,000
Benefit($)/Cost($) [2]			0.042	0.172
Dose Reduction (person-rem)/Million $s [3]			31	100
Value/Impact Ratio [4] ($/Person-rem reduction)			32,130	9,900

Notes: (a) High estimate based on worst case of entire pool inventory at site with 860 people per square mile population density and Zion land use factors.

(1) Cost of health consequences set at $1,000 per person-rem.

(2) Averted costs divided by NRC + Industry implementation and operational costs.

(3) Public dose reduction divided by NRC + Industry implementation and operational cost.

(4) Cost of NRC + Industry implementation and operation divide by public dose reduction.

Table 5.2.6
Benefit/Cost Ratio Sensitivity Analysis for Alternative 2 (1988 $s)

Parameter Under Study	New Value	Net Benefit ($1,000)	Benefit/ Cost Ratio (1)
Baseline Best Estimate		-1,446,000	0.042
Discount Rate	10%	-1,453,000	0.038
Health Effects	$ 500/person-rem	-1,476,000	0.022
	$2,000/person-rem	-1,406,000	0.069
Site Economics	West Virginia	-1,453,000	0.038

Note: (1) None of these assumptions changes the risk reduction in person-rem averted, which remains constant at 47,000 person-rem averted. The implementation cost also is not changed. The value/impact ratio remains $32,130 per averted person-rem.

5.3 Alternative 3 - Improve Cooling/Make-Up Systems

Four generic spent fuel pool cooling and make-up systems have been described in Section 4.7.6. The probability of failure of these systems to fail to provide adequate cooling and make-up to the spent fuel ranges from 2.2×10^{-5} per reactor year to 3.6×10^{-6} per reactor year, without consideration for recovery. With recovery, the probability of damage to spent fuel is estimated to be in the 1×10^{-8} per reactor year range, with an upper bound value of 1×10^{-6} per reactor year.

A beyond design basis earthquake, as a result of the low seismic capacity of non-safety grade electrical components (motor control centers and switchgear), is estimated to result in a probability of damage to spent fuel on the order of about 5×10^{-8} per reactor year. Essential components to either the cooling system or the make-up system, or both systems, are designed to the SSE and deterministically demonstrated to perform the safety function of maintaining the spent fuel in a safe and subcritical configuration for all credible storage conditions.

5.3.1 Risk Reduction Estimate

Although a loss of cooling and subsequent heatup is a very slow event (on the order of several days), analyses have shown that after the spent fuel is uncovered, the remaining water would block air circulation and cladding overheating would occur for fuel which had been cooled for one year (Ref. 8). However, because of the lack of air circulation within the spent fuel holders, the oxidation reaction would be oxygen starved and the cladding would not melt. Thus, BNL concludes that catastrophic failure of the spent fuel would not be expected. Consequence estimates for ruptured fuel pins was performed in NUREG/CR-4982 (Ref. 10), and the resulting offsite consequences were found to be minimal, about 4 person-rem given the accident (see Table 4.6.2).

The economics of such an accident appear to be important. Since the reactor could not operate until the spent fuel pool was available, the cost of replacement power, until the spent fuel pool building was decontaminated and the equipment repaired, could be considerable. It is estimated by BNL (Ref. 13) that repairs and decontamination would take one month to one year depending on the degree of fuel damage and contamination. Replacement power costs estimates were obtained based on the method presented in Section 5.1. The onsite costs range from $19 to $227 million (1988 $s) conditional upon a spent fuel pool accident (Ref. 36). Integrated over the remaining lifetime of a typical plant, 30 years (the industry average), the expected cost associated with the gradual coolant loss sequences (without discount) could be as high as $150,000, based on a 2.2×10^{-5} per reactor year event (without credit for recovery actions). The low value is estimated to be $12,500, without discount.

5.3.2 Cost of Improved Cooling/Make-Up Systems

Two alternative systems for improvement of the spent fuel pool cooling system were evaluated by BNL (Ref. 13) to assess the potential cost-benefit for each of the four generic system types:

1. Provide another full capacity pump and associated valves to eliminate the need for running the cooling system without a backup pump (System C and D). The first order approximation of the cost of this option is estimated by BNL to be $50,000 (1983 $), or $60,000 (1988 $s) based on Section 5.1.4 cost escalation factors.

2. Provide a completely independent make-up train, BNL assumed this system to be similar to the primary spent fuel pool supply train. The hardware requires include a Category I water storage tank (200,000 gallon capacity), pumps, controls, and piping. The first order approximation of the cost of the independent make-up train plus overhead and maintenance costs were estimated by BNL to be one million dollars (1983 $s), or $1.2 million (1988 $s).

5.3.3 Value/Impact Summary

The cost-benefit characteristics of these options are summarized in Table 5.3.1. For the additional make-up train, the analyses assume 100% reduction in the initiating frequency, that is complete recover of the potential loss, and the averted costs are calculated at a 5% discount over the remaining average plant life of 30 years. The addition of a full capacity pump to System C or D would result in a risk reduction to the equivalent frequency of System A or B. For example the change in the initiating frequency for System C would be from 2.2×10^{-5} to 3.8×10^{-6} per reactor year, or a change of 1.8×10^{-5} per reactor year.

The only system which might benefit from either of these options is System C without credit for recovery actions. The generalized presentation of the Standard Review Plan requirements indicate that additional requirements, to improve the cooling/make-up system, would not result in a cost-beneficial improvement. When recovery actions are considered, the most appropriate estimate for the cost-benefit ratio is System D.
The current requirements for the design of the spent fuel pool cooling and make-up systems, when credit for operator action to diagnose and recovery from a loss of cooling event is considered, are judged to be satisfactory. This finding is based, in part, on the assumption that,

as a result of IE Bulletins and Information Notices (see Section 5.1 above), licensees are aware of the need to assure that adequate instrumentation is available and maintained to alert the operators to degradation in the spent fuel pool or its support systems.

Table 5.3.1
Value/Impact for Generic Improvements to the SFP Cooling Systems[1]
(5% Discount Rate - 1988 $s)

System	Description (Frequency)	Option	Cost of Option ($1,000)	Averted Cost Range[2] ($1,000)		Benefit/Cost Ratio Range	
				Low	High	Low	High
A	Minimum SRP (3.8×10^{-6}/R-y)	1. Add Pump	60	None			-
		2. Make-up train	1,200	1.1	13.1	0.001	0.011
B	Minimum SRP With Credit for Fire Hose (1.9×10^{-7}/R-y)	1. Add Pump	60	None			-
		2. Make-up train	1,200	0.1	6.5	0.001	0.005
C	Old System w/ Both trains 30% of time (2.2×10^{-5}/R-y)	1. Add Pump	60	3.5	41.4	0.058	0.690[3]
		2. Make-up train	1,200	6.3	75.7	0.005	0.063
D	Old System With Credit for Fire Hose (1.1×10^{-6}/R-y)	1. Add Pump	60	0.2	2.1	0.003	0.035
		2. Make-up train	1,200	0.3	3.8	0.001	0.003

Notes: (1) Spent fuel cladding ruptures and releases gaseous fission products, no Zircaloy cladding fire. The offsite consequences are small, 4 person-rem given the loss of cooling cooling/make-up. Value/impact ratio, in $s per averted person-rem, is very large (well in excess of $1,000 per averted person-rem), however economics of spent fuel cladding rupture could be important.

(2) Averted costs of replacement power and cleanup/repair of spent fuel pool. Low estimate is for one month outage, high estimate is for one year outage.

(3) Based on a 10% discount rate, the averted cost estimate is reduced to $24,700 and the benefit/cost ratio is reduced to 0.41. Similar reductions apply to all options at a 10% discount rate.

5.4 Alternative 4 - Install Spray Systems

Post-accident spray systems have been considered as a potentially significant mitigative measure for spent fuel pool accidents. A scoping value/impact assessment was performed by BNL (Ref. 13) to provide some insights into the potential cost effectiveness of installing spray systems. The guidelines outlined in NUREG/CR-3568 (Ref. 36) for "First Approximation of Benefits and Costs" were used.

BNL emphasized that this assessment is scoping in nature due to the many assumptions involved and large uncertainties in data and decontamination factors assumed for spray systems.

5.4.1 Risk Reduction Estimate

The principle reduction effect of the spray systems is achieved by decontaminating radiological releases thus permitting greater retention of fission products in the pool and the pool building. Results of analyses of severe reactor accidents in support of NUREG-1150 (Ref. 42), indicate that containment spray systems can be significantly effective in reducing source terms and severity of consequences of nuclear reactor accidents (Ref. 43).

In this assessment, it is assumed that the major benefit of spray systems results from reduction in the offsite consequences. The onsite property damage is not effected, that is cleanup and repair and replacement power costs would still be incurred due to spent fuel damage and a Zircaloy fire.

The effectiveness of the spray system is measured by the decontamination factor (DF), the amount of radioactive species released to the environment without the spray divided by the amount released with the spray. Decontamination factors for a spent fuel pool spray system are difficult to estimate without detailed calculations, therefore BNL assumed that the DF would be 45 based on NUREG-1150 analysis for the Surry plant containment spray system effectiveness. The effects of a DF of 45 on the results of MACCS consequence calculations are provided in Table 5.4.1, and compared to the previous case without sprays. The effects of a spray system with a DF of 45 has the effect of reducing the offsite consequences to a small fraction of their original levels, therefore this can be considered to be an upper bound measure of the potential benefit of a post-accident spray system.

5.4.2 Cost of Installing Spray Systems

Preliminary construction and industry maintenance costs were estimated by BNL. Assumed hardware requirements included a Category I water storage tank (200,000 gallon capacity) and a spray system including pumps, spray nozzles and associated hardware. The cost, on a first approximation basis, is estimated to be $1.2 million (1988 $s) per spent fuel pool (Ref. 13).

The NRC cost associated with this option is estimated to be $100,000 (1988 $s) per spent fuel pool, roughly equivalent to one staff-year review effort per pool at $75,000 per staff-year (NUREG/CR-4627, Abstract 5.2, Ref. 39) plus $25,000 for the development and approval of a Technical Specification for the control of the administration, surveillance and maintenance of the spray system.

Table 5.4.1
Offsite Health and Property Damage Estimates (1988 $s)
With Pool Spray System (DF = 45)

Case Description	Whole Body Dose (person-Rem per-Event)		Offsite Property Damage (1988 $s)	
	Without Spray	With Spray	Without Spray	With Spray
Best Estimate Consequences Last discharge 90 days after discharge, 50 mile radius Based on 340 people/square mile	7.97×10^{6}	1.25×10^{6}	4.0×10^{9}	7.2×10^{7}
Worst Case Estimate Consequences Total inventory 30 days after discharge, 50 mile radius Based on 860 people/square mile	2.56×10^{7}	6.78×10^{6}	3.0×10^{10}	5.2×10^{8}

5.4.3 Value/Impact Summary

The value/impact, cost-benefit analysis is provided in terms of the mean industry risk from spent fuel pool accidents in Table 5.4.2. The best estimate accident frequencies are used and the best estimate consequences, based on fission product release from 1/3 of a reactor core, are used. The conditional probability of the Zircaloy fire, given the loss of water from the spent fuel pool, is 1.0 for the PWRs and 0.25 for the BWRs. Since the amount of spent fuel which could become involved in the release is uncertain, a sensitivity study using the worst case consequences, full spent fuel pool inventory at a high population site, is also provided.

The risk is comprised of 69 PWR spent fuel pools with a spent fuel damage probability of 1.95×10^{-6} per reactor year (including seismic events and conditional Zircaloy fire probability of 1.0 given loss of water) and 39 BWR spent fuel pools with a spent fuel damage probability of 1.71×10^{-6} per reactor year (including seismic events and conditional Zircaloy fire probability of 0.25 given loss of water). The mean remaining lifetime for the PWR spent fuel pool is 29.8 reactor years, and 27.9 years for the BWR spent fuel pool.

The dose reduction estimate is derived from the change in the offsite health consequences shown in Table 5.4.1, 6.72×10^{6} person-rem per accident for the best estimate case and 1.88×10^{7} person-rem per accident for the worst case. The offsite property damage costs are estimated using the revised MACCS values (with sprays), discount at a 5% rate over 30 years. The onsite property damage costs are assumed to be unchanged, cleanup and repair and replacement power costs are incurred.

The best estimate value/impact ratio for this alternative is estimated to be $3,340 per averted person-rem and exceeds the general guideline value of $1,000 per averted person-rem. While the high estimate is seen to be marginally cost effective ($1,200 per averted person-rem), the use of Zion site demography for the high estimate evaluation results is an overly conservative estimate of the risk reduction properties of a given plant modification (860 people per square mile).

Table 5.4.2
Summary of Industry Wide Value/Impact Analysis for Alternative 4
Based on a Spray System DF of 45 (1988 $s)

Attribute	Dose Reduction (person-Rem) Best Est.	Dose Reduction (person-Rem) High Est.[a]	Cost ($1,000) Best Est.	Cost ($1,000) High Est.[a]
Public Health [1]	39,450	110,500	39,450	110,500
Occupational Exposure (Accidental)	negligible	negligible		
Onsite Property Damage			0	0
Offsite Property Damage (5% discount)			13,000	100,000
Industry Implementation and Operation			-130,000	-130,000
NRC Development/Implementation and Operation			- 10,800	- 10,800
Net Benefit			- 88,400	+ 69,700
Benefit($)/Cost($) [2]			0.373	1.50
Dose Reduction (person-rem)/Million $s [3]			280	840
Value/Impact Ratio [4] ($/Person-rem reduction)			3,340	1,200

Notes: (a) High estimate based on worst case of entire pool inventory at site with 860 people per square mile population density and Zion land use factors.

(1) Cost of health consequences set at $1,000 per person-rem.

(2) Averted costs divided by NRC + Industry implementation and operational costs.

(3) Public dose reduction divided by NRC + Industry implementation and operational cost.

(4) Cost of NRC + Industry implementation and operation divide by public dose reduction.

5.5 Alternative 5 - Modify Spent Fuel Storage Rack Designs

This proposed alternative would require the licensee to compartmentalize the spent fuel storage pool by installing partitions (and individual coolant supply diffusers for each compartment) to limit the extent of the accident, or modify the storage racks to improve air circulation, should the spent fuel storage pool drain. This alternative is directed towards risk mitigation, and to a lesser extent prevention.

This alternative was not quantified as part of this value/impact study. The results of the cladding heatup calculation suggest that the only rack geometry that would result in mitigation is low density racks. The probability of a loss of water from the spent fuel pool would not be changed. Compartmental restructuring of the spent fuel is not judged to be feasible without a significant loss in the storage capacity and the resulting need for additional at reactor dry storage is expected to overwhelm any potential risk reduction.

5.6 Alternative 6 - Cover Fuel Debris With Solid Materials

This proposed alternative would require the development of a contingency plan to dump massive amount of solid materials into a drained spent fuel pool to cover the rubble bed to a depth of several feet. The necessary materials would not be stockpiled on site, but could be obtained in a timely manner on an ad hoc basis, the materials (sand, clay, dolomite, boron compounds, lead, etc.) being commonly available in all parts of the country. This alternative would be directed at risk mitigation, not prevention.

This alternative was not quantified as part of this value/impact study. The contingency plan would be concerned with a low frequency event (on the order of 1×10^{-6} per reactor year), with potential high consequence event. The results at Chernobyl can be used as a rough gauge of the efficacy of this measure, when carried out on a strictly ad hoc basis with no apparent advanced planning. However, since the dominant risk sequence for the spent fuel pool accident is a beyond design basis earthquake, BNL concludes that it is dubious that the measures could be implemented soon enough to prevent the major release to the environment during the first few hours of the accident (Ref. 13).

5.7 Alternative 7 - Improve Ventilation Gas Treatment System

This alternative would require the installation of a building ventilation and filter system capable of reducing the concentration of airborne radioactivity before discharge to the environment. This alternative would be directed at risk mitigation, not prevention.

This alternative was not quantified as part of this value/impact study. Again the dominant risk contribution results from the beyond design basis seismic failure of the spent fuel pool structure, a low frequency high consequences accident. To be effective, the spent fuel pool building structure would have to maintain its integrity and the system itself would have to be designed to survive the postulated peak ground acceleration which result in the spent fuel pool failure. Additional investigations into this alternative are not considered to be reasonable.

5.8 Relationships With Other Requirements and Activities

5.8.1 Severe Accident Policy Statement

A recently published report by LLNL, "Evaluation of External Hazards to Nuclear Power Plants in the United States - Seismic Hazard," NUREG/CR-5042, Supplement 1 (Ref. 31), summarizes the result of the study of the risk of core damage due to seismic initiated events.

The overall objective of the LLNL study "is to present information that assists the NRC staff in deciding whether seismic vulnerability searches for nuclear power plants should be in the implementation of the Severe Accident Policy Statement." To accomplish this objective, the LLNL report:

> 1. Considers effects of the evolution of design requirements and design practices on plant seismic capacity.
>
> 2. Identifies other specific review area of potential seismic vulnerability, including seismically induced fires and floods, spent fuel pools and seismic common-mode failures.
>
> 3. Identifies programs which address item 1 and/or item 2, and assess the extent to which these programs provide useful information on seismic capacity of nuclear plants.
>
> 4. Recommends incorporating appropriate items from above into the seismic margins program or other seismic vulnerability searches.

The LLNL report considered the results presented in NUREG/CR-4982, "Severe Accidents in Spent Fuel pools in Support of Generic Safety Issue 82" (Ref 10), and concluded that

> "A comparison of the results of the fuel pool analysis with the two figures of merit is difficult since the fuel pool failure does not constitute core damage and any potential release involves long lived radioactive material. In addition, it is difficult to draw conclusions concerning spent fuel pools based on only a single generic analysis. Therefore, any decision on the inclusion of spent fuel pools into the severe accident policy implementation requires more data and analysis, and cannot be concluded at this time."

The first figure of merit considered by LLNL is the core damage frequency. In numerical terms LLNL uses a mean core damage frequency in the range of 1×10^{-5} (or less) per reactor year as meeting the Commissioners stated objective, in the Policy statement on Safety Goals, as:

> "providing reasonable assurance, given consideration to the uncertainties involved, that a core damage accident will not occur at a U.S. nuclear power plant."

The second figure of merit is the frequency of a large release. In the Policy Statement on Safety Goals, the following guidance is given as a general performance guideline:

> "Consistent with the traditional defense-in-depth approach and the accident mitigation philosophy requiring performance of containment systems, the overall mean frequency of a large release of radioactive material to the environment from a reactor accident should be less than 1 in 1,000,000 per year of reactor operation."

The current status of this guideline is that the NRC staff is giving detailed consideration to how such a performance guideline can be implemented, including how to define more precisely the definition of a "large release of radioactive material to the environment." In the LLNL study, a large release of radioactive material to the environment has been defined as a release of a substantial fraction of the radioactive core in a time period relatively early in the postulated accident scenario. This definition was derived from Probabilistic Risk Assessment (PRA) literature which has defined a "large early release." Further discussion on the applicability of such guidance to Generic Issue 82 is presented in Section 6.2.

5.8.2 Seismic Design Margins Program

The current objectives of the Seismic Design Margins Program are:

> 1. To develop and improve guidance for assessing the inherent capability of nuclear power plants to withstand earthquakes above the design level.
>
> 2. To provide an effective and efficient means to identify vulnerabilities of nuclear plants to seismic events.

The seismic margins approach has chosen as one of its figures of merit a high confidence of low probability of failure (HCLPF). The HCLPF is a conservative representation of capacity and in simple terms corresponds to the earthquake level at which it is extremely unlikely that failure will occur. Two approaches are recommended for estimating the component HCLPF values: the PRA fragility approach and the Conservative Deterministic Failure Margins (CDFM) approach.

The CDFM HCLPF approach has been developed and used by EPRI in a trial review of the Catawba Nuclear Station, with a seismic margins earthquake (SME) of 0.3 g. The resultant HCLPF for core damage sequences was found to be 0.24 g. An NRC sponsored review panel examined the EPRI work and found the methodology can accomplish its main objective and is reasonably accurate (NUREG/CR-5042, Supplement 1, Section 4, Ref. 31).

The PRA HCLPF approach has been used by the NRC to evaluate core damage sequences at Maine Yankee. The SME was also set at 0.3 g for this study. The HCLPF was found to be 0.21 g, and later revised to 0.27 g after the licensee committed to upgrading the refueling water storage tank.

The HCLPF approach used in the seismic design margins program does not use the seismic hazard curves. That is, the probability of a core damage sequences due to a seismic initiator are not evaluated in the traditional terms of frequency per reactor year used in PRAs. Instead the HCLPF value can be compared to the SME value. A plant HCLPF value greater than or equal

to the SME would be considered to have adequate capacity since the SME would be chosen to assure adequacy. If the HCLPF value is less than the SME, then the site specific hazard curve could be used to estimate the recurrence frequency for that level of earthquake.

In NUREG/CR-5042, LLNL concludes that plant HCLPF capacity represents a conservative estimate at which there is a high confidence of a low probability of core damage. A more realistic parameter is the plant median capacity which is more than a factor of two greater than the HCLPF. It has been suggested that two times the plant HCLPF capacity could be used in conjunction with the median site specific hazard curve to obtain a recurrence frequency for comparison with some evaluation criterion. In light of the screening approach used for seismic margin reviews, LLNL goes on to conclude that research is needed to address what may be the appropriate factor that can be used along with the plant HCLPF capacity and what would be an appropriate evaluation criterion.

Until more definitive guidance is developed and approved by the Commission for the assessment of the external seismic hazard risk, the currently accepted guidelines for a regulatory impact analysis are used to define the risk. The mean failure frequency is used. The mean frequency is currently used for external events based on the use of the mean frequency in evaluating risk from internal events. Component and systems failures are described by their estimated mean failure rates.

6. DECISION RATIONALE

The risk from the storage of spent fuel in the spent fuel storage pool at light water reactors is dominated by the beyond design basis earthquake accident scenario. The seismic capacity, or fragility, of two older spent fuel pools indicate that the high confidence of low probability of failure (HCLPF) is about three times the safe shutdown earthquake (SSE) design level. The HCLPF values are estimated to be 0.5 for the BWR and 0.65 g for the PWR spent fuel pools studied. The safe shutdown earthquake (SSE) for the two plants are 0.14 g and 0.2 g, respectively. The median peak ground acceleration needed to fail these pools is estimated to be in the 1.4 to 2.0 g range, a factor of ten higher than the SSE design value. A report prepared by the American Society of Civil Engineers (Ref. 29) also concluded that, in general, the seismic design of nuclear facility structures results in median factors of safety on the order of 4 to 19 based on post-1973 design criteria.

The structural capacity of the elevated BWR pool is lower than that for the PWR pool located at the ground level, however the lower conditional probability of a Zircaloy fire for the BWR fuel assembly design (0.25 as compared to the PWR value of 1.0) offsets the higher seismic failure frequency. The probability of a Zircaloy cladding fire, resulting from the loss of water from the spent fuel pool, is estimated to have a mean value of 2×10^{-6} per reactor year for either the PWR or the BWR spent fuel pool. The seismic event contributes over 90% of the PWR probability, and nearly 95% for the BWR.

The source term for the spent fuel pool accident is not the same as the source term associated with core damage accidents. The consequences of a spent fuel pool accident which results in the complete loss of water is dominated by the long lived isotopes, such as cesium and strontium. The health consequences are dominated by the risk of latent cancer fatalities due to long term exposures.

The best estimate of the consequences of a spent fuel pool accident which results in spent fuel damage to approximately one-third of an equivalent reactor core is 8×10^{6} person-rem. This total dose translates to a public health risk from a spent fuel pool accident of 480 person-rem over an average remaining licensed lifetime of 30 years. The best estimate offsite property damage cost is $4,000 million (1988 $s). The best estimate values are based on a population density of 340 people per square mile within a 50 mile radius from the site and result from the release of radionuclides from the last fuel discharge, 90 days after being discharged. The best estimate of the onsite costs for a SFP accident is $1,180 million (1988 $s), including five years of replacement power to replace the damaged spent fuel pool. Based on an average remaining lifetime of 30 years and a 5% discount rate, the present value of the offsite property damage is estimated to be $124,300 and the present value of the onsite property damage is estimated to be $32,400. As an upper bound, worst case, the consequences of the release of the full fuel pool at a high population site (860 people per square mile within a 50 mile radius from the site), 26×10^{6} person-rem, was used to evaluate the sensitivity of the consequences for proposed alternatives. The corresponding estimate in offsite property damage is $30,000 million (1988 $s).

The consequences, in person-rem, from a spent fuel pool accident are relatively insensitive to the quantity of spent fuel assumed to be released during an accident, when the typical assumptions regarding interdiction dose and decontamination are applied. In the MACCS consequence calculations, no planned evacuation was assumed, however, persons expected to receive more than 25 rem from ground shine in seven days were assumed to be relocated in one day. An additional dose limit over 30 years of 25 rem was also used to determine the

interdiction level. MACCS also includes a separate interdiction criteria for crops: crops are interdicted if the resulting ingestion doses would exceed 25 millirem per year. This dose rate is the U.S. Environmental Protection Agency allowable chronic environmental dose rate for normal activities.

The amount of contamination, or land interdiction area, is strongly influenced by the quantity of spent fuel assumed to be released. Sensitivity studies have been performed for the release from the last refueling discharge and for release from the full inventory of a spent fuel pool which has accumulated the equivalent of about four cores in spent fuel assemblies. Sensitivity calculations to study the possible effects of fission product retention on structures and to study the possible effects of a spent fuel pool post-accident spray systems were also performed. The results of these analysis (based on the last discharge assumption) indicated that a decontamination factor assumption of ten reduces the consequences by a factor of two, and the interdiction area by a factor of ten (Ref. 10). A decontamination factor of 45 results in a reduction in consequences of a factor of six and a factor of about 55 in the value of offsite property damage (Ref. 13).

6.1 Comparison to the Backfit Criteria (10 CFR 50.109)

The value impact evaluation, presented in Section 5, for the proposed alternatives for Generic Issue 82 does not indicate that cost effective options are available to mitigate the risk of beyond design basis accidents in spent fuel pools. The option to use low density storage racks for recently discharged fuel has a best estimate value impact ratio of $32,000 per averted person-rem. Low density racks would decrease the frequency of a Zircaloy cladding fire by at least a factor of five to ten, and the value impact ratio is based on 100% reduction in public dose. For the worst case, a high population site with the full fuel pool inventory being released, the value impact ratio is $9,900 per averted person-rem. When compared to the general guideline value of $1,000 per averted person-rem, the low density option is not justified.

The use of a post-accident spray system to mitigate the consequences of a spent fuel pool accident has a best estimate value impact ratio of $3,300 per averted person rem, with a worst case estimate of $1,200 per averted person rem. This assumes that a post-accident spray system can be designed to withstand the beyond design basis earthquake which causes failure of the spent fuel pool structure and has a decontamination factor (DF) of at least 45. Other structures and equipment within the spent fuel storage pool building (for example the refueling crane) would also have to be reviewed to assure that their failure would not compromise the proposed spray system. Under the worst case release assumption, full fuel pool inventory at a high population site, this option is marginally cost beneficial but still exceeds the general guideline value of $1,000 per averted person-rem. However the complete spent fuel pool inventory being released is considered to be highly unlikely. Results of cladding fire propagation calculations indicate that only fuel which is one to two years old could be involved in the release. Also, the demographics are a high estimate of the attributes of a typical plant modification (860 people per square mile).

Potential improvements to the spent fuel pool cooling and make-up systems were also examined. The potential risk to the general public is estimated to be very small, on the order of 3 to 4 person-rem, given a loss of cooling event which results in failure of the spent fuel cladding but not a Zircaloy cladding fire. The value/impact ratios are very large, well in excess of the general guideline value of $1,000 per averted person-rem, however the economics could

be important if the spent fuel pool is unavailable and the reactor is shutdown until cleanup and repairs are completed. The cost-benefit ratios for either an additional cooling pump or an additional make-up train were found to be less than one.

Three additional alternatives, (1) to modify the spent fuel storage rack designs, (2) to cover the spent fuel debris with solid materials, and (3) to improve the ventilation gas treatment system, were not explicitly quantified. Compartmental modification to the storage rack designs would result in the displacement of fuel from the spent fuel pool to at-reactor storage casks, a costly option as shown in Alternative 2. Considering that the risk from a spent fuel pool accident is a result of a beyond design basis earthquake, it it highly unlikely that materials could be transported to the site to cover the spent fuel debris in time to reduce the releases of radioactive materials from the spent fuel pool. Finally, since the integrity of the spent fuel building structure following a beyond design basis earthquake is questionable, improvements in the ventilation gas treatment system would be difficult to obtain.

Therefore, the backfit criteria (Ref. 44) that (1) a substantial increase in the overall protection of the public health and safety is achieved, and (2) the direct and indirect costs of implementation are justified, are not met for any of the alternatives considered.

6.2 Comparison to the Safety Goal Policy Statement

The frequency of damage to the spent fuel is estimated to be on the order of 2×10^{-6} per reactor year, including the beyond design basis seismic earthquake. This value, when compared to a target value of 1×10^{-4} (or 5×10^{-5}) for a core damage accident, represents a small part of the overall frequency of core damage - 2% to 4%.

The frequency of a release of radioactive material to the environment is assumed to be the same as the frequency of spent fuel damage. The underlying assumption is that the spent fuel pool housing (refueling building, auxiliary building or secondary building) fails due to either the dominant seismic event or due the extreme temperature conditions which would accompany a Zircaloy cladding fire and fuel melting scenario. The spent fuel pool housing does not provide a containment barrier similar to the containment structure surrounding the reactor core, especially under the conditions postulated to dominate the release of radioactive materials.

It is difficult to compare the estimated 2×10^{-6} per reactor year release frequency due to a spent fuel pool accident to a target value of 1×10^{-6} per reactor year for a large release, particularly without a definition for "large release" . The spent fuel pool source term is not similar to the core damage (or melt) source term and the consequences of a spent fuel pool accident are dominated by latent cancer risks. A possible definition is used in current PRA studies; that is, a "large release" is considered to be an "early, large release" associated with an environmental release within a few hours of a core damage accident (presumably from 100% power). Another definition of a "large release" currently being considered by the staff is a release that has a potential for causing an offsite early fatality (see for example NUREG-1150, Ref. 42). Either of these definitions, in particular any consideration for early fatalities, appear to suggest that the spent fuel pool release is not a "large release."

Societal risk to the public is based on the statistically expected number of early and latent cancer fatalities. The Safety Goal Policy Statement (Ref. 45) currently defines the early fatality area calculation as that within one mile from the site boundary. A ten mile radius is defined for calculating latent cancer fatalities. The language of the Policy Statement also requires that the

risk from an accident at a nuclear power plant be 0.1% of that normally encountered by the public. Based on recent data (Ref. 46) the total fatality rate from cancer in the U.S. is 189.3 per 100,000 persons, or a risk of 1.9×10^{-3} per year. Therefore it can be inferred that a latent cancer fatality rate for nuclear power plant operations of 2×10^{-6} per reactor year, or less, is consistent with the safety goal.

To meet the general objective for societal risk, the probability of a latent cancer fatality from a spent fuel pool accident should not be more than a relatively small fraction of an overall target value for nuclear power plant operations. The best estimate MACCS calculation for the spent fuel pool source term, for 340 people per square mile over a 50 mile radius, predicts a consequence of 8 million person-rem per event. The dose conversion factor for latent cancer fatalities is in the 150 to 200 latent cancer fatalities per million person-rem range. The expected number of latent cancer fatalities is 1,600 per event, and the latent cancer fatality rate would be 0.0032 per reactor year (1,600 latent cancer fatalities per event times 2×10^{-6} events per reactor year) for the affected population.

The mean population within a 10 mile radius of a reactor site is 57,000 people (based on a mean density of 182 people per square mile), and 2,670,000 people within a 50 mile radius (based on 340 people per square mile) in the year 2,000 (Ref. 47). The expected number of cancer fatalities from all causes in the 50 mile radius is 0.2% of the population, or 5,340 per year. In a 10 mile radius, the expected number of cancer fatalities is 114 per year. Using 0.1% of 10 mile radius value, a target value for latent cancer fatalities from the operation of a nuclear power plant would be less than 0.114 latent cancer fatalities per reactor year. The 0.0032 latent cancer fatalities per reactor year associated with the spent fuel pool accident is less than 3% of the 0.114 per year target value based on the calculation area specified in the Safety Goal Policy Statement, even without correcting for the fact that only a fraction of the 50 mile radius latent cancer fatalities would occur within the 10 mile radius.

The estimated frequency of a spent fuel pool accident, 2×10^{-6} reactor year, resulting in spent fuel damage meets a target objective of a few percent of a 1×10^{-4} to 5×10^{-5} per reactor year value for overall core damage frequency. The target objective for a "large release" of 1×10^{-6} per reactor year is marginally met, within a best estimate factor of two, but subject to interpretation since the definition of "large release" is still under development. In meeting the societal risk objective of 0.1% of the normally occurring risk to the public given the release frequency of 2×10^{-6} per reactor year, the latent cancer fatality rate from a spent fuel pool accidents is estimated to be less than 3% of the target value for the operation of a nuclear power plant.

Therefore, the risk and consequences of a spent fuel pool accident appear to meet the Safety Goal Policy Statement public health objectives. They would also meet the proposed 1×10^{-6} per reactor year large-release frequency guidelines, at least pending definition of a "large release" by the Commission. Therefore, Alternative 1 - "No Action" is justified.

6.3 Other Considerations

In addition to implementing the requirements contained in 10 CFR Part 50 Appendix A of the "General Design Criteria," and 10 CFR Part 20, concerning radiation doses being kept as low as is reasonably achievable, licensees should have implemented additional or corrective actions based on the following guidance:

1. IE Bulletin 84-03, "Refueling Cavity Water Seals," issued August 24, 1984. (Ref. 21)

2. IE Information Notice 84-93, "Potential for Loss of Water From the Refueling Cavity," issued December 17, 1984. (Ref. 24)

3. Generic Letter 85-11, "Completion of Phase II of 'Control of Heavy Loads at Nuclear Power Plants' NUREG-0612," issued June 28, 1985. (Ref. 4)

4. IE Information Notice 87-13, "Potential for High Radiation Fields Following Loss of Water from Fuel Pool," issued February 24, 1987. (Ref. 34)

5. IE Information Notice 87-43, "Gaps in Neutron-Absorbing Material in High-Density Spent Fuel Storage Racks," issued September 8, 1987. (Ref. 33)

6. IE Information Notice 88-65, "Inadvertent Drainages of Spent Fuel Pools," issued August 18, 1988. (Ref. 25)

7. IE Information Notice 88-92, "Potential for Spent Fuel Pool Draindown," issued November 22, 1988. (Ref. 26)

Based on compliance with the GDCs and licensees taking corrective actions identified as a result of reviewing facility designs and operations based on IE Bulletins and Information Notices, the frequency of a spent fuel pool accident resulting in a Zircaloy cladding fire and the release of fission products to the environment from internal events, such as missiles, heavy load drops, loss of cooling or make-up, inadvertent drainage or siphoning and pneumatic seal failures, is estimated to be on the order of 2×10^{-7} per reactor year. Operator diagnosis and recovery are important factors considered in the development of the event frequencies for these events and portions of this evaluation are premised on licensees having taken appropriate actions in response to the concerns identified to prevent similar occurrences, or at least understand the potential consequences of these events and develop appropriate procedures to respond to them and to mitigate the consequences.

The overall frequency of a spent fuel pool accident resulting in a release of radioactive materials to the environment is estimated to be 2×10^{-6} per reactor year for a light water reactor spent fuel storage pool when the external seismic hazard is included. The beyond design basis earthquake dominates the risk, 90% to 95% of the total. The HCLPF value is estimated to be three times the safe shutdown earthquake (SSE) value peak ground acceleration value, in the 0.5 to 0.65 g range. The median capacity is estimated to be in the 1.4 to 2.0 g range. 10 CFR Part 100 Appendix III.(c) defines an SSE as:

> "that earthquake which is based upon an evaluation of the maximum earthquake potential considering regional and local geology and seismology, and specific characteristics of local subsurface material. It is that earthquake which produces the maximum vibratory ground motion for which certain structures, systems, and components are designed to remain functional. These structures, systems, and components are those necessary to assure: (1) the integrity of the reactor coolant pressure boundary, (2) the capability to shutdown the reactor and maintain it in a safe shut down condition, or (3) the capability to prevent or mitigate the consequences of accidents which could result in potential off-site exposures comparable to the guideline exposures of 10 CFR Part 100."

In NUREG/CR-5042, Supplement 1 (Ref. 31), LLNL reviewed available PRA literature to determine the seismic hazard contribution to core damage accidents. A review of analyses for A-45, "Decay Heat Removal Requirements," indicates that the dominant earthquake range for core damage falls within the 0.2 to 0.4 g range. A review of Zion and LaSalle Seismic Safety Margins Research Program (SSMRP) analyses also concludes that the 0.2 to 0.4 g range dominates core damage from seismic initiators. The dominant component failures, contributing to core damage, were found to be:

1. Yard Tanks - condensate storage tanks, refueling water storage tanks.

2. Electrical Equipment - batteries, buses, cabinet anchorage, contacts, relays, transformers.

3. Diesel Generator Peripherals - fuel oil tanks, lube oil tanks, coolers.

4. Structural failures - block walls, service water buildings, reactor internals.

5. Equipment Anchorages.

In other words, this type of spent fuel pool accident requires an earthquake larger than that which would result in core damage and the release of radioactive material to the environment. The mean core damage frequencies due to the seismic hazard are in the 3×10^{-6} to 1.4×10^{-4} per reactor year range based on published PRA results, with seismic related release frequencies in the range of 2×10^{-7} to 1.4×10^{-4} per reactor year for peak ground accelerations in the 0.2 to 0.4 g range (NUREG/CR-5042, Supplement 1, Table 3-3, Ref. 31). The spent fuel pool accident is estimated to have a frequency on the order of 2×10^{-6} per reactor year for a peak ground acceleration in excess of 0.5 g.

In estimating the likelihood of a beyond design basis earthquake resulting in a failure of a spent fuel pool, uncertainty can be introduced into the evaluation when attempting to characterize the seismic hazard of a site. The seismic hazard is a quantification of the probability of exceeding a given peak ground acceleration on an annual basis. As shown in NUREG/CR-5176, and also

noted in an NRC memorandum dated December 29, 1988 (Ref. 48), the uncertainty in estimating the seismic risk is about an order of magnitude, and relates to how expert judgment is used in the development of the site characterizations.

For each of the two plants studied by LLNL in NUREG/CR-5176, a family of seismic hazard curves were convolved with a family of plant-level seismic fragility curves to obtain a probability distribution of the frequency of occurrence of the seismic initiated accident under study. At the time this work was performed by LLNL, the complete family of seismic hazards curves were not available for the two plants studied, other than at some selected percentile values. When the seismic hazard curves are grouped in this manner, the specific features of the individual hazard curves (for example, they may intersect one another) are lost. Median and 95 percentile hazard curves were used by LLNL to develop a discrete set of seismic hazard curves for each of the two plants studied. A lognormal distribution was used for the purpose of obtaining approximate risk estimates. The resulting lognormal distribution was cutoff at different percentile values to judge the sensitivity of the results. A cutoff value of 99 percent was recommended for use by LLNL in NUREG/CR-5176. The resultant frequency estimate for spent fuel damage due to a beyond design basis earthquake is 2.0×10^{-6} per reactor year for the LWR spent fuel pools studied in NUREG/CR-5176.

More recently, EQE Engineering, Inc., the same subcontractor employed by LLNL for the NUREG/CR-5176 effort, re-evaluated the seismic risk for the same two plants based on true mean seismic hazard curve data (Ref. 48). EQE provided two sets of results based on the use of two sets of experts, the "5 G-Experts" and the "4 G-Experts." The resultant mean annual frequency of failure of the spent fuel pool structures decreases by a factor of 8.8 for the BWR spent fuel pool and 2.8 for the PWR spent fuel pool by removing one seismic ground motion expert, or "outlier," from the seismic hazard characterization estimate (for example when going from the "5 G-Expert" to the "4 G-Expert" ground motion expert judgment). Similar results were obtained by LLNL in NUREG/CR-5176 in going from a cutoff value of 100 percent to 99 percent, by eliminating a small portion of the tails from the lognormal distribution curves. Since the tail of the lognormal distribution extends to infinity, it might be possible to get values of the probability of exceedance greater than one. Truncation of the lognormal distribution curves at an exceedance value less than one, at 0.99, was used in the LLNL study. The relative magnitudes are similar. For the "5 G-Expert" values, the more recent plant specific BWR seismic failure frequency from the EQE study could be a factor of 5.5 higher than the earlier LLNL evaluation. Similarly, the more recent plant specific PWR seismic failure frequency could be a factor of 2.6 higher than the earlier LLNL evaluation. Based on the "4 G-Expert" values, the earlier LLNL evaluation of the seismic failure frequency is slightly higher than the more recent EQE values for both spent fuel pools studied. The mean seismic failure frequencies for the two methods are summarized in Table 6.3.1.

Due to the skewed nature of the distribution of expert judgment, the mean is a highly unstable estimate of the seismic hazard . In these distributions the most extreme opinion weighs heavily when the mean is calculated. The mean, which is an arithmetic average of all inputs, frequently exceeds the 85th percentile of all the inputs. This problem created by the skewed distribution of expert judgment exists for either method, the actual true arithmetic mean or the lognormal distribution.

A re-evaluation for Alternative 2, the use of low-density storage racks for recently discharged fuel, using these higher seismic failure frequencies results in a best estimate value/impact ratio of $9,500 per averted person-rem. Using the worst case assumptions, the value/impact ratio is

$3,000 per averted person-rem. Alternative 2 is judged to be the most practical option for reducing the risk and the implementation costs are well defined. While a re-evaluation for Alternative 4, the installation of a post-accident spray system, indicates a marginally acceptable best estimate value/impact ratio of $1,050 per averted person-rem, the uncertainty in the implementation cost of this option is large. The implementation cost is based solely on the installation of the spray system and does not consider the potential for the need to reinforce other parts of the spent fuel storage building structures to assure that their failure in a beyond design basis earthquake would not compromise the spray system. Therefore, even with the higher seismic frequencies, the staff would not conclude that any of the options considered would be cost-effective.

Although these studies conclude that most of the spent fuel pool risk is derived from beyond design basis earthquakes, this risk is no greater than the risk from core damage accidents due to seismic events beyond the safe-shutdown earthquake. Therefore, reducing the risk from spent fuel pools due to events beyond the safe-shutdown earthquake would still leave a comparable risk due to core damage accidents. Because of the large inherent safety margins in the design and construction of the spent fuel pool, Alternative 1 - "No Action" is justified.

When taken together, the discussions presented in Sections 6.1, 6.2 and 6.3 form the basis for a decision that no corrective actions are justified. The risk due to beyond design basis accidents in spent fuel pools, while not negligible, are sufficiently low that the added costs involved with further risk reductions are not warranted.

Table 6.3.1
Summary of SFP Seismic Failure Frequency Estimates

Pool Type	NUREG/CR-5176 Results		NRR True Mean Results	
	Cutoff Value (per cent)	Frequency (per R-year)	Expert Group	Frequency (per R-year)
Elevated BWR	100	3.8×10^{-5}	5 G-Experts	3.7×10^{-5}
	99	6.7×10^{-6}	4 G-Experts	4.2×10^{-6}
On Ground PWR	100	8.6×10^{-6}	5 G-Experts	4.7×10^{-6}
	99	1.8×10^{-6}	4 G-Experts	1.7×10^{-6}

Note: The NUREG/CR-5176 frequencies at the 99 per cent cutoff level were used in this Regulatory Analysis as being representative of the best estimate, generic values for an elevated BWR spent fuel pool and a PWR spent fuel pool located at the ground elevation.

7. IMPLEMENTATION

No regulatory action is necessary for the resolution of this issue. This regulatory analysis and the supporting contractor reports have been made publicly available as part of their normal distributions.

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Appendix A

Spent Fuel Data and Storage Requirements

The Department of Energy (DOE), Office of Civilian Radioactive Waste Management (OCRWM) is responsible for the management and ultimate permanent disposal of the civilian spent fuel and high level radioactive waste generated as a result of commercial nuclear power plant operations in the U.S. This responsibility is prescribed under the provisions of the Nuclear Waste Policy Act of 1982 (NWPA) (as amended).

The greatest portion of the radioactive waste covered under this government responsibility will be spent nuclear fuel discharged from commercial nuclear power plants. Because most of the spent fuel that will ultimately require disposal has not yet been generated, planning for the management and disposal of this spent fuel must be largely based on projections of future spent fuel discharges from commercial nuclear power plants.

The OCRWM plans for management and disposal of spent fuel are based on the DOE Energy Information Administration (EIA) nuclear energy projections. These data are used for this Regulatory Analysis, in support of resolution of Generic Issue 82, "Beyond design Basis Accidents in Spent Fuel Pool," to estimate the additional cost of at-reactor storage of spent fuel.

The data source is DOE/RL-87-11, "Spent Fuel Storage Requirements 1987," September 1987, United States Department of Energy, Richland Operations Office. Data used by the NRC, taken from this report, are provided in Tables A.1 through A.4 of this Appendix.

Table A.1. Nuclear Power Plant Data

	PLANT NAME	UTILITY NAME	STATE	DESIGN REAC TYPE	NET (MWE)	STARTUP DATE	SHUTDOWN DATE	PRESENT(a) CAPAC.	MAX.(a) CAPAC.	REACTOR VENDOR	FULL CORE SIZE (a)	MTIHM
	ARK NUCLEAR 1	ARK PWR & LGT CO.	AR	PWR	850	1974	2008	968	968	BW	177	82
	ARK NUCLEAR 2	ARK PWR & LGT CO.	AR	PWR	912	1980	2012	988	988	CE	177	74
	BEAVER VALLEY 1	DUQUESNE LIGHT COMPANY	PA	PWR	835	1976	2016	833	833	WE	157	73
	BEAVER VALLEY 2	DUQUESNE LIGHT COMPANY	PA	PWR	857	1987	2026	1088	1088	WE	157	72
	BELLEFONTE 1	TENNESSEE VALLEY AUTHORITY	AL	PWR	1235	1992(f)	2028	1058	1058	BW	205	93
	BELLEFONTE 2	TENNESSEE VALLEY AUTHORITY	AL	PWR	1235	1995(f)	2030	270	1058	BW	205	93
	BIG ROCK 1	CONSUMERS PWR CO.	MI	BWR	72	1965	2001	441	441	GE	84	11
A	BRAIDWOOD 1	COMMONWEALTH EDISON COMPANY	IL	PWR	1175	1987	2026	1050	1050	WE	193	82
A	BRAIDWOOD 2	COMMONWEALTH EDISON COMPANY	IL	PWR	1175	1988	2027	0	0	WE	193	82
B	BROWNS FERRY 1	TENNESSEE VALLEY AUTHORITY	AL	BWR	1065	1974	2014	3471	3471	GE	764	140
B	BROWNS FERRY 2	TENNESSEE VALLEY AUTHORITY	AL	BWR	1065	1975	2014	3133	3471	GE	764	140
	BROWNS FERRY 3	TENNESSEE VALLEY AUTHORITY	AL	BWR	1065	1977	2017	2353	3471	GE	764	140
	BRUNSWICK 1	CAROLINA POWER & LIGHT COMPANY	NC	BWR(c)	821	1977	2010	1767	1803	GE	560	103
	BRUNSWICK 2	CAROLINA POWER & LIGHT COMPANY	NC	BWR(c)	821	1975	2010	1325	1839	GE	560	102
A	BYRON 1	COMMONWEALTH EDISON COMPANY	IL	PWR	1120	1985	2024	1050	1050	WE	193	82
A	BYRON 2	COMMONWEALTH EDISON COMPANY	IL	PWR	1120	1987	2026	0	0	WE	193	82
	CALLAWAY 1	UNION ELEC COMPANY	MO	PWR	1171	1984	2024	1340	1340	WE	193	86
B	CALVERT CLF 1	BALTIMORE GAS & ELEC CO.	MD	PWR	845	1975	2014	830	830	CE	217	84
B	CALVERT CLF 2	BALTIMORE GAS & ELEC CO.	MD	PWR	845	1977	2016	1000	1000	CE	217	84
	CATAWBA 1	DUKE POWER COMPANY	SC	PWR	1145	1985	2025	1419	2615	WE	193	89
	CATAWBA 2	DUKE POWER COMPANY	SC	PWR	1145	1986	2026	1421	2615	WE	193	82
	CLINTON 1	ILLINOIS PWR CO.	IL	BWR	933	1987(f)	2027	2672	2672	GE	624	114
B	COMANCHE PK 1	TEXAS UTILITIES GENERATING CO.	TX	PWR	1150	1989	2030	260	1695	WE	193	89
B	COMANCHE PK 2	TEXAS UTILITIES GENERATING CO.	TX	PWR	1150	1989	2030	0	1687	WE	193	83
A	COOK 1	INDIANA & MICH ELEC CO.	MI	PWR	1030	1975	2009	2048	2270	WE	193	88
A	COOK 2	INDIANA & MICH ELEC CO.	MI	PWR	1100	1978	2009	0	0	WE	193	78
	COOPER STN	NEBRASKA PUB PWR DISTRICT	NE	BWR	778	1974	2008	2366	2366	GE	548	101
	CRYSTAL RVR 3	FLORIDA PWR CORP	FL	PWR	825	1977	2016	676	1157	BW	177	82
	DAVIS-BESSE 1	TOLEDO EDISON CO.	OH	PWR	906	1978	2017	735	735	BW	177	83
	DIABLO CANYON 1	PACIFIC GAS AND ELECTRIC CO.	CA	PWR	1086	1985	2025	270	1324	WE	193	89
	DIABLO CANYON 2	PACIFIC GAS AND ELECTRIC CO.	CA	PWR	1119	1986	2025	270	1324	WE	193	89
	DRESDEN 1	COMMONWEALTH EDISON COMPANY	IL	BWR	200	1960	1984	720	720	GE	464	47
	DRESDEN 2	COMMONWEALTH EDISON COMPANY	IL	BWR	794	1970	2008	3537	3537	GE	724	125
	DRESDEN 3	COMMONWEALTH EDISON COMPANY	IL	BWR	794	1971	2006	3537	3537	GE	724	125
	DUANE ARNOLD	IOWA ELEC LIGHT & POWER CO.	IA	BWR	538	1975	2010	2050	2050	GE	368	67
	ENRICO FERMI 2	DETROIT EDISON COMPANY	MI	BWR	1093	1987(f)	2025	2305	2305	GE	764	140
	FARLEY 1	ALABAMA POWER COMPANY	AL	PWR	829	1977	2012	1407	1407	WE	157	73
	FARLEY 2	ALABAMA POWER COMPANY	AL	PWR	829	1981	2012	1407	1407	WE	157	73
	FITZPATRICK	PWR AUTHORITY OF STATE OF NY	NY	BWR	821	1975	2015	2244	2854	GE	560	103
	FORT CALHOUN	OMAHA PUB PWR DIST	NE	PWR	486	1973	2008	729	729	CE	133	47
	FT ST VRAIN	PUB SVC CO OF COLORADO	CO	HTG	330	1979	2007	504	504	GA	1482	16
	GINNA	ROCHESTER GAS & ELEC CORP	NY	PWR	490	1970	2006	1016	1016	WE	121	43
	GRAND GULF 1	SYSTEM ENERGY RESOURCES,INC.	MS	BWR	1250	1985	2022	3124	3124	GE	800	145

Table A.1. Nuclear Power Plant Data (con't)

	PLANT NAME	UTILITY NAME	STATE	REAC TYPE	DESIGN NET (MWE)	STARTUP DATE	SHUTDOWN DATE	PRESENT(a) CAPAC.	MAX.(a) CAPAC.	REACTOR VENDOR	FULL CORE SIZE (a)	MTIHM
	HADDAM NECK	NORTHEAST UTILITIES	CT	PWR	582	1968	2007	1168	1168	WE	157	64
	HARRIS 1	CAROLINA POWER & LIGHT COMPANY	NC	PWR	940	1987(f)	2026	480	3351	WE	157	73
B	HATCH 1	GEORGIA PWR COMPANY	GA	BWR	777	1974	2009	3025	3181	GE	560	103
B	HATCH 2	GEORGIA PWR COMPANY	GA	BWR	784	1979	2012	2765	2845	GE	560	104
	HOPE CREEK	PUBLIC SERV. ELEC AND GAS CO.	NJ	BWR	1118	1987(f)	2026	1078	3976	GE	764	141
	HUMBOLDT BAY	PACIFIC GAS AND ELECTRIC CO.	CA	BWR	65	1963	1976	486	486	GE	184	13
	INDIAN PT 1	CONSOLIDATED EDISON CO.	NY	PWR	265	1962	1980	756	756	BW	120	23
	INDIAN PT 2	CONSOLIDATED EDISON CO.	NY	PWR	873	1974	2006	980	980	WE	193	88
	INDIAN PT 3	PWR AUTHORITY OF STATE OF NY	NY	PWR	965	1976	2015	840	1317	WE	193	89
	KEWAUNEE	WISCONSIN PUBLIC SERVICE CORP	WI	PWR	535	1974	2014	603	963	WE	121	46
	LACROSSE	DAIRYLAND PWR COOP	WI	BWR	50	1969	2002	440	440	AC	72	8
B	LASALLE CTY 1	COMMONWEALTH EDISON COMPANY	IL	BWR	1122	1982	2022	1080	1080	GE	764	140
B	LASALLE CTY 2	COMMONWEALTH EDISON COMPANY	IL	BWR	1122	1984	2023	1080	1080	GE	764	140
	LIMERICK 1	PHILADELPHIA ELEC CO.	PA	BWR	1055	1986	2024	2040	2040	GE	764	141
	LIMERICK 2	PHILADELPHIA ELEC CO.	PA	BWR	1055	1990	2029	2040	2040	GE	764	140
	MAINE YANKEE	MAINE YANKEE ATOMIC PWR CO.	ME	PWR	825	1972	2008	1476	1476	CE	217	80
	MCGUIRE 1	DUKE POWER COMPANY	NC	PWR	1180	1981	2021	1359	1463	WE	193	89
	MCGUIRE 2	DUKE POWER COMPANY	NC	PWR	1180	1984	2023	1421	1463	WE	193	89
	MILLSTONE 1	NORTHEAST UTIL SVC CO.	CT	BWR	660	1970	2010	2184	2184	GE	580	103
	MILLSTONE 2	NORTHEAST UTIL SVC CO.	CT	PWR	870	1975	2015	1112	1112	CE	217	88
	MILLSTONE 3	NORTHEAST UTIL SVC CO.	CT	PWR	1150	1986	2025	756	1836	WE	193	89
	MONTICELLO	NORTHERN STATES PWR COMPANY	MN	BWR	545	1971	2007	2217	2237	GE	484	86
	NINE MILE PT 1	NIAGARA MOHAWK POWER CORP	NY	BWR	620	1969	2005	2362	2776	GE	532	94
	NINE MILE PT 2	NIAGARA MOHAWK POWER CORP	NY	BWR	1080	1987	2026	2530	4049	GE	764	140
A	NORTH ANNA 1	VIRGINIA POWER	VA	PWR	907	1978	2018	1737	1737	WE	157	72
A	NORTH ANNA 2	VIRGINIA POWER	VA	PWR	907	1980	2020	0	0	WE	157	73
A	OCONEE 1	DUKE POWER COMPANY	SC	PWR	887	1973	2013	1298	1312	BW	177	82
A	OCONEE 2	DUKE POWER COMPANY	SC	PWR	887	1974	2013	0	0	BW	177	82
	OCONEE 3	DUKE POWER COMPANY	SC	PWR	886	1974	2014	818	825	BW	177	82
	OYSTER CRK 1	GPU NUCLEAR	NJ	BWR	650	1969	2004	2600	2600	GE	560	98
	PALISADES	CONSUMERS PWR CO.	MI	PWR	805	1971	2011	798	798	CE	204	80
	PALO VERDE 1	ARIZONA PUBLIC SERVICE CO.	AZ	PWR	1270	1986	2024	665	1329	CE	241	99
	PALO VERDE 2	ARIZONA PUBLIC SERVICE CO.	AZ	PWR	1270	1986	2025	665	1329	CE	241	99
	PALO VERDE 3	ARIZONA PUBLIC SERVICE CO.	AZ	PWR	1270	1987	2026	665	1329	CE	241	99
	PEACHBOTTOM 2	PHILADELPHIA ELEC CO.	PA	BWR	1065	1974	2008	3814	3814	GE	764	140
	PEACHBOTTOM 3	PHILADELPHIA ELEC CO.	PA	BWR	1065	1974	2008	3819	3819	GE	764	140
	PERRY 1	CLEVELAND ELEC ILLUM CO.	OH	BWR	1265	1987	2026	4020	4020	GE	748	138
	PILGRIM 1	BOSTON EDISON CO.	MA	BWR	655	1972	2008	2320	2320	GE	580	103
A	POINT BEACH 1	WISCONSIN ELEC PWR CO.	WI	PWR	497	1970	2007	1502	1502	WE	121	46
A	POINT BEACH 2	WISCONSIN ELEC PWR CO.	WI	PWR	497	1972	2008	0	0	WE	121	45
A	PRAIRIE ISL 1	NORTHERN STATES PWR CO.	MN	PWR	530	1973	2008	1386	1386	WE	121	44
A	PRAIRIE ISL 2	NORTHERN STATES PWR CO.	MN	PWR	530	1974	2008	0	0	WE	121	40

Table A.1. Nuclear Power Plant Data (con't)

PLANT NAME	UTILITY NAME	STATE	REAC TYPE	DESIGN NET (MWE)	STARTUP DATE	SHUTDOWN DATE	PRESENT(a) CAPAC.	MAX.(a) CAPAC.	REACTOR VENDOR	FULL CORE SIZE (a)	MTIHM
B QUAD CITIES 1	COMMONWEALTH EDISON COMPANY	IL	BWR	789	1973	2007	3657	3657	GE	724	129
B QUAD CITIES 2	COMMONWEALTH EDISON COMPANY	IL	BWR	789	1973	2007	3897	3897	GE	724	126
RANCHO SECO 1	SACRAMENTO MUNICIP UTIL DISTR	CA	PWR	918	1975	2008	1080	1080	BW	177	82
ROBINSON 2	CAROLINA POWER & LIGHT COMPANY	SC	PWR	700	1971	2007	544	544	WE	157	66
RVR BEND 1	GULF STATES UTILITIES	LA	BWR	936	1986	2025	3172	3172	GE	624	116
SALEM 1	PUBLIC SERV. ELEC. AND GAS CO.	NJ	PWR	1115	1977	2016	1133	1170	WE	193	89
SALEM 2	PUBLIC SERV. ELEC. AND GAS CO.	NJ	PWR	1115	1981	2020	1140	1170	WE	193	89
E SAN ONOFRE 1	SOUTHERN CALIF EDISON CO.	CA	PWR	436	1968	1999	216	216	WE	157	58
E SAN ONOFRE 2	SOUTHERN CALIF EDISON CO.	CA	PWR	1070	1983	2012	800	800	CE	217	91
E SAN ONOFRE 3	SOUTHERN CALIF EDISON CO.	CA	PWR	1080	1984	2013	800	800	CE	217	90
SEABROOK 1	NHY DIVISION OF PSNH	NH	PWR	1150	1987(f)	2031	660	1236	WE	193	89
A SEQUOYAH 1	TENNESSEE VALLEY AUTHORITY	TN	PWR	1148	1981	2021	1381	1381	WE	193	89
A SEQUOYAH 2	TENNESSEE VALLEY AUTHORITY	TN	PWR	1148	1982	2022	0	0	WE	193	89
SHOREHAM	LONG ISL LGT CO.	NY	BWR	849	1988(b)	2027	2176	2685	GE	560	102
SOUTH TEXAS 1	HOUSTON LIGHTING & POWER CO.	TX	PWR	1250	1987	2027	196	1969	WE	193	105
SOUTH TEXAS 2	HOUSTON LIGHTING & POWER CO.	TX	PWR	1250	1989	2028	0	1969	WE	193	104
ST LUCIE 1	FLORIDA PWR & LGT CO.	FL	PWR	830	1976	2010	728	728	CE	217	81
ST LUCIE 2	FLORIDA PWR & LGT CO.	FL	PWR	804	1983	2023	1076	1076	CE	217	81
SUMMER 1	SOUTH CAROLINA ELEC & GAS CO.	SC	PWR	900	1984	2024	1276	1276	WE	157	72
A SURRY 1	VIRGINIA POWER	VA	PWR	788	1972	2012	1044	1044	WE	157	72
A SURRY 2	VIRGINIA POWER	VA	PWR	788	1973	2013	1764	1764(e)	WE	157	72
B SUSQUEHANNA 1	PENNSYLVANIA PWR & LGT CO.	PA	BWR	1065	1983	2022	2840	2840	GE	764	137
B SUSQUEHANNA 2	PENNSYLVANIA PWR & LGT CO.	PA	BWR	1065	1985	2024	2840	2840	GE	764	137
THREE MILE ISL 1	GPU NUCLEAR	PA	PWR	819	1974	2008	752	1401(g)	BW	177	82
TROJAN	PORTLAND GENERAL ELEC	OR	PWR	1130	1976	2011	1408	1408	WE	193	89
E TURKEY PT 3	FLORIDA PWR & LGT CO.	FL	PWR	693	1972	2007	1376	1404	WE	157	72
E TURKEY PT 4	FLORIDA PWR & LGT CO.	FL	PWR	693	1973	2007	614	636	WE	157	72
B VOGTLE 1	GEORGIA POWER COMPANY	GA	PWR	1069	1987	2027	288	1117(g)	WE	193	89
B VOGTLE 2	GEORGIA POWER COMPANY	GA	PWR	1069	1988	2028	288	1117(g)	WE	193	89
VT YANKEE 1	VT YANKEE NUCLEAR PWR CORP	VT	BWR	514	1972	2012	1690	2870	GE	368	68
WASH NUCLEAR 2	WASH PUB PWR SUPPLY SYSTEM	WA	BWR	1100	1984	2023	2658	2658	GE	764	140
WATERFORD 3	LOUISIANA POWER & LIGHT	LA	PWR	1104	1985	2024	1088	1366	CE	217	89
A WATTS BAR 1	TENNESSEE VALLEY AUTHORITY	TN	PWR	1165	1989(f)	2025	1294	1294	WE	193	89
A WATTS BAR 2	TENNESSEE VALLEY AUTHORITY	TN	PWR	1165	1990(f)	2027	0	0	WE	193	89
WOLF CREEK 1	WOLF CREEK NUCLEAR OPERATING CO.	KS	PWR	1150	1985	2025	1327	1340	WE	193	89
YANKEE-ROWE 1	YANKEE ATOMIC ELEC CO.	MA	PWR	175	1961	2001	440	721	WE	76	18
A ZION 1	COMMONWEALTH EDISON COMPANY	IL	PWR	1085	1973	2008	2079	2079	WE	193	89
A ZION 2	COMMONWEALTH EDISON COMPANY	IL	PWR	1085	1974	2008	0	0	WE	193	89

A INDICATES COMMON POOL SHARED BY TWO REACTORS

B INDICATES POOLS CONNECTED BY TRANSFER CANAL: CAPACITIES AND INVENTORIES ARE COMBINED WITH ONLY ONE FULL CORE RESERVE

E INDICATES POOLS REQUIRING CASK TRANSFER: CAPACITIES AND INVENTORIES ARE COMBINED WITH ONLY ONE FULL CORE RESERVE

Table A.1. Nuclear Power Plant Data (con't)

STORAGE SITES	UTILITY NAME	STATE	TYPE FUEL STORED	STARTUP DATE	SHUTDOWN DATE	PRESENT(a) CAPAC.	MAX.(a) CAPAC.
(c) BRUNSWICK 1 PWR	CAROLINA POWER & LIGHT COMPANY	NC	PWR	1977	2010	160	160
(c) BRUNSWICK 2 PWR	CAROLINA POWER & LIGHT COMPANY	NC	PWR	1975	2010	144	144
DOE ID (INEL) (EG&G)	DEPARTMENT OF ENERGY	ID	BWR			(h)	(h)
DOE ID (INEL) (EG&G)	DEPARTMENT OF ENERGY	ID	HTG			(h)	(h)
DOE ID (INEL) (EG&G)	DEPARTMENT OF ENERGY	ID	PWR			(h)	(h)
DOE OH (BATTELLE)	DEPARTMENT OF ENERGY	OH	PWR			(h)	(h)
DOE WA (HANFORD)	DEPARTMENT OF ENERGY	WA	BWR			(h)	(h)
DOE WA (HANFORD)	DEPARTMENT OF ENERGY	WA	PWR			(h)	(h)
(d) HARRIS 1 BWR POOL	CAROLINA POWER & LIGHT COMPANY	NC	BWR	1987	2026	0	2057(g)
MORRIS-BWR/PWR	MORRIS OPERATION (AFR)	IL	BWR		2002	3735(i)	3775(i)
MORRIS-BWR/PWR	MORRIS OPERATION (AFR)	IL	PWR		2002	1660(i)	1660(i)
WEST VALLEY	WEST VALLEY DEMONSTRATION PRJ.	NY	BWR			(h)	(h)
WEST VALLEY	WEST VALLEY DEMONSTRATION PRJ.	NY	PWR			(h)	(h)
(j) OTHER			PWR			(h)	(h)

BWR PLANTS TOTAL : 39	CURRENTLY OPERATING: 32	TOTAL MWE: 33705	CURRENTLY OPERATING MWE: 26312		
PWR PLANTS TOTAL : 80	CURRENTLY OPERATING: 63	TOTAL MWE: 75800	CURRENTLY OPERATING MWE: 56375		
HTGR PLANTS TOTAL : 1	CURRENTLY OPERATING: 1	TOTAL MWE: 330	CURRENTLY OPERATING MWE: 330		
OPERATING & PLANNED PLANTS TOTAL : 120	CURRENTLY OPERATING: 96	TOTAL MWE: 109835	CURRENTLY OPERATING MWE: 83017		
RETIRED PLANTS TOTAL : 3		TOTAL MWE: 530			

NOTE: UTILITY DATA AS OF 12/31/1986

(a) IN ASSEMBLIES

(b) SHOREHAM ISSUED A LICENSE IN 1983 BUT HAS NOT OPERATED. 1988 STARTUP ESTIMATED BASED ON PROJECTED FIRST DISCHARGE IN 1989.

(c) SOME ROBINSON 2 PWR FUEL IS STORED AT THE BRUNSWICK (BWR) REACTORS.

(d) IN 1985, HARRIS 1 IDENTIFIED SPACE FOR THE FUTURE STORAGE OF BWR FUEL. (HARRIS 1 IS A PWR.)

(e) INCLUDES STORAGE CAPACITY OF DRY STORAGE INSTALLATION (ISFSI).

(f) STARTUP DATE BASED ON PROJECTED YEAR OF FIRST DISCHARGE.

(g) CURRENT AS OF 12/31/86

(h) CAPACITY FOR STORAGE UNKNOWN.

(i) POOL CAN HOLD BOTH FUEL TYPES. CAPACITY SHOWN REFLECTS ENTIRE POOL IN USE FOR ONE TYPE OF FUEL ONLY.

(j) ONE ROBINSON ASSEMBLY HAS BEEN SENT TO A LOCATION WHICH DOES NOT HAVE AN EIA ID.

Table A.2. Projected Cumulative Storage Requirements--Maximum AR Capacity, Assemblies

ASSEMBLIES

POOL		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
ST LUCIE 1	PWR	42	122	122	194	270	270	346	422	422	498	574	574	650	726	726	802	878	878	954
MILLSTONE 1	BWR	128	128	324	324	520	520	716	716	912	912	1108	1108	1304	1304	1500	1500	1696	1696	1892
PALISADES	PWR	0	19	19	87	87	155	155	223	291	291	359	359	427	427	495	563	563	631	631
OCONEE 1&2	PWR	0	0	62	182	242	302	422	482	602	662	782	842	962	1022	1082	1202	1322	1322	1442
OCONEE 3	PWR	0	0	1	1	61	121	121	181	241	241	301	361	421	421	481	541	541	601	661
ROBINSON 2	PWR	0	0	0	40	88	149	149	197	245	245	306	354	402	402	463	511	511	559	620
BRUNSWICK 1	BWR	0	0	0	157	157	345	345	533	717	717	905	1093	1093	1277	1277	1465	1653	1653	1837
LASALLE CTY 1&2	BWR	0	0	0	144	364	584	1024	1244	1464	1904	2124	2344	2784	3004	3224	3664	3884	4104	4544
BRUNSWICK 2	BWR	0	0	0	0	37	37	225	413	413	597	785	785	973	973	1157	1345	1345	1533	1717
CALVERT CLF 1&2	PWR	0	0	0	0	0	5	101	197	293	389	485	581	677	773	869	965	1061	1157	1253
LACROSSE	BWR	0	0	0	0	0	13	37	61	85	85	109	133	157	181	205	205	205	205	205
PILGRIM 1	BWR	0	0	0	0	0	0	160	160	356	356	548	548	740	740	740	936	936	1128	1128
PRAIRIE ISL 1&2	PWR	0	0	0	0	0	0	22	102	182	222	302	382	462	542	582	662	742	822	902
BYRON 1&2	PWR	0	0	0	0	0	0	0	99	99	267	435	435	603	771	771	939	1107	1107	1275
INDIAN PT 2	PWR	0	0	0	0	0	0	0	17	17	85	153	153	221	221	289	357	357	425	425
OYSTER CRK 1	BWR	0	0	0	0	0	0	0	68	68	200	348	348	488	628	628	768	912	912	912
FORT CALHOUN	PWR	0	0	0	0	0	0	0	8	8	53	98	98	143	188	188	233	278	278	323
ZION 1&2	PWR	0	0	0	0	0	0	0	0	71	143	287	359	431	575	647	719	863	935	1007
BIG ROCK 1	BWR	0	0	0	0	0	0	0	0	15	35	35	55	75	95	95	95	95	95	95
LIMERICK 1	BWR	0	0	0	0	0	0	0	0	152	152	372	592	592	812	1032	1032	1240	1456	1456
SAN ONOFRE 1,2,&3	PWR	0	0	0	0	0	0	0	0	139	300	409	570	679	945	1054	1163	1272	1381	1490
SEQUOYAH 1&2	PWR	0	0	0	0	0	0	0	0	40	40	200	280	360	520	600	680	760	920	1000
DAVIS-BESSE 1	PWR	0	0	0	0	0	0	0	0	9	9	70	130	130	190	250	250	310	370	370
POINT BEACH 1&2	PWR	0	0	0	0	0	0	0	0	49	113	177	241	305	369	433	497	561	625	689
ARK NUCLEAR 1	PWR	0	0	0	0	0	0	0	0	0	17	17	77	77	137	197	197	257	257	317
BRAIDWOOD 1&2	PWR	0	0	0	0	0	0	0	0	0	99	99	267	435	435	603	771	771	939	1107
BEAVER VALLEY 1	PWR	0	0	0	0	0	0	0	0	0	25	94	94	163	163	232	232	301	370	370
MAINE YANKEE	PWR	0	0	0	0	0	0	0	0	0	48	121	121	194	267	267	340	413	413	486
NINE MILE PT1	BWR	0	0	0	0	0	0	0	0	0	152	152	332	332	516	516	700	700	884	884
HADDAM NECK	PWR	0	0	0	0	0	0	0	0	0	0	3	3	56	108	161	161	213	266	266
ENRICO FERMI2	BWR	0	0	0	0	0	0	0	0	0	0	135	135	427	427	715	715	1007	1295	1295
COOPER STN	BWR	0	0	0	0	0	0	0	0	0	0	6	122	234	346	458	570	682	794	902
MILLSTONE 2	PWR	0	0	0	0	0	0	0	0	0	0	51	116	116	177	242	242	307	368	368
PEACHBOTTOM 2	BWR	0	0	0	0	0	0	0	0	0	0	216	216	444	672	672	900	1128	1128	1356
PEACHBOTTOM 3	BWR	0	0	0	0	0	0	0	0	0	0	41	41	261	481	481	701	701	921	1141
FITZPATRICK	BWR	0	0	0	0	0	0	0	0	0	0	134	134	310	486	486	662	838	838	1014
SALEM 1	PWR	0	0	0	0	0	0	0	0	0	0	47	47	127	207	207	287	367	367	447
DRESDEN 2	BWR	0	0	0	0	0	0	0	0	0	0	0	67	67	225	383	383	541	699	699
COOK 1&2	PWR	0	0	0	0	0	0	0	0	0	0	0	61	149	317	397	485	565	653	821
GRAND GULF 1	BWR	0	0	0	0	0	0	0	0	0	0	0	104	372	372	640	908	908	1176	1444
LIMERICK 2	BWR	0	0	0	0	0	0	0	0	0	0	0	132	132	348	564	564	780	780	996
WASH NUCLEAR2	BWR	0	0	0	0	0	0	0	0	0	0	0	110	286	426	582	750	898	1066	1210
ARK NUCLEAR 2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	21	89	89	157	225	225	293

Table A.2. Projected Cumulative Storage Requirements--Maximum AR Capacity, Assemblies (con't)

ASSEMBLIES

POOL		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
DUANE ARNOLD	BWR	0	0	0	0	0	0	0	0	0	0	0	0	118	246	246	366	486	486	614
VT YANKEE 1	BWR	0	0	0	0	0	0	0	0	0	0	0	0	12	12	144	276	276	408	540
NORTH ANNA 1&2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	119	183	247	375	439	503	631
KEWAUNEE	PWR	0	0	0	0	0	0	0	0	0	0	0	0	24	61	98	135	172	209	246
YANKEE-ROWE 1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	36	36	36	36	36	36	36
DRESDEN 3	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	61	219	219	377	535	535
HATCH 1&2	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	130	326	718	914	1110	1502
SUSQUEHANNA 1&2	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	96	560	792	1024	1488	1720
GINNA	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	27	59	91	123	155	187
ST LUCIE 2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46	118	118	190	262
SALEM 2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	71	155	155	239	323
BROWNS FERRY3	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	161	161	389	617	617
WATTS BAR 1&2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51	211	211	371	451
TURKEY PT 3&4	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	144	192	240
BROWNS FERRY1&2	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	34	490	718
TROJAN	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	85
INDIAN PT 3	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	80
RANCHO SECO 1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43	104
PALO VERDE 1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
QUAD CITIES 1&2	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23
MCGUIRE 1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29
CRYSTAL RVR 3	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72
CALLAWAY 1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37
PWR ASSEMBLIES		42		204		748		1316		2708		5370		8390		11933		15943		20312
			141		504		1002		1928		3747		6505		10299		14125		17848	
BWR ASSEMBLIES		128		324		1078		2507		4182		7018		11201		17011		23649		30996
			128		625		1499		3195		5110		8399		13858		20429		27497	
TOTAL ASSEMBLIES		170		528		1826		3823		6890		12388		19591		28944		39592		51308
			269		1129		2501		5123		8857		14904		24157		34554		45345	

Table A.3. Projected Cumulative Storage Requirements--Maximum AR Capacity, MTIHM

METRIC TONS

POOL		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
ST LUCIE 1	PWR	15	46	46	73	102	102	131	160	160	189	218	218	247	276	276	305	335	335	364
MILLSTONE 1	BWR	23	23	58	58	92	92	127	127	162	162	197	197	231	231	266	266	301	301	336
PALISADES	PWR	0	7	7	34	34	61	61	88	115	115	142	142	170	170	197	224	224	251	251
OCONEE 1&2	PWR	0	0	29	84	112	140	195	223	279	307	362	390	445	473	501	557	612	612	668
OCONEE 3	PWR	0	0	0	0	28	56	56	84	112	112	139	167	195	195	223	250	250	278	306
ROBINSON 2	PWR	0	0	0	17	38	63	63	84	105	105	130	151	172	172	197	218	218	238	263
BRUNSWICK 1	BWR	0	0	0	29	29	64	64	99	134	134	169	204	204	238	238	274	309	309	343
LASALLE CTY 1&2	BWR	0	0	0	26	66	106	186	226	266	347	387	427	507	547	587	667	707	747	827
BRUNSWICK 2	BWR	0	0	0	0	7	7	42	77	77	112	147	147	182	182	216	251	251	287	321
CALVERT CLF 1&2	PWR	0	0	0	0	0	2	38	74	110	145	181	213	249	285	321	357	393	429	465
LACROSSE	BWR	0	0	0	0	0	1	4	7	9	9	12	14	17	20	22	22	22	22	22
PILGRIM 1	BWR	0	0	0	0	0	0	28	28	63	63	97	97	131	131	131	165	165	199	199
PRAIRIE ISL 1&2	PWR	0	0	0	0	0	0	8	36	65	79	107	135	164	192	206	235	263	291	320
BYRON 1&2	PWR	0	0	0	0	0	0	0	42	42	113	184	184	255	326	326	397	468	468	539
INDIAN PT 2	PWR	0	0	0	0	0	0	0	8	8	38	69	69	100	100	130	161	161	192	192
OYSTER CRK 1	BWR	0	0	0	0	0	0	0	12	12	36	62	62	87	112	112	137	163	163	163
FORT CALHOUN	PWR	0	0	0	0	0	0	0	3	3	19	35	35	51	67	67	83	99	99	115
ZION 1&2	PWR	0	0	0	0	0	0	0	0	32	65	131	164	197	263	296	329	394	427	460
BIG ROCK 1	BWR	0	0	0	0	0	0	0	0	2	5	5	7	10	12	12	12	12	12	12
LIMERICK 1	BWR	0	0	0	0	0	0	0	0	27	27	66	105	105	144	183	183	220	258	258
SAN ONOFRE 1,2,&3	PWR	0	0	0	0	0	0	0	0	56	119	163	226	270	372	416	460	504	548	592
SEQUOYAH 1&2	PWR	0	0	0	0	0	0	0	0	18	18	92	129	166	239	276	313	350	423	460
DAVIS-BESSE 1	PWR	0	0	0	0	0	0	0	0	4	4	33	61	61	89	117	117	145	173	173
POINT BEACH 1&2	PWR	0	0	0	0	0	0	0	0	18	41	64	87	110	133	156	179	203	226	249
ARK NUCLEAR 1	PWR	0	0	0	0	0	0	0	0	0	8	8	36	36	64	91	91	119	119	147
BRAIDWOOD 1&2	PWR	0	0	0	0	0	0	0	0	0	42	42	113	184	184	255	326	326	397	468
BEAVER VALLEY 1	PWR	0	0	0	0	0	0	0	0	0	12	44	44	76	76	108	108	140	172	172
MAINE YANKEE	PWR	0	0	0	0	0	0	0	0	0	18	46	46	74	102	102	130	158	158	186
NINE MILE PT1	BWR	0	0	0	0	0	0	0	0	0	26	26	57	57	89	89	120	120	152	152
HADDAM NECK	PWR	0	0	0	0	0	0	0	0	0	0	1	1	20	39	59	59	78	97	97
ENRICO FERMI2	BWR	0	0	0	0	0	0	0	0	0	0	25	25	78	78	130	130	183	236	236
COOPER STN	BWR	0	0	0	0	0	0	0	0	0	0	1	22	43	63	83	104	124	145	164
MILLSTONE 2	PWR	0	0	0	0	0	0	0	0	0	0	19	44	44	68	92	92	117	140	140
PEACHBOTTOM 2	BWR	0	0	0	0	0	0	0	0	0	0	38	38	79	119	119	160	200	200	240
PEACHBOTTOM 3	BWR	0	0	0	0	0	0	0	0	0	0	7	7	46	85	85	124	124	163	202
FITZPATRICK	BWR	0	0	0	0	0	0	0	0	0	0	24	24	55	86	86	118	149	149	180
SALEM 1	PWR	0	0	0	0	0	0	0	0	0	0	22	22	58	95	95	132	168	168	205
DRESDEN 2	BWR	0	0	0	0	0	0	0	0	0	0	0	11	11	38	64	64	91	117	117
COOK 1&2	PWR	0	0	0	0	0	0	0	0	0	0	0	28	64	136	173	208	245	281	353
GRAND GULF 1	BWR	0	0	0	0	0	0	0	0	0	0	0	18	66	66	113	160	160	207	255
LIMERICK 2	BWR	0	0	0	0	0	0	0	0	0	0	0	23	23	62	100	100	138	138	177
WASH NUCLEAR2	BWR	0	0	0	0	0	0	0	0	0	0	0	19	50	75	102	132	158	188	213
ARK NUCLEAR 2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	9	37	37	66	94	94	122
DUANE ARNOLD	BWR	0	0	0	0	0	0	0	0	0	0	0	0	21	44	44	65	87	87	109

Table A.3. Projected Cumulative Storage Requirements--Maximum AR Capacity, MTIHM (con't)

METRIC TONS

POOL		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
VT YANKEE 1	BWR	0	0	0	0	0	0	0	0	0	0	0	0	2	2	26	49	49	73	96
NORTH ANNA 1&2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	55	85	114	173	203	232	292
KEWAUNEE	PWR	0	0	0	0	0	0	0	0	0	0	0	0	9	23	37	51	65	79	94
YANKEE-ROWE 1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	8	8	8	8	8	8	8
DRESDEN 3	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	10	37	37	63	90	90
HATCH 1&2	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	24	60	133	170	206	279
SUSQUEHANNA 1&2	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	17	97	137	177	257	297
GINNA	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	9	21	32	43	54	66
ST LUCIE 2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	46	46	74	102
SALEM 2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	71	71	111	150
BROWNS FERRY3	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	29	71	112	112
WATTS BAR 1&2	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	97	97	171	208
TURKEY PT 3&4	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	66	88	110
BROWNS FERRY1&2	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	89	130
TROJAN	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	39
INDIAN PT 3	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	36
RANCHO SECO 1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	48
PALO VERDE 1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
QUAD CITIES 1&2	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
MCGUIRE 1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
CRYSTAL RVR 3	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33
CALLAWAY 1	PWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16
PWR MTIHM		15		83		315		553		1126		2234		3489		4973		6663		8528
			53		209		424		802		1550		2706		4279		5899		7476	
BWR MTHIM		23		58		194		452		752		1261		2005		3033		4221		5535
			23		113		271		577		919		1505		2474		3646		4905	
TOTAL MTIHM		38		140		509		1004		1879		3495		5494		8006		10886		14063
			76		322		695		1379		2469		4211		6753		9545		12382	

Table A.4. 1986 Inventory and Projected Annual Reactor Discharges, Assemblies

REACTOR		INV.(a) 1986	ASSEMBLIES 1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
ARK NUCLEAR 1	PWR	448	0	60	0	60	60	0	60	0	60	60	0	60	0	60	60	0	60	0	60
ARK NUCLEAR 2	PWR	288	0	68	68	0	68	68	0	68	68	0	68	0	68	68	0	68	68	0	68
BEAVER VALLEY 1	PWR	293	73	0	69	0	69	69	0	69	0	69	69	0	69	0	69	0	69	69	0
BEAVER VALLEY 2	PWR	0	0	0	37	0	73	0	73	73	73	0	73	0	73	73	0	73	73	0	73
BELLEFONTE 1	PWR	0	0	0	0	0	0	0	0	64	72	0	84	84	0	84	0	84	84	0	84
BELLEFONTE 2	PWR	0	0	0	0	0	0	0	0	0	0	64	72	0	84	84	0	84	0	84	84
BIG ROCK 1	BWR	168	22	22	20	20	20	20	20	20	20	20	0	20	20	20	64	0	0	0	0
BRAIDWOOD 1	PWR	0	0	0	88	88	0	88	88	0	84	84	0	84	84	0	84	84	0	84	84
BRAIDWOOD 2	PWR	0	0	0	0	88	0	88	88	0	88	84	0	84	84	0	84	84	0	84	84
BROWNS FERRY1	BWR	1328	0	0	0	0	0	228	0	228	0	228	228	0	228	228	0	228	0	228	228
BROWNS FERRY2	BWR	1192	0	0	284	0	220	0	224	228	0	228	0	228	228	0	228	228	0	228	0
BROWNS FERRY3	BWR	1004	0	0	0	268	228	0	228	0	228	228	0	228	228	0	228	0	228	228	0
BRUNSWICK 1	BWR	840	188	0	188	184	0	188	0	188	184	0	188	188	0	184	0	188	188	0	184
BRUNSWICK 1	PWR	160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BRUNSWICK 2	BWR	756	0	188	188	0	184	0	188	188	0	184	188	0	188	0	184	188	0	188	184
BRUNSWICK 2	PWR	144	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BYRON 1	PWR	0	88	88	0	88	88	0	84	84	0	84	84	0	84	84	0	84	84	0	84
BYRON 2	PWR	0	0	88	0	88	88	0	88	84	0	84	84	0	84	84	0	84	84	0	84
CALLAWAY 1	PWR	84	96	0	80	84	0	84	84	0	84	84	0	84	84	0	84	84	0	84	84
CALVERT CLF 1	PWR	618	0	96	0	96	0	96	0	96	0	96	0	96	0	96	0	96	0	96	0
CALVERT CLF 2	PWR	432	88	0	96	0	96	0	96	0	96	0	96	0	96	0	96	0	96	0	96
CATAWBA 1	PWR	64	68	0	69	68	72	72	0	72	73	73	0	72	72	72	72	0	73	72	72
CATAWBA 2	PWR	0	0	65	68	64	64	69	0	60	80	72	0	72	73	72	0	73	72	72	72
CLINTON 1	BWR	0	0	140	192	0	160	176	0	172	168	0	172	172	0	172	172	0	172	172	0
COMANCHE PK 1	PWR	0	0	0	0	64	64	64	0	68	64	64	68	64	64	68	64	64	68	64	64
COMANCHE PK 2	PWR	0	0	0	0	0	68	64	64	68	64	64	68	64	64	68	64	64	68	64	64
COOK 1	PWR	546	80	0	80	80	0	80	80	0	80	0	80	80	0	80	80	0	80	0	80
COOK 2	PWR	424	0	88	0	0	88	88	0	88	88	0	88	0	88	88	0	88	0	88	88
COOPER STN	BWR	648	0	136	116	116	116	116	120	112	116	116	112	116	112	112	112	112	112	112	108
CRYSTAL RVR 3	PWR	302	93	0	81	0	72	0	72	0	72	0	72	0	72	0	72	0	72	0	72
DAVIS-BESSE 1	PWR	197	0	65	61	0	61	61	0	61	61	0	61	60	0	60	60	0	60	60	0
DIABLO CANYON 1	PWR	51	0	68	0	84	0	85	0	85	0	85	0	85	0	85	0	85	0	85	0
DIABLO CANYON 2	PWR	0	51	68	0	84	0	85	0	85	0	85	0	85	0	85	0	85	0	85	0
DRESDEN 1	BWR	683	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRESDEN 2	BWR	1606	0	168	158	0	158	158	0	158	158	0	158	158	0	158	158	0	158	158	0
DRESDEN 3	BWR	1456	152	0	160	0	158	158	0	158	158	0	158	158	0	158	158	0	158	158	0
DUANE ARNOLD	BWR	696	128	120	0	120	128	0	120	120	0	128	120	0	120	128	0	120	120	0	128
ENRICO FERMI2	BWR	0	0	0	232	292	0	276	0	296	0	292	288	0	292	0	288	0	292	288	0
FARLEY 1	PWR	410	0	68	65	0	68	65	0	68	65	0	68	65	0	68	65	0	68	65	0
FARLEY 2	PWR	256	64	0	68	65	0	68	65	0	68	65	0	68	65	0	68	65	0	68	65

Table A.4. 1986 Inventory and Projected Annual Reactor Discharges, Assemblies (con't)

REACTOR		INV.(a) 1986	ASSEMBLIES 1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
FITZPATRICK	BWR	1012	188	164	0	176	180	0	176	176	0	180	176	0	176	176	0	176	176	0	176
FORT CALHOUN	PWR	334	45	45	0	45	45	0	45	45	0	45	45	0	45	45	0	45	45	0	45
GINNA	PWR	470	36	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
GRAND GULF 1	BWR	264	288	0	268	268	0	268	268	0	268	268	0	268	268	0	268	268	0	268	268
HADDAM NECK	PWR	594	57	0	48	53	52	0	53	52	0	53	52	0	53	52	53	0	52	53	0
HARRIS 1	BWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HARRIS 1	PWR	0	0	53	0	52	52	0	53	52	0	52	53	0	52	52	0	53	52	0	52
HATCH 1	BWR	1107	240	196	0	196	196	0	196	196	0	196	196	0	196	196	0	196	196	0	196
HATCH 2	BWR	745	0	184	184	196	0	196	196	0	196	196	0	196	196	0	196	196	0	196	196
HOPE CREEK	BWR	0	0	232	232	0	232	232	0	232	232	0	232	232	0	232	232	0	232	232	0
HUMBOLDT BAY	BWR	390	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INDIAN PT 1	PWR	160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INDIAN PT 2	PWR	464	68	0	68	0	68	68	0	68	0	68	68	0	68	0	68	68	0	68	0
INDIAN PT 3	PWR	292	76	0	76	76	0	76	0	76	76	0	76	0	76	76	0	76	0	76	76
KEWAUNEE	PWR	369	45	37	33	41	37	45	37	37	37	37	37	37	37	37	37	37	37	37	37
LACROSSE	BWR	261	24	24	0	24	24	24	24	24	24	0	24	24	24	24	24	72	0	0	0
LASALLE CTY 1	BWR	132	324	0	188	220	0	220	220	0	220	220	0	220	220	0	220	220	0	220	220
LASALLE CTY 2	BWR	0	224	232	0	220	220	0	220	220	0	220	220	0	220	220	0	220	220	0	220
LIMERICK 1	BWR	0	268	272	0	224	0	228	216	0	220	0	220	220	0	220	220	0	208	216	0
LIMERICK 2	BWR	0	0	0	0	328	220	0	208	0	224	212	0	216	0	216	216	0	216	0	216
MAINE YANKEE	PWR	793	73	76	0	73	73	0	73	73	0	73	73	0	73	73	0	73	73	0	73
MCGUIRE 1	PWR	219	69	72	0	72	72	72	0	73	72	72	72	0	73	72	72	0	72	72	73
MCGUIRE 2	PWR	186	73	69	64	69	0	60	80	72	0	73	72	72	72	0	72	73	72	0	72
MILLSTONE 1	BWR	1536	196	0	196	0	196	0	196	0	196	0	196	0	196	0	196	0	196	0	196
MILLSTONE 2	PWR	474	0	77	85	52	0	68	0	65	61	0	64	65	0	61	65	0	65	61	0
MILLSTONE 3	PWR	0	84	0	84	84	0	84	84	0	84	84	0	84	84	0	84	84	0	84	84
MONTICELLO	BWR	428	116	0	128	116	0	124	116	0	120	0	120	120	0	120	120	0	120	120	0
MORRIS	BWR	2047	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MORRIS	PWR	350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NINE MILE PT1	BWR	1444	0	200	0	192	0	196	0	176	0	188	0	180	0	184	0	184	0	184	532
NINE MILE PT2	BWR	0	0	0	296	0	276	0	264	0	284	0	268	0	280	0	276	0	276	0	276
NORTH ANNA 1	PWR	294	61	65	0	65	65	0	65	65	0	65	65	0	65	64	0	64	64	0	64
NORTH ANNA 2	PWR	235	69	0	65	65	0	65	65	0	65	65	0	65	65	0	64	64	0	64	64
OCONEE 1	PWR	590	57	0	60	60	60	0	60	60	60	0	60	60	60	0	60	60	60	0	60
OCONEE 2	PWR	381	49	0	60	60	0	60	60	0	60	60	60	0	60	60	0	60	60	0	60
OCONEE 3	PWR	529	0	60	60	0	60	60	0	60	60	0	60	60	60	0	60	60	0	60	60
OYSTER CRK 1	BWR	1392	0	128	136	0	128	172	0	152	0	132	148	0	140	140	0	140	144	0	556
PALISADES	PWR	545	0	68	0	68	0	68	0	68	68	0	68	0	68	0	68	68	0	68	0
PALO VERDE 1	PWR	0	80	77	0	93	77	0	93	77	0	93	77	0	93	77	0	93	77	0	93
PALO VERDE 2	PWR	0	0	92	85	0	85	77	0	93	77	0	93	77	0	93	77	0	93	77	0
PALO VERDE 3	PWR	0	0	0	92	85	0	85	77	0	93	77	0	93	77	0	93	77	0	93	77

Table A.4. 1986 Inventory and Projected Annual Reactor Discharges, Assemblies (con't)

REACTOR		INV.(a) 1986	ASSEMBLIES 1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
PEACHBOTTOM 2	BWR	1462	272	0	308	0	284	0	264	220	0	228	228	0	228	228	0	228	228	0	228
PEACHBOTTOM 3	BWR	1496	268	0	0	216	236	0	220	216	0	224	220	0	220	220	0	220	0	220	220
PERRY 1	BWR	0	0	220	0	244	200	0	228	224	0	224	224	0	224	224	0	224	224	224	0
PILGRIM 1	BWR	1320	0	196	0	0	192	0	192	0	196	0	192	0	192	0	0	196	0	192	0
POINT BEACH 1	PWR	446	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
POINT BEACH 2	PWR	408	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
PRAIRIE ISL 1	PWR	386	45	40	40	41	40	0	40	40	40	40	40	40	40	40	0	40	40	40	40
PRAIRIE ISL 2	PWR	415	0	40	40	40	40	40	40	40	40	0	40	40	40	40	40	40	40	40	40
QUAD CITIES 1	BWR	1393	172	0	160	160	0	160	172	0	160	160	0	160	160	0	160	160	0	160	160
QUAD CITIES 2	BWR	1428	0	168	160	0	160	160	0	160	160	0	160	160	0	160	160	0	160	160	0
RANCHO SECO 1	PWR	267	0	57	65	0	69	69	0	61	61	0	61	0	57	61	0	61	0	57	61
ROBINSON 2	PWR	270	48	61	0	48	48	61	0	48	48	0	61	48	48	0	61	48	0	48	61
RVR BEND 1	BWR	0	164	0	224	180	0	192	204	0	188	196	0	192	192	0	196	192	0	192	192
SALEM 1	PWR	344	83	0	85	85	101	0	81	85	0	80	80	0	80	80	0	80	80	0	80
SALEM 2	PWR	174	0	73	89	0	97	101	93	0	85	84	0	84	84	0	84	84	0	84	84
SAN ONOFRE 1	PWR	146	0	52	52	0	0	52	0	52	0	52	0	52	0	157	0	0	0	0	0
SAN ONOFRE 2	PWR	147	109	0	109	0	109	0	109	0	109	109	0	109	0	109	0	109	0	109	0
SAN ONOFRE 3	PWR	147	0	109	0	109	0	109	0	109	109	0	109	0	109	0	109	0	109	0	109
SEABROOK 1	PWR	0	0	64	0	64	64	64	64	64	0	64	64	64	64	64	0	64	64	64	64
SEQUOYAH 1	PWR	212	0	0	80	80	0	80	80	0	80	0	80	80	0	80	80	0	80	80	0
SEQUOYAH 2	PWR	136	80	0	80	0	80	80	0	80	80	0	80	0	80	80	0	80	0	80	80
SHOREHAM	BWR	0	0	0	204	0	176	160	0	172	184	0	184	184	0	184	184	0	184	184	0
SOUTH TEXAS 1	PWR	0	0	0	56	54	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
SOUTH TEXAS 2	PWR	0	0	0	0	56	54	52	52	52	52	52	52	52	52	52	52	52	52	52	52
ST LUCIE 1	PWR	444	109	80	0	72	76	0	76	76	0	76	76	0	76	76	0	76	76	0	76
ST LUCIE 2	PWR	164	93	0	72	72	0	72	72	0	72	72	0	72	72	0	72	72	0	72	72
SUMMER 1	PWR	112	68	68	0	68	68	0	68	68	0	68	68	0	68	68	0	68	68	0	68
SURRY 1	PWR	488	0	69	49	56	0	53	53	0	53	53	0	53	53	0	52	52	0	52	52
SURRY 2	PWR	385	0	65	49	0	57	53	0	53	53	0	53	53	0	53	52	0	52	52	0
SUSQUEHANNA 1	BWR	488	240	0	248	228	0	236	232	0	232	232	0	232	232	0	232	232	0	232	232
SUSQUEHANNA 2	BWR	324	0	236	228	0	232	232	0	232	232	0	232	232	0	232	232	0	232	232	0
THREE MILE ISL 1	PWR	284	0	73	0	73	73	69	0	73	0	73	73	0	73	73	0	72	72	0	72
TROJAN	PWR	379	57	47	48	49	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48
TURKEY PT 3	PWR	424	77	60	0	48	0	52	48	48	0	48	48	0	48	48	0	48	48	0	48
TURKEY PT 4	PWR	446	0	52	52	0	48	48	48	0	48	48	0	48	48	0	48	0	48	48	0
VOGTLE 1	PWR	0	0	84	84	0	84	84	0	84	84	0	84	84	0	84	84	0	84	84	0
VOGTLE 2	PWR	0	0	0	84	0	84	84	0	84	84	0	84	84	0	84	84	0	84	84	0
VT YANKEE 1	BWR	1322	136	0	132	132	0	132	132	0	132	132	0	132	132	0	132	132	0	132	132
WASH NUCLEAR2	BWR	128	148	168	160	148	156	156	156	172	140	156	172	144	176	140	156	168	148	168	144
WATERFORD 3	PWR	92	0	88	88	0	88	88	0	88	88	0	88	88	0	88	88	0	88	88	0

Table A.4. 1986 Inventory and Projected Annual Reactor Discharges, Assemblies (con't)

REACTOR		INV.(a) 1986	ASSEMBLIES 1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
WATTS BAR 1	PWR	0	0	0	0	64	72	0	80	80	0	80	0	80	80	0	80	80	0	80	0
WATTS BAR 2	PWR	0	0	0	0	0	64	72	0	80	0	80	80	0	80	80	0	80	0	80	80
WEST VALLEY	BWR	85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WEST VALLEY	PWR	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WOLF CREEK 1	PWR	52	52	76	0	76	76	0	76	76	0	76	76	0	76	76	0	76	76	0	76
YANKEE-ROWE 1	PWR	341	36	40	0	36	0	40	36	0	40	36	0	40	36	0	76	0	0	0	0
ZION 1	PWR	574	0	76	72	0	72	72	0	72	72	0	72	72	0	72	72	0	72	72	0
ZION 2	PWR	503	80	72	0	76	72	0	72	72	0	72	72	0	72	72	0	72	72	0	72
FT ST VRAIN	HTG	0	0	240	0	282	0	240	0	240	0	240	0	240	0	240	0	1482	0	0	0
RESEARCH SITES	PWR	97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESEARCH SITES	BWR	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESEARCH SITES	HTG	720	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PWR ASSEMBLIES		20309	3155	3577	3873	4010	3593	3259	3974	3954	3599										
			2644	3200	3677	3171	3647	3967	4121	3225	3502	3935									
BWR ASSEMBLIES		30605	3394	4468	4408	4440	4788	4380	4276	4488	5292										
			3758	4990	4680	5000	4640	5024	5088	5032	4588	5192									
HTG ASSEMBLIES		720	240	282	240	240	240	240	240	1482	0										
			0	0	0	0	0	0	0	0	0	0									
TOTAL ASSEMBLIES		51634	6789	8327	8521	8690	8621	7879	8490	9924	8891										
			6402	8190	8357	8171	8287	8991	9209	8257	8090	9127									

(a) PERMANENTLY DISCHARGED SPENT FUEL. THIS INCLUDES SOME SPENT FUEL, APPROXIMATELY 140 MTIHM, PHYSICALLY RESIDENT IN THE REACTOR CORE ON DECEMBER 31, 1986 WHICH IS NOT PLANNED TO UNDERGO ANY FUTURE IRRADIATION.

NRC FORM 335 (2-84) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

SEE INSTRUCTIONS ON THE REVERSE.

1. REPORT NUMBER (Assigned by TIDC, add Vol. No., if any)

NUREG-1353

2. TITLE AND SUBTITLE

Regulatory Analysis for the Resolution of Generic Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools"

3. LEAVE BLANK

4. DATE REPORT COMPLETED

MONTH: February | YEAR: 1989

5. AUTHOR(S)

Edward D. Throm

6. DATE REPORT ISSUED

MONTH: April | YEAR: 1989

7. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)

Division of Safety Issue Resolution
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

8. PROJECT/TASK/WORK UNIT NUMBER

GI-82

9. FIN OR GRANT NUMBER

10. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)

Division of Safety Issue Resolution
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

11a. TYPE OF REPORT

Regulatory Analysis

b. PERIOD COVERED (Inclusive dates)

12. SUPPLEMENTARY NOTES

13. ABSTRACT (200 words or less)

Generic Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools," addresses the concerns with the use of high density storage racks for the storage of spent fuel, and is applicable to all Light Water Reactor spent fuel pools.

This report presents the regulatory analysis for Generic Issue 82. It includes (1) a summary of the issue, (2) a summary of the technical findings, (3) the proposed technical resolution, (4) alternative resolutions considered by the Nuclear Regulatory Commission, (5) an assessment of the benefits and cost of the alternatives considered, (6) the decision rationale, and (7) the relationships between Generic Issue 82 and other NRC programs and requirements.

Based on this evaluation, the NRC staff concludes that no new regulatory requirements are warranted concerning the use of high density storage racks.

14. DOCUMENT ANALYSIS - a. KEYWORDS/DESCRIPTORS

Spent Fuel Pools, Generic Safety Issue, Value/Impact Analysis, Probabilistic Risk Assessment, Zircaloy Cladding Fire, PWRs, BWRs, Seismic Hazard, Fragility, Reracking

b. IDENTIFIERS/OPEN-ENDED TERMS

15. AVAILABILITY STATEMENT

Unlimited

16. SECURITY CLASSIFICATION

(This page) Unclassified

(This report) Unclassified

17. NUMBER OF PAGES

18. PRICE

From:	Bulletin News
To:	NRC-editors@bulletinnews.com
Subject:	NRC News Summary for Thursday, March 17, 2011
Date:	Thursday, March 17, 2011 7:08:13 AM
Attachments:	NRCSummary110317.doc NRCSummary110317.pdf NRCClips110317.doc NRCClips110317.pdf

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NUCLEAR REGULATORY COMMISSION NEWS SUMMARY

THURSDAY, MARCH 17, 2011 7:00 AM EDT

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TODAY'S EDITION

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NRC NEWS:

US Officials At Odds With Japanese Counterparts On Gravity Of Nuclear Crisis.

Japan continued to command the attention of US media outlets last night and this morning, with front pages headlines on major dailies and 48 minutes and 45 seconds of combined airtime on the network newscasts devoted to the nuclear crisis. The coverage highlights that yesterday, US officials distanced themselves from some of the measures adopted by their Japanese counterparts -- even as anger appears to be growing in Japan over the government's handling of the crisis.

NBC Nightly News (3/16, lead story, 4:35, Williams, 8.37M) said in its lead story that "for much of" Wednesday there was "a disagreement between the Americans and the Japanese over how dangerous the nuclear crisis is and how much radiation is being released into the environment." Also in its lead report last night, the CBS Evening News (3/16, lead story, 4:15, Smith, 6.1M) described the Japanese people as "increasingly distrustful, given the wave of conflicting reports and mixed messages," and added that "on Capitol Hill, US Energy Secretary and nuclear expert Steven Chu said he, too, is baffled." Chu was shown saying, "There are conflicting reports, and so, we don't really know in detail what's happening."

"In addition," Politico (3/17, Dixon, 25K) reports, "the State Department has recommended that American citizens within a 50-mile radius of the stricken power plant evacuate, contradicting advice from the Japanese government." Politico

adds that NRC Chairman Gregory Jaczko and White House press secretary Jay Carney "said the State Department suggestion came based on NRC's standards for evacuating citizens." Carney, "under heavy questioning from the White House press corps, insisted that the difference "is not about the quality of information" from Japan."

The US position on the 50-mile radius, the Los Angeles Times (3/17, Maugh, 681K) reports, "further" illustrated "the split between the two countries." The New York Times (3/17, McDonald, Drew, 1.01M) notes that "Japanese officials have evacuated the area within 20 kilometers (12 miles) of the plant and told people who live 20 to 30 kilometers away (12 to 19 miles) to stay indoors and seal their homes." Also, "the top government spokesman, Yukio Edano, told reporters on Wednesday that the levels of radiation detected at the edge of the evacuation zone on Wednesday do not pose an immediate danger to human health."

The Washington Post (3/17, Maese, 605K) reports, "US Ambassador John Roos said Wednesday afternoon that he thought Tokyo was still safe from radiation, and he initially supported Japan's estimation that those beyond the 19-mile radius from the nuclear plants were not at risk." However, "later, when radiation levels in the air above the plant spiked dangerously for the second consecutive day, Roos issued a recommendation based on a review of 'the deteriorating situation' by experts from the NRC and the Energy Department." The Wall Street Journal (3/17, Shirouzu, Smith, 2.09M) also reports the story under the headline "US Sounds Alarm On Radiation."

NBC Nightly News (3/16, story 2, 1:45, Williams, 8.37M) reported on "what the head of the US Nuclear Regulatory Commission said…to Congress about one" of the Fukushima reactors. Jaczko was shown saying, "We believe that secondary containment has been destroyed and there is no water in the spent fuel pool. And we believe that radiation levels are extremely high." Added NBC, "In other words, the Americans saying that it's worse than Japanese officials have let on."

On its front page, the New York Times (3/17, A1, Sanger, Wald, Tabuchi, 1.01M) reports that Jaczko's remarks "suggested a serious split between Washington and its closest Asian ally at an especially delicate moment." The Times adds that "Jaczko's most startling assertion was that there was now little or no water in the pool storing spent nuclear fuel at the No. 4 reactor of the Fukushima Daiichi Nuclear Power Station, leaving fuel rods stored there exposed and bleeding radiation into the atmosphere. As a result, he said, 'We believe that radiation levels are extremely high, which could possibly impact the ability to take corrective measures.'"

McClatchy (3/17, Gordon) reports that "frank assessment" put forth by Chu and Jaczko "stood in contrast to Japanese officials, who continue to downplay the threat posed by the damaged plant." McClatchy adds that "testifying back-to-back at what was slated to be a mundane House budget hearing, Chu and Jaczko described the event as the worst nuclear calamity in a quarter century and perhaps ever, based on reports from a team of 39 US technicians dispatched to monitor the situation." The Financial Times (3/16, Soble, Nakamoto, Dembosky, 448K) also reports on the apparent split between US and Japanese assessments of the situation.

The New York Times (3/17, A1, Tabuchi, Belson, Onishi, 1.01M) reports on its front page, "With all the euphemistic language on display from officials handling Japan's nuclear crisis, one commodity has been in short supply: information." In fact, "foreign nuclear experts, the Japanese press and an increasingly angry and rattled Japanese public are frustrated by government and power company officials' failure to communicate clearly and promptly," as "evasive news conferences followed uninformative briefings as the crisis intensified over the past five days." The Wall Street Journal (3/17, Bussey, 2.09M) runs a similar analysis under the headline "The Crisis In Japan: A Hunger For Information."

The Washington Post (3/17, Higgins, 605K) reports that in Japan, "many are asking what happened to the country's much-vaunted flair for organization," and "those suffering…can't understand why a country as affluent as theirs can't keep gasoline, the lifeblood of a modern economy, flowing and why towns across the northeast have been plunged into frigid darkness for five days."

Voice of America (3/17, Saine) notes Chairman Jaczko "arrived late to Wednesday's hearing because he had been called for a meeting to the White House on Japan's nuclear crisis. Jaczko described the dire situation at Japan's Fukishima nuclear plant, saying radiation levels at the [fourth] reactor at that plant are 'extremely high.' … 'For a comparable situation in the United States, we would recommend an evacuation to a much larger radius than has currently been provided in Japan,' he said."

According to Bloomberg News (3/17, Lomax), Chairman Jaczko told a House Energy and Commerce Committee panel, "We believe that the secondary containment has been destroyed and there is no water in the spent-fuel pool." The "spent-fuel pool at the plant's Unit 3, which was in service, may be cracked and losing water, Jaczko said." Jaczko said radiation at the site is fluctuating and at peak levels is life-threatening, Bloomberg News (3/17, Lomax) reports. "The peak levels 'would be lethal within a fairly short period of time,' he said. The pool at the plant's Unit 3, which was in service, may be cracked and losing water, Jaczko said. 'We would recommend an evacuation to

a much larger radius than has currently been provided by Japan,' Jaczko said."

Differences Between Pressurized Water And Boiling Water Reactors Discussed. An aside on Bloomberg West with Emily Chang & Cory Johnson (3/16, 11:07pm EDT) discusses the difference between boiling water reactor technology – what in use at the Fukushima plant – and pressurized water reactor technology.

Amid Fears About Safety Of US Reactors, Chu And Jaczko Defend Nuclear Industry. A significant subset of stories on Japan's nuclear crisis deal with worries about the safety of US reactors. The network newscasts, for example, devoted 8 minutes and 15 seconds to that aspect of the story.

The CBS Evening News (3/16, story 6, 2:30, Couric, 6.1M), for example, reported that Secretary of State Clinton, during an interview on CNN's Situation Room (3/16, Blitzer), "echoed the thoughts of many Americans" when "she said: 'What's happening in Japan raises questions about the safety of nuclear plant here in the US.'" CBS added that "the nuclear emergency in Japan is of particular significance to Americans living close to older nuclear reactors of exactly the same design as the crippled Japanese plant. Twenty-three of the boiling water reactors Mark-1, built by General Electric, mostly in the 1970s, are still operating at 16 plants spread across much of the country."

ABC World News (3/16, story 7, 2:40, Harris, 8.2M) reported that "the fear that what's happening over in Japan could happen here in America was on full display on Capitol Hill" on Wednesday. Sen. Frank Lautenberg was shown saying, "We have a situation that is scaring the life out of everybody." ABC also noted, "This is what Democrat Henry Waxman said when asked if American nuclear reactors are safe." Waxman was shown saying, "No, I can't reach that conclusion. Nor can anybody at this point. The industry tells us to relax, we're okay. I wouldn't take anything like that at face value." ABC went on to report that "the Energy Secretary told Congress that President Obama continues to support the idea of building new nuclear reactors in this country. But the fears are spreading."

AFP (3/17, Sheridan) notes that Energy Secretary Chu "defended the US nuclear industry," and said that "nuclear energy 'has an important role to play in our energy portfolio.'" Later, asked "by Texas Democratic Congressman Joe Barton if Obama still supports nuclear construction in the United States, given the crisis in Japan following a potent quake and tsunami there last week, Chu answered: 'We are asking for loan guarantees. The present budget is also calling for small modular reactors. That position has not been changed.'" Meanwhile, NRC Chairman Jaczko "said the commission is currently reviewing 12 applications for new nuclear reactors." Said Jaczko, "It is important that the NRC maintain our commitment to continuous improvement."

USA Today (3/17, Eisler, 1.83M) notes that Chu said "Americans 'should have full confidence' in the safety of the 104 nuclear power reactors across the USA." The Hill's Andrew Restuccia (3/16) reports in a blog entry that Jaczko "came under tough questioning from lawmakers, many of whom have nuclear plants in their states and are worried that what is happening in Japan could happen in their backyards." Jaczko "said the NRC would 'take action' to address issues in the US if a review of what is happening in Japan yields new information."

NBC Nightly News (3/16, story 4, 3:05, Williams, 8.37M), meanwhile, said during its reporting on "that Fukushima nuclear plant" that "there are 23 similar models here in the US." NBC (Myers) added, "US regulators in the '70s and '80s also expressed concerns about whether the Mark I's containment was strong enough. GE said since those concerns most Mark I reactors have been upgraded, which experts agree improved safety." Moreover, "based on what is now known, experts say the biggest problem in Japan wasn't the reactor design itself but that the tsunami knocked out all power, including backup systems."

McClatchy (3/17, Hotakainen, Lightman) reports on the "debate rekindled by the frightening blasts at the Fukushima Daiichi nuclear complex in Japan," and asks, "Is the potential catastrophe in Japan making this debate any different? Or will...Obama's view that nuclear power is needed to combat climate change be enough to change the dynamics?" While "opponents are seizing the moment...Washington lawmakers have been reluctant to promise any change in policy."

Politico (3/17, Dixon, 25K) reports that "the ongoing crisis in Japan has some Democrats on Capitol Hill casting a more suspicious eye to the nuclear industry and the NRC." Sens. Barbara Boxer and Dianne Feinstein "sent a letter to the NRC on Wednesday expressing their concern for San Onofre and Diablo Canyon, two nuclear plants in their state. The senators want NRC to 'perform a thorough inspection' of the two plants and address questions about their ability to withstand an earthquake or tsunami."

The Huffington Post's Chris Kirkham (3/17) reports that "the Diablo Canyon nuclear plant, which sits less than a mile from an offshore fault line, was not required to include earthquakes in its emergency response plan as a condition of being granted its license more than a quarter of a century ago." And "though experts warned from the beginning that the plant would be vulnerable to an earthquake, asserting 25 years ago that it required an emergency plan as a condition of its license, the Nuclear Regulatory Commission fought against making such a provision mandatory as it allowed the facility to be built." The Wall Street Journal (3/17, Smith,

2.09M) runs a similar story under the headline "Japan Crisis Puts Spotlight On Reactors In US."

The Washington Post (3/17, Yang, Mufson, 605K) reports, "Scott Burnell, a spokesman for the NRC, said that when Congress passed the Atomic Energy Act of 1954, which gave the commission authority to hand out licenses, lawmakers were less concerned with engineering than with blocking companies from developing monopolies in their markets." The Post adds that "the NRC said that regulators are constantly monitoring the plants and that a renewal does not give a reactor free rein to operate more loosely." Said Burnell, "If it's capable of running for 40, we can tack on 20 and then consider things from there."

WPost Backs Course Outlined By Chu, Jaczko. Under the headline "Too Soon To Write Off Nuclear Power," the Washington Post (3/17, 605K) editorializes that "Chu insisted Wednesday that he and President Obama want to retain nuclear energy as an option, and they have good reason to do so. Generating electricity carries risks, no matter how you do it." Chu and Jaczko "are right to have the government closely examine what happens in Japan and adjust US policy as necessary. But the Fukushima plant is old. New plants would use more sophisticated technology."

Poll Finds Growing Concerns With Nuclear Energy. USA Today (3/17, Eisler, 1.83M) reports, "Americans' support for nuclear power has fallen, as 70% of those surveyed in a new USA Today/Gallup Poll say they've grown more concerned about the industry's safety based on the crisis unfolding at reactors in Japan." USA Today adds that according to the poll, "Americans oppose building more nuclear plants by 47%-44%," whereas "support for using nuclear energy was at 57% when Gallup asked a similar question about a week before Friday's earthquake and tsunami left Japan struggling to avert catastrophic meltdowns and fires at three damaged nuclear plants."

The Washington Post (3/17, Wallsten, Eggen, 605K) reports, Sen. Barbara Boxer (D-Calif.), questioning NRC Chairman Jaczko, "wondered about the response in the European Union, which has announced plans to test its plants for emergency preparedness. 'I would very much like to know why those respected allies of us have taken that action' while the United States has not, Boxer said. Industry lobbyists said they were pleased with the administration's reaction, suggesting that moving too quickly to halt building plans or interfere with plant operations would create more problems than it would solve." But "Rep. Edward J. Markey (D-Mass.) called for a moratorium on new construction in seismically active areas and for additional safety measures at existing plants."

The New York Times (3/17, A13, Wald, 1.01M) says that Chairman Jaczko's pledge that the NRC "would take a methodical look at Japan and incorporate lessons from the disaster" drew "praise and criticism that was often consonant with a lawmaker's political position on nuclear power and other forms of energy. 'US nuclear facilities remain safe,'" Mr. Jaczko told lawmakers, adding, "We will continue to work to maintain that level of protection."

E&ENews PM (3/17, Northey) notes that Chairman Jaczko "said NRC is not planning on changing its approach to permitting new applications but will incorporate any findings from the unfolding disaster in northeast Japan. Those findings, he said, could generate additional costs for the agency, which he said may need to return to Capitol Hill to request new funding." The Asbury Park (NJ) Press (3/17, Chebium) also covered the hearing.

MSNBC Report Says Indian Point Unit 3 Is Most At Risk Of Damage From Earthquake. On its "Open Channel" blog, MSNBC (3/17, Dedman) covers comments from New York Gov. Andrew Cuomo, who "ordered a safety review of the Indian Point nuclear plant" after "one of its reactors ranked first for risk of damage from an earthquake in a study published Wednesday." The MSNBC report was based on NRC damage estimate data for the nation's 104 commercial nuclear power plants, and Indian Point Unit 3 was rated as the most at risk from an earthquake. The NRC said Unit 3 "had a 1 in 10,000 chance each year of damage to its radioactive core from an earthquake." MSNBC said the NRC published the initial data in August, "allowing msnbc.com to rank the plants by risk. The NRC public affairs staff stressed to all callers on Wednesday that it had not done the rankings, but it did not question the accuracy of the data."

The AP (3/17) reports New York Gov. Andrew Cuomo said Wednesday "that he wants to review information from the Nuclear Regulatory Commission about safety of a nuclear plant that lies near a seismic fault line 35 miles north of Manhattan." Cuomo told reporters, "Frankly, that was surprising to me," adding, "So that matter is a concern. We are going to check into it...immediately." The Governor said the state's review will include the Indian Point Energy Center on the Hudson River in suburban Westchester County.

WTOL-TV Toledo, OH (3/17, 6:02AM EST, 35,004) reports that according to a recent ranking by the Nuclear Regulatory Commission, "the Indian Point 3 facility in New York is the most" vulnerable to a catastrophic failure caused by an earthquake. The state of Ohio had two nuclear sites on the list, Davis-Besse Power Plant and Fermi 2." WTOL-TV adds that there was 104 plants total on

WTLV-TV Jacksonville, FL (3/17, 6:04 AM EST, 61,862) adds that "reactors in Massachusetts, Pennsylvania and Tennessee round out at the top five." NRC officials said that the plants that are at the top of the ranking due to the fact that the "design standards may have been lower when earthquake risk was thought to be minimal."

Beaver Valley Unit 1 Fifth Most Vulnerable Plant. The Pittsburgh Tribune-Review (3/17, Olson, 175K) reports, "Pennsylvania is home to three of the 10 US nuclear power plants most vulnerable to an earthquake, including the Beaver Valley plant in Shippingport, according to Nuclear Regulatory Commission data." On the list of the plants seen as most vulnerable to earthquake damage, "Beaver Valley 1 reactor in Shippingport ranks fifth-most at risk, with a 1 in 20,833 chance of it suffering reactor core damage during an earthquake, according to data reported Tuesday by msnbc.com." FirstEnergy spokesman Todd Schneider said "Beaver Valley remains safe and is capable of withstanding at least a 5.8 scale earthquake, which is highly unlikely for this area."

Limerick Station Is Third-Highest Earthquake Risk In US. Similarly, the Montgomery (PA) News (3/17, Brandt, 21K) notes that "A Nuclear Regulatory Commission study released less than a year ago ranked Exelon Nuclear's Limerick Generating Station as being the nation's nuclear plant with the third-highest risk of being [damaged] by an earthquake. The study came about as a result of the US Geologic Survey's 2008 updating of earthquake risks around the country using more sophisticated measurements and modeling than were used in the 1996 and 2002 versions." Thanks to the new data, the NRC "increased the risk of an earthquake damaging both reactors at Limerick by 141 percent, making it the third most at risk, after the Pilgrim Nuclear Plant in Plymouth, Mass., and the Indian Point Atomic Generating Station in Buchanan, N.Y."

Oconee Nuclear Station Ranked 8th Most At Risk From Earthquake. The Anderson Independent-Mail (3/17, 39K) reports, "The Oconee Nuclear Station has the eighth-greatest risk of suffering a catastrophic failure from an earthquake among the nation's 66 nuclear power plants," the NRC says. According to the report, "In any given year, there is a 1-in-23,256 chance of an earthquake damaging the cores of the three nuclear reactors at the Duke Energy-owned plant on Lake Keowee." The report finds "Oconee Nuclear Station faces a slightly higher risk of damage from earthquakes than the Diablo Canyon nuclear power plant in Avila Beach, Calif., which has two reactors between the San Andreas Fault and the Pacific Ocean."

Diablo Canyon Situated On Newly Discovered Shoreline Fault. The AP (3/17) reports, "Two years before an immense coastal earthquake plunged Japan into a nuclear crisis, a geologic fault was discovered about a half-mile from a California seaside reactor — alarming regulators who say not enough has been done to gauge the threat to the nation's most populous state." At "issue at Diablo Canyon is not what is known, but what is not. Preliminary research at the site, which sits on a wave-washed bluff above the Pacific, found its twin reactors could withstand a potential earthquake generated by the recently identified Shoreline Fault, just off the coast." Still, regulators have pressed plant owner PG&E "to conduct sophisticated, independently reviewed studies that they say are needed to fully assess the danger at a site within 200 miles of Los Angeles."

The Salem (OR) Statesman Journal (3/17, Barton, 40K) reports, "Sen. Barbara Boxer chastised federal officials Wednesday for not reviewing a 2008 report that raised concerns about how a seismic event could threaten the safety of 8 million Californians who live within 50 miles of the state's nuclear plants." Boxer "accused Nuclear Regulatory Commission officials of lacking interest in an October 2008 report by the California Energy Commission that raised concerns about potential earthquake effects on the Diablo Canyon Power Plant and the San Onofre Nuclear Generating Station. Both are situated near fault lines." Boxer, "demanded to know" whether NRC officials "knew how many people lived within 50 miles of San Onofre in Southern California. Raising her voice, she said, 'I'm going to tell you how many: 7.4 million people.'"

KGTV-TV San Diego, CA (3/17, 1:12am PDT, 4,020) reports, "Senator Barbara Boxer was one of several lawmakers from California grilling the Nuclear Regulatory Commission today, about the threat of a similar disaster, at San Onofre." San Onofre nuclear plant is in an earthquake zone and, according to Sen. Boxer, has 7.4 million people living near it. KGTV-TV adds that the nuclear plant is "built to withstand a 7.0 quake, but a 2008 report by the state said San Onofre could experience larger and more frequent earthquakes than it was designed to handle." KGTV-TV also reports that the "Nuclear Regulatory Commission never acted on that report."

San Onofre Protected By Sea Wall. According to Wall Street Journal (3/17, Casselman, Spegele, 2.09M) coverage of the report on whether US facilities can withstand, noted the San Onofre Station's 30-foot sea wall protecting the plant from tsunamis. Commenting on the wall's strength Southern California Edison spokesman Steven Conroy said, "Based on historical information from scientists, the wall is capable of dealing with any type of tsunami that would be generated by an earthquake."

Kucinich Asks NRC To Close FirstEnergy Nuclear Plants. The Cleveland Plain Dealer (3/17, Eaton, 266K) reports, "In light of safety problems at Japanese nuclear power plants that have been compromised by natural disasters, Cleveland Democratic Rep. Dennis Kucinich is asking the Nuclear Regulatory Commission to shut down US nuclear facilities run by 'bad actors,' including Akron-based FirstEnergy." Kucinich, in a letter dated March 16, and addressed to NRC Chairman Gregory P. Jaczko, "says Japan's failing nuclear power plants warrant a fresh

assessment of US nuclear catastrophe preparedness." The paper says "Kucinich has a history of enmity with FirstEnergy that dates back to his days as Cleveland's mayor, when he resisted pressure to sell Cleveland's municipal power plant to FirstEnergy's Cleveland Electric Illuminating Co. subsidiary." FirstEnergy spokesman Todd Schneider said "safety is the company's top priority."

The Washington D.C. Examiner (3/16, Spinelli) reported that the nuclear crisis in Japan "has turned some Ohioans' attention to the state's two existing but aging nuclear power plants on Ohio's North Coast and a new one proposed for construction in the south close to the Ohio River." The paper said Kucinich, "a long-time outspoken critic of nuclear power plants," was "referring to what he told the NRC in a 2007 letter were 'a number of serious management problems at the Perry facility' owned by FirstEnergy, Ohio's mega-utility whose failure in August 2003 to trim limbs that touched electric wires resulted in 50 million people from Ohio to New York City falling into darkness when their lights went out."

Japan Crisis May Dampen Maryland's Nuclear Expansion Plans. The Delmarva Daily Times (3/17, Marso) reports, "Maryland's only nuclear power plant is fundamentally different from the endangered Fukushima plant in Japan, but what's happening on the other side of the world could suppress the public's appetite for more reactors here." Maryland Comptroller Peter Franchot said: "Public opinion has changed in the last couple days." The paper says the state's Calvert Cliffs Nuclear Power Plant, "has two pressurized water reactors. Proposals to add a third reactor stalled in financial negotiations and a French company's bid to take on the expansion now appears even less likely to come to fruition."

Iowa Senators Seek To Delay Nuclear Power Plants. The AP (3/17) reports, "Some Iowa senators want to delay action on bills that would make it easier for energy companies to build nuclear power plants in Iowa, given the nuclear crisis unfolding in Japan." Notably, "nine Democratic senators sent a letter to their colleagues on Wednesday saying they are 'extremely concerned about proposed legislation that appears to be on the fast track to pave the way' for more nuclear plants in Iowa." The lawmakers sought to delay the legislation, and asked for a commission "to investigate the issue."

Texas Nuclear Opponents Seek To Halt Proposed Atomic Plant. The AP (3/17) reports, "Opponents of a proposed Texas nuclear power plant are urging federal regulators" to "halt the permit application" for a proposed nuclear plant in Victoria County in view of the Japan crisis. Exelon Corp. is in the "preliminary stages of trying to acquire permitting for a proposed nuclear plant in Victoria County."

On its website and on the air, KRIV-TV Houston (3/16) reported Exelon Power Texas is defending its plans to construct the power plant. A hearing was held Wednesday over the company's plea for an early site permit, the TV station noted.

On its website, KJTV-TV Lubbock, Texas (3/16) reported the group opposing the nuclear plant, Texans for A Sound Energy Policy Alliance, said the plant in Victoria County will be relying on Guadalupe River, which is drought prone. Bill Jones, a spokesman for the group, said the best place for the nuclear plant is where there is plentiful supply of salt water, which is on the coast.

New Crack Found At Containment Building Of Crystal River plant. The Ocala Star Banner (3/17, Hiers) reports, "A new crack in Progress Energy's Crystal River nuclear plant's containment building has forced the utility company to again scrap its plans to fire up the facility in April. The delay marks the fifth time in 18 months the utility giant has pushed back its start-up date." On Monday, Progress reported to the NRC "that testing equipment had detected irregularities in the wall and 'upon further inspection there was a separation that wasn't previously there,' said NRC spokesman Roger Hannah."

Duke's Rogers Still Committed To Nuclear Power. The Orlando Sentinel (3/17, 206K) is reporting that Duke Energy CEO Jim Rogers "said Tuesday that the company's desire to build more nuclear plants in the wake of catastrophe in Japan is still strong." According to WRAL-TV, Rogers said, "Our commitment hasn't faltered." Duke "was in front of regulators in North Carolina on Tuesday setting the stage for a law similar to one passed in Florida that would allow it to charge customers up front for new nuclear plants before they decide whether or not they will actually be built."

Duke Doesn't Plan To Postpone Cherokee County Nuclear Project. The Anderson Independent-Mail (3/17, 39K) reports, "Duke Energy has no plans to postpone building a nuclear plant in Cherokee County in light of the overheating and explosions at a Japanese nuclear facility after last week's powerful earthquake and tsunami." Duke Energy's Rita Sipe "said it's too early to tell what impact the impending disaster will have on the industry, but the company will continue" with the NRC's "process for building the $11 billion William S. Lee III plant. The licensing process will likely take two more years, and the plant would come online in 2020 or 2021, according to company plans, Sipe said."

Exelon's Rowe Reconsidering Nuclear Power Plans. The Crain's Chicago Business (3/17, Daniels, 45K) reports, "Exelon Corp., confronting the disquieting questions raised by the unfolding nuclear disaster in Japan, is reconsidering a $3.7-billion plan to add capacity to the country's largest fleet of nuclear power plants." Exelon CEO John Rowe said "that plans to add a combined 1,500 megawatts of capacity over eight years through improvements to most of its plants were in question, as the Chicago-based power giant awaits safety reviews by the Nuclear Regulatory Commission that are 'sure to come.'" He added that "the NRC was likely to look at backup generators at nukes following the catastrophic power failures at the stricken Japanese plant that disabled cooling systems, leading to overheating, explosions and radioactive releases."

Surgeon General Clarifies Comments About Public's Need For Iodine Pills. NBC Nightly News (3/16, story 5, 1:35, Williams, 8.37M) remarked on the "run on iodine pills in stores and on eBay where we found a few active auctions at exorbitant prices for them," and added that "while the Surgeon General yesterday said Americans should have the pills as a precaution, she later adjusted those remarks." NBC's Nancy Snyderman said that Surgeon General Regina Benjamin "sent me a text message that said I never intended to imply people go out and buy pills. She was referring to pills like these that people are taking to block the thyroid from taking up radioactive iodine." On Tuesday, NBC Nightly News (3/15, story 5, 2:20, Welker, 8.37M) had reported that Benjamin said that buying iodine pills was "a good idea." Benjamin was shown saying, "It's definitely appropriate, we have to be prepared."

Molly Hennessy-Fiske writes at the Los Angeles Times (3/17, 681K) "L.A. Now" blog that a spokesperson for US Surgeon General Regina Benjamin "has clarified her position on whether people should stock up on potassium iodide as protection against nuclear radiation from Japan." Noting that the CDC identifies the substance as potentially preventing the "thyroid from absorbing radioactive iodine," Hennessey-Fiske reports that on in Tuesday comments in California, Benjamin "appeared to contradict the message from other public health officials that the pills are unnecessary and may have harmful side effects." However, she had "framed her comment within the broad context of disaster preparedness" and told the press "she had not heard about panicked California residents stocking up on potassium iodide." On Wednesday, the spokesperson "clarified Benjamin's position," stating that Benjamin had not recommended stockpiling or prophylactic use of potassium iodide.

Radiation Fears Prompt West Coast Rush For KI Tablets Despite Warnings. Noting that "scientists and meteorologists say any trace radiation would be completely diffused as it comes across the Pacific," NBC Nightly News (3/16, story 5, 1:35, Williams, 8.37M) reported that such assurance "hasn't stopped a run on iodide pills in stores and on eBay where we found a few active auctions at exorbitant prices for them today. While the Surgeon General yesterday indicated Americans should have the pills as a precaution, she later adjusted those remarks. Consumers are warned not to take the pills unless exposed to radiation."

The Washington Post (3/17, Stein, 605K) reports that despite reassurances from scientists and authorities that there is little risk of radiation from the nuclear crisis in Japan reaching US territory, "Fearful residents have flooded health officials in western states...with anxious questions, and some authorities have begun issuing updates about air monitoring for radiation." Meanwhile, "The two US companies that make potassium iodide, which can reduce the risk of thyroid cancer from exposure to iodine-131, are being overwhelmed by demands for the medication from individuals, pharmacies, hospitals, day-care centers and others." Despite increased vigilance on the part of US authorities, "thousands of people are seeking potassium iodide. CVS's online pharmacy sold out of it over the weekend, a spokesperson said."

Julie Mason writes at Politico's (3/17) "44" blog that the reactor breach in Japan "has sparked a run on iodine supplements and Geiger counters on the West Coast -- as conflicting messages radiate from the White House about Americans' safety." Noting that President Obama's statement that "any nuclear release dissipates by the time it gets even to Hawaii, much less the mainland of the United States," is in contrast with Benjamin's having said "it was right to be prepared and that stocking up on iodine pills was not an overreaction," Mason adds that "experts warn that taking the supplements can do more harm than good, and aren't even necessary. All the same, the EPA is setting up radiation monitors along the coast, reports the San Jose Mercury News."

Noting that demand for KI pills "was strongest on the US West Coast," AFP (3/17, Thurston) reports that firms making the drug are overwhelmed. "'The spike is enormous ... we were out of stock by Friday night,' said Alan Morris, president of Anbex, which supplies the drug to individuals and retailers, including online." AFP juxtaposes the run on KI with "the head of the US Nuclear Regulatory Commission [having] warned of 'extremely high' radiation levels from the Fukushima plant." Meanwhile, "The California Department of Public Health's interim director, Howard Backer, also stressed the risks involved in taking potassium iodide unnecessarily." This piece also mentions Benjamin's "apparent miscommunication" and her office's subsequent clarification.

Hawaiian Stores Sold Out Of KI. AFP (3/17) reports that Hawaiians are also scouring sold-out stores for the pills, though officials there "warned that taking potassium iodide

could have unwanted side effects. ... 'As soon as people heard about the first explosion (in Japan), people wiped our shelves clean,' said Amber Simone of the Honolulu branch of the Down to Earth health food store chain, which has five branches." AFP explains, "Thyroid glands quickly absorb radioactive iodine, causing damage. But iodide pills can block radioactive iodine from being taken into the thyroid gland, according to the CDC."

Officials Warn Of KI Dangers, Side Effects. The Chicago Sun-Times (3/17, Guy, McKinney, 256K) reports that as residents as far east as Chicago "scoop up potassium iodide supplements," local officials warn that they "are needless and could cause adverse side effects. 'Residents who take potassium iodide out of concern of possible radiation exposure from the events in Japan could be putting their health at risk due to side effects,' said Dr. Damon Arnold, director of Illinois' Department of Public Health, which recommends against taking the tablets at this time. ... Potassium iodide...can be harmful to people with allergies to iodine or shellfish and to those with thyroid problems, renal disease and certain skin disorders and chronic diseases."

Pharmaceutical Manufacturers Ramp Up Production Of Potassium Iodide. CNN Newsroom (3/16, 3:37pm) broadcast, "Despite reassurances from health experts, people are buying up these things, these potassium iodide pills in the US, especially along the west coast. Now some manufacturers like Flemming Pharmaceuticals say they're bombarded with requests for the drug. They've ramped up production. This even as the US Nuclear Regulatory Commission says it does not expect, does not expect, harmful radiation levels from Japan to reach American soil."

Bilirakis Calls On Obama To Boost US KI Stockpiles. CQ Today (3/17, Ota) reports that FL9 Rep. Gus Bilirakis (R) is urging the "Obama administration to expand stockpiles of anti-radiation medication for distribution to Americans living near the nation's nuclear power plants." Noting the influence of the Japanese crisis, CQ adds that MA7 Rep. Edward J. Markey (D) has joined Bilirakis in "renewing earlier efforts to get the government to distribute potassium iodide to those living within 20 miles of this country's 104 nuclear plants. A bioterrorism law (PL 107-188) enacted nine months after the 2001 terrorist attacks called on federal authorities to supply states and local governments with sufficient amounts of the medication for residents living less than 20 miles from a plant. But the law allowed changes to the distribution plan if better alternatives were devised."

US Relying On Aging Reactor Fleet More Than Ever. The Washington Post (3/17, Yang, Mufson, 605K) reports on the state "of nuclear energy in this country, where the average plant was built in 1980 and the cost of launching new reactors -- and, industry executives say, safer ones -- remains prohibitively high." The US, "is leaning more heavily than ever on the first generation of plants built decades ago, even as critics worry that aging reactors have some dangerous weaknesses." While aging plants "are not necessarily failing plants," safety issues have come under "scrutiny as workers in Japan try to fend off a nuclear meltdown at the Fukushima Daiichi plant, whose reactors were designed by General Electric in the 1960s." NRC spokesman Scott Burnell, "said that when Congress passed the Atomic Energy Act of 1954, which gave the NRC authority to hand out licenses, lawmakers were less concerned with engineering than with blocking companies from developing monopolies in their markets."

Nuclear Industry Lobbying Picks Up Speed In Wake Of Japan Crisis. In contrast to the observation that most of the commentary over the last several news cycles has come from anti-nuclear interests and activists, the Boston Globe (3/17, Emery, Slack, 253K) reports, "The nuclear power industry has mounted a concerted lobbying push on Capitol Hill this week to reassure members of Congress who are concerned about the Japanese nuclear plant disaster and potential for a similar incident in the United States." The "industry's success at explaining the technical issues and addressing concerns of elected officials and the American public could prove pivotal to the future of nuclear power," which had begun to enjoy renewed support after years of inaction. Rep. Edward J. Markey (D-MA), said the nuclear industry has "a very powerful lobbying force, which is being felt on the Hill right now." Since the weekend, "the Nuclear Energy Institute, the industry's trade organization, and its members have dispatched representatives to conduct large-scale briefings and have prepared fact sheets for lawmakers about safety threats in Japan."

Nuclear Output Increases Slightly. Bloomberg News (3/17, McClelland) reports, "US nuclear-power output rose 0.3 percent after power increased at the Calvert Cliffs 2 reactor in Maryland and NextEra Energy Inc. boosted the Turkey Point Unit 3 in Florida, the Nuclear Regulatory Commission said." Constellation "boosted its 867-megawatt Calvert Cliffs 2 reactor to 56 percent of capacity from 10 percent yesterday. Another reactor at the plant, the 867-megawatt Calvert Cliffs 1, is operating at full power."

Most Top Lawmakers Not Ready For New Nuclear Moratorium. CNN correspondent Dana Bash said on CNN Newsroom (3/16, 3:40pm) she has "spoken to several lawmakers who are strong supporters of nuclear energy, and they have said they're worried about what this horrible crisis in Japan means for nuclear energy in the US,

which has been gaining traction in recent years on both sides of the aisle. Some Democrats who have long opposed nuclear energy, they are seizing on this, calling for a moratorium on US plants. Talking to congressional leaders on both sides of the aisle, they don't seem to be ready for that."

ABC affiliate, KSPR-TV Springfield, Missouri (3/16, 11:13pm EDT) broadcast, "Helicopters dispatched to drop water on the Fukushima Daiichi nuclear plant in Japan were called off, as a cloud of smoke erupted from one of the reactors Wednesday. Elevated radiation levels were detected. It's the latest setback at the plant that took a direct hit from last week's earthquake and tsunami. The IAEA confirms, three of the six reactors' cores are damaged. The Japanese power company says they're close to getting power to the reactor pumps."

Indiana Lawmakers' Nuclear Power Enthusiasm Dampened On Japan Problems. Following the events in Japan, the Indianapolis Star (3/17, Russell, 190K) reports that state "leaders are backing away from an effort to promote nuclear power here, and nuclear critics are stepping up their opposition." Having just passed legislation in the Indiana Senate last month that "would encourage the construction of the state's first nuclear plant or perhaps a small, modular nuclear plant," attitudes have "changed in a hurry in recent days, as news from Japan grows bleaker. ... Indiana officials say it's time to pause and reassess the benefits and risks of nuclear power." Sen. Beverly Gard said it was time to "take a step back," and put nuclear power "on the back burner until the crisis in Japan is under control."

Space Weather Could Cause Problems For US Nuclear Reactors. In his series on space weather, Steve Tracton at the Washington Post (3/17, 605K) "Capital Weather Gang" blog writes on whether nuclear power plants are vulnerable to the effects of solar storms. "The issue is whether diesels and their onsite fuel supply would last long enough to keep the core from melting given that resupply would be a challenging proposition given the societal and infrastructure disruptions caused by effects of a possible catastrophic solar storm." Because of the issues in Japan, Tracton believes this issue "ought to be" considered.

VA Disability Claim Described Possible Radiation Exposure At Navy Base. On its website, WEWS-TV Cleveland, OH (3/16, Regan) said an "exclusive...investigation" that it conducted "reveals the federal government was aware of possible radiation exposure and failed to act." The "new information was contained within a 2004 disability claim filed" with the Department of Veterans Affairs that "describes possible radiation exposure from a leaking nuclear power plant that supplied power" to a US Navy base in Antarctica. The "revelation comes on the heels of a request" by US Sen. Sherrod Brown (D-OH) to "Defense Secretary Robert Gates for a full investigation into the extent of radiation exposure for an estimated 15,000 Navy personnel who served at McMurdo Station, Antarctica during the 1960s and 70s." WEWS-TV (3/16, 6:09 p.m. ET) aired a similarly negative story.

TSA Officials Grilled Over Body Scanners. Two TSA officials "defended" their agency's use of full-body scanners in front of a "skeptical" House panel yesterday, the Washington Times (3/17, 77K) reports. Republican Rep. Jason Chaffetz was joined by several witnesses in raising safety and privacy concerns regarding the passenger screening machines. On the privacy issue, Chaffetz is quoted saying "nobody has to look at my grandmother naked to secure an airplane." Marc Rotenberg, executive director of the Electronic Privacy Information Center, "expressed doubt about TSA's contention that it does not save images," noting that his organization has "obtained from the US Marshals Service more than 100 images" from a machine in Orlando. Meanwhile, David Brenner, director of Columbia University's Center for Radiological Research, "testified that despite a low individual risk, it's possible that radiation from backscatter machines could cause cancer in 100 people a year."

Brenner "noted that the TSA uses the full-body X-ray scanners at some airports but allows passengers at other airports to pass through millimeter wave scanners, which do not use ionizing radiation," USA Today (3/17, Young, 1.83M) reports. "X-rays," however, "are a carcinogen," he said. Robin Kane, TSA's assistant administrator for technology, maintained that the "technology is safe." He "emphasized that the machines are necessary to protect the public from terrorists and that they have been thoroughly tested by independent experts."

FD: OPM Director Calls For New Performance-Review Upgrades For GS System. In his "Federal Diary" column for the Washington Post (3/17, 605K), Joe Davidson writes of Office of Personnel Management director John Berry's call for a new federal performance-management system that may prove to be an "evolution" for the General Schedule system and a "reprieve" for the classification that covers most federal workers. In remarks at Gallaudet University, Berry said the new "system that would replace the current methods of performance reviews, which he said are 'infrequent and rote.'" Davidson says Berry had been an archrival of the 60-year-old GS system, but in his speech, he "offered 'a basic blueprint for changing the way we manage

personnel performance, and ultimately organizational performance, without changing the law or the pay system.'"

INTERNATIONAL NUCLEAR NEWS:

Japanese Plant "Teetering On The Brink." The situation continued to deteriorate at the Fukushima Dai Ichi nuclear plant, Wednesday. The spent fuel pool at unit 4 was reported to be without water in testimony in the US House and Japanese emergency personnel desperately attempted to stop the damage, but were often prevented from doing so.

ABC World News (3/16, lead story, 4:00, Sawyer, 8.2M) reported, "This is what an American official told us today: It would be hard to describe how alarming the situation is inside Japan's nuclear power plant -- teetering on the brink of a multi-reactor meltdown." The "last ditch hope" are 50 "workers heading in on what he called a suicide mission, and even that may be too late." ABC (Raddatz) added, "We are told it is like a horror movie, fighting a monster you cannot see, you cannot touch but you know is coming to get you."

ABC World News (3/16, story 3, 2:00, Sawyer, 8.2M) later reported on the "brave nameless men" who "stand ready to lay down their lives to slay a fire-breathing dragon," and noted (Chang) their "one last ditch effort, as the world holds its collective breath."

The Los Angeles Times (3/17, Magnier, King, Hall, 681K) reports, "Japanese authorities embarked Thursday on a series of desperate new measures to try to avert full reactor meltdowns at a stricken nuclear complex." The Times adds that "as US and Japanese officials disagreed on how to characterize the seriousness of the nuclear crisis, police planned to use a water cannon truck -- normally used for crowd control -- to try to cool an overheated and possibly dry spent-fuel pool, one of an escalating series of malfunctions at the Daiichi plant in Fukushima prefecture, 150 miles north of Tokyo."

The AP (3/17) reports, "Japanese military helicopters dumped loads of seawater onto a stricken nuclear reactor Thursday, trying to avoid full meltdowns as plant operators said they were close to finishing a new power line that could restore cooling systems and ease the crisis." The AP adds, "A Japanese military CH-47 Chinook helicopter began dumping seawater on the damaged reactor of Unit 3 at the Fukushima complex at 9:48 a.m., said defense ministry spokeswoman Kazumi Toyama. The aircraft dumped at least four loads on the reactor, though much of the water appeared to be dispersed in the wind."

On ABC World News (3/16, story 2, 2:50, Sawyer, 8.2M), nuclear expert Joe Cirincione said, "It's hard to see what they can do," and added that "the situation's been getting worse. This is really a last line of defense. The 50 workers are doing their best, they may give their lives in this. But it's hard for me to see how they can get enough water or have enough reinforcement to the containment vehicles to prevent the core meltdown and a possible breech of two reactors."

On the CBS Evening News (3/16, story 2, 2:05, Couric, 6.1M), James Acton, a nuclear safety expert with the Carnegie Endowment, said, "Right now the biggest cause of concern is the highly radioactive used nuclear fuel because that material is sitting outside of the heavily reinforced containment building. And all that's standing between it and the outside world is a big pool of water, and a weak outer containment shell."

The Los Angeles Times (3/17, Demick, 681K) reports, "An awful realization is setting in for those trapped in the vicinity of the crippled Fukushima nuclear complex: People are afraid to help them. ... Aid agencies are reluctant to get too close to the plant," and "radiation fears mingled with a sickening sense of abandonment Wednesday."

Meanwhile, USA Today (3/17, Weise, 1.83M) reports, "millions of people struggled for a sixth day with inadequate food, heat and no water service. Temperatures hovered in the mid-30s, with biting winds and snow flurries. Police say more than 452,000 people are staying in temporary shelters, some sleeping on the floor in school gymnasiums." Moreover, "several thousand people are listed as missing."

Asked on CNN's Situation Room (3/16, Blitzer) if it is time for Americans to leave Japan, Secretary of State Clinton replied, "Well, we are monitoring that. And we are listening to the experts, because we want to make an informed decision if a decision becomes necessary." Blitzer: "So as of now, you're not telling people to leave?" Clinton: "As of this minute. But again, we are in close touch with our embassy."

The AP (3/17, Hosaka) reports that "Australia, Britain and Germany advised their citizens in Japan to consider leaving Tokyo and earthquake-affected areas, joining a growing number of governments and businesses telling their people it may be safer elsewhere."

Helicopters Make Water Drops As Technicians Work To Restore Power To Dai Ichi Plant. On its website, CNN (3/17) reports Japanese military helicopters "dumped water Thursday on and near the Nos. 3 and 4 units at Japan's Fukushima Daiichi nuclear plant in the latest attempt to halt the nuclear accident that appeared to be spinning out of control." Initially, "just a few drops were carried out before the operation was suspended," and an NHK "commentator said about 100 would be needed for the operation to succeed." Earlier in the day, "engineers were planning to begin the process of restoring power to the stricken nuclear complex," a critically important effort "'using the power lines from outside,'

said the official with the Nuclear and Industrial Safety Agency."

USA Today (3/17, Vergano, 1.83M) reports, "Emergency workers shuttled into and out of Japan's Fukushima Dai-ichi nuclear plant today as they scrambled to contain melting nuclear cores and even wider releases of dangerous radiation. After temporarily evacuating the plant for five hours in the face of high radiation, the 180 workers, in shifts of 50 at a time, resumed pumping seawater into the plant's three damaged reactors." The "workers were hailed as heroes in Japan." Keiichi Nakagawa of the Department of Radiology at University of Tokyo Hospital said, "I don't know any other way to say it, but this is like suicide fighters in a war."

On its "OnDeadline" blog, USA Today (3/17, Winter, 1.83M) says, "Among the emergency efforts at the Fukushima plant," TEPCO "says it trying to install new power lines to restart the cooling systems that failed after Friday's magnitude 9 earthquake and resulting tsunami. NHK TV says the plant operator hopes to run the new lines from another power plant through a makeshift switchboard Thursday, essentially creating giant jumper cables. High radiation thwarted work Wednesday."

The New York Post (3/17, 474K) adds that according to NHK, three "twin-rotor CH-47 Chinooks from the Japanese Self-Defense Forces (SDF) were used in the operation" to drop two loads of seawater "on the plant's damaged No. 3 reactor, with the third load dropped on the No. 4 reactor." Eleven "water cannon trucks were also en route to the plant to spray water from the ground onto the No. 3 reactor."

ABC News (3/16, Muir, Hopper, Tanglao, Forer) reported on its website, "When radiation levels surged following a fire at Unit 4 and a rising cloud of radioactive vapor from unit 3, officials deemed it too risky for the plant workers to continue their critical work of pumping sea water on the damaged reactors and fuel ponds. 'The workers cannot carry out even minimal work at the plant now,' Chief Cabinet Secretary Yukio Edano told the Associated Press. 'Because of the radiation risk we are on standby.'"

Containment On Dai Ichi No. 2 Reactor May Be Breached. Bloomberg News (3/17, Lundgren, Srivastava) reports, "Japanese authorities are concerned about the condition of the pools of units 3 and 4, the International Atomic Energy Agency said yesterday. ... The crisis at Fukushima worsened yesterday when Tokyo Electric said the containment chamber at the No. 2 reactor may have been breached because pressure dropped suddenly. Clouds of steam were seen rising from the reactor building after a fire at the No. 4 Reactor. The 50 workers remaining at the plant were pulled out yesterday after radiation temporarily rose to unsafe levels," though they returned later.

Jaczko Says Loss Of Water Could Hamper Ability To Make Repairs. According to Financial Times (3/17, Kirchgaessner, McGregor, 448K) Jaczko testified that he believed the water loss in the No 4 reactor spent fuel pool "could possibly impact the ability to take corrective measures." Wall Street Journal (3/17, Tracy, 2.09M) carried similar coverage.

Reuters (3/17, Doggett) adds Jaczko said the NRC's information "is limited" as to what's happening onsite, but he added that with the high levels of radiation, "It would be very difficult for emergency workers to get near the reactors. The doses they could experience would potentially be lethal doses in a very short period of time."

TEPCO, Japanese Nuclear Regulators, Dispute Jaczko's Claim. The AP (3/17, Talmadge, Yamaguchi) reports that if "Jaczko was correct, this would mean there was nothing to stop the fuel rods from heating and ultimately melting down. The outer shell of the rods could also ignite with enough force to propel the radioactive fuel inside over a wide area." Japan's nuclear safety agency and TEPCO "which operates the six-unit Fukushima Dai-ichi complex, denied Jaczko's statements that the water is gone from the pool. Utility spokesman Hajime Motojuku said the 'condition is stable' at Unit 4, which was shut when the earthquake and tsunami hit last week." The AP (3/17) ran a shorter version of its coverage.

Gunter Says Water Could Feed Spent Fuel Pool Fire. Paul Gunter of Beyond Nuclear appeared on MSNBC's "Last Word with Lawrence O'Donnell" (3/16, 11:09pm EDT) and said that in Japan, there is an "unparalleled event where an entire reactor core is melting down or poised to meltdown. Certainly slumping. It's turning into this mass that is issuing hydrogen and oxygen gas, and in fact, as it heats up, if you try to put water on it, the water that goes on to this heating up mass will actually again separate out, chemically separate out into more hydrogen, more oxygen, and you actually could feed this accident with the water to try to quench it."

Many Viewers Oppose New Reactor At Callaway Plant. NBC affiliate, KOMU-TV Columbia, Missouri (3/16, 11:10pm EDT) broadcast, "Some mid-Missourians flocked to our Facebook more convinced than ever about the danger of legislation leading to a second nuclear reactor at the Callaway nuclear power plant. Republican lawmakers argue a second plant could bring jobs and growth. But our viewers think higher utility rates to fund nuclear energy could keep businesses away."

Kan Government Faulted For Failing To Inform On Nuclear Crisis. In a commentary for Tokyo Sankei Shimbun (3/17) Political Desk Editor Mataso Inui wrote that the government of Prime Minister Naoto Kan has "totally failed to take an adequate initial action to deal with explosion at the No. 1 nuclear reactor building of the Fukushima No. 1 nuclear

power plant. In almost an hour after the accident, Nippon Television Network Corporation aired the video footage of the explosion, which was then released to the rest of the world by BBC. It was 2 hours after the explosion when the chief spokesman held a news conference and 5 hours after the accident when he admitted the occurrence of the blast." Inui adds the "delay in disclosing information has led to various rumors such as that saying, 'The government might be hiding the real information.'"

Jaczko Urges Personnel To Withdraw To About 80 Kilometers From Fukushima. BBC News (3/16, 11:14pm EDT) reports, "We heard from Gregory Jaczko, who is the chair of the Nuclear Regulatory Commission. Now, he warned that US military personnel and citizens in Japan should actually withdraw to a radius of about 80 kilometers from Fukushima and the current exclusion zone is about 20 kilometers. The United States is assessing the situation in more serious terms, or at least their assessment is serious."

IAEA, G-7 To Hold Meetings On The Situation In Japan. Bloomberg News (3/16, Inajima, Sato) reports, "The United Nations' nuclear agency will call an emergency meeting to discuss the crisis in Japan as a breach at the stricken Fukushima Dai-Ichi plant increased the risk of a radioactive leak. " IAEA head Yukiya Amano "is flying to Tokyo to talk with authorities today and will return for the meeting as soon as possible, he told reporters in Vienna yesterday. It will be the first extraordinary meeting of the agency's 35-member board since his election to succeed Mohamed ElBaradei two years ago."

Under the headline "Atomic Agency's Assessment Lags," the Wall Street Journal (3/17, Crawford, Hansen, 2.09M) reports on criticism of the IAEA's performance, particularly its failure to send a team of experts to Japan until six days after the crisis got underway -- a development that forced the agency to rely on assessments from the Japanese government.

Meanwhile, the New York Times (3/17, Saltmarsh, 1.01M) notes that "France is arranging a discussion among finance ministers and central bankers from the Group of 7 countries to assess the economic effects of the crisis in Japan and a possible response." According to an anonymous "French official," the G-7 would weight "measures to support Japan, improve liquidity if needed and calm financial markets. The official said the discussion was likely to take place by conference call Thursday or Friday, depending on the availability of hard-pressed Japanese officials."

Bloomberg News (3/17, Tirone, Biggs, Lomax) reports, "The United Nations' nuclear agency plans an emergency meeting on the crisis. Japan faces a 'serious situation,' Yukiya Amano, head of the International Atomic Energy Agency, told reporters in Vienna before departing for talks with authorities in Tokyo today. Amano said fuel stored in units 4, 5 and 6 at the Tepco facility is exposed and releasing radiation. Separately, Tepco official Masahisa Otsuku said the No. 2 reactor's containment vessel may have been breached."

Military Keeps "Watchful Eye" On Health Of US Solders Involved In Relief Efforts. The Christian Science Monitor (3/17, Mulrine, 48K) reports, "The US military is keeping a watchful eye on the health of US forces in Japan and on radiation levels emitted by Japan's Fukushima I nuclear power plant as it continues its extensive relief efforts." The Monitor adds that "there is reason for concern among US military officials. Already the US Navy's 7th Fleet was forced to reposition its ships and aircraft 'after detecting low-level contamination in the air and on its aircraft operating in the area,' according to a statement released by the fleet Monday." And "perhaps the most alarming development is that radiation has also been detected on US troops themselves."

Crisis Plays Havoc With World Markets, Presents Challenge To US Economy. The Financial Times (3/17, MacKenzie, Politi, 448K) reports that top G-7 finance officials were to hold talks this morning on the Japanese crisis' effect on world markets. Yesterday, the New York Times (3/17, Wassener, 1.01M) reports, "the Japanese stock market sank again Thursday morning and the yen hit a record high against the US dollar after a US nuclear official warned that the situation at a damaged reactor was more serious than Tokyo has acknowledged." The Wall Street Journal (3/17, Frischkorn, Ng, 2.09M) runs a similar report.

Politico (3/17, White, 25K) reports that "the unfolding crisis...has begun to have an impact on the fragile recovery of the US economy despite assurances by Obama administration officials and many analysts that it does not pose a significant threat to economic growth here or across the globe." On Wednesday, "stocks plunged again," and "despite a modest late day recovery, Wall Street's three major indices have been falling for nearly a week, wiping out most of their gains for the year after rising sharply on hopes for a robust US economic rebound.."

"Financial markets," says the AP (3/17), "were jolted for a third day," and "the losses were broad. Each of the 30 stocks that make up the Dow Jones industrial average fell, with IBM Corp. and General Electric Co. losing the most. All 10 company groups in the Standard & Poor's 500 index, the basis for most US mutual funds, lost ground."

USA Today (3/17, Shell, 1.83M) notes that "the Standard & Poor's 500 index fell nearly 2% to 1257. The drop extended its decline since its Feb. 18 bull market high to 6.4%."

AFP (3/17) reports that the Dow "posted a sharp triple-digit fall, sinking 242.12 points (2.04 percent) to finish at 11,613.30," and "the tech-rich Nasdaq Composite plummeted

50.51 points (1.89 percent) to 2,616.82." The Wall Street Journal (3/17, Conway, 2.09M) and Financial Times (3/17, Stafford, Blas, Farchy, 448K) also note the Wall Street numbers.

More Commentary On Japan. In a New York Times (3/17, 1.01M) op-ed, Hiroki Azuma of Waseda University writes, "The Japanese are an unfortunate people who have rarely felt pride in their country or government since the defeat in World War II. This has been particularly true in the last 20 years, during the prolonged recession after our economic bubble burst. ... But this time, the situation is different. ... Only recently the Japanese people and the government were seen as indecisive and selfish, muddled with complaints and bickering. But now, they are boldly trying to defend the nation together, as if they are a changed people. ... Oddly enough, the Japanese are proud to be Japanese now."

In a New York Times (3/17, 1.01M) op-ed, author Ryu Murakami writes, "There is a mass of confused and conflicting information. Some say the situation is worse than Three Mile Island, but not as bad as Chernobyl; others say that winds carrying radioactive iodine are headed for Tokyo, and that everyone should remain indoors and eat lots of kelp, which contains plenty of safe iodine. ... I want to remain here [in Yokohama], side by side with my family and friends and all the victims of the disaster. I want to somehow lend them courage, just as they are lending courage to me."

Experts Say Risks Of Radiation Diminish With Distance. AFP (3/17, Kwek) reports that the head of France's Institute for Radiological Protection and Nuclear Safety, Jacques Repussard said a plume of radioactivity would likely "extend from 'several dozen kilometres'" around Fukushima Daiichi nuclear plant, but would "have no consequences for health in Tokyo, 250 kilometres to the south-east. Britain's Chief Scientific Officer, Professor John Beddington, told the British embassy in Tokyo that even in the worst-case scenario, an explosion following a meltdown would only be serious for the local area." Thinking about the Chernobyl plant disaster, Professor Beddington "said the problems with Chernobyl were exacerbated by people 'continuing to drink the water and continuing to eat vegetables'."

Japan Nuclear Crisis Forces Re-Evaluation Among Other Atomic Power Countries. The AP (3/17, Charlton) reports, "Japan's nuclear crisis reverberated in atomic power-friendly countries Wednesday, with China saying it would hold off on approving new nuclear plants and French lawmakers questioning top energy executives about the safety of their reactors." AP says several governments "have put their nuclear future on hold" for the time being "as concerns grown even among pro-nuclear governments about the safety of the 442 reactors operating around the world." European Union "energy officials agreed Tuesday to apply stress tests on plants across the 27-nation bloc," while Spanish Prime Minister Jose Luis Rodriguez Zapatero has requested studies on the vulnerability of the six nuclear plants in Spain to earthquakes and flooding. Venezuelan President Hugo Chavez has called off plans to develop nuclear energy following the Japan crisis.

The Wall Street Journal (3/17, Carney, 2.09M) provided details of the European Union response, saying Brussels has made efforts for a united response to the Japan crisis, saying members states should carry out tests to check the security status of their nuclear plants.

The Financial Times (3/17, Hook, 448K) reports China's suspension of approval for nuclear plants in the country means halting a program that makes up nearly 40 percent of the proposed reactors across the globe.

New Nuclear Units In US Could Come Under Increased Scrutiny. Reuters (3/17, Driver, O'Grady), citing analysts, says requests for setting up new nuclear reactors in the US will receive increased scrutiny as a result of the Japan crisis. Some say the new rules could even threaten the existence of some nuclear plants.

Chile Sticks To Nuclear Plan Despite Growing Crisis In Japan. The AP (3/17, Quilodran, Warren) reports, "Chile's president insisted Wednesday on signing a nuclear accord with the United States during President Barack Obama's visit next week, saying the country must keep reactors as a potential option for fueling the booming economy despite anxieties about Japan's disaster." AP says doubts "about nuclear power is rising in Chile, too, but President Sebastian Pinera said the country needs to double its energy resources and can't be afraid to consider all the alternatives."

Czech Prime Minister Reaffirms Support To Nuclear Power. The Wall Street Journal (3/16, Carney, 2.09M) "New Europe" blog reported Czech responded to Germany's decision to idle several nuclear plants in view of the Japan crisis by reaffirming its support for nuclear power. Czech Prime Minister Petr Necas said he sees no reason to succumb to "hysteria," noting that the central European region doesn't face any risks of tsunami or major earthquakes.

A separate "New Europe" blog in the Wall Street Journal (3/16, Kruk, 2.09M) reported that, citing Poland's Economy Ministry, Poland would not face a nuclear catastrophe that is unfolding in Japan because of its geographic location as well as the modern nuclear power plants it proposes to build. Poland has plans to construct two nuclear power plants.

Indonesia Says Won't Waver From Plans To Build Nuclear Plants. Reuters (3/16, Nathalia, Suharmoko)

reported that Indonesia said it will not waver in its plans to build nuclear plants, in spite of the current nuclear crisis in Japan. Indonesia, like Japan, is located in an earthquake prone region.

Malaysia Seizes Suspected Nuclear Weapons Parts. AFP (3/17) reports, "Malaysian police confirmed on Thursday they have seized two containers which may contain parts used to make nuclear weapons, from a ship bound for western Asia." The confirmation follows "a front page story in the influential Sun daily which said police had seized 'parts of an equipment believed used to make weapons of mass destruction, including nuclear warhead' from a ship about 10 days ago."

According to the AP (3/17), Home Minister Hishamuddin Hussein said the "seized suspicious equipment found in two containers" were "shipped from a Chinese port." He said the parts need to be "verified by both local and international agencies," a process he said could take "weeks or months." Malaysia, he added, "is seeking information from China."

US Criticizes Iranian Arms Smuggling. The AP (3/17) reports the Administration on Wednesday "implicitly" criticized Iran after Israel intercepted a ship carrying weapons bound for "Palestinian militants" in Gaza. In a statement, State Department spokesman Mark Toner said in the US "condemns illicit smuggling of arms and ammunition."

Meanwhile, another AP (3/17) report from Ankara says Turkey grounded an Iranian cargo plane yesterday "so its shipment could be searched." The Foreign Ministry, however, denied reports "that Turkish military jets forced the plane to land at Diyarbakir airport on Tuesday night to search it for an alleged cargo of arms from Iran to Syria."

AFP (3/17) reports the plane "was still grounded at Diyarbakir airport on Wednesday where the search was ongoing."

After Intel Briefing, Lieberman Says Iran "Seriously" Seeking Nukes. AFP (3/17) reports, "An influential US Senator said Wednesday after a closed-door, classified intelligence briefing on Iran that Tehran is working "seriously" to develop nuclear weapons." Said Sen. Joe Lieberman, "I can't say much in detail, but it's pretty clear that they're continuing to work seriously on a nuclear weapons program."

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NUCLEAR REGULATORY COMMISSION NEWS CLIPS

THURSDAY, MARCH 17, 2011 7:00 AM EDT

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NRC News:

NRC Sounds Alarm On Japan Crisis (POLITCO)

By Darius Dixon
Politico, March 17, 2011

American experts dispatched to Japan say the crisis at the Fukushima Daiichi nuclear plant warrants greater precautions than previously acknowledged, the top US nuclear official said Wednesday, which touched off a flurry of new speculation about the severity of the disaster.

Nuclear Regulatory Commission Chairman Gregory Jaczko said the spent-fuel pools at Fukushima Daiichi's Unit 4 reactor may be empty and a crack may be present in the spent-fuel pool for the No. 3 reactor. Without proper cooling, spent-fuel rods will continue to heat and potentially ignite, dispersing radioactive elements and making an already complicated situation evermore difficult to contain.

In addition, the State Department has recommended that American citizens within a 50-mile radius of the stricken power plant evacuate, contradicting advice from the Japanese government.

Jaczko, who briefed President Barack Obama and senior White House officials earlier in the day, made the rounds on the network and cable broadcasts Wednesday evening.

"The information that we have is coming from staff people that we have in Tokyo who are interfacing with counterparts in the nuclear industry in Japan, and I've confirmed with them that they believe the information they have is reliable," Jaczko told ABC News.

"We believe that there is no water in the spent-fuel pool known as No. 4, and I would say that it is my great hope that the information that we have is not accurate," he added. "I would hope for the sake of everyone that the situation is not at the state that we think it is."

Meanwhile, Tokyo Electric Power Co., the nuclear plant operator, denied Jaczko's assessment, saying that the "condition is stable" at Unit 4, according to the AP.

The 50-mile evacuation recommendation created confusion as well, as for the first time the advice to American citizens in Japan differed from advice from the Japanese government.

Jaczko and White House press secretary Jay Carney said the State Department suggestion came based on NRC's standards for evacuating citizens.

Carney, under heavy questioning from the White House press corps, insisted that the difference "is not about the quality of information" from Japan.

The NRC chairman also appeared in front of the House Energy and Commerce Committee and a Senate Environment and Public Works Committee gathering filled mostly with Democrats.

"We're working off the best information available that we have," Jaczko told reporters Wednesday. "Some of that information is coming from a team that we have dispatched to Japan that is working with the utility."

The ongoing crisis in Japan has some Democrats on Capitol Hill casting a more suspicious eye to the nuclear industry and the NRC.

California Democratic Sens. Barbara Boxer and Dianne Feinstein sent a letter to the NRC on Wednesday expressing their concern for San Onofre and Diablo Canyon, two nuclear plants in their state. The senators want NRC to "perform a thorough inspection" of the two plants and address questions about their ability to withstand an earthquake or tsunami.

At the Environment and Public Works Committee briefing, Boxer told Jaczko, "I don't hear anything proactive" coming out of the NRC, "and I worry about that."

US Officials Express Strong Concerns About Japan Nuclear Crisis (LAT)

Gregory Jaczko, head of the US Nuclear Regulatory Commission, says the crisis is worse than Japanese officials appear to be letting on. 'This is a situation where people may be called in to sacrifice their lives,' he says of the crew working there.

By Thomas H. Maugh Ii, Los Angeles Times

Los Angeles Times, March 17, 2011

-- As the crisis continues to unfold at the Fukushima No. 1 (Daiichi) nuclear power plant, a growing disparity between Japanese and US attitudes toward the problem is becoming apparent.

Whereas Japanese authorities have generally been restrained in their pronouncements about the risks, American officials are becoming increasingly vocal.

Japanese officials, for example, have consistently said the amount of radiation escaping from the damaged power plant remains relatively small. But on Wednesday, Gregory Jaczko, head of the US Nuclear Regulatory Commission, said that he believes the spent fuel cooling pond atop reactor no. 4 at the facility about 150 miles north of Tokyo has boiled dry and that it is now spewing large amounts of radiation into the air.

"We believe that around the reactor site there are high levels of radiation," he said. "It would be very difficult for emergency workers to get near the reactors. The doses they could experience would potentially be lethal doses in a very short period of time."

About 180 workers are now back at the site, up from the skeleton crew of 150 who were there overnight. Jaczko later told CNN that, "This is a situation where people may be called in to sacrifice their lives. ... It's very difficult for me to contemplate that, but it's... it may have reached that point."

Further illustrating the split between the two countries, the US military warned all its personnel in Japan not to go within 50 miles of the Fukushima No. 1 facility without specific clearance. The US Embassy in Tokyo cautioned civilians within the 50-mile zone to either evacuate or stay inside their houses and keep all windows closed.

The Japanese government, in contrast, called for a much more limited evacuation of everyone living within a 12-mile radius of the plant and warned those within 18 miles to stay inside.

The government's "repeated assurances that the [observed doses outside the plant are] too low to affect people's health does not square with what we know," said Dr. Ira Helfand, a past president of Physicians for Social Responsibility.

Perhaps reflecting the growing concern Thursday morning over the radiation leakage from the spent fuel pool, officials of Tokyo Electric Power Co., which owns the plant, began using helicopters to dump water onto the pool on reactor no. 4. Engineers had planned to do that Wednesday but called off the operation because steam and radioactivity rising from the pool made it too dangerous for the pilots. The helicopters, from Japan's Self-Defense Forces, dropped water on both reactor no. 3 and the spent fuel pool on the building containing reactor no. 4.

Instead, they had hoped to shoot water into the pool using water cannons. But they have not been able to do that yet because too much debris from the tsunami and the earlier explosions is blocking the way.

The pool contains an estimated 125 tons of uranium fuel pellets, much more than is contained in any of the reactors. Moreover, the fuel rods in the pool are not enclosed in a containment vessel, so that if they start burning, radiation will escape directly into the environment.

Company officials also said they are nearing completion of a new power line that will bring electricity to the site from the grid. That will provide a consistent source of power for valves and controllers in the plant and perhaps could be used to power the pumps that supply water to the cooling ponds. It will not help the damaged reactors, however, because their cooling pumps were too badly damaged in the series of explosions that racked the three reactors that were in operation at the time of the magnitude 9.0 earthquake.

The US Air Force also plans to use a Global Hawk drone based in Guam on Thursday to take high-resolution images of the plant to help officials better assess the extent of the damage. The cameras on the drone can take better pictures than are possible with manned aircraft, which have to avoid the radiation plumes at the site.

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Times wire services were used in compiling this report.

US Urges Wider No-Go Area Around Nuclear Plant (NYT)

By Mark Mcdonald And Kevin Drew

New York Times, March 17, 2011

TOKYO — The United States told its citizens and military personnel on Wednesday to stay at least 50 miles away from the stricken nuclear plant in northern Japan, a much wider radius of safety than the Japanese government has set for its people.

"We are recommending, as a precaution, that American citizens who live within 50 miles (80 kilometers) of the Fukushima Nuclear Power Plant evacuate the area, or to take shelter indoors if safe evacuation is not practical," the American Embassy in Tokyo said in its statement to civilians. Separately, American military personnel have been told that unless they are given specific orders to the contrary, they should not go within 50 miles of the plant on the ground or in the air.

Japanese officials have evacuated the area within 20 kilometers (12 miles) of the plant and told people who live 20 to 30 kilometers away (12 to 19 miles) to stay indoors and seal their homes. But the top government spokesman, Yukio Edano, told reporters on Wednesday that the levels of radiation detected at the edge of the evacuation zone on Wednesday do not pose an immediate danger to human health.

The American recommendation to stay outside a 50-mile radius came after a review of radiation data by the United States Nuclear Regulatory Commission, and was based on what the commission would recommend "in a comparable situation in the US," its chairman, Gregory Jaczko, said on Wednesday.

The divergent advice on the safe distance to keep from the power plant reflected the spreading anxiety in Japan and around the world about the unfolding nuclear disaster. Neighboring nations scoured atmospheric data for any sign of radiation

blowing their way, expatriates prepared to relocate away from the plant or leave Japan entirely, and jittery investors sold stocks heavily, pushing major market indexes down sharply for a third day.

Emperor Akihito took the unprecedented step of addressing his people on television Wednesday, telling them in a recorded message broadcast nationwide that he was "deeply worried" about the ongoing nuclear crisis and asking them to act with compassion "to overcome these difficult times."

An official with the Imperial Household Agency said that Akihito had never before delivered a nationally televised address of any kind, not even in the aftermath of the Kobe earthquake in 1995 that killed more than 6,000 people. His address on Wednesday was videotaped.

The message broadcast on Wednesday afternoon was the first public comment from Akihito, 77, since a devastating earthquake and tsunami struck northern Japan last Friday, and they underscored the urgency of multiple crises confronting the country. Akihito expressed his concern for the survivors of the disaster and thanked the rescue teams working under difficult conditions in the north. Before the emperor's address, the crisis took another turn for the worse. The authorities said a containment vessel in a second reactor unit at the stricken Fukushima Daiichi plant in northeastern Japan might have ruptured and appeared to be releasing radioactive steam. That would be the second vessel to be compromised in two days.

A spike in radiation levels at the plant suspended some critical efforts to pump water into several reactors to keep them cool. Earlier in the morning, the company that runs the plant reported that a fire was burning at a different reactor.

A huge relief operation continued as an estimated 440,000 people prepared to spend a sixth night in temporary shelters and evacuation centers in a region where the weather has turned blustery and cold. Local officials expressed frustration at the handling of the evacuation.

"The anxiety and anger being felt by people in Fukushima have reached a boiling point," Yuhei Sato, the governor of Fukushima prefecture, told the NHK broadcast network. While the government plans for further evacuations if conditions worsen, he said, the shelters housing people who have already been evacuated are already short of food and other supplies. "We lack everything," he said.

Weather forecasters predicted a cold front moving into the region would send the overnight temperatures in northeast Japan below freezing, and the government said the cold posed a health risk for evacuees.

The death toll from the combined natural and manmade disasters climbed inexorably. By Wednesday night, more than 4,300 people had been confirmed killed and more than 7,800 remained unaccounted for; the authorities say the final tally of the dead is likely to exceed 10,000.

Aftershocks kept people across northern Japan on edge Wednesday. The United States Geological Survey recorded 54 earthquakes by midafternoon, four of them with magnitudes higher than 6.0. A strong morning shock caused buildings to sway in central Tokyo for about 30 seconds.

Rescue teams from 13 nations continued to search for survivors, and more nations were preparing to send teams. Helicopters shuttled back and forth, part of a mobilization of some 100,000 troops, the largest in Japan since World War II, to assist in the rescue and relief work.

More foreign nations on Wednesday issued cautionary advice to their citizens in Japan. Serbia, Croatia and Belgium told their citizens to leave the country, while France, Australia and the Philippines urged their nationals to either leave Japan or move south, away from the stricken nuclear plant. China continued a mass evacuation of its citizens from the earthquake and tsunami zone begun earlier in the week, while the French Embassy asked Air France to provide planes to ferry its citizens out of Japan.

A number of foreign airlines have suspended flights to Tokyo and have shifted operations to cities farther south.

The United States ambassador to Japan, John V. Roos, issued a statement on Wednesday addressing the growing public unease over the nuclear crisis. American officials agreed with the Japanese government's advice urging people living within about 12 miles of the damaged plant to evacuate, and within about 18 miles to remain indoors.

"Let me also address reports of very low levels of radiation outside the evacuation area detected by US and Japanese sensitive instrumentation," Mr. Roos said in the statement. "This bears very careful monitoring, which we are doing. If we assess that the radiation poses a threat to public health, we will share that information and provide relevant guidance immediately."

The Japanese stock market recouped some of the losses from the previous two days of steep selloffs, despite the continued uncertainty. The benchmark Nikkei 225 index closed up 5.7 percent on Wednesday, and the broader Topix gained 6.6 percent, though both indexes remained far below their levels of a week ago. Even so, shares of Tokyo Electric Power, the operator of the Fukushima Daiichi nuclear plant, continued to plunge on Wednesday.

Mark McDonald reported from Tokyo, and Kevin Drew from Hong Kong. Ken Belson contributed reporting from Tokyo, Sharon LaFraniere from Beijing, and Bettina Wassener from Hong Kong.

Japanese Drop Water From Air On Stricken Nuclear Plant (WP)

By Rick Maese

Washington Post, March 17, 2011

TOKYO — Six days into the world's worst nuclear emergency in 25 years, the crisis at one of Japan's damaged power plants worsened, prompting the United States to urge Americans to stay at least 50 miles from the plant — four times the distance recommended by the Japanese government.

The dire warning from American officials came on the heels of congressional testimony from Gregory Jaczko, chairman of the US Nuclear Regulatory Commission, who said that a deep pool holding uranium fuel at the Fukushima Daiichi facility sat empty of water needed to prevent releases of radiation.

That assessment, the first detailed comments by an American official about Fukushima Daiichi, provided an even more worrisome picture than the one provided by the government in Tokyo and gave millions in Japan on Thursday a heightened sense of concern as they try to determine how far and how fast radioactive material might spread.

In their latest efforts to contain the growing problems at the plant, Japanese officials returned to a plan they had aborted just one day earlier, regarding it as too dangerous. A military helicopter flew four times over the unstable reactors in units 3 and 4 Thursday morning, the Boeing CH-47 dropping 7 1 / 2 tons of seawater on the buildings each time in a bid to replenish the water in the storage pool.

If left exposed to the air, the spent-fuel rods would start to decay and release radioactivity into the air.

Japanese police stood ready to also address the problem from the ground, using a water cannon to spray the reactors from outside — a plan that NHK television, which broadcast the helicopter mission nationally, characterized as a "last-ditch effort."

With Japan's northeastern coastline ravaged and fears of radiation growing, Emperor Akihito made rare public remarks Wednesday, saying he was "deeply concerned about the nuclear situation."

The emperor's televised address — his first at a time of national crisis — underscored the gravity of the moment and highlighted the myriad problems still plaguing Japan nearly a week after the 9.0-magnitude earthquake and tsunami struck: a death toll that grows by the day; conflicting safety and evacuation information; growing distrust by locals and foreigners who call Japan home; a scarcity of gas, food and other resources; and the difficulty some aid workers have had delivering supplies.

The National Police Agency released updated numbers Thursday morning: 4,377 people dead and 9,083 missing. But the list of casualties is expected to reach far higher.

Failed attempts by Japanese officials to bring the Fukushima Daiichi reactors under control, coupled with the US analysis of the situation inside the facility, suggested a greater likelihood that high levels of radiation are leaking from the plant.

Jaczko, speaking in Washington before members of the House Energy and Commerce Committee, said that Fukushima Daiichi's unit 4 reactor appeared to have suffered a hydrogen explosion and that there "is no water in the spent fuel pool. And we believe that radiation levels are extremely high."

A report on the Japanese crisis this week by Barclays Capital said, "Never, never, never allow the water level in a nuclear reactor to fall below the level of the fuel. This is the mantra pounded into the minds of nuclear power plant operators all over the world." The report added, "It is hard to overemphasize the importance of the 'keep the fuel covered' training and design of these plants." One of the report's authors formerly provided such training at a US commercial nuclear plant.

The lack of water in at least one spent-fuel pool sparked fears of a worst-case scenario: the fuel could combust.

"If there's no water in there, the spent fuel can start a fire," said Eric Moore, a consultant to the NRC on plant design and safety issues. "Once you have that fire, there's a high risk of radiation getting out, spewed by the fire."

Japanese officials have called for a 121/ 2-mile evacuation zone around the coastal nuclear plant, about 150 miles north of Tokyo, and asked that people between 121 / 2 and 19 miles away stay indoors. Their assessment did not change Wednesday, even though plumes of white steam billowed from unit 3 of the Fukushima Daiichi plant.

NHK footage Thursday morning showed relatively small amounts of steam rising from units 2, 3 and 4 at Fukushima Daiichi. The exact cause of the steam was not immediately clear.

US Ambassador John V. Roos said Wednesday afternoon that he thought Tokyo was still safe from radiation, and he initially supported Japan's estimation that those beyond the 19-mile radius from the nuclear plants were not at risk. "Our experts continue to be in agreement . . . to continue to follow the advice of the Japanese government in this regard," Roos said.

But later, when radiation levels in the air above the plant spiked dangerously for the second consecutive day, Roos issued a recommendation based on a review of "the deteriorating situation" by experts from the NRC and the Energy Department.

"Consistent with the NRC guidelines that apply to such a situation in the United States, we are recommending, as a precaution, that American citizens who live within 50 miles (80 kilometers) of the Fukushima Nuclear Power Plant evacuate the area or to take shelter indoors if safe evacuation is not practical," Roos said in a statement.

The recommendation appeared to reflect more stringent US standards on radiation exposure, rather than differing assessments of radiation that had escaped from the plants.

Earlier Wednesday, the Pentagon announced that US forces participating in relief operations in Japan would not be allowed within 50 miles of the plant. Officials also said some flight crews are being issued potassium iodide tablets, which can reduce the risk of thyroid cancer from radiation exposure. The measure was described as precautionary. Several US helicopter crews have been exposed to low levels of radiation, but no service members have shown signs of illness.

In order for the workers at Fukushima Daiichi to resume trying to cool the damaged reactors, Japan's health and welfare minister had to waive the nation's standard of radiation exposure, increasing the level of acceptable exposure from 100 millisieverts to 250 — five times the level allowed in the United States.

Japanese officials were working on a plan to deliver water and cool the reactors from the ground. In addition, a spokesman for Tokyo Electric Power, which owns the facility, said that a power line being laid to the plant to help restore the reactor cooling systems is almost complete and that engineers plan to test it "as soon as possible," according to the Associated Press.

US Sounds Alarm On Radiation (WSJ)

By Norihiko Shirouzu And Rebecca Smith

Wall Street Journal, March 17, 2011

Full-text stories from the Wall Street Journal are available to Journal subscribers by clicking the link.

US Calls Radiation "Extremely High," Sees Japan Nuclear Crisis Worsening (NYT)

By David E. Sanger, Matthew L. Wald And Hiroko Tabuchi

New York Times, March 17, 2011

WASHINGTON — The chairman of the United States Nuclear Regulatory Commission gave a far bleaker appraisal on Wednesday of the threat posed by Japan's nuclear crisis than the Japanese government had offered. He said American officials believed that the damage to at least one crippled reactor was much more serious than Tokyo had acknowledged, and he advised Americans to stay much farther away from the plant than the perimeter established by Japanese authorities.

The announcement opened a new and ominous chapter in the five-day-long effort by Japanese engineers to bring the six side-by-side reactors under control after their cooling systems were knocked out by an earthquake and a tsunami last Friday. It also suggested a serious split between Washington and its closest Asian ally at an especially delicate moment.

The Congressional testimony by Gregory Jaczko, the chairman of the commission, was the first time the Obama administration had given its own assessment of the condition of the plant, apparently mixing information it had received from Japan with data it had collected independently.

Mr. Jaczko's most startling assertion was that there was now little or no water in the pool storing spent nuclear fuel at the No. 4 reactor of the Fukushima Daiichi Nuclear Power Station, leaving fuel rods stored there exposed and bleeding radiation into the atmosphere.

As a result, he said, "We believe that radiation levels are extremely high, which could possibly impact the ability to take corrective measures."

His statement was quickly but not definitively rebutted by officials of Tokyo Electric Power, the Daiichi's plant's operator, and Japan's nuclear regulatory agency.

"We can't get inside to check, but we've been carefully watching the building's environs, and there has not been any particular problem," said Hajime Motojuku, a spokesman for Tokyo Electric. Speaking on Thursday morning in Japan, Takumi Koyamada, a spokesman for the regulatory agency, said that when it was checked 12 hours earlier, water remained in the spent fuel pool at reactor No. 4.

"We cannot confirm that there has been a loss in water," he said.

On Wednesday night, Mr. Jaczko reiterated his earlier statement and added that commission representatives in Tokyo had confirmed that the pool was empty. He said Tokyo Electric and other officials in Japan had confirmed that, and also stressed that high radiation fields were going to make it very difficult to continue having people work at the plant.

If the American analysis is accurate and emergency crews at the plant have been unable to keep the spent fuel at that inoperative reactor properly cooled — it needs to remain covered with water at all times — radiation levels could make it difficult not only to fix the problem at reactor No. 4, but to keep servicing any of the other problem reactors at the plant. In the worst case,

experts say, workers could be forced to vacate the plant altogether, and the fuel rods in reactors and spent fuel pools would be left to meltdown, leading to much larger releases of radioactive materials.

While radiation levels at the plant have varied tremendously, Mr. Jaczko said that the peak levels reported there "would be lethal within a fairly short period of time." He added that another spent fuel pool, at Reactor No. 3, might also be losing water and could soon be in the same condition. Efforts to pour in water by dumping it from helicopters were suspended, for fear that the helicopter crews would receive too large a dose of radiation.

Mr. Jaczko's testimony came as the American Embassy in Tokyo, on advice from the Nuclear Regulatory Commission, told Americans to evacuate a radius of "approximately 50 miles" from the Fukushima plant.

The advice to Americans in Japan represents a graver assessment of the risk in the immediate vicinity of Daiichi than the warnings made by the Japanese themselves, who have told everyone within 20 kilometers, about 12 miles, to evacuate, and those 20 to 30 kilometers to take shelter. While maps of the plume of radiation being given off by the plant show that an elongated cloud will stretch across the Pacific, American officials said it would be so dissipated by the time it reached the West Coast of the United States that it would not pose a health threat.

"We would recommend an evacuation to a much larger radius than has currently been provided by Japan," Mr. Jaczko said. That assessment seems bound to embarrass, if not anger, Japanese officials, suggesting they have miscalculated the danger or deliberately played down the risks.

It was not immediately clear how many people live within the zone around the plant that American officials believed should be evacuated. But the zone gets far closer to the city of Sendai, with its population of one million, which took the brunt of the earthquake last week.

At a hearing on Wednesday, Senator Barbara Boxer, chairman of the Senate Environment and Public Works Committee, pointed out that 50 miles could take in a huge number of people; San Onofre, in her home state, California, has seven million people living within that radius, she said.

American officials were careful to offer no public comparisons to past nuclear accidents when discussing the Fukushima disaster. But clearly the crisis in Japan already far outstrips what happened at Three Mile Island in Pennsylvania, where very little radiation escaped a crippled reactor. The effort now is to keep the Japanese crisis, involving at least three reactors that had been in active use before the quake, and three others that were inactive but had storage pools for spent fuel, from escalating to the levels of the worst nuclear disaster in history: Chernobyl.

Though the plant's reactors shut down automatically when the quake struck on Friday, the subsequent tsunami wiped out the backup electronic pumping and cooling system necessary to keep the fuel rods in the reactors and the storage pools for spent nuclear fuel covered with cool water.

The spent fuel pools can be even more dangerous than the active fuel rods, as they are not contained in thick steel containers like the reactor core. As they are exposed to air, the zirconium metal cladding on the rods can catch fire, and a deadly mix of radioactive elements can spew into the atmosphere. The most concern surrounds Cesium-137, which has a half-life of 30 years and can get into food supplies or be inhaled.

Mr. Jaczko (pronounced YAZZ-koe) said radiation levels might make it impossible to continue what he called the "backup backup" cooling functions that have so far helped check the fuel melting inside the reactors. Those efforts consist of using fire hoses to dump water on overheated fuel and then letting the radioactive steam vent into the atmosphere.

Those emergency measures, carried out by a small squad of workers and firefighters, represent Japan's central effort to forestall a full-blown fuel meltdown that would lead to much higher releases of radioactive material into the air.

Mr. Jaczko's testimony, the most extended comments by a senior American official on Japan's nuclear disaster, described what amounts to an agonizing choice for Japanese authorities: keep sending workers into an increasingly contaminated area in a last-ditch effort to cover nuclear fuel with water, or do more to protect the workers but risk letting the pools of water boil away — and thus risk a broader meltdown.

The Japanese authorities have never been as specific as Mr. Jaczko was in his testimony about the situation at reactor No. 4, where they have been battling fires for more than 24 hours.

According to Tokyo Electric's data, the spent fuel pool at the No. 4 reactor contains 548 fuel assemblies that were in use at the reactor until last November, when they were move to the storage pool on the site. That means that the fuel rods were only recently taken out of active use and that their potential to burn and release radioactivity is higher than spent fuel in storage for a longer period.

Experts say workers at the plant probably could not approach a fuel pool that was dry, because radiation levels would be too high. In a normally operating pool, the water not only provides cooling but also shields workers from gamma radiation. A plan

to dump water into the pool, and others like it, from helicopters was suspended because the crews would be flying right into a radioactive plume.

Earlier in the day, Japanese authorities announced a different escalation of the crisis at Daiichi when they said that a second reactor unit at the plant might have suffered damage to its primary containment structure and appeared to be releasing radioactive steam.

The break, at the No. 3 reactor unit, worsened the already perilous conditions at the plant, a day after officials said the containment vessel in the No. 2 reactor had also cracked.

But in one of a series of rapid and at times confusing pronouncements on the crisis, the authorities insisted that damage to the containment vessel at the No. 3 reactor — the main focus of concern earlier on Wednesday — was unlikely to be severe.

At a hearing in Washington on Wednesday held by two subcommittee of the House Energy and Commerce Committee, Energy Secretary Steven Chu said, "We think there is a partial meltdown" at the plant."

"We are trying to monitor it very closely," he said. "We hear conflicting reports about exactly what is happening in the several reactors now at risk. I would not want to speculate about what is happening."

David E. Sanger and Matthew L. Wald reported from Washington, and Hiroko Tabuchi from Tokyo. Keith Bradsher contributed reporting from Hong Kong.

US Officials: Japanese Should Widen Nuclear Evacuation Zone (MCT)

By Greg Gordon, Mcclatchy Newspapers

McClatchy, March 17, 2011

WASHINGTON — Energy Secretary Steven Chu said Wednesday that US officials believe at least one Japanese nuclear power reactor is in "partial meltdown," and the top federal nuclear power regulator said that radiation is so high it warrants a much wider evacuation zone.

Gregory Jaczko, the chairman of the Nuclear Regulatory Commission, said the US embassy in Japan has advised American citizens to move at least 50 miles from the earthquake-devastated Fukushima Daiichi Nuclear Power Station. The Japanese government has so far ordered evacuations in a 20-kilometer, or 12-mile, radius of the plant, and urged people within 20 to 30 kilometers merely to take shelter.

Their frank assessment stood in contrast to Japanese officials, who continue to downplay the threat posed by the damaged plant. However, since the disaster began to unfold over the weekend, each reassuring statement was followed by a new setback.

Testifying back-to-back at what was slated to be a mundane House budget hearing, Chu and Jaczko described the event as the worst nuclear calamity in a quarter century and perhaps ever, based on reports from a team of 39 US technicians dispatched to monitor the situation.

Unlike the 1979 Three Mile Island incident in Pennsylvania and the deadly 1986 disaster at the Chernobyl nuclear plant in the former Soviet Union, the Fukushima crisis entails at least four of the six reactors at a single plant. The events raise the specter that a meltdown of one reactor could spew so much radiation as to hobble already impaired attempts to avoid disasters at the others.

Chu told a joint hearing of two House Energy and Commerce subcommittees that the Japanese incidents "actually appear to be more serious than Three Mile Island," the worst-ever US accident.

Questioned later by Rep. Doris Matsui, D-Calif., he noted that the Pennsylvania reactor also had a partial meltdown, but its containment vessel didn't fail and was able to contain the radiation. Chu said he "wouldn't want to speculate on exactly what will happen" in Japan.

Jaczko was measured as he described the predicament in the Fukushima plant's No. 4 reactor, which was actually off line when last week's 9.0 earthquake hit the region and triggered a towering tsunami that leveled property and knocked out electric power. In that reactor, however, a cooling system failed for nearly as dangerous spent fuel.

"What we believe at this time is that there has been a hydrological explosion in this unit due to an uncovering of the fuel in the fuel pool," he said. "We believe that the secondary containment has been destroyed, that there is no water in the spent fuel pool.

"And we believe that radiation levels are extremely high, which could possibly impact the ability to take corrective measures."

Absent water, nuclear fuel rods can rapidly heat toward their 2,200-degree melting point, beginning a meltdown, in which uranium forms a puddle and begins to melt anything beneath it. If it reaches critical mass, it could explode, sending a white cloud of highly radioactive dust into the air.

Jaczko said the three reactors that were operating when the earthquake hit were shut down following normal procedures.

"We believe that, in general for these three reactors, they have suffered some degree of core damage from insufficient cooling from loss of offsite power and inability of diesel generators to operate successfully following the tsunami," he said.

While pumping of seawater has provided some cooling, he said, the No. 2 reactor core "is not stable," though its thick reactor containment vessel appears to be intact. Water levels in the spent fuel pools of both that reactor and reactor No. 3 appear to be decreasing, heightening the risks further, he said.

US crews took 1,700 pounds of monitoring equipment, including aerial measurement systems, with them, Chu told the panels.

US Fears Worsening Japan Crisis (FT)

By Jonathan Soble And Michiyo Nakamoto In Tokyo And April Dembosky

Financial Times, March 16, 2011

Full-text stories from the Financial Times are available to FT subscribers by clicking the link.

Flaws In Japan's Leadership Deepen Sense Of Crisis (NYT)

By Hiroko Tabuchi, Ken Belson And Norimitsu Onishi

New York Times, March 17, 2011

TOKYO — With all the euphemistic language on display from officials handling Japan's nuclear crisis, one commodity has been in short supply: information.

When an explosion shook one of many stricken reactors at Japan's Fukushima Daiichi nuclear plant on Saturday, power company officials initially offered a typically opaque, and understated, explanation.

"A big sound and white smoke" were recorded near Reactor No. 1, the plant's operator, Tokyo Electric Power, announced in a curt memo. The matter "was under investigation," it added.

Foreign nuclear experts, the Japanese press and an increasingly angry and rattled Japanese public are frustrated by government and power company officials' failure to communicate clearly and promptly about the nuclear crisis. Pointing to conflicting reports, ambiguous language and a constant refusal to confirm the most basic facts, they suspect officials of withholding or fudging crucial information about the risks posed by the ravaged Daiichi plant.

The sound and white smoke on Saturday turned out to be the first in a series of explosions that set off a desperate struggle to bring four reactors under control after their cooling systems were knocked out by the earthquake and tsunami.

Evasive news conferences followed uninformative briefings as the crisis intensified over the past five days. Never has postwar Japan needed strong, assertive leadership more — and never has its weak, rudderless system of governing been so clearly exposed. With earthquake, tsunami and nuclear crisis striking in rapid, bewildering succession, Japan's leaders need skills they are not trained to have: rallying the public, improvising solutions and cooperating with powerful bureaucracies.

"Japan has never experienced such a serious test," said Takeshi Sasaki, a political scientist at Gakushuin University. "At the same time, there is a leadership vacuum."

Politicians are almost completely reliant on Tokyo Electric Power, which is known as Tepco, for information, and have been left to report what they are told, often in unconvincing fashion.

In a telling outburst, the prime minister, Naoto Kan, berated power company officials for not informing the government of two explosions at the plant early Tuesday morning.

"What in the world is going on?" Mr. Kan said in front of journalists, complaining that he saw television reports of the explosions before he had heard about them from the power company. He was speaking at the inauguration of a central response center of government ministers and Tepco executives that he set up and pointedly said he would command.

The chief of the International Atomic Energy Agency said late Tuesday in a press conference in Vienna that his agency was struggling to get timely information from Japan about its failing reactors, which has resulted in agency misstatements.

"I am asking the Japanese counterparts to further strengthen, to facilitate, communication," said the agency's chief, Yukiya Amano. A diplomat in Vienna familiar with the agency's operations echoed those sentiments.

"It's so frustrating to try to get good information" from the Japanese, the diplomat said, speaking on the condition of anonymity so as not to antagonize officials there.

The less-than-straight talk is rooted in a conflict-averse culture that avoids direct references to unpleasantness. Until recently, it was standard practice not to tell cancer patients about their diagnoses, ostensibly to protect them from distress. Even Emperor Hirohito, when he spoke to his subjects for the first time to mark Japan's surrender in World War II, spoke circumspectly, asking Japanese to "endure the unendurable."

There are also political considerations. In the only nation that has endured an atomic bomb attack, acute sensitivity about radiation sickness may be motivating public officials to try to contain panic — and to perform political damage control. Left-leaning news outlets have long been skeptical of nuclear power and of its backers, and the mutual mistrust led power companies and their regulators to tightly control the flow of information about nuclear operations so as not to inflame a spectrum of opponents that includes pacifists and environmentalists.

"It's a Catch-22," said Kuni Yogo, a former nuclear power planner at Japan's Science and Technology Agency. He said that the government and Tepco "try to disclose only what they think is necessary, while the media, which has an antinuclear tendency, acts hysterically, which leads the government and Tepco to not offer more information."

The Japanese government has also decided to limit the flow of information to the public about the reactors, having concluded that too many briefings will distract Tepco from its task of bringing the reactors under control, said a senior nuclear industry executive.

At a Tepco briefing on Wednesday, tempers ran high among reporters. Their questions focused on the plumes of steam seen rising from Daiichi's Reactor No. 3, but there were few answers.

"We cannot confirm," an official insisted. "It is impossible for me to say anything at this point," another said. And as always, there was an effusive apology: "We are so sorry for causing you bother."

"There are too many things you cannot confirm!" one frustrated reporter replied in an unusually strong tone that perhaps signaled that ritual apologies had no place in a nuclear crisis.

Yukio Edano, the outspoken chief cabinet secretary, has been one voice of relative clarity. But at times, he has seemed unable to make sense of the fast-evolving crisis. And even he has spoken too ambiguously for foreign news media.

On Wednesday, Mr. Edano told a press conference that radiation levels had spiked because of smoke billowing from Reactor No. 3 at Fukushima Daiichi, and that all staff members would be temporarily moved "to a safe place." When he did not elaborate, some foreign reporters, perhaps further confused by the English translator from NHK, the national broadcaster, interpreted his remarks as meaning that Tepco staff members were leaving the plant.

From CNN to The Associated Press to Al Jazeera, panicky headlines shouted that the Fukushima Daiichi plant was being abandoned, in stark contrast to the calm maintained by Japanese media, perhaps better at navigating the nuances of the vague comments.

After checking with nuclear regulators and Tepco itself, it emerged that the plant's staff members had briefly taken cover indoors within the plant, but had in no way abandoned it.

The close links between politicians and business executives have further complicated the management of the nuclear crisis.

Powerful bureaucrats retire to better-paid jobs in the very industries they once oversaw, in a practice known as "amakudari." Perhaps no sector had closer relations with regulators than the country's utilities; regulators and the regulated worked hand in hand to promote nuclear energy, since both were keen to reduce Japan's heavy reliance on fossil fuels.

Postwar Japan flourished under a system in which political leaders left much of the nation's foreign policy to the United States and domestic affairs to powerful bureaucrats. Prominent companies operated with an extensive reach into personal lives; their executives were admired for their roles as corporate citizens.

But over the past decade or so, the bureaucrats' authority has been greatly reduced, and corporations have lost both power and swagger as the economy has floundered.

Yet no strong political class has emerged to take their place. Four prime ministers have come and gone in less than four years; most political analysts had already written off the fifth, Mr. Kan, even before the earthquake, tsunami and nuclear disaster.

Two years ago, Mr. Kan's Japan Democratic Party swept out the virtual one-party rule of the Liberal Democratic Party, which had dominated Japanese political life for 50 years.

But the lack of continuity and inexperience in governing have hobbled Mr. Kan's party. The only long-serving group within the government is the bureaucracy, which has been, at a minimum, mistrustful of the party.

"It's not in their DNA to work with anybody other than the Liberal Democrats," said Noriko Hama, an economist at Doshisha University.

Neither Mr. Kan nor the bureaucracy has had a hand in planning the rolling residential blackouts in the Tokyo region; the responsibility has been left to Tepco. Unlike the orderly blackouts in the 1970s, the current ones have been carried out with little warning, heightening the public anxiety and highlighting the lack of a trusted leader capable of sharing information about the scope of the disaster and the potential threats to people's well-being.

"The mistrust of the government and Tepco was already there before the crisis, and people are even angrier now because of the inaccurate information they're getting," said Susumu Hirakawa, a professor of psychology at Taisho University.

But the absence of a galvanizing voice is also the result of the longstanding rivalries between bureaucrats and politicians, and between various ministries that tend to operate as fiefdoms.

"There's a clear lack of command authority in the current government in Tokyo," said Ronald Morse, who has worked in the Defense, Energy and State Departments in the United States and in two government ministries in Japan. "The magnitude of it becomes obvious at a time like this."

Keith Bradsher contributed reporting from Hong Kong, William J. Broad from New York, and Mark McDonald from Tokyo.

The Crisis In Japan: A Hunger For Information (WSJ)

By John Bussey

Wall Street Journal, March 17, 2011

Full-text stories from the Wall Street Journal are available to Journal subscribers by clicking the link.

Japan's Slow Tsunami Response Stirs Anger (WP)

By Andrew Higgins

Washington Post, March 17, 2011

With city hall under water, phones dead and his superiors tending to their own private agonies, Chikara Abe faced a bureaucrat's nightmare: "Everything is in chaos. I don't get any orders," said the local government official.

Fed up with waiting for instructions, Abe offered his services to a group of teachers who have stepped in to help fill a void left by the breakdown of one of the world's most capable and usually omnipresent government bureaucracies.

Since a 9.0-magnitude quake Friday, Japan's machinery of state has been swamped by a cascade of crises: a tsunami that wiped towns and village off the map; an out-of-control nuclear power plant that has put the entire country on edge; and shortages of food, power and gasoline that have left the northern part of one of Asia's richest nations with the miseries of the world's paupers.

Authorities have hardly been idle. But in places such as Ishinomaki , a town on Japan's northeast coast now half-submerged in water, many are asking what happened to the country's much-vaunted flair for organization.

Unlike victims of earthquakes in Haiti, Indonesia or China, those suffering in Japan expect their government to work and can't understand why a country as affluent as theirs can't keep gasoline, the lifeblood of a modern economy, flowing and why towns across the northeast have been plunged into frigid darkness for five days.

"I never expected anything like this in modern Japan. It is like fiction," said Yutaka Iwasawa, a 25-year-old forklift operator. With the first floor of his house under water, he and his family huddle on the second floor. They go to bed as soon as the sun goes down because it is too cold and damp to do anything else.

The military, which has mobilized 100,000 troops for relief work, delivers water in stricken areas, hunts for bodies and has flown risky missions to dump water on a nuclear power plant belching radioactive smoke. In Ishinomaki, soldiers operate from a baseball stadium on dry land.

But the state, overwhelmed by problems, has abdicated some of its most basic duties, some say. "The government is not doing anything. They are not present here," said Akase Hiroyuki, the principal of Ishinomaki's Nakazato Primary School. Along with 20 of his teaching staff, he runs a shelter for 1,200 people left homeless and hungry by the tsunami. Classrooms serve as dormitories, and the school's gymnasium has become a food-distribution center.

When Emperor Akihito made a rare television address on Wednesday, his soothing words were not heard in Ishinomaki: No one has watched TV since power failed Friday.

Foreign governments and charities have pledged money and sent a few rescue teams to Japan, but fear of exposure to radiation and uncertainty over what they can accomplish has limited their role. A German medical aid group pulled out after barely 24 hours in Japan.

China has trumpeted the work of a 15-man rescue team it sent Sunday to assist its former archenemy and current rival. The US Marine Corps made its own highly publicized but minuscule contribution Wednesday: It delivered a few pallets of bottled water.

What riles Japanese, though, is the seeming inability of their government to get a grip on the scale of a disaster that has left about 450,000 people without homes, left thousands still uncounted for and snatched away the certainties by which tens of millions had lived their lives.

Masayoshi Funabasama, a civil engineer who lives near Ishinomaki in an area not damaged by the tsunami, fumed at official assurances that there is no need for alarm. He got up before dawn to go hunting for gasoline. "Things may look normal, but I can assure you nothing is normal," he said. "We have no fuel, no water, no food, and we have children to take care of."

At the refugee center at Ishinomaki's primary school, Abe, the government worker in search of orders and order, has been put to work at a registration desk for survivors seeking shelter. It posts their names on blackboards — a vital service for people who are looking for lost family members and friends.

"To be honest, I don't do much," he said."The teachers are doing most of the work."

Katsuyoshi Hiyasaka, a scrap-metal worker, took shelter at the school with his wife, a cleaner, after their house was flooded. He is still wearing the work uniform he had on when he fled. His workplace has vanished beneath the muddy lake that covers the town center.

Asked what officials are doing to help, he laughed and said: "I've been looking for them, but I haven't seen them yet."

The food provided by the teachers comes mostly from private donors, although the local government provided a now-exhausted supply of instant noodles. No one here is starving, but reliance on random gifts from shops and local farmers has produced a bizarre menu that mixes strawberries and sugared crackers, bananas and bars of chocolate.

Supplies are running low, and daily rations have been cut. Hiyasaka, the scrap worker, said he used to watch TV coverage of natural disasters in Haiti and other impoverished countries and was shocked by the chaos.

Even Japanese order has a breaking point, he said. "The less food there is and the more strain there is, patience will run out. I don't know what will happen."

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American Official Warns Significant Radiation Risk In Japan (VOA)

By Cindy Saine

Voice of America, March 17, 2011

U.S Nuclear Regulatory Chairman Gregory Jaczko told a congressional panel that his commission is recommending a larger evacuation radius from Japan's Fukishima nuclear plant than Japan has ordered.

Jaczko arrived late to Wednesday's hearing because he had been called for a meeting to the White House on Japan's nuclear crisis. Jaczko described the dire situation at Japan's Fukishima nuclear plant, saying radiation levels at the fourh reactor at that plant are "extremely high." He said the State Department is issuing a new recommendation for US citizens in Japan.

"For a comparable situation in the United States, we would recommend an evacuation to a much larger radius than has currently been provided in Japan," he said.

Watch William Ide's report on the severity of the nuclear crisis

Jaczko said the US Ambassador in Japan has been told that it would be appropriate to evacuate US citizens to a 80 kilometer radius from the Fukishima nuclear plant. Japan had ordered citizens to take precautions within a 30 kilometer-radius, with a 20 kilometer evacuation radius from the nuclear plant, and advising those within a 30 kilometer radius to stay indoors.

The combined natural disasters of an earthquake and a tsunami have put Japan's Fukishima nuclear power plant in danger of a meltdown. Jaczko and Energy Secretary Steven Chu were both on Captiol Hill to testify on their agencies' budget proposals for 2012, but the crisis in Japan dominated the hearing.

Democratic Congresswoman Doris Matsui of California expressed the concern felt by many across the world when she posed this question to Energy Secretary Chu: "Mr. Secretary, what happens if there is a meltdown in one or more of the Japanese reactors, and the containment system fails?"

Chu said he is getting conflicting reports from Japan about the current situation. "We are trying to monitor very closely, we hear conflicting reports about exactly what is happening at the several reactors that are now at risk, and I would not want to speculate on exactly what will happen," he said.

Chu admitted that the situation in Japan is already worse than the nuclear disaster at Three Mile Island in the US state of Pennsylvania in 1979, America's worst nuclear accident. Nuclear Regulatory Chairman Jaczko sought to reassure Americans that nuclear power plants are built in the United States to withstand earthquakes, tsunamis and all kinds of natural disasters. Energy Secretary Chu reaffirmed President Obama' support for nuclear power as one of a diverse set of energy sources, and said the adminstration is committed to learning from Japan.

A number of US lawmakers expressed their support for nuclear power as an important source of electricity and of well-paid jobs for those who work at the 104 nuclear plants in the United States.

"Obviously nuclear energy plays a vital role in the energy needs of our country today. It provides roughly 20 percent of all electricity generated in America," said Republican Congressman Ed Whitfield of Kentucky.

But some, such as Democratic Representative Ed Markey of Massachusetts, said the unfolding tragedy in Japan should make the United States fundamentally re-think its energy policy as other countries are.

"China, Venezuela, Germany, Switzerland and other countries are shutting down older plants and scrapping plans for new ones. We too need a seismic shift in our approach to nuclear reactor safety," Markey said.

In its 2012 budget proposal, the Obama administration has asked for an additional $36 billion for loan guarantees for nuclear power plant construction.

Nuclear Chief Jaczko Says 'No Water' In Spent-Fuel Pool At Japan Reactor (BLOOM)

By Simon Lomax

Bloomberg News, March 17, 2011

US Nuclear Regulatory Commission Chairman Gregory Jaczko said all the water has drained from the spent-fuel pool at a crippled nuclear reactor in Japan, resulting in the release of high levels of radiation.

"We believe that the secondary containment has been destroyed and there is no water in the spent-fuel pool," Jaczko said today at a hearing of a House Energy and Commerce Committee panel.

The unit at the Fukushima Daiichi plant wasn't operating at the time of the March 11 earthquake and tsunami, Jaczko said.

The spent-fuel pool at the plant's Unit 3, which was in service, may be cracked and losing water, Jaczko said.

Japan Reactor Loses All Cooling Water For Spent Fuel, NRC Head Jaczko Says (BLOOM)

By Simon Lomax

Bloomberg News, March 17, 2011

All cooling water has drained from the spent-fuel pool at one of the crippled nuclear reactors in Japan, causing the release of high levels of radiation, US Nuclear Regulatory Commission Chairman Gregory Jaczko said.

"We believe that the secondary containment has been destroyed and there is no water in the spent-fuel pool," he said today at a hearing of a House Energy and Commerce Committee panel in Washington. "We believe that radiation levels are extremely high, which could possibly impact the ability to take corrective measures."

The unit at the Fukushima Daiichi plant wasn't operating at the time of the March 11 earthquake and tsunami, said Jaczko, the chief US regulator of nuclear-power plants.

The Associated Press reported that Japanese officials denied all the water has drained and said the reactor, known as Unit 4, is stable.

Radiation at the Japanese site is fluctuating and at peak levels is life-threatening, Jaczko said.

The peak levels "would be lethal within a fairly short period of time," he said. The pool at the plant's Unit 3, which was in service, may be cracked and losing water, Jaczko said.

US citizens in the area have been urged to evacuate to 50 miles (80 kilometers) from the plant site, the same distance in the event of a nuclear accident in the US, Jaczko said.

"We would recommend an evacuation to a much larger radius than has currently been provided by Japan," Jaczko said.

The NRC has 11 officials in Tokyo helping the Japanese government respond to the nuclear crisis. Japanese officials are injecting seawater into three reactors to try to keep them cool, Jaczko said.

The earthquake and tsunami in Japan crippled Tokyo Electric Power Co.'s Fukushima Daiichi nuclear plant with explosions, fires and radiation leaks. The containment vessels for the three operating reactors are reportedly functional, Jaczko said.

Jaczko said US nuclear plants remain safe, and harmful radiation from damaged reactors in Japan isn't expected to reach the US The US power plants are designed to withstand natural disasters, including earthquakes and tsunamis, Jaczko said.

"At this time we don't have any specific actions that are necessary to add to the safety" of US reactors, he said. A "thorough and systematic review" will be conducted after the Japanese crisis passes for possible additional actions, he said.

US Still Wants To Expand Nuclear Energy: Chu (AFP)

By Kerry Sheridan

AFP, March 17, 2011

WASHINGTON (AFP) – The United States still wants to expand nuclear plant construction despite the Japan disaster and sees nuclear power as a key part of clean energy efforts, Energy Secretary Steven Chu said Wednesday.

Testifying at a House subcommittee hearing about President Barack Obama's request for energy funds in the fiscal year 2012 budget, Chu defended the US nuclear industry, which provides about 20 percent of America's power through 104 nuclear plants.

Nuclear energy "has an important role to play in our energy portfolio," Chu said, noting that the president's budget asks Congress for $36 billion in loan guarantee authority to "jumpstart the domestic nuclear industry."

Asked by Texas Democratic Congressman Joe Barton if Obama still supports nuclear construction in the United States, given the crisis in Japan following a potent quake and tsunami there last week, Chu answered:

"We are asking for loan guarantees. The present budget is also calling for small modular reactors. That position has not been changed."

Barton responded: "So that's a yes?"

"Yes," Chu answered.

"Given, again, what has happened, do you and the president want Congress to support the full 36 billion that you have put in the budget?" Barton asked.

"Yes," Chu said.

The US nuclear industry has largely stalled, with no new plants built to completion since the March 28, 1979 accident at Three Mile Island, a partial reactor meltdown that led to "very small" releases of radioactivity, according to the US Nuclear Regulatory Commission (NRC).

No one was killed and no immediate injuries were linked to the incident, but it stirred an outcry that blocked further expansion of the US nuclear program.

"I think the events unfolding in the Japan incidents actually appear to be more serious than Three Mile Island. To what extent we don't really know now," Chu added.

"I think we will, no matter what happens, going forward try to take the lessons of Fukushima and apply them to our existing fleet and any future reactors we will be building."

An attempt to launch nuclear renaissance in the United States has faltered due to heavy costs associated with reactor construction, which the Obama administration hopes can be overcome through government-backed loan guarantees.

Obama vowed on Tuesday to "further improve" the safety of US atomic facilities.

The NRC chairman Gregory Jaczko said the commission is currently reviewing 12 applications for new nuclear reactors.

"It is important that the NRC maintain our commitment to continuous improvement," Jaczko said in prepared remarks ahead of his testimony, which was to begin at 1730 GMT.

"We also, however, have an additional imperative, in light of the prevailing budgetary climate and the strong desire by many to see federal agencies do more with less."

Poll: Fears Of Nuclear Disaster In US Rise After Japan Quake (USAT)

By Peter Eisler, Usa Today

USA Today, March 17, 2011

WASHINGTON — Americans' support for nuclear power has fallen, as 70% of those surveyed in a new USA TODAY/Gallup Poll say they've grown more concerned about the industry's safety based on the crisis unfolding at reactors in Japan.

Americans oppose building more nuclear plants by 47%-44%, the poll finds. Support for using nuclear energy was at 57% when Gallup asked a similar question about a week before Friday's earthquake and tsunami left Japan struggling to avert catastrophic meltdowns and fires at three damaged nuclear plants.

The new poll shows that worries about a similar disaster in the USA have climbed amid the crisis in Japan: 39% of those surveyed say they've grown "a lot more concerned," and 31% say they've become "a little more concerned."

The poll of 1,004 adults has a margin of error of +/—4 percentage points.

Those concerns were reflected Wednesday in Congress as members of both parties quizzed federal officials about the likelihood that similar problems could occur at US nuclear power plants.

Americans "should have full confidence" in the safety of the 104 nuclear power reactors across the USA, Energy Secretary Steven Chu said in response to questions from lawmakers at a hearing on President Obama's proposed energy budget for 2012. Nevertheless, he said, the administration will be "gathering whatever lessons that can be learned (from the events in Japan) ... and will apply them to all the nuclear facilities we have in the United States."

Chu noted that the Energy Department and the Nuclear Regulatory Commission have sent a few dozen staff members to Japan to offer technical assistance "and also, for our own sake, to know what's happening directly."

Opinion among lawmakers at the hearing mirrored the public sentiment measured in the poll: Republicans are slightly more likely to support development of nuclear energy and Democrats a bit more inclined to oppose it.

"I am not straying from my support for nuclear energy as a vital component of America's present and future energy mix," said Rep. Fred Upton, R-Mich., who chairs the House Committee on Energy and Commerce. "It is just as important to dispel overstated fears as it is to discuss legitimate concerns."

Several lawmakers said the events in Japan are particularly worrisome because the reactors in peril there are similar in design to roughly two dozen operating in the USA. What's more, they said, Japan is a country widely viewed as among the most prepared in the world to handle such crises.

Japan "is not some Third World country with rinky-dink technology," said Rep. Diana DeGette, D-Colo. Noting that the Japanese had multiple fail-safe systems in place and had used computer models and other sophisticated planning tools to prepare for such events, she asked, "Do we really have the kinds of modeling we need to develop nuclear energy safely in this country?"

Chu said the administration remains committed to nuclear power as one component of a balanced energy strategy and reiterated support for an administration plan to provide $54 billion in loan guarantees for companies seeking financing to build nuclear power plants.

Public opinion on nuclear power has ebbed and flowed in various polls over the years.

Surveys in the early 1970s found support as high as 70% for increased reliance on nuclear power, but that number slid to around 40% in 1979 after the partial meltdown at the Three Mile Island nuclear plant in Pennsylvania. Support rebounded then dropped again after the 1986 meltdown at the Chernobyl plant in Ukraine. In recent years, it has hovered around 50%.

Industry officials say they're not surprised that public support for nuclear power has slipped again amid the crisis in Japan, where the earthquake and tsunami damaged critical systems at reactors and fuel storage facilities across three different power plants. In several instances, power failures crippled cooling systems that are used to keep nuclear fuel rods from superheating. That led to radiation releases and ongoing risks of a nuclear meltdown, which could release dangerous levels of contamination into the environment.

"Given virtually a week of wall-to-wall coverage of the events in Japan, it would be shocking if there weren't some slippage in support" for nuclear power, said Steve Kerekes, a spokesman for the Nuclear Energy Institute, which does research and advocacy for the nuclear industry. Rebuilding that support "will take time," he added. "It means we will have to work that much harder, which we are prepared to do, both in terms of operating our facilities even more safely than we do, and in communicating that to Americans across the country."

The new poll shows that women have a lower regard for nuclear power than men — 56% of women responding to the survey said they oppose it, while 36% of male respondents held that opinion. And there was greater support for nuclear power among people at higher income levels, with a peak of 63% support among respondents from households making $7,500 or more a month.

Senate Dems Call For Broad Review Of Nation's Nuclear Reactors (HILL)

By Andrew Restuccia

The Hill, March 17, 2011

Senate Democrats on Wednesday called for a broad review of the nation's nuclear reactors after the head of the Nuclear Regulatory Commission (NRC) offered an assessment of the evolving nuclear crisis in Japan.

Gregory Jaczko, the head of the commission, came under tough questioning from lawmakers, many of whom have nuclear plants in their states and are worried that what is happening in Japan could happen in their backyards.

"We've got an inferno in front of us and we have to make sure that we do whatever we can to stop it," Sen. Frank Lautenberg (D-N.J.) said during a Senate Environment and Public Works Committee hearing.

He and other panel members accused Jaczko of not doing everything he could to ensure that US nuclear reactors can withstand major natural disasters.

Jaczko said the NRC would "take action" to address issues in the US if a review of what is happening in Japan yields new information.

"We want to get good facts and make good, credible, reliable decisions, and that may take a bit of time," Jaczko said.

Jaczko testified as the situation in Japan appeared to take a turn for the worse. The White House advised Americans to stay at least 50 miles away from the Fukushima Daiichi Nuclear Power Station, where workers have struggled to prevent a complete meltdown. Japan has advised people to stay only 12 miles away from the power station.

Sen. Barbara Boxer (D-Calif.), the panel's chairwoman, was among those calling for a review. "I don't hear anything proactive, and I worry about that," said Boxer, who argued that the NRC is "doing nothing" to assess US reactor safety.

She said the NRC needs to act immediately to conduct a review of the safety of US reactors.

But Jaczko countered that the NRC is indeed taking proactive measures.

"We are going to be looking very seriously at what happened in Japan, and if we get any information that says there's a safety issue, we'll take action," Jaczko said. "We are not doing nothing."

Boxer called on the NRC to begin reviewing all nuclear reactors in earthquake-prone areas.

She raised concerns that reactors might not be prepared for an earthquake of historic proportions, noting that the reactors at the Fukushima Daiichi Nuclear Power Station plant were prepared to deal with a magnitude-7.9 quake. Last week's temblor registered a 9.0.

"I don't have the answer on how many plants are near earthquakes, but the fact that there's any disturbs me and the fact that a tsunami could come without warning worries me," she said.

Jaczko stressed that the NRC requires all nuclear facilities to show that they can withstand earthquakes beyond those expected in the region.

He also said the NRC took a series of steps after 9/11 to ensure that US reactors are prepared for a terrorist attack. Those procedures, which require reactors to be able to cool the reactor core in the event of a loss of power, would apply to a major natural disaster, he said.

The Obama administration, along with many pro-nuclear lawmakers, has stood by its support for nuclear power despite the disaster in Japan.

Nuclear industry officials, who have blanketed Washington in the days since the earthquake and tsunami in Japan, have cautioned lawmakers against condemning nuclear power in light of the crisis, advocating a go-slow approach.

Many Democrats, in contrast, are saying the nation should rethink nuclear power. They argued on Wednesday that lawmakers need to be able to reassure their constituents that nuclear energy is safe and said they cannot do that right now given the crisis in Japan.

"We also have a responsibility to our constituents," Boxer said. "I can't really look them in the eye and say never."

Boxer and Sen. Dianne Feinstein (D-Calif.) sent a letter to Jaczko on Wednesday calling for an "immediate inspection" of two nuclear power plants in the state.

Lautenberg said Wednesday that it may be necessary to shut down certain reactors in order to conduct adequate safety inspections.

"This fire alarm has now gone off, and it's screeching for help," Lautenberg said.

Sen. Tom Carper (D-Del.) echoed Lautenberg's concerns.

"Everything I do I know I can do better. The same is true for the nuclear power industry," Carper said.

The disaster in Japan could be an "opportunity to look at every one of our 104 facilities, starting with the ones that would be most at risk if we had a tsunami," he said.

Sen. Bernie Sanders (I-Vt.) pressed Jaczko on whether the NRC would relicense nuclear power plants that have similar designs to those facing a meltdown in Japan.

"I don't want to speculate right now about whether we'd license any particular design," Jaczko said. "We don't have detailed information about what caused the problem in Japan."

Japan's Crisis Intensifies Debate: Is Nuclear Worth It? (MCT)

By Rob Hotakainen And David Lightman, Mcclatchy Newspapers

McClatchy, March 17, 2011

WASHINGTON — As the six-day nuclear crisis worsened in Japan on Wednesday, China announced it was suspending construction to rethink its designs for nuclear plants, following the lead of Switzerland and Germany.

In Washington, Energy Secretary Steven Chu, a big proponent of nuclear power, told Congress that the Obama administration wants money to help power companies build from six to eight new plants in the US

And opponents of nuclear power were busy arguing that the health risks facing Japanese citizens are much worse than the public is being led to believe.

They're all examples of a debate rekindled by the frightening blasts at the Fukushima Daiichi nuclear complex in Japan: For the first time since the nuclear disasters at Three Mile Island and Chernobyl, people around the globe are trying to figure out the pros and cons of nuclear safety.

Committees are meeting on Capitol Hill, with politicians demanding answers. And experts on all sides are offering their views. Such a roiling debate, combined with escalating costs, stopped the industry cold in America three decades ago.

Now comes the question: Is the potential catastrophe in Japan making this debate any different? Or will President Barack Obama's view that nuclear power is needed to combat climate change be enough to change the dynamics?

The debate intensified Wednesday as the US urged all Americans living within 50 miles of the damaged plant in Japan to evacuate. And the chairman of the Nuclear Regulatory Commission said Japan faces an increasingly dangerous situation.

Opponents are seizing the moment — but Washington lawmakers have been reluctant to promise any change in policy.

Senate Commerce Committee Chairman Jay Rockefeller, D-W.Va., for instance, noted that while he's "not a big fan of nuclear power . . . We don't make (decisions) out of emotion; we don't make them because of a catastrophe in another country. So before we make the decision, let's be thoughtful about it."

Nevertheless, foes of nuclear power pushed hard.

In a conference call with reporters, Ira Helfand, past president of the Physicians for Social Responsibility, said a meltdown of each reactor at Japanese plant would be the equivalent of "a thousand Hiroshimas."

He said that people living as far away at Tokyo are at risk, and that any assurance that the total dose of radiation is low "needs to be taken with a grain of salt." He said that people could be susceptible to cancers if they inhale or ingest just a small dose of radiation, even if they're far away from an exploding reactor.

"No dose is safe," he said.

"It's an extremely serious situation," added David Richardson, an associate professor of epidemiology at the University of North Carolina.

Most health officials say there's no health risk to Americans, because any radioactive material would disperse by the time it reached the West Coast.

And Marvin Resnikoff, a nuclear physicist and an international consultant on radioactive waste issues, said it would take from five to eight days for any radioactive material to get across the ocean.

"This is going to be a continual problem for months," he noted.

Chu went to Capitol Hill for the second consecutive day to sell the president's plan, which seeks $36 billion in loan guarantees for new power plants as part of the White House's 2012 budget.

He dismissed a suggestion by Democratic Rep. Henry Waxman of California that Congress needs to hold hearings on the safety of the industry, saying an internal assessment will "naturally occur" as US officials study what went wrong in Japan.

"We're always increasing the safety of our reactors," Chu said.

While the $36 billion would pay for six to eight nuclear plants, Chu said the White House hopes for the industry to have enough confidence that the private sector would then step in and pay more of the costs.

He said the administration hasn't changed its thinking on nuclear power since the crisis in Japan began unfolding.

Most lawmakers aren't eager to pursue policy changes, either. While they want more information about the safety of nuclear power in the US, and are proposing more hearings, most stopped short of proposing any legislation.

"I don't think there should be a mad rush to say nuclear power generation is bad. I think we need a timeout and take a look at it," said Senate Majority Leader Harry Reid, D-Nev. "And I'm sure we'll have the experts tell us some things we could have done better."

Senate Republican leader Mitch McConnell, R-Ky., took a similar view. "I just don't think we ought to, in the wake of a crisis, be making long-term decisions about America's energy sufficiency."

Part of their dilemma is that a lot of lawmakers have nuclear plants in their districts and states, plants that have long operated efficiently and provided much-needed power — with no emissions. About 20 percent of the country's electricity is generated by nuclear plants.

House Minority Whip Steny Hoyer, D-Md., who calls himself a "strong supporter of nuclear power" and has a nuclear plant in his southern Maryland district, was also circumspect.

"I think (the Japan crisis) is a wake-up call to look very seriously at the safety of (nuclear) reactors," he said, "to make sure that they are, in fact, as secure as we can possibly make them from natural disasters, as well as manmade attacks on them."

As a result, Reid said, "There will be some activity, some hearings. I think there's nothing wrong with that as it relates to nuclear power. But I think the main issue is let's not be rambunctious. Let's take our time."

Meanwhile, Sen. Patty Murray, D-Wash., the chairwoman of the Senate Veterans' Affairs Committee, urged the military to carefully track radiation exposure for US service members who are aiding in the Japanese relief efforts.

She said that 17 military personnel who had been aboard three helicopters were exposed to low levels of contamination when they flew through a plume of radioactive contaminants.

In the past, Murray said, the military has had a "track record of failing to monitor exposures," which has made it difficult for previous generations of veterans to receive benefits.

(Tom Lasseter contributed to this article from Beijing.)

At California Nuclear Plant, Emergency Response Plans Don't Include Earthquakes (HUFFPOST)

By Chris Kirkham

Huffington Post, March 17, 2011

As the world's attention remains focused on the nuclear calamity unfolding in Japan, American nuclear regulators and industry lobbyists have been offering assurances that plants in the United States are designed to withstand major earthquakes.

But the Diablo Canyon nuclear plant, which sits less than a mile from an offshore fault line, was not required to include earthquakes in its emergency response plan as a condition of being granted its license more than a quarter of a century ago. Though experts warned from the beginning that the plant would be vulnerable to an earthquake, asserting 25 years ago that it required an emergency plan as a condition of its license, the Nuclear Regulatory Commission fought against making such a provision mandatory as it allowed the facility to be built.

Officials at Pacific Gas and Electric Company, the utility that operates Diablo Canyon, did not respond to calls seeking comment before the story was published. After publication, a spokesman for the company said the plant does have an earthquake procedure that had been implemented during a 2003 earthquake near the facility, and that staff are trained to respond. The company did not provide further details upon request.

As Americans absorb the spectacle of a potential nuclear meltdown in Japan -- one of the world's most proficient engineering powers -- the regulatory review that ultimately enabled Diablo Canyon to be built without an earthquake response plan amplifies a gnawing question: Could the tragedy in Japan happen at home?

Experts who recall how the California plant came to be erected offer a disconcerting answer: Yes. And some are calling for more urgent government action to review safety at nuclear plants across the country.

"What they're displaying now is exactly what was wrong in the past with the nuclear establishment, which is that they didn't have their priorities right," said Victor Gilinsky, who served on the Nuclear Regulatory Commission during the Diablo Canyon debate and agreed with the call for greater attention to earthquakes in emergency plans. "They're more concerned about the protection of the plants, and installation of further plants, than they are about public safety. The president should be saying, 'I want every single plant reviewed.'"

Back when the California plant was being finalized in the mid-1980s, local activists and environmental lawyers sued the Nuclear Regulatory Commission in an effort to slow the project, arguing that the clear risks from earthquakes nearby required additional planning.

The case made its way to the US Court of Appeals in Washington, D.C., where a 5-4 majority -- including current Supreme Court Justice Antonin Scalia and former Clinton independent counsel Kenneth Starr -- ruled that earthquakes did not have to be included in the plant's emergency response plans.

The underlying theory was that the plant's design, which came after years of planning and geological studies, could withstand any foreseeable earthquake in the area -- the same assumption that guided thinking in Japan.

"What they're saying is that there could be an earthquake, but in no way could it ever cause a radioactive release at the same time," said Rochelle Becker, who led the San Luis Obispo, Calif., group that first sued the Nuclear Regulatory Commission over earthquake preparedness in the 1980s. "I'm pretty sure we now have evidence that it does."

A spokeswoman for the Nuclear Regulatory Commission confirmed that the Diablo Canyon plant is not required to have an emergency response plan for earthquakes because the commission is satisfied that the plant's structure will be able to withstand an earthquake in the area -- calculated as a maximum magnitude of 7.5.

But officials at Tokyo Electric Co., the operator of Japan's stricken Fukushima Daiichi plant, said over the weekend that the strongest earthquake they had anticipated was much lower than the magnitude-9.0 quake that struck last Friday.

"That's a lesson that we ignore at our own peril, because we could be wrong, too," said Joel Reynolds, the attorney who originally brought the case against the Nuclear Regulatory Commission and who is now a senior attorney with the Natural Resources Defense Council in California. "It is a story as old as science that we're always learning new things. We're always discovering the unexpected."

Critics have raised particular questions about how a standard emergency response to a nuclear disaster could be complicated if it had been caused by an earthquake, where roads and other surrounding infrastructure would also be impaired.

So far, the commission has not specifically recommended any changes to safety regulations or emergency response procedures at nuclear plants in the United States.

"All our plants are designed to withstand significant natural phenomena like earthquakes, tornadoes and tsunamis," the commission's chairman, Gregory B. Jaczko, said earlier this week. "We believe we have a very solid and strong regulatory infrastructure in place now." He added that the commission would "continue to take new information and see if there are changes that we need to make with our program."

Michael Mariotte, the executive director of the Nuclear Information and Resource Service, a group critical of the nuclear industry and the regulatory process, said the pushback on response planning reflects an environment where the industry is helped along by regulators.

"That's the logic behind a lot of our nuclear regulation, unfortunately, is that it's designed to accommodate the operation of a plant, and not necessarily the protection of the public," Mariotte said. "If they acknowledged that an earthquake occurred that damaged the plant, then they're also acknowledging that an earthquake has damaged the transportation infrastructure, that you can't get people out properly, that the plant doesn't work, and then it can't be approved."

At the time the Diablo Canyon case was being litigated in the mid-1980s, the Nuclear Regulatory Commission and the electric utility looking to build the plant had been dealing with more than a decade's worth of federal and state reviews for the facility. Federal regulators were comfortable with their seismic reviews of the remote coastal area between Los Angeles and San Francisco.

Comments made during closed meetings, later released to the public, showed that some NRC commissioners were concerned that additional public hearings surrounding the emergency response plan and earthquakes would slow the process further.

"One of the things that I think makes me shy away often from hearings is because as soon as we hear the word 'hearing,' you see so much time elapse that it maybe over-influences one," then-NRC Chairman Nunzio J. Palladino, who has since passed away, said at the time. "I do feel that at this late stage, requiring a delay while we wait for a hearing is not in the best national interest."

When the case involving earthquake response was eventually litigated all the way to the federal appeals court in D.C., which ultimately sided with the Nuclear Regulatory Commission, the five-member majority noted that there had already been extensive review of seismic activity around the plant.

"We can think of no potential natural or unnatural hazards, regardless of their improbability, that the Commission would not be required to consider," failed Reagan Supreme Court nominee Robert Bork wrote in an opinion for the appellate court. "That is a prescription for licensing proceedings that never end and plants that never generate electricity."

The four dissenting judges, including current Supreme Court Justice Ruth Bader Ginsburg, noted: "The very purpose of the exercise is to plan for the unthinkable eventuality that the design safeguards will not prevent an accident."

"It defies common sense to exclude evidence about the complicating effects of earthquakes from a proceeding dealing with how to respond to a nuclear accident at a plant located three miles from an active fault, a plant in which seismic concerns dominated the design and construction proceedings for well over a decade," the justices wrote.

In recent years, the utility that operates Diablo Canyon, Pacific Gas and Electric Company, has recently found another fault line less than a mile from the plant after conducting research with the US Geological Survey. The plant's original design had accounted for a fault that was farther offshore -- about three miles from the plant.

The spokeswoman for the Nuclear Regulatory Commission, Lara Uselding, said the utility has not found evidence that the newly discovered fault line would pose a risk to the plant. The commission is currently reviewing the company's geological report. Subscribe to the HuffPost Money newsletter!

Japan Crisis Puts Spotlight On Reactors In US (WSJ)

By Rebecca Smith

Wall Street Journal, March 17, 2011

Full-text stories from the Wall Street Journal are available to Journal subscribers by clicking the link.

Japan Quake Puts Spotlight On Aging US Nuclear Reactors, Cost Of Building New Ones (WP)

By Jia Lynn Yang And Steven Mufson

Washington Post, March 17, 2011

One day before the nightmare began at the Fukushima Daiichi nuclear plant in Japan, a reactor in Vermont with the same decades-old design was getting a big thumbs-up from US regulators.

The 38-year-old Vermont Yankee plant, which state lawmakers say is well past its prime, has an operating license that is set to expire next year. Last Thursday, the Nuclear Regulatory Commission (NRC) agreed to add 20 more years to the life of the plant.

This is the state of nuclear energy in this country, where the average plant was built in 1980 and the cost of launching new reactors — and, industry executives say, safer ones — remains prohibitively high. The United States, which relies on nuclear power for 20 percent of its electricity, is leaning more heavily than ever on the first generation of plants built decades ago, even as critics worry that aging reactors have some dangerous weaknesses.

Aging plants are not necessarily failing plants. US nuclear facilities have less down time than they did a decade or two ago.

But safety issues have come under scrutiny as workers in Japan try to fend off a nuclear meltdown at the Fukushima Daiichi plant, whose reactors were designed by General Electric in the 1960s. Over the years, some experts have pointed out flaws in two critical components unique to GE's design: the placement of spent fuel rods above the reactor and the strength of the reactor's containment vessel. These issues, some experts worry, could now be creating problems for the Japanese.

<b/>GE defends its model, calling the Boiling Water Reactor Mark 1 "the industry's workhorse." Out of 105 reactors in the United States, 23 are BWR Mark 1s. The two oldest — Oyster Creek in New Jersey and Nine Mile Point in New York — began operating in 1969. Utility companies running the reactors with the Mark 1 design insist that they are built to last and that many components have been replaced over the years.

The NRC has renewed licenses for 17 of these reactors and 62 altogether; it has rejected none. All reactors were originally granted 40-year licenses when they began operating, and the renewals are for 20 years.

'Arbitrary' time frame

"There was nothing magic about the 40-year span," said Peter Bradford, a former NRC commissioner. "It wasn't as though somebody said, from an engineering standpoint, 'What's the year after which the plants will start to fall apart?' The 40 years was arbitrary to begin with."

Scott Burnell, a spokesman for the NRC, said that when Congress passed the Atomic Energy Act of 1954, which gave the commission authority to hand out licenses, lawmakers were less concerned with engineering than with blocking companies from developing monopolies in their markets.

The NRC said that regulators are constantly monitoring the plants and that a renewal does not give a reactor free rein to operate more loosely.

"If it's capable of running for 40, we can tack on 20 and then consider things from there," Burnell said.

The NRC said renewal hinges on how a plant affects its surrounding environment and on the condition of its aging equipment.

Sometimes it demands costly changes. Exelon has decided to close down the 42-year-old Oyster Creek nuclear plant after regulators requested that it install new cooling towers. The company also cited low electricity demand and the prospect of large capital expenditures. It will close the plant in 2019, 10 years before its license extension runs out.

After the Three Mile Island accident in 1979, regulators examined all reactors for their ability to withstand severe hydrogen gas leaks and required Mark 1 plant operators to add venting stacks to make the reactors safer in case of a severe accident.

Even when Washington gives the green light, state-level support is usually needed.

In Vermont, Entergy, the owner of the Vermont Yankee plant, has faced fierce opposition from state lawmakers and environmental groups as it seeks a license renewal. In February of last year, the Vermont Senate voted to stop the plant from operating past 2012, based on radioactive leaks and the collapse of a cooling tower in 2007.

Vermont Yankee provides one-third of the state's energy, but opponents of the plant argue that other energy sources are available nearby, including a Canadian utility.

The disagreement between the NRC and the state of Vermont over the license renewal could leave the plant in legal limbo. At any rate, the NRC has said that there will be delays in issuing the license for Vermont Yankee because its staff is busy helping Japanese officials.

Entergy, based in New Orleans, announced in November that it was considering putting Vermont Yankee up for sale.

"We continue to believe Vermont Yankee can continue providing the people of Vermont clean, safe, reliable power for another 20 years," said Michael Burns, an Entergy spokesman.

Ripples from Japan

Japan's crisis is giving people pause far beyond Vermont, threatening efforts by utilities to build new facilities.

Just a week ago, Duke Energy was optimistic about getting the North Carolina legislature to approve a measure that would have sharply reduced the financial risks of its plan to build a nuclear plant in Lee, S.C. The measure would allow Duke to charge customers for building costs before completing the project.

But Tuesday, Duke chief executive James Rogers got a grilling from the North Carolina Utilities Commission, and the legislation was put on hold.

A similar bill in Indiana also hit a snag this week. A report in a Platts newsletter said that state Senate President David Long (R) urged his colleagues to "take a deep breath" and watch events in Japan before proceeding with the measure.

In Texas, a San Antonio municipal utility on Tuesday suspended talks with NRG Energy over a deal to purchase future electricity supplies from a proposed nuclear power plant in south Texas. NRG, considered a leading candidate for the next chunk of federal loan guarantees for nuclear plants, wants to expand its nuclear capacity at a facility about 90 miles southwest of Houston.

Last year, NRG signed a deal that made Tokyo Electric Power Co., owner of the stricken Japanese plants, a minority partner in the project. Tepco, burdened with costs at Fukushima Daiichi, could face difficulty following through on its pledge to invest as much as $280 million.

Just a month ago, President Obama proposed expanding the government's loan guarantee program from the $18.5 billion allocated in 2005 to $54.5 billion. Earlier he announced conditional approval for a loan to a Southern Co. plant in Georgia.

Even before the Japanese crisis, the much ballyhooed "nuclear renaissance" ran the danger of being stillborn. The discovery of economic ways to tap into vast reserves of natural gas locked in shale rock has lowered the price of natural gas.

Exelon, the nation's biggest nuclear utility, with 17 plants, estimates that new nuclear plants are more expensive than any other energy source except photovoltaic cells.

"Neither new nuclear, coal with carbon capture and sequestration, wind nor solar are economic," John Rowe, chief executive of Exelon, said in a speech last week. "They are not economic because of energy prices, an excess of generating capacity and very low load growth."

Aneesh Prabhu, an analyst at Standard & Poor's, estimates that natural gas would have to be more than 50 percent more expensive than it is today before building a new nuclear power plant would make clear economic sense.

The Japanese crisis just adds another degree of difficulty. A lot of utility executives are asking: If the United States isn't building new nuclear plants and is nervous about extending the life span old ones, how will the country generate enough electricity?

"Clearly costs are going to rise, and what we're focusing on is the licensing renewals for existing plants and costs for existing plants," said Steven J. Dreyer, managing director of US utilities, power and project finance at Standard & Poor's. "This may be the final nail in the coffin for new nuclear development at least in the near term."

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Too Soon To Write Off Nuclear Power (WP)

Washington Post, March 17, 2011

FIRST CAME an earthquake so powerful that it shifted Japan's largest island, Honshu, eight feet eastward. Thirty minutes later a tsunami washed away thousands of lives. Now, a third disaster threatens as technicians desperately try to keep the Fukushima Daiichi nuclear power station from releasing radioactive material.

During all of this, the Japanese people have reacted with fortitude. In a rare television appearance, the emperor asked Japanese to "hand in hand, treat each other with compassion and overcome these difficult times." That seems to be exactly what they are attempting; and the skeleton staff at Fukushima Daiichi is taking on more than its share, only briefly evacuating the site after detecting a radiation spike on Tuesday, then returning to continue cooling the reactors.

Though the reactors are shut down, they are still producing immense quantities of heat. It doesn't appear that catastrophic levels of radiation have leaked from the plant's thick containment barriers, but US officials still have few details. The next few days will be critical.

On this side of the Pacific, the crisis has reinvigorated a debate on nuclear safety. Opponents of atomic power say this crisis proves that the risks can never be eliminated. That's true. There will always be challenges that designers don't fully anticipate.

Yet Energy Secretary Steven Chu insisted Wednesday that he and President Obama want to retain nuclear energy as an option, and they have good reason to do so. Generating electricity carries risks, no matter how you do it. Burning fossil fuels pumps harmful gases and particulates into the air every day, causing respiratory illness and cancer in thousands. People die in explosions of coal mines, oil drilling rigs and natural gas pipelines. Unlike nuclear energy, burning fossil fuels contributes to the gravest environmental threat of our time — climate change, which is likely to affect not thousands or millions of people, but billions.

Nuclear accidents pose a uniquely frightening danger: the prospect, in a worst case, of large swaths of territory being poisoned and uninhabitable for decades or longer. Mr. Chu and Nuclear Regulatory Commission Chairman Gregory B. Jaczko are right to have the government closely examine what happens in Japan and adjust US policy as necessary. But the Fukushima plant is old. New plants would use more sophisticated technology, such as small-scale high-temperature gas reactors that use fuel in forms that shrink the risk of meltdown further still. A proposed nuclear plant in Georgia would not require backup power in order to activate emergency cooling systems.

Events in Japan will affect the "nuclear renaissance" to some extent, no matter what Mr. Chu or anyone else says, and all the more if the damage is not contained. Our thoughts, as ever, are with the Japanese people struggling to cope; beyond that, it is too soon to form broad and absolute judgments on relative risks.

US Takes Conservative Approach In Response To Nuclear Crisis In Japan (WP)

By Peter Wallsten And Dan Eggen

Washington Post, March 17, 2011

In sharp contrast to governments across the world that are moving to warn their citizens in Japan about radiation hazards and to reassess their own nuclear power programs, the Obama administration is pursuing a cautious course - standing firmly behind the US nuclear industry.

As France and Germany advised their citizens to leave the Tokyo metropolitan area, the United States urged Americans to move beyond a 50-mile radius of the damaged Fukushima Daiichi plant. That's farther than the 20-mile buffer imposed by the Japanese government, but short of an evacuation of the country.

And as governments from Berlin to Beijing this week were closing older nuclear plants for inspection or halting new permits, Obama administration officials reiterated support Wednesday for keeping nuclear power as a key part of US policy and said there were no plans to shut down plants.

In recent days, White House officials have said that the US program, with 104 plants, is safe and that the independent Nuclear Regulatory Commission monitors every facility.

Testifying on Capitol Hill, Energy Secretary Steven Chu told House members that the federal budget called for new nuclear plants. "That position hasn't been changed," he said.

The approach underscores the prominent role that nuclear power has played in President Obama's broader energy agenda. He has called for investing in a range of energy sources - including wind, solar and nuclear power - in addition to oil to increase US energy independence and reduce carbon emissions. As part of his 2012 budget request, Obama is seeking $36 billion in additional loan guarantees to help jump-start the costly process of building new nuclear plants.

But the administration's stance also highlights the political challenges Obama confronts as he deals with energy policy. Republicans and many Democrats, eyeing rising gas prices, are pushing for more oil drilling in the Gulf of Mexico and elsewhere, in addition to a stepped-up commitment to nuclear energy. At the same time, in the wake of the gulf oil spill and as the Japan crisis unfolds, the White House faces pressure from many on the left to restrict drilling and rethink nuclear power.

Sen. Barbara Boxer (D-Calif.), questioning an NRC official in a Senate hearing, wondered about the response in the European Union, which has announced plans to test its plants for emergency preparedness.

"I would very much like to know why those respected allies of us have taken that action" while the United States has not, Boxer said.

Industry lobbyists said they were pleased with the administration's reaction, suggesting that moving too quickly to halt building plans or interfere with plant operations would create more problems than it would solve.

NRC Chairman Gregory Jaczko said Monday that the agency "will always take whatever steps are necessary to ensure the safety and security of nuclear power plants in this country." He said that "right now, we believe we have a very strong program in place." Since then, some critics have tried to apply more pressure.

Rep. Edward J. Markey (D-Mass.) called for a moratorium on new construction in seismically active areas and for additional safety measures at existing plants. Another Democrat, Sen. Richard Blumenthal of Connecticut, sent a letter to the NRC asking whether the United States can learn lessons from the Japan disaster. Blumenthal wrote that the crisis has "raised concerns - expressed to me by Connecticut residents - about whether a similar problem could occur in the United States."

The Union of Concerned Scientists plans to issue a report Thursday assessing 14 "near misses" last year at US nuclear plants and is urging the Obama administration to reconsider its stance.

"To run around and basically say this can't happen here and we need to move forward is not really the message I would be coming out with right now," said Ellen Vancko, the union's nuclear energy and climate change project manager.

Dave Hamilton, director of global warming and energy programs at the Sierra Club, said that the Obama administration appears trapped by its efforts to use nuclear power to attract Republican support for its energy policies.

"They've made a commitment that they can't just walk away from," Hamilton said. "But I have a hard time believing they will be able to hold to that path as the public continues to be exposed to the hazards of radiation and the limits of this technology. . . . You only think nuclear is a good idea if you really don't think about the risks."

Nuclear Agency Tells A Concerned Congress That US Industry Remains Safe (NYT)

By Matthew L. Wald

New York Times, March 17, 2011

WASHINGTON — Facing questions about the implications of Japan's nuclear catastrophe for power plants in the United States, the Nuclear Regulatory Commission's top official said Wednesday at two Congressional hearings that his agency would take a methodical look at Japan and incorporate lessons from the disaster.

The pledge from the official, Gregory Jaczko, the commission's chairman, drew praise and criticism that was often consonant with a lawmaker's political position on nuclear power and other forms of energy.

"US nuclear facilities remain safe," Mr. Jaczko told two House Energy and Commerce subcommittees, which had originally planned to consider his agency's budget for the coming fiscal year at the hearing. "We will continue to work to maintain that level of protection."

Reactors are designed to meet the challenges of "the most severe natural phenomena historically reported," he said. For earthquakes, that means any that occur within 200 miles of the reactor, and a margin of error, he said.

While it remains unclear if the crisis at Fukushima will be as serious as the Chernobyl nuclear plant explosion in Ukraine in 1986, it will have much more direct implications for the American civilian power plant industry. At the time of the accident in Ukraine, then ruled by the Soviet Union, the United States had only one reactor that remotely resembled the Soviet one, and it was soon closed.

Yet a score of reactors in this country are very similar to the ones in Japan.

Some members of the committee seemed satisfied with Mr. Jaczko's replies and turned to a variety of other energy questions. "I personally believe that nuclear energy must be part of any portfolio of renewable energy sources that will fuel this country moving forward," said Representative Bobby L. Rush of Illinois, the ranking Democrat on the Subcommittee on Energy and Power of the House Energy and Commerce Committee.

On the Senate side, Barbara Boxer, the California Democrat who is chairwoman of the Environment and Public Works Committee, told Mr. Jaczko that his agency should consider shutting down some older plants until more was known about the shortcomings of the reactors in Japan and the dimensions of the crisis. "I'm looking at you for more leadership than I've gotten," she said.

The secretary of energy, Steven Chu, took a position similar to Mr. Jaczko's in testimony at the House hearing. "We are going to be looking very, very closely at the events happening in Japan and take those lessons," he said.

"You can be assured, with the Nuclear Regulatory Commission leading, but the Department of Energy providing any assistance, to look again at the current, existing nuclear power plants and any that are being considered."

Representative Joe L. Barton, Republican of Texas, badgered Dr. Chu on whether the administration still favored federal help for new reactors. Dr. Chu gave a professorial answer, but Mr. Barton cut him off and cornered him into whittling his response down to one word, "yes."

"That's what I wanted you to say," Mr. Barton said.

Representative Henry A. Waxman, Democrat of California, was not satisfied.

"We do have a problem that now, so much of our eggs are in the nuclear basket," he said, referring to the nation's reliance on nuclear power for roughly 20 percent of its electricity.

"After Chernobyl, many said such an event could not happen in the US, because the Soviet Union's nuclear sector was not as advanced as our own," Mr. Waxman said. "But Japan is a highly developed country. It is as technologically sophisticated as us, and there's much concern in the US that a similar accident could here."

Representative Edward J. Markey, Democrat of Massachusetts, renewed calls for delaying the licensing of a new reactor, the Westinghouse AP1000, until everyone was satisfied about its ability to perform in earthquakes.

Last month the Nuclear Regulatory Commission signaled that it was moving toward approving the reactor design, which would be deployed for projects like an expansion of Plant Vogtle in Georgia, where holes have been dug for two AP1000 reactors.

Mr. Jaczko tried to explain to the House committee that his agency did not require reactors to be designed to meet an earthquake of a certain magnitude, but rather the likely ground-shaking motion at their locations. He demonstrated by filling a glass half full of water and thumping his hand on the table to make the water move.

Representative Lois Capps, a California Democrat, complained that the commission had stopped short of considering the possibility of near-simultaneous catastrophes, like an earthquake and a tsunami. "We have just witnessed an earthquake, a tsunami and a meltdown," she said.

Radiation Levels 'Extremely High' At Fukushima Plant -- NRC Chairman (EEPM)

By Hannah Northey

E&ENews PM, March 17, 2011

The Nuclear Regulatory Commission chairman painted a grim picture of the nuclear crisis at Japan's crippled Fukushima Daiichi power plant for a House subcommittee today.

While conceding his agency has "limited information" about what is happening at the plant, Chairman Gregory Jaczko told lawmakers the commission believes "core cooling is not safe at" Unit 2 and is concerned about falling water levels in the spent fuel pool.

At Unit 3, he said, the spent fuel "integrity has been compromised." And at Unit 4, the situation was more dangerous following a hydrogen explosion, Jaczko told the Energy and Power Subcommittee.

"We believe that secondary containment has been destroyed, that there is no water in the spent fuel pool, and we believe that radiation levels are extremely high" and that could hinder operators' efforts, Jaczko said.

After prompting by lawmakers, the NRC chief said elevated radiation readings at one spent fuel pool "would be lethal within a short period of time."

NRC has sent at least 11 experts with knowledge of boiling water reactors to Japan, he said, and reaffirmed the agency's earlier stance that the United States would not experience dangerous levels of radioactivity from the power plant hit by a tsunami after a mammoth earthquake Friday. But NRC has advised Japanese officials to evacuate people from a larger area around the reactor.

Lawmakers peppered the chairman with site-specific questions on the safety of plants and whether US reactor proposals -- including license extensions for existing power plants and 12 applications for 20 new reactors -- could withstand the impacts of earthquakes, tsunamis, tornadoes or other natural disasters.

Jaczko said NRC is not planning on changing its approach to permitting new applications but will incorporate any findings from the unfolding disaster in northeast Japan. Those findings, he said, could generate additional costs for the agency, which he said may need to return to Capitol Hill to request new funding.

The chairman spoke in the wake of another hearing today at which Energy Secretary Steven Chu asserted that the Obama administration is firmly supporting the continued licensing of nuclear power plants, as well as its ongoing request for nuclear loan guarantees of $36 billion in its fiscal 2012 budget request (Greenwire, March 16).

Jaczko defended the president's fiscal 2012 budget request, including more than $1 billion for the nuclear reactor safety program and nuclear materials and waste safety programs. Those funds allow the agency to oversee the country's 104 nuclear reactors and 31 research and test reactors and to conduct rulemakings and inspections.

NRC is also asking for more than $279 million for new reactors, an increase of $12.5 million, for licensing and inspecting new projects, including 15 combined licenses and two new combined license applications.

Nuclear Regulator Says US Plants Safe (ASBPP)

By Raju Chebium

Asbury Park Press, March 17, 2011

WASHINGTON — Added safety measures US nuclear plants were required to adopt after the Sept. 11, 2001, terrorist attacks would help prevent catastrophic problems like the ones Japan is grappling with, the top federal nuclear regulator told Congress this afternoon.

Gregory B. Jaczko, chairman of the US Nuclear Regulatory Commission, said the government required nuclear plants to keep emergency equipment on the premises, build backup power systems and have enough coolant available to cool down the reactors and prevent meltdowns.

Those and other adaptations made over the past few decades should help US nuclear plants withstand cataclysmic events like the earthquake and tsunami that struck Japan last week, Jaczko said.

The US government will study what went wrong in Japan to modify domestic response strategies in the case of nuclear accidents, he added.

"We want to get hard facts from Japan," he said in response to questions from Sen. Frank Lautenberg, D-N.J. "We don't have detailed information about what exactly caused the problems in Japan. We don't know what systems were disabled and why they were disabled."

During a briefing Jaczko provided to the Senate Environment and Public Works Committee, Lautenberg said he was worried by news that harmful radiation appears to have spread 50 miles from the Fukushima Daiichi Nuclear Power Plant in northern Japan. Millions of New Jerseyans live within 50 miles of the Oyster Creek Generating Station in Lacey Township.

Blog; Open Channel - Gov. Cuomo Orders Review Of N.Y. Reactor After Report On Quake Data (MSNBC)

By Bill Dedman

MSNBC, March 17, 2011

New York Gov. Andrew Cuomo ordered a safety review of the Indian Point nuclear plant just up the Hudson River from New York City, after one of its reactors ranked first for risk of damage from an earthquake in a study published Wednesday.

The report by msnbc.com was based on damage estimates for 104 commercial nuclear power plants from the Nuclear Regulatory Commission, the federal agency that supervises the industry. The highest risk of damage from an earthquake, according to the NRC's data, was at Indian Point's reactor No. 3, which the NRC said had a 1 in 10,000 chance each year of damage to its radioactive core from an earthquake. The plant lies near the Ramapo Fault zone.

"We are going to check into it ... immediately," Cuomo, the state's new Democratic governor and former attorney general, told WNBC TV in New York. "This plant in this proximity to New York City was never a good risk. But this is new information we are going to pursue."

Cuomo told WNBC that he discussed the issue with leaders of the state Senate and General Assembly in a closed-door session on Wednesday. It was not immediately clear what sort of review Cuomo plans, or who would conduct it.

The NRC data had been published in August for nuclear power plants in the central and eastern United States, and this week the NRC provided additional data to msnbc.com for the few plants in the western states, allowing msnbc.com to rank the plants by risk. The NRC public affairs staff stressed to all callers on Wednesday that it had not done the rankings, but it did not question the accuracy of the data.

The NRC has emphasized that it believes the risk is low of damage to a nuclear power plant from an earthquake.

"Operating nuclear power plants are safe," the NRC said when it reported the new risk estimates. Every plant is designed with a margin of safety beyond the strongest earthquake anticipated in that area, the NRC says, but the new data on earthquakes show that the margin of safety has been reduced.

The full ranking of 104 nuclear power plants is here.

The Indian Point plant, which has two active reactors, provides up to one-third of the electric power for New York City and suburban Westchester County, N.Y. The plant's second reactor had a lower risk of major damage from a quake, according to the NRC, estimated at 1 in 30,303 each year, still about twice the risk of the typical nuclear power plant. The plant is 24 miles from New York City. Statewide, New York has six commercial nuclear reactors at four plants.

The plant's license is up for renewal. Cuomo, when he was attorney general, said the plant should be closed. In 2007 he called the plant "a catastrophe waiting to happen."

A spokesman for EntergyCorp., the New Orleans company that operates Indian Point, dismissed the possibility of it having troubles like the Fukushima Dai-ichi plant in Japan.

"I say only if a tsunami could make its way ... up New York Harbor and the Hudson River, somehow avoid New York City, and drench our plant," Jim Streets, director of communications at Entergy Nuclear Northeast, told CBS New York on Wednesday. "It just doesn't seem very realistic to me."

The NRC study based its damage estimates on US Geological Survey data for earthquakes, as well as each plant's type of design and construction.

The study was also mentioned at Wednesday's US Senate hearing on nuclear power. Sen. Kirsten Gillibrand (D-N.Y.) read from the article to the NRC chairman, Gregory B. Jaczko. He said he wasn't aware of it.

Cuomo: NY Will Review Safety At Nuclear Plant (AP)

Associated Press, March 17, 2011

Full-text stories from the Wall Street Journal are available to Journal subscribers by clicking the link.

NRC: Shippingport Reactor 5th Of 10 Riskiest US Plants (PITTR)

Shippingport reactor 5th of 10 riskiest US plants

By Thomas Olson

Pittsburgh Tribune-Review, March 17, 2011

Pennsylvania is home to three of the 10 US nuclear power plants most vulnerable to an earthquake, including the Beaver Valley plant in Shippingport, according to Nuclear Regulatory Commission data.

The federal agency that oversees nuclear energy evaluates the nation's 104 nuclear power reactors for the chance of an earthquake causing a catastrophic failure each year, based on 2008 and 1989 geological data.

The Beaver Valley 1 reactor in Shippingport ranks fifth-most at risk, with a 1 in 20,833 chance of it suffering reactor core damage during an earthquake, according to data reported Tuesday by msnbc.com.

The power plant is operated by FirstEnergy Corp. in Akron, Ohio. The Beaver Valley 1 nuclear reactor was designed by Westinghouse Electric Co. and came on line in 1976.

"Beaver Valley remains safe and is capable of withstanding at least a 5.8 scale earthquake, which is highly unlikely for this area," said FirstEnergy spokesman Todd Schneider.

"Safety is our top priority. So residents shouldn't be concerned," Schneider said. "If an event did occur, we have an emergency plan to protect the public."

Westinghouse designed the Beaver Valley reactor, as well as five others in the top 10 list of vulnerable reactors. The ratio is not surprising, given that the Cranberry company designed 62 of the 104 nuclear reactors in the United States and roughly 45 percent of the world's 440 nuclear reactors.

Westinghouse spokesmen could not be reached for comment.

The earthquake that struck Japan was initially recorded as magnitude 8.9 but was upgraded Tuesday by the US Geological Survey to a 9.0 event.

The commission assessed earthquake risk to nuclear reactors to "screen for plants needing a further look," said Diane Screnci, spokeswoman for the NRC's regional office in King of Prussia.

"Currently, the operating nuclear power plants in the United States remain safe, with no need for immediate action," Screnci said. The NRC evaluated reactors based on "ground motions" associated with the largest earthquake that could hit a plant's vicinity.

However, handicapping the odds of an earthquake is a difficult science, experts said.

"The longer the period I look at, the more confidence I have in my predictions," said Kent Harries, associate professor of structural engineering mechanics at the University of Pittsburgh, who has studied seismic events and effects on buildings.

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"If you want to predict whether an earthquake will occur this year, your estimate is probably pretty poor," Harries said. "But if you want to predict whether there would be one in the next 30 years, your prediction is probably pretty darn good."

The NRC data show the nuclear reactor most at risk of failure from an earthquake is the Indian Point 3 reactor in Buchanan, N.Y., along the Hudson River, 24 miles north of New York City. Also designed by Westinghouse, the plant stands a 1 in 10,000 chance of failure from an earthquake.

Harries said that a 1 in 10,000 chance in a given year is about the same as a 1 percent chance of an event in the next 100 years.

"There is risk in any human activity. US power plants pose extremely low risk when compared to other activities including dying from heart disease, smoking cigarettes and driving a car," said Tom Kauffman, spokesman for the Nuclear Energy Institute, an industry trade organization in Washington.

America's nuclear reactors operate "with an additional margin of safety" above the standards set in NRC regulations, Kauffman said. The commission used "conservative" analytics to drive risk levels, which are not indicative of a "Fukushima-level accident," he said, referring to the power plant in Japan affected by the country's devastating earthquake and tsunami.

The report stated the third-highest risk was found at the Limerick 1 and 2 reactors at a power plant 21 miles northwest of Philadelphia. They stand a 1 in 18,868 chance of core damage in a quake and were designed by General Electric Co., according to NRC data.

Three Mile Island, the Middletown plant, remembered for a radiation leak and partial core meltdown in 1979, ranks 10th-most at risk. The reactor there was designed by Babcock & Wilcox and stands a 1 in 25,000 chance of suffering core damage in an earthquake.

Each year, the odds are 1 in 74,176 that the typical nuclear power reactor in the United States will experience a catastrophic failure and radioactive leak from an earthquake, according to the msnbc.com report, citing NRC calculations.

Those odds are 10 times better than a person winning $10,000 with a ticket in the Powerball multistate lottery -- which is a 1 in 723,145 chance.

"We, as a society, have to determine what is an acceptable risk," Harries said.

NRC: Limerick Nuclear Plant Is Third-highest Earthquake Risk In US (MONTNWS)

By Evan Brandt

Montgomery (PA) News, March 17, 2011

This map of earthquake risks in the US, updated in 2008 by the United States Geologic Survey, is one reason Exelon Nuclear's Limerick Generating Station was ranked by the Nuclear Regulatory Commission as the nation's third most at risk of being damaged by an earthquake.

View and purchase photos A Nuclear Regulatory Commission study released less than a year ago ranked Exelon Nuclear's Limerick Generating Station as being the nation's nuclear plant with the third-highest risk of being damanged by an earthquake.

The study came about as a result of the US Geologic Survey's 2008 updating of earthquake risks around the country using more sophisticated measurements and modeling than were used in the 1996 and 2002 versions.

As a result of the new data, the NRC has increased the risk of an earthquake damaging both reactors at Limerick by 141 percent, making it the third most at risk, after the Pilgrim Nuclear Plant in Plymouth, Mass., and the Indian Point Atomic Generating Station in Buchanan, N.Y.

The chance of an earthquake damaging the plant has now been raised to 1 in 18,868.

The previous risk rating was 1 in 45,455.

For comparison purposes, as outlined in an MSNBC article, the chance of winning the grand prize in the next Powerball lottery is 1 in 195,249,054.

The study also reveals that of the top 10 nuclear plants most at risk from earthquake damage, three are in Pennsylvania, more than any other state.

The other two are the Shippingport Atmonic Power Station in Shippingort, Beaver County; and the Three Mile Island plant in Middletown, Dauphin County.

This story will be updated as more information is made available.

Oconee Nuclear Station Ranked 8th-highest On List For Quake Risk (ADERSN)

Anderson Independent-Mail, March 17, 2011

ANDERSON — The Oconee Nuclear Station has the eighth-greatest risk of suffering a catastrophic failure from an earthquake among the nation's 66 nuclear power plants, according to the US Nuclear Regulatory Commission.

In any given year, there is a 1-in-23,256 chance of an earthquake damaging the cores of the three nuclear reactors at the Duke Energy-owned plant on Lake Keowee, according to a report that the federal agency released in November.

To put those odds in perspective, consider that a person who buys a $1 Powerball lottery ticket has a 1-in-195,249,054 chance of winning the jackpot.

Last year's report was intended to update the assessment of risks that earthquakes pose to the nation's nuclear power plants. The odds of an earthquake damaging the Oconee Nuclear Station previously had been listed at 1 in 100,000. The new earthquake risk figure represents an increase of 330 percent over the earlier estimate for the plant, which began operating in 1973.

According to the report, Oconee Nuclear Station faces a slightly higher risk of damage from earthquakes than the Diablo Canyon nuclear power plant in Avila Beach, Calif., which has two reactors between the San Andreas Fault and the Pacific Ocean.

Two of the other three nuclear power plants in South Carolina also are in the nation's top 20 in terms of risks for earthquake damage, according to the report.

The V.C. Summer Nuclear Station, which is about 20 miles northwest of Columbia, faces the 12th-greatest risk of earthquake-related damage, with annual odds of 1 in 26,316. South Carolina Electric & Gas Co. is the plant's majority owner.

"Regardless of where a plant lies on the list, there is an extremely low risk for damage to any nuclear plant in the United States," said Rhonda Maree O'Banion, a spokeswoman for Scana Corp., the parent company of South Carolina Electric and Gas. "V.C. Summer Nuclear Station is designed to withstand an earthquake greater in size than the area has ever experienced."

The Catawba Nuclear Station in York, which is owned by Duke Energy, faces the 13th-highest risk of earthquake-related damage, with annual odds of 1 in 27,027.

Duke Energy officials could not be reached for comment Wednesday. But the company's website says each of Duke's nuclear power plants feature designs that protect them from earthquakes and other disasters.

The US nuclear power plant facing the greatest risk of core damage from an earthquake is the Indian Point facility in Buchanan, N.Y., which has an annual risk of 1 in 10,000, according to the report. A nuclear power plant in Fulton, Mo., has the lowest risk of earthquake damage, with annual odds of 1 in 500,000.

While California has a well-known reputation for earthquakes, South Carolina also has a history of seismic activity.

Summerville, which is near Charleston, was at the epicenter of the largest earthquake on the East Coast. That quake, which happened on Aug. 31, 1886, was estimated at 7.0 on the Richter scale. It damaged 2,000 buildings.

Pickens County was the apparent center of an earthquake on Oct. 20, 1924, that shook most of South Carolina, western North Carolina, northeastern Georgia and eastern Tennessee, according to the US Geological Survey.

A moderate earthquake awakened many residents in Anderson on Oct. 20, 1958.

The most recent earthquake in the Palmetto State happened near Summerville on Feb. 25. It measured 1.5 on the Richter scale.

Duke Energy and South Carolina Electric & Gas Co. have proposed building four additional nuclear reactors in South Carolina.

Some experts are warning that the nuclear crisis in Japan could derail efforts to revive the US industry. But a Scana Corp. executive said earlier this week that the company remains hopeful about gaining approval for its plans to add two more reactors to the V.C. Summer Nuclear Station by 2019.

"We remain committed to our new nuclear generation strategy and our intent is to remain on schedule," Scana Corp. President Kevin Marsh said.

US Nuclear Plants Located Near Geologic Faults (AP)

Associated Press, March 17, 2011

LOS ANGELES (AP) — Two years before an immense coastal earthquake plunged Japan into a nuclear crisis, a geologic fault was discovered about a half-mile from a California seaside reactor — alarming regulators who say not enough has been done to gauge the threat to the nation's most populous state.

The situation of the Diablo Canyon plant is not unique. Across the country, a spider's web of faults in the Earth's crust raises questions about earthquakes and safety at aging nuclear plants, amplified by horrific images from Japan, where nuclear reactors were crippled by a tsunami caused by a 9-magnitude quake.

The Indian Point Energy Center, for example, lies near a fault line 35 miles north of Manhattan; on Wednesday, New York Gov. Andrew Cuomo ordered a safety review at the plant.

But none of the questions are more pressing than in quake-prone California, where about 10 powerful shakers — stronger than magnitude 7 — have hit since 1900.

At issue at Diablo Canyon is not what is known, but what is not.

Preliminary research at the site, which sits on a wave-washed bluff above the Pacific, found its twin reactors could withstand a potential earthquake generated by the recently identified Shoreline Fault, just off the coast.

But that hasn't satisfied California regulators. Since late 2008, when the undersea crack was identified, they have pressed plant owner Pacific Gas & Electric Co. to conduct sophisticated, independently reviewed studies that they say are needed to fully assess the danger at a site within 200 miles of Los Angeles.

The recently discovered fault is close to, and might intersect with, another bigger crack three miles offshore, and the fear is the two faults could begin shaking in tandem, creating a larger quake than either fault would be capable of producing on its own.

"We don't yet have a firm idea of the hazard posed by the Shoreline Fault," says Thomas Brocher, director of the Earthquake Science Center at the US Geological Survey in Menlo Park, Calif., who led the team that discovered the fault.

State Sen. Sam Blakeslee, a Republican who holds a doctorate in earthquake studies, wants PG&E to pull back an application to extend the plant's operating license for 20 years until more is known.

"Aging nuclear power plants and large, active fault systems should not be in close proximity. This isn't exactly rocket science," Blakeslee says. Because the Shoreline Fault is so close to the Diablo Canyon plant it "can produce shaking far in excess of what's expected."

The US Nuclear Regulatory Commission and PG&E say the plant is safe and built to withstand a magnitude 7.5 earthquake, the maximum considered possible for the site. Damage from a Japan-like tsunami is unlikely, because the reactors sit on an 85-foot cliff above the ocean and fault structure in the area differs from the Pacific Rim.

Critics around the United States say the government has moved too slowly to assess possible threats from earthquakes.

NRC spokeswoman Lara Uselding said she did not know of a single case in which a US reactor was damaged by a quake. But this does not dispel concerns that may be unavoidable because the study of earthquakes remains an imprecise science. They cannot be predicted, and the damage — as witnessed in Japan — can be catastrophic.

The dangers of earthquakes have been raised repeatedly by opponents of nuclear energy. The Perry nuclear plant, east of Cleveland, lies within 40 miles of two faults; in 1986, a year before the plant opened, a 5.0 earthquake shook the area, but didn't damage the plant, said Todd Schneider, a FirstEnergy spokesman. There have since been less severe quakes.

A citizens group filed suit after the quake, trying to block the plant from opening. They argued that an earthquake greater than the plant was built to withstand was likely to occur in the future; US Supreme Court Justice Antonin Scalia turned down their request.

The plant's design includes piping with shock absorbers intended to prevent breakage in a quake. "Before the plants are even built, there's research done by seismologists and geologists to determine what the maximum earthquake could be," Schneider said. "The plants are designed beyond that."

Indian Point, too, is safe and built to withstand earthquakes, says a spokesman for owner Entergy Nuclear. But earlier this week, Rep. Nita Lowey, D-N.Y., urged the NRC to look closely at the earthquake preparedness there. A 2008 analysis of earthquake activity around New York City found that many small faults that were believed to be inactive could contribute to a major temblor, and that a line of seismic activity comes within two miles of the plant on the Hudson River.

Another fault line near Indian Point was already known, so the findings suggest Indian Point is at an intersection of faults. The environmental group Riverkeeper says seismic studies used to assess safety are decades out of date.

Major earthquakes are rare in the southeast United States, although the region is crossed by the New Madrid fault in the west and a fault near Charleston, S.C. in the east. University of Georgia geologist Jim Wright said although the plate sitting under the southeast is stable it's also rigid, meaning the jolt from an earthquake would carry farther than in a region where the earth's crust has been fragmented by seismic activity.

The Atlanta-based Southern Co. has reviewed seismic activity in the area that could impact the Wayneboro, Ga., site where it has two operating reactors and hopes to build two more. Among the largest known regional earthquakes was an 1886 earthquake that struck Charleston, S.C., about 85 miles from the Plant Vogtle site, according to the company's regulatory filings.

To this day, geologists are divided on exactly which faults caused the earthquake. Southern Co. spokesman Beth Thomas said the company's reactors comply with federal requirements that they be able to safely withstand the strongest earthquake that could be expected in a 10,000-year period. Thomas said the company has not seen anything in Japan to make it alter its current operations.

The Tennessee Valley Authority's Browns Ferry plant, which is located near Athens, Ala., has boiling water reactors similar in design to the malfunctioning reactors in Japan. That plant was designed to withstand a 6.0-magnitude earthquake based on its proximity to the New Madrid fault, TVA spokesman Duncan Mansfield said.

The TVA's Watts Bar nuclear plant at Spring City, Tenn., and its Sequoyah plant at Soddy-Daisy, Tenn., are designed to withstand a 5.8-magnitude quake based on an 1897 tremor at Giles County, Va., Mansfield said. None of the TVA's reactors are seen as being vulnerable to tsunamis since they are so far inland.

Arkansas' only nuclear plant is located about 150 miles away from the New Madrid fault zone, which produced a series of large quakes in 1811 and 1812, including several over magnitude 7. The shaking was so strong that it reportedly caused the Mississippi River to flow backward and could be felt as far away as New England. Arkansas Nuclear One officials said the plant is designed to withstand natural disasters including quakes, has an emergency plan in place, and routinely trains for the worst-case scenario.

Using increasing sensitive technology, scientists are constantly identifying new faults in the country, sometimes after earthquakes are detected. In Southern California alone, there are an estimated 10,000 earthquakes a year, though most of them are too small to be noticed by residents.

The state's senators, Barbara Boxer and Dianne Feinstein, on Wednesday sent a letter to Nuclear Regulatory Commission Chairman Gregory Jaczko, asking that the agency "perform a thorough inspection" of the plants at Diablo Canyon and San Onofre.

A 30-foot concrete seawall surrounds San Onofre, built along the beach in northern San Diego County, where officials say it's strong enough to withstand major quakes and any potential tsunami.

Diablo Canyon, whose reactors began operating in the mid-1980s, has a long history of seismic issues. The discovery of the offshore Hosgri Fault in 1971, after the plant's construction permits were issued, forced a major, costly redesign.

Brocher, the USGS scientist, said scientists do not know how fast the adjacent sides of the Shoreline Fault are sliding, a key measurement to determine potential danger. A higher rate of slippage leads to increased pressure — and a greater chance for an earthquake.

With the two faults in proximity "the uncertainty is ... to what extent they might interact," says Barbara Byron, a senior nuclear policy adviser for the California Energy Commission. Since 2008, the commission has urged the plant to conduct three-dimensional mapping of the Shoreline Fault, using technology employed in oil exploration.

Funding has been approved for the study. In testimony to the NRC last year, she called the plant's seismic data "incomplete ... outdated" and urged a review of its evacuation plans.

Uselding, the NRC spokeswoman, said preliminary reviews found that it's unlikely an earthquake would take place directly under Diablo Canyon, but that potential shaking could cause minor damage to buried piping and conduits.

Diablo Canyon has an extensive seismic monitoring system, ready to detect any shifts in the area. "Potential impacts of the Shoreline Fault fall within all safety margins," company spokesman Kory Raftery said.

To University of Southern California professor Naj Meshkati, an expert on earthquakes and nuclear power plants, the risk is not the massive plant structures but the reliability of backup systems that failed in the Japanese tsunami.

While such a large quake and killer wave is unlikely in California, the plants face similar dangers in backup equipment.

"If someone says this cannot happen here, they should really ... take a very hard look at some of their assumptions," Meshkati said.

Boxer Worried About Nuke Plants Near California Coastal Faults (SSJ)

By Paul C. Barton

Salem (OR) Statesman Journal, March 17, 2011

WASHI NGTON -- Sen. Barbara Boxer chastised federal officials Wednesday for not reviewing a 2008 report that raised concerns about how a seismic event could threaten the safety of 8 million Californians who live within 50 miles of the state's nuclear plants.

The California Democrat accused Nuclear Regulatory Commission officials of lacking interest in an October 2008 report by the California Energy Commission that raised concerns about potential earthquake effects on the Diablo Canyon Power Plant and the San Onofre Nuclear Generating Station. Both are situated near fault lines.

She made the charge at special briefing for the Senate Environment and Public Works Committee on the implications for US nuclear plants of the earthquake and tsunami-generated fires and explosions at Japan's Fukushima Dai-ichi plant.

Boxer, chairwoman of the panel, demanded to know at one point whether NRC officials knew how many people lived within 50 miles of San Onofre in Southern California. Raising her voice, she said, "I'm going to tell you how many: 7.4 million people." Later, she told them 500,000 were living within a 50-mile radius of Diablo Canyon, in Central California.

Fifty miles is regarded as the immediate danger zone for radiation released in a severe nuclear power plant incident.

The California Energy Commission report said more information was needed at both plants to assess how they would hold up in a major earthquake. It said the state had a 99.7 percent chance of a magnitude-6.7 quake or greater occurring in the next 30 years. The quake that hit Japan last week was magnitude 9.

"Right now we don't have detailed information about the accident in Japan," said Gregory B. Jaczko, chairman of the federal panel. But he pledged that the agency would undertake a "systematic and methodical review" of all 55 U. S. nuclear plants, including 104 nuclear reactors.

Japan's nuclear crisis began with Friday's earthquake and the resulting tsunami that struck the country's northeastern coast. The tsunami knocked out backup diesel generators at Fukushima Dai-ichi that are used to pump water over nuclear fuel to keep it cool. Since then, reactors at the plant have been rocked by explosions and have leaked radiation. Technicians at the plant have desperately tried to cool the plant's reactor cores with seawater.

Winds were expected to blow the radiation out to sea Wednesday and Thursday. Some of that radiation could reach the US, but not at harmful levels, experts say.

At least 23 American plants employ a reactor similar to the one in Japan.

Making a proper assessment of lessons for American plants from the Japanese incident "will take a little bit of time," Jaczko said, adding, "We want to get good facts and make good decisions."

Boxer, though, said other countries were already taking steps at their nuclear reactors of the same make and design as the one in Japan.

"I'm not hearing anything proactive" from NRC officials, she said.

Boxer, joined by Democratic Sen. Frank Lautenberg of New Jersey and Independent Sen. Bernie Sanders of Vermont, told Jaczko and his staff that the matter was urgent.

"People tend to think a tragic event will never occur until the day after it happens," Sanders said.

Lautenberg said what's happening in Japan "is scaring the life out of people."

Jaczko said he was confident that American plants had electrical backup if power needed for water cooling was lost. When it comes to electrical power, American plants have "backups of backups," he said.

Administration officials also said Wednesday that there is no reason to worry about the safety of nuclear plants in the US

"The American people should have full confidence that the United States has rigorous safety regulations in place to ensure that our nuclear power is generated safely and responsibly," Energy Secretary Steven Chu told lawmakers at a House

subcommittee hearing. "The administration is committed to learning from Japan's experience as we work to continue to strengthen America's nuclear industry."

Nuclear energy supplies about 20 percent of America's electricity and 70 percent of its electricity from clean, non-carbon sources, according to the administration. Energy officials are seeking up to $36 billion in additional loan guarantee authority in fiscal 2012 to promote nuclear power.

Americans' support for nuclear power has fallen, as 70 percent of those surveyed in a new USA TODAY/Gallup Poll say they've grown more concerned about the industry's safety based on the crisis unfolding in Japan.

Boxer said the Japanese thought their plant could withstand a major quake were got horribly surprised.

She said she wanted immediate inspections of the California plants.

Reactors On Fault Lines Getting Fresh Scrutiny (WSJ)

Critics Ask if Facilities Can Withstand Worst-Case Quakes

By Ben Casselman And Brian Spegele

Wall Street Journal, March 17, 2011

Full-text stories from the Wall Street Journal are available to Journal subscribers by clicking the link.

Rep. Dennis Kucinich Asks Feds To Shut Down FirstEnergy Nuclear Plants (Plain Dealer)

By Sabrina Eaton

Plain Dealer, March 17, 2011

In light of safety problems at Japanese nuclear power plants that have been compromised by natural disasters, Cleveland Democratic Rep. Dennis Kucinich is asking the Nuclear Regulatory Commission to shut down US nuclear facilities run by "bad actors," including Akron-based FirstEnergy.

In a March 16 letter to NRC Chairman Gregory P. Jaczko, Kucinich says Japan's failing nuclear power plants warrant a fresh assessment of US nuclear catastrophe preparedness.

He cites incidents as far back as 1985 at FirstEnergy's Davis Besse nuclear plant near Toledo in claiming that "operators of nuclear power plants with demonstrated poor safety records should not be allowed to continue to put the public at risk."

"This conduct is the product of an inveterate, corrupt culture of long standing deceit and corner-cutting on safety," Kucinich's says of FirstEnergy. "With such an abysmal record, they, and other nuclear power plant operating companies with poor performance records should not be allowed to continue to operate nuclear power plants."

FirstEnergy spokesman Todd Schneider said safety is the company's top priority.

"It's unfortunate that Congressman Kucinich is using the tragic situation in Japan to further his political agenda," said Schneider.

NRC spokeswoman Viktoria Mitlyng said Kucinich has contacted the NRC before about FirstEnergy, and the commission will "respond to this letter as we do to all correspondence from members of Congress."

She said NRC believes US nuclear power plants are built to withstand natural disasters "at the highest possible level, plus a margin," and that FirstEnergy has adequately addressed past safety issues.

"If the NRC didn't have confidence that the plant can be operated safely, the plant would be shut down," Mitlyng said.

Kucinich has a history of enmnity with FirstEnergy that dates back to his days as Cleveland's mayor, when he resisted pressure to sell Cleveland's municipal power plant to FirstEnergy's Cleveland Electric Illuminating Co. subsidiary.

Failures At Fukushima Turn Eyes To Troubled, Proposed Nuclear Plants In Ohio (DCEX)

Washington D.C. Examiner, March 17, 2011

COLUMBUS, Ohio (CGE) - The magnitude 9 earthquake last week off the coast of northern Japan that triggered a tsunami that devastated large swaths of the small country, and created a riveting crisis of four nuclear reactors that are failing by the hour, has turned some Ohioans' attention to the state's two existing but aging nuclear power plants on Ohio's North Coast and a new one proposed for construction in the south close to the Ohio River.

Kucinich to NRC: Sort out bad actors

Ohio Congressman Dennis Kucinich, a long-time outspoken critic of nuclear power plants, intends to ask the Nuclear Regulatory Commission Wednesday to look at the safety of the nation's 104 nuclear power plants "through the prism" of the failing Fukushima nuclear power in northeast Japan that is failing further by the hour. Now the ranking minority member of a subcommittee of the Oversight and Government Reform Committee that he chaired last year that has oversight authority over the

NRC, Kucinich, speaking on MSNBC Tuesday night, said he wants "to make sure all the bad actors in the industry are sorted out quickly" and that nuclear plants with a history of difficulty, including dishonesty by their operators, should be shut down.

Kucinich was referring to what he told the NRC in a 2007 letter were "a number of serious management problems at the Perry facility" owned by FirstEnergy, Ohio's mega-utility whose failure in August 2003 to trim limbs that touched electric wires resulted in 50 million people from Ohio to New York City falling into darkness when their lights went out. Among the management problems Kucinich spoke of were a 2002 finding by the NRC Office of Investigations that concluded that FirstEnergy's application for access was falsified at Perry; that overtime records were deliberately falsified at Perry so as to appear to comply with technical specifications; and that the NRC found "creative timekeeping" at the Perry plant.

Kucinich has called for the shuttering of Ohio's two FirstEnergy-owned nuclear power plants - Davis-Besse Nuclear Power Station, Unit 1 [35 miles NE of Cleveland] and Perry Nuclear Power Plant, Unit 1 [21 miles ESE of Toledo].

Arguing that nuclear power plants are horrendously expensive - recent costs associated with facilities in San Antonio, TX and Canada are between $18-$26 billion - take upwards of a decade to build, are unappealing to Wall Street investors, are susceptible to earthquakes and attacks by terrorist and produce nuclear waste that are difficult to transport and store, Kucinich said the US has a generation of older plants that become more prone to problems the longer they are operated, but which are being pushed further because their owners want to "wring every dime of profit" out of them.

Kucinich, who made news a few weeks back when dental problems from chomping down on a surprise olive pit caused such severe dental work that the cost to repair it ended in a lawsuit that was settled out of court, said the incident in Japan with its now-failed nuclear reactor "should be a cautionary tale" he wants the NRC to heed.

Kucinich recalled an event at Davis-Besse that resulted in a football-sized crater in the reactor vessel that, had it not be contained, would escalated to the magnitude of the incident at Three Mile Island, the nation's worst nuclear event. The Cleveland congressman said a mandated independent assessment into the incident showed FirstEnergy tried to deceive the government about safety violations at its Davis-Besse facility. "Only a slim steel liner stood in the way of radioactive release into the air, which would have jeopardized the safety of millions of residents of the state of Ohio," he wrote in his letter to the NCR.

FirstEnergy draws distinction to Japan crisis

With an elected official like Kucinich calling for a new review of nuclear power plants, especially the two Ohio plants owned by FirstEnergy, it's no surprise that FirstEnergy has a different view. A FirstEnergy spokesman said that while there are similarities between The Fukushima nuclear power plant, now in serious trouble with four of its six reactors leaking radioactive materials, and its Perry plant in Lake County, there are differences, too. Todd Schneider told Dan Haggerty of WEWS news that both plants are boiling water nuclear reactors built by General Electric, with Perry being an evolution from the plants in Japan. Schneider also identified differences, saying the Perry plant has a larger containment unit and underground backup fuel tanks while the Fukushima reactors have above-ground backup fuel tanks, which rushing waters from the tsunami washed away.

A Nuclear Regulatory Commission spokesman told Haggerty that the Perry plant "met all cornerstone objectives," and ranks among the highest scoring nuclear facilities in the US

Sierra Club oppose Davis-Besse license extension

Patricia Marida, chairman of the Nuclear Issues Committee of the Ohio Sierra Club, testified to the NCR against renewing a 20-year extension of FirstEnergy's license to operate Davis-Besse. Speaking on behalf of The Sierra Club, whose policy is to oppose nuclear energy in its entirety based on environmental, health, and public expense issues throughout the nuclear fuel cycle, Marida first noted that use of electricity in Ohio has been decreasing for a number of years. Based on this fact, Marida said a 20-year extension of the Davis Besse operating license is unfounded on the grounds of future electric generating needs.

She argued that the process by which First Energy and the NCR allowed a delay in the inspection of the reactor head in 2002, coming within 1/8 inch of a nuclear disaster that would have left the Midwest uninhabitable and the Great Lakes, the world's largest supply of fresh water, filled with radioactive contamination, "shows that the public should have no confidence whatsoever in the ability of First Energy to self-regulate or in the NRC to rigorously enforce and inspect so dangerous an operation as a nuclear reactor."

FirstEnergy, Marida said, was willing to take these incredible risks simply based on profits. "Not only that, but corporate culture makes it difficult for any one person to buck the system or feel responsible for anything other than following the orders of their immediate superiors," she said in her written testimony.

Duke Energy proposes 3rd nuclear reactor for Ohio?

Ohio's third and newest nuclear power plant, a $10 billion proposal for a facility in Piketon in southern Ohio, about 95 miles east of Cincinnati, is being proposed by Duke Energy, which has about 800,000 electric customers in Greater Cincinnati and Northern Kentucky. The project, announced nearly a year and half ago, could depend on the outcome of the Japanese nuclear crisis, Dan Haggerty of WEWS reported.

Proposed as a public-private initiative, the 1,600 megawatt nuclear plant, to be cited at the former uranium processing facility in Piketon, is part of the Southern Ohio Clean Energy Park Alliance. The proposed Piketon facility would be Ohio's third nuclear power plant and the first since the Perry nuclear plant in Lake County came on line in 1987.

Duke operates three nuclear plants in the Carolinas and is developing a fourth one there. Haggerty said the Ohio project would require other investors to share in the massive costs as well as unspecified changes in state utility law.

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Japan Crisis Casts Pall Over Md. Nuclear Power Expansion (delmarva)

By Marso

Delmarva Daily Times, March 17, 2011

aryland's only nuclear power plant is fundamentally different from the endangered Fukushima plant in Japan, but what's happening on the other side of the world could suppress the public's appetite for more reactors here.

The Fukushima plant, damaged by a 9.0 earthquake and ensuing tsunami on March 11, has six boiling water reactors. Maryland's Calvert Cliffs Nuclear Power Plant, located in Lusby on the southwest coast of the Chesapeake Bay, has two pressurized water reactors. Proposals to add a third reactor stalled in financial negotiations and a French company's bid to take on the expansion now appears even less likely to come to fruition.

"Public opinion has changed in the last couple days," Maryland Comptroller Peter Franchot said.

Franchot said economics are still the biggest obstacle for proponents of a Calvert Cliffs expansion, but the situation in Japan would have a "huge impact on the Nuclear Renaissance" across the country.

Questions about the design of boiling water reactors appear to date back almost to the time Fukushima started operating in 1971. The Center for Public Integrity reported March 15 that in 1972 Stephen Hanauer, a senior member of the Atomic Energy Commission staff, said the "pressure suppression" safeguards built into such reactors were not as effective as "dry" radiation containment structures like towers or domes.

As a pressurized water reactor plant, Calvert Cliffs does not allow water to boil within the reactor core, but rather transfers the heat to a steam generator which produces electricity. Pressurized water reactors have domed containment units that enclose the reactors entirely -- including the steam generator and pressurizer.

Diane Screnci, of the Nuclear Regulatory Commission's Office of Public Affairs, said the containment units are made of reinforced concrete with a steel lining.

Screnci said boiling water reactors and pressurized water reactors have similar safety records.

"Both of those types of plants are operating in the United States and operating safely," she said.

Constellation Energy owns the Calvert Cliffs plant. Mark Sullivan, director of communications for the company's nuclear group, said via e-mail that safety was the company's top priority.

"We have emergency response plans in place which are approved at the federal, state and local government agencies," Sullivan said. "The plans have detailed procedures which are routinely reviewed and used in training of our teams. We have training exercises and drills to test our ability to effectively implement our plan and are formally evaluated by the NRC."

Sullivan also said Calvert Cliffs' reactors would be shut down if certain levels of seismic activity were detected in the area and that the NRC required all plants to be designed to withstand natural phenomena like tsunamis.

Quakes and tsunamis are exceedingly unlikely around Calvert Cliffs. According to the US Geological Survey, there has never been an earthquake centered in the Washington, D.C., area in recorded history (though the area has felt mild effects from quakes centered elsewhere).

Nathan Hultman, a University of Maryland professor in the School of Public Policy who is an expert on atomic energy policy, said reactor containment units in the US are built to withstand tremendous impacts -- even the force of a plane flying into them, a scenario that came up after the terrorist attacks of Sept. 11, 2001.

But Hultman said the cooling ponds where used nuclear rods are placed at most facilities are sometimes more vulnerable. Spent rods must be radioactively cooled for several years before they can enter "dry cask" storage. Fires have broken out in some of the pools at the damaged Fukushima plant, sending high levels of radiation into the atmosphere.

"Even if someone did try to fly an airplane into a nuclear reactor ... it's likely not going to actually break the reactor and release radioactivity," Hultman said. "But if you fly the airplane into the pool of spent fuel, you can create essentially a dirty bomb, right, from just this activity and maybe even set the thing on fire."

Sullivan did not respond to an e-mail and phone message Wednesday inquiring about how Calvert Cliffs stores and protects spent nuclear rods during cooling.

Hultman said Fukushima was on the "knife edge" Wednesday -- that there is still the possibility of containment, but the plant is teetering on the brink of disaster. He said that if containment fails, low levels of radiation might reach the US, which could sour the nation on nuclear power for a long time.

Even if the Fukushima crisis is completely contained today, he added, it would still be the second-worst nuclear power accident in history, trailing only the Chernobyl disaster. That explosion at a nuclear power plant in Ukraine in 1986 gave off a cloud of radioactive fallout that caused thousands of cancer deaths.

Fukushima could lead to more US regulations, which would make it more costly to operate old plants or build new ones. Hultman said that could be all it takes to stop a "Nuclear Renaissance" in its tracks after 30 years of safe operation.

"In the end you're only boiling water to create electricity -- that's all you're doing with a nuclear power plant," Hultman said. "You can create electrical potential in all kinds of other ways and move electrons in all kinds of other ways. So if a utility's looking at needing to fill a load, the combination of public opinion and changes in costs, both of those have to go into their decision. Clearly it's going to be more difficult, in the near term at least."

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David Saleh Rauf contributed to this report.

Iowa Senators Want To Wait On Nuclear Power Plants (AP)

Associated Press, March 17, 2011

DES MOINES, Iowa (AP) -- Some Iowa senators want to delay action on bills that would make it easier for energy companies to build nuclear power plants in Iowa, given the nuclear crisis unfolding in Japan.

Nine Democratic senators sent a letter to their colleagues on Wednesday saying they are "extremely concerned about proposed legislation that appears to be on the fast track to pave the way" for more nuclear plants in Iowa. They asked that such legislation not be advanced this year, and that a commission be formed to investigate the issue.

The senators -- Daryl Beall, Dennis Black, Joe Bolkcom, Dick Dearden, Bob Dvorsky, Gene Fraise, Jack Hatch, Rob Hogg and Pam Jochum -- cited several areas of concern in their letter, including the potential danger nuclear facilities can pose to the public.

"There are significant safety and financial liability concerns, especially after the nuclear disaster in Japan," the senators wrote.

Japan is struggling to avoid complete reactor meltdowns at a plant badly damaged by last Friday's powerful earthquake and tsunami.

The senators expressed concern about the costs involved with determining where to build new plants, and with the permitting and monitoring processes once they're built.

Former Gov. Chet Culver signed a bill last year allowing MidAmerican Energy to study the viability of building a nuclear power plant in Iowa.

Hogg, D-Cedar Rapids, said legislation in the Senate would require MidAmerican Energy to apply with the state to build a nuclear plant and effectively guarantees a recovery of the company's costs. He said that would cost each customer of the company several thousand dollars.

Hogg also said nuclear power should be the main issue for an entire legislative session, as any decisions the Legislature makes will affect generations of Iowans. The bill amounts to a statement that Iowa is giving a green light for a nuclear plant to be built, he said.

"Nuclear power is being sold as something that's safe and reliable," Hogg said. "But the problem is when something goes wrong it goes very wrong."

Ann Thelen, spokeswoman for MidAmerican, said the plant design the company is considering for Iowa is newer and safer than Japan's Fukushima Dai-ichi plant.

"Advances in nuclear technology have dramatically changed the prospects for adding nuclear generation to the state's energy portfolio," Thelen said. "While we haven't ruled out certain plant designs, we are very interested in small modular reactors. Small modular reactor designs have a number of benefits, including enhanced safety features."

Proponents of nuclear power note there have only been three major reactor accidents in the 50-year history of civil nuclear power: Chernobyl, Three Mile Island and the ongoing crisis in Japan.

Jane Magers, who represents a number of groups opposed to nuclear energy, commended the senators for signing the letter but questioned why a letter is even necessary.

"They're going out on a limb," Magers said. "I just cannot understand why the Legislature is holding on to this, but they're apparently holding on to it hard."

Iowa has one nuclear power plant near Cedar Rapids, and MidAmerican Energy is studying building another plant.

The letter comes a day before a Senate subcommittee is set to debate the legislation. MidAmerican Energy President and CEO William Fehrman is expected to attend the subcommittee meeting on Thursday.

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Nuclear Opponents In Texas Seize On Japan Crisis (AP)

Associated Press, March 17, 2011

VICTORIA, Texas

Opponents of a proposed Texas nuclear power plant are urging federal regulators to consider Japan's emergency efforts to avert a nuclear meltdown.

The Atomic Safety and Licensing Board on Wednesday began a two-day hearing in Victoria. Chicago-based Exelon Corp. is in the preliminary stages of trying to acquire permitting for a proposed nuclear plant in Victoria County.

The Nuclear Regulatory Commission scheduled the hearing before last week's earthquake in Japan crippled nuclear reactors and caused radiation levels to soar.

The group Texans for a Sound Energy Policy wants federal regulators to halt the permit application. It planned to tell the panel that "everyone should be sobered" by the events in Japan.

Opinions Clash On Victoria Nuclear Plant Permit (KRIVTV)

KRIV-TV Houston, TX, March 17, 2011

Exelon Power Texas is defending preliminary plans to build a nuclear power plant near Victoria.

A Wednesday hearing in Victoria focused on the company's request for an early site permit.

"The whole concept behind an early site permit is once that is issued, it would allow us to reserve a particular parcel of land here in Victoria County for up to 20 years," said Exelon's William Scott.

Scott said it's not known if or when the company would actually seek to build the plant.

But a plant opponent, Regional Water Planning Board member Bill Jones, insisted an early site permit should be denied.

"Once the early site permit is in, the camel's got his nose under the tent and there's no telling what will happen after that," Jones said.

Jones argued the Japan disaster is a warning to those who want to build the Victoria plant. Scott, however, said it's grossly unfair to compare Japan with the proposed Victoria project.

"You would have to assume that there's a major earthquake somewhere along the Texas Gulf Coast and there would be a subsequent tsunami following that would somehow push inland 35 miles."

Possible Nuclear Sites In Texas Look To Learn From Japan|myFOXlubbock (KJTV)

KJTV-TV Lubbock (TX), March 17, 2011

Opponents of building a nuclear power plant in Victoria are urging federal regulators to consider Japan's emergency efforts to avert a nuclear meltdown. The Atomic Safety and Licensing board is holding a two day hearing in Victoria. Chicago-based Exelon Corporation is in the preliminary stages of trying to acquire permitting for a proposed nuclear plant in the Guadalupe River Estuary. The group "Texans for A Sound Energy Policy wants federal regulators to halt the permit application. Texas Land Commissioner Jerry Patterson said nuclear energy is safe and we'll likely see more of it in the future. He says the main concern is how to deal with nuclear waste.

Bill Jones, Texans for A Sound Energy Policy Alliance: "The best place for any new nuclear power plant is where there is an infinite supply of salt water, and that is on the coast, where the south Texas nuclear project is. Our problem with Victoria, is that the plant is relying on the drought prone Guadalupe River. The Exelon plant depends on billions of gallons of fresh water from a drought prone river for cooling and so that poses a serious safety concern. It also poses a threat to the whole eco-system from here to the bay."

Commissioner Patterson: "Last news report that I got on that, it's the spent fuel rods. Those fuel rods ought to be off site, being re-processed into good commodities for energy. It's all about science, it's all about technology. With the appropriate application of science and technology, nuclear will remain safe and become even safer."The Nuclear Regulatory Commission scheduled the Victoria hearing before last week's earthquake in Japan crippled the Fukishima Diachii nuclear reactors and caused radiation levels to soar.The Commission announced on March 2nd that expansion plans for the existing south Texas project nuclear power plant has passed a final environmental impact assessment. The plant near Bay City, about 11 miles inland from Matagorda Bay, is seeking permission to add two new reactors.

Tokyo Electric, which operates the Fukishima plant, has a small ownership stake in the south Texas project.

3/11/11

Click here for Texas Tech's Near Real-Time Map of quake aftershocks

Link Ministries website

Ag Day Lubbock - The Cooking Cowboy's Cowboy Spaghetti

http://pedersonsfarms.com/2011/03/cowboy-spaghetti/Ag Day Lubbock - High Plains Underground Water Conservation District Public Meeting Schedule

http://www.hpwd.com/

3/9/11

Submit tips to Lubbock Policeor call Crimeline at 741-1000

Citibus website

Ag Day Lubbock - High Plains Underground Water District proposed Restrictions: http://www.hpwd.com/HPWD%202011%20Rule%20Amendments/HPWD%20Proposed%20Amendments%20Drafted%202-22-11.pdf

Ag Day Lubbock - Corn Producers Association of Texas Prese Release: http://texascorn.org/cornwebsite/files/22511_HPWDRegulations.pdf

3/8/11

FOX 34 Your Health - info on peanut butter

3/7/11

Ag Day Lubbock - National Resources Conservation Service information for assistance with wildfires

3/5/11

Ag Day Lubbock - Groundwater Debate information http://www.texascattleraisers.org/news_releases_blog/

3/4/11

Forbes Magazine's Top 10 Happiest Jobs

03/03/11

Texas Superintendent Salary Table

03/02/11

To follow Zoe Romano, who is running coast to coast to help benefit the Boys and Girls Clubs of America, you can find her blog here.

Telephone number for the Clovis Police Department: (575) 769-1921 begin_of_the_skype_highlighting (575) 769-1921 end_of_the_skype_highlighting begin_of_the_skype_highlighting (575) 769-1921 end_of_the_skype_highlighting.

Renovations of facility providing basic amenities for homeless at 13th & Ave A

Monetary Donations can be mailed to:

c/o Gary Light

Link Ministries

1117 65th Drive

Lubbock, TX 79412

Call: (806) 747-2542

Unapproved Drugs

Mayor's Beans & Cornbread Luncheon

11 a.m. to 1:30 p.m. Friday, March 4

Tickets $10

Specialty Crop Block Grant Program

03/01/11

To vote for your favorite Blue Ribbon Small Business Award winner click here.

CASA of the South Plains needs more volunteers - click for more info

02/28/11

To attend Barbara Bush speech at Lubbock Women's Club:

Reservations for the event will be accepted by phone beginning at 9 a.m., Tuesday, March 8, by calling (806) 763-6448. Due to limited seating, reservations will be restricted to no more than four per person. Tickets are $75 each and require payment by credit card. Cancellations are required by Wednesday, April 13.

More information on the CHL course featured in news story

2/25/11
Children's Health Insurance meeting - 10 a.m. to 1 p.m. Saturday, Feb. 26, Monterey High School Cafeteria
More information on CHIP
2/23/11
Federal Government Continuing Resolution (HR-1)
2/22/11
Find the Hero in You - United Blood Services
More information on collections in Lubbock County
2/21/11
TAWC Field Day
Thursday, Feb. 24 from 8 a.m. to 1 p.m.
Floyd County Unity Center in Muncy, Texas
Sick Children's Clinic
1002 Avenue A
Lubbock, Texas 79401
806-762-1805
2/19/11
Llano Estacado Roboraiders - Team 1817
www.team1817.org
2/17/11
Census county-by-county population changes
Census county-by-county population
Instructions on how to text a tip to the Lubbock Police Department.
Click here to submit a tip online for the Lubbock Police Department.
To phone in a tip, call 806-741-1000
Click Here for more information on energy funds for low-income families.
2/16/11
Laura W. Bush Institute for Women's Health taking steps to fight breast cancer - more info
For information on Energy Assistance funds, call the Texas Department of Housing and Community Affairs toll free at (877) 399-8939
Texas Tech advising students to take bus this spring break - more info
Money Matters - Small Business Administration, TTU Small Business Development Center
2/15/11
Click here for a link to the 2011 Texas on Brink Report
2/14/11
Danny Gunn's burial set for 2pm at the Terrace Cemetery in Post. A service will be held at 4pm at the Post High School Auditorium.
Idalou school system will dismiss at noon on Wednesday.
A scholarship fund has been set up: Danny Gunn Memorial Scholarship
C/O Troy Stegemoeller
Vista Bank P O Box 858
Idalou TX 79329
02/13/11
Laugh for the Cure
Doors open 6:30 p.m.
Tickets $30+ **TICKETS PURCHASED 2/15/2011 @ www.livingsocial.com $15**
Comedy Show & Live Auction
call 806-698-1900 or www.komenlubbock.org
02/11/11
Click here for more information on Organ and Tissue Donation
02/10/11

Applications for the Texas Department of Agriculture's Family Land Heritage Program are due May 1, 2011.

02/10/11

"The Weir" at the Garza Theatre

The Hotel Garza

302 East Main

Post, Tx

806-495-3962

Dinner and Ticket package:

Dinner for two and tickets to the show $59

Reservations only

Call and reserve your tickets todayTheatre packages:

Dinner for two, tickets to the show, and one nights stay

starting at $139 for standard room

02/09/2011

Health info - "To Bones With Love", free seminar 6 p.m. February 10, American State Bank Operations Annex, 1501 Avenue Q.

Money Matters link - more information on assisting elderly citizens with mobile phones

02/08/2011

Southwest Farm and Ranch Classic at Lubbock Memorial Civic Center, Tuesday through Thursday 9:00 a.m. To 5:00 p.m.

For more details, visit http://swclassic.com/

To apply to Hobbs police department02/04/2011

Small businesses looking for more information on "Live Longer, Live Stronger" call Carla McGee at (806) 725-0643

02/04/2011

Tips on what to do with frozen pipes

02/03/2011

Lubbock Land Company survey on Lubbock housing market

02/01/2011

2010 Dietary Guidelines for Americans

http://www.cnpp.usda.gov/dietaryguidelines.htm

01/28/11

Abbeville Dentistry 5255 79th Street, Lubbock

Free dental care

Saturday, January 29th, 8 am - 2 pm for those in serious need.

First 100 patients - on a first-come, first-serve basis

Click here for a link for more info

To provide info on 10 most wanted suspect Timothy Rosales:

Call the Crime Stoppers hotline at 1-800-252-TIPS (8477).

Or text the letters DPS—followed by your tip—to 274637 (CRIMES) from your cell phone.

Or go to to find out more. go to http://www.txdps.state.tx.us/wanted/topTenFugitives.htm#;view=Details/fugitive=10

01/26/11

Texas Department of Public Safety Amnesty Plan

Vigil and services for Elizabeth Ennen:

A fund has been established at American State bank for Elizabeth Ennen's family.

Students and friends plan a candlelight vigil at 6:30 p.m. Thursday at the Monterey High School flagpole.

Services are set for 10:30 a.m. Friday at Sanders Funeral Home, 1420 Main St.

To donate to Somer Thompson Foundation

1/21/11

Volunteers are still needed to help organize donations for victims of the Twin Oaks fire.

There is no need for further material donations, plenty have been received.

Monetary donations are always welcome. You can mail those to the Salvation Army at P.O. Box 2785 Lubbock, TX 79408 or to the American Red Cross at 2201 19th Street Lubbock, TX 79401

For information on volunteering, please contact the Salvation Army at (806) 765-

1/20/11Training for volunteers to help count area homeless:

Salvation Army - 10am, Wednesday, January 26th

Call 806-765-9434 1/19/11

Info on free tax preparations1/18/11Volunteer at Boys and Girls Club

Volunteer at South Plains Food Bank

1/17/11State of the City Registration

01/11/11

Lubbock Water Conservation Ordinance

When you're on the go, stay up to date with forecasts on your favorite radio station.

FOX Talk 950-100.7FM

Listen for weather updates twice an hour on FOX Talk 950-100.7FM. Our staff of meteorologists has the latest information through every day. You'll also hear up-to-the-minute reports four times an hour during FOX Talk In The Morning.

Catch an expanded agricultural forecast during Ag Talk at around 1:30 p.m. Also, an extended forecast is heard around 5:25 during The Drive Home with Jeff Klotzman.

You'll hear an updated regional forecast from Texas State Network meteorologists weekday mornings at 5:10 and 5:45 and afternoons around 12:20.

Tune here for expanded live coverage when warranted during severe weather.

Magic 93.7 and Stars 97-3

While listening to your favorite music, you'll get the latest weather for the South Plains on Magic 93.7FM and Stars 97-3FM.

Double T 104-3

During Game Day Live! you'll hear updated weather from Matt and Laura, letting you know what to expect for your game day experience and what weather the Red Raiders will face.

A New Crack In Progress Energy's Crystal River Nuclear Plant's Containment Building Has Forced The Utility Company To Scrap Its Plans To Fire Up The Facility In April | Ocala.com (OCB)

By Fred Hiers

Ocala Star Banner, March 17, 2011

A new crack in Progress Energy's Crystal River nuclear plant's containment building has forced the utility company to again scrap its plans to fire up the facility in April.

The delay marks the fifth time in 18 months the utility giant has pushed back its start-up date. The containment vessel wall is meant to keep any harmful radiation inside if there were ever a leak in the reactor container.

North Carolina-based Progress Energy has 65,000 customers in Marion County and more than 1.6 million throughout Florida. It reported Monday to the US Nuclear Regulatory Commission that testing equipment had detected irregularities in the wall and "upon further inspection there was a separation that wasn't previously there," said NRC spokesman Roger Hannah.

The crack is the second in the containment vessel wall, which has caused the utility company millions of dollars in repairs and lost fuel costs.

Progress Energy spokesperson Cherie Jacobs said the postponement in the utility's start-up date at Crystal River reflects the complexity and precision of the restarting process and the company's focus on safety.

Jacobs insisted that "we're not even sure there is a crack," but only that acoustic monitoring equipment detected an anomaly that might be a separation in the wall. The company's press release said only that there was an "indication" of a crack. Jacobs said investigators were still studying the evidence and don't yet know the extent of the problem or where it's located along the walls.

Crystal River's repair story began in September 2009 when Progress shut down the 838-megawatt nuclear power plant to replace aging generators. To do that, workers cut through the facility's containment vessel wall. The plan was to have the plant operational again by December 2009. But when they cut into the wall, workers found a 25-foot long crack in the concrete. The plant's focus was then to determine its cause and repair it.

The crack is now known to have been caused by a series of steel cables that were built like a web inside the containment walls. The tension of the cables — which are inside sleeves encased within the containment wall — can be adjusted to pressurize the wall and facility. That tension gives the wall its ability to flex should there be an explosion within the reactor.