From: Vonna Ordaz NKR
To: Glenn Kelly, Jason Schaperow, Michael Cheok
Date: Thu, May 20, 1999 12:15 PM
Subject: **Input from Jim O'brien**

FYI

m/25

From: James O'Brien , NRR
To: Vonna Ordaz
Date: Thu, May 20, 1999 8:57 AM
Subject: **Re: Fwd: Meeting Cancelled**

Sorry, I am so late on this. My schedule has been busy and I really didn't see how this fit into any conclusions you might be trying to reach.

However, I should have been more proactive to either get it out of the outline or provide the input. I hope the attached will be useful. (I also attached a file with the basis for EP info I gave you previsously.. this may not fit into your outline ... use as you feel is appropriate)

IV C. Evaluation of Existing Accident Dose Assessments for Beyond Design Basis Spent Fuel Pool Accidents

The NRC has sponsored three analyses to estimate the dose consequences of beyond design basis spent fuel pool accidents at nuclear power plants. The results of these analyses are contained in contractor reports NUREG/CR-4982, NUREG/CR-5281, and NUREG/CR-6451. The inputs to these dose analyses were reviewed as part of this evaluation to determine if they represent current operating and storage practices and if they are applicable to decommissioned plants.

IV C.1. Review of Dose Consequence Analysis Inputs

Inputs to dose consequence analyses can be grouped in the following categories:

- source term
- atmospheric dispersion
- population density
- emergency response actions

Inputs under each of these categories include:

<u>Source Term</u>
- Spent Fuel Isotopic Inventory (a function of fuel burnup and decay time)
- Release Fractions from the fuel for given accident scenarios
- Decontamination factors
- Heat content of plume
- Plume release duration

<u>Atmospheric Dispersion</u>
- Stability
- Wind Speed
- Precipitation

<u>Population Density</u>
- persons per square mile at various radial distances and azimuthal locations

<u>emergency response actions</u>
- percent of population evacuating
- speed of evacuation
- relocation assumptions (e.g. dose threshold)

The inputs assumed for each of these parameters is discussed below.

<u>Source Term</u>
The first two dose consequence analysis , i.e., NUREG/CR- 4982 and NUREG/CR-5281, were performed to support resolution of Generic Safety Issue 82, "Beyond Design Basis Accidents in

Spent Fuel Pools." The spent fuel pool inventory for a BWR (Millstone Unit 1) and a PWR (Ginna) were utilized for these analyses. The inventories were calculated using the ORIGEN2 code and considered the actual operating histories of the plants. These reactors where selected based upon perceived vulnerability to beyond design basis accidents and the relatively large inventories of spent fuel. The decay time considered was 30 days and 90 days. The release fractions were determined for a zirconium fire event using the CORSOR code.

NUREG/CR-6451 was performed to provide a technical basis for requirements for permanently shutdown reactors. The spent fuel pool inventory was developed from both the Department of Energy's Spent Fuel Data Base and the default core inventories provided in the MELCOR Accident Consequence Code System (MACCS). The decay time evaluated was for 12 days following shutdown (for the zirconium fire event) and one year after shutdown (for the gap release scenario). The release fractions were calculated based upon NUREG/CR-4982 data modified to account for studies associated with gap inventory and high burnup fuel. In addition cases were run which used a decontamination factor of ten.

<u>Atmospheric Dispersion</u>

Atmospheric dispersion was based upon an "generalized meteorology" (uniform wind rose) for NUREG/CR-4982 and the Zion site meteorology for NUREG/CR-5281. NUREG/CR-6451 utilized meteorology data from around Omaha, Nebraska (considered to be a "mean" meteorology).

<u>Population Density</u>

The population density assumed for NUREG/CR-4982 was 100 persons per square mile. The population density assumed for NUREG/CR-5281 was based upon the population around the Zion site 860 persons per square mile. In addition, a best estimate case was analyzed which assumed 340 people per square mile. The population density assumed for NUREG/CR-6451 was a uniform distribution of 1000 persons per square mile between 0 to 30 miles (base on the end of life average population density from Regulatory Guide 4.7), a large city of 10 million was considered to be located within 30 to 50 miles and uniform population of 280 persons per square mile was assumed elsewhere in this region. This population distribution was selected to reasonable envelop the majority of the current reactor sites and account for future population growth over the life of the plant.

<u>Emergency Response</u>

All of the studies considered the same emergency response scenario. The scenario is that no evacuation occurs and that people are relocated at one day following the release if projected doses were to exceed 25 rem in seven days.

IV C.2. Dose Consequence Results

The dose consequence results were reported in several manners in these reports including:

- Prompt Fatalities (NUREG/CR-6451)
- Latent fatalities (NUREG/CR-6451)
- Societal Dose (NUREG/CR-4982,NUREG/CR-5281,NUREG/CR-6451)
- Condemned Land (NUREG/CR-6451)
- Property Damage (NUREG/CR-5281)

- Total cost (NUREG/CR-6451)
- Interdiction area (NUREG/CR-4982)

A summary of representative results is included in the following table.

REPORT	SCENARIO DESCRIPTION	CONSEQUENCE MEASURE	RESULT
NUREG/CR-4982	Last Fuel Discharge Decay time 90 days	Societal Dose	7.97E7 person-rem
NUREG/CR-5281	Last Fuel Discharge Decay time 90 days	Societal Dose	2.3E6 person-rem
NUREG/CR-6451	Last Fuel Discharge Decay time 12 days	Societal Dose	8.1E7 person-rem
NUREG/CR-4982	Last Fuel Discharge Decay time 90 days	Interdiction area	224 square miles
NUREG/CR-6451	Last Fuel Discharge Decay time 12 days	Interdiction area	776 square miles
NUREG/CR-5281	Last Fuel Discharge Decay time 90 days	Offsite Property Damage ($1983)	3.41E9
NUREG/CR-6451	Last Fuel Discharge Decay time 12 days	Total Cost	2.74E11
NUREG/CR-6451	Last Fuel Discharge Decay time 12 days	Early Fatalities	33
NUREG/CR-6451	Last Fuel Discharge Decay time 12 days	Latent Fatalities	94,600

IV C.3. Applicability to Inputs and Consequence results to Permanently Shutdown Reactors

An evaluation of the applicability of each of the input categories to current fuel storage conditions is described below.

Source Term

The source terms used in NUREG/CR-4982 and NUREG/CR-5281 were representative of smaller reactors (Millstone 1 2011 MWth and Ginna 1520 MWth) and fuel storage inventories of 1983. Most current operating reactors have power levels (e.g., 3400 MWth) and store larger inventories of spent fuel **[need to verify and provide estimates]**.

The source term used in NUREG/CR-6451considered a 1987 DOE database and default inventories in MACCS. **[further work needs to be done to determine present storage conditions versus the new conditions]**

The release fractions utilized in the previous studies were primarily based upon an analysis which utilized the CORSOR code **[further work is needed to research the appropriateness of the release fractions]**

Atmospheric Dispersion

Each of the studies used different meteorology data to evaluate the atmospheric dispersion. However, each of the studies to utilize average or mean meteorology. These data are appropriate for use in generically evaluating consequences at current reactors. **[further research could be performed to determine range of met conditions for operating reactors]**

Population Density

Each of the studies used different population density inputs. The population density used in NUREG/CR-6451 was selected to reasonable envelop the majority of the current reactor sites and account for future population growth over the life of the plant. Therefore this population density distribution should be appropriate for current reactors

Emergency Response

All of the studies utilizes similar emergency response assumptions. These included an assumption that no people would evacuate prior to passage of the plume of radioactive material. Different assumptions may be appropriate based upon estimates of the time for the accident to progress to the point of the release of radioactive material and public warning times. In addition, the dose threshold for relocation was set at 25 rem. Current EPA guidance is for relocation at 2 rem.

The conclusion regarding the applicability of the consequence analysis (as reported in NUREG/CR-4982, NUREG/CR-5281, and NUREG/CR-6451) is that the assumption utilized are appropriate for current reactors and fuel storage conditions except for the assumed emergency response actions. In addition, further research is needed to evaluate the release fractions assumed for the zirconium fire event and to verify the spent fuel pool inventories.

Appendix A

Evaluation of Technical Criteria for Emergency Preparedness Requirements

This Appendix is an evaluation of the potential technical criteria for establishing emergency preparedness (EP) requirements for permanently shutdown reactors.

In order to gain perspective on potential technical criteria and methods for EP for permanently shutdown reactors, the staff examined the technical basis of EP requirements for operating plants and analyzed design-basis and severe-accident data for permanently shutdown reactors. The staff's evaluation consists of two parts. Section A1 is a review of the rationale, criteria, and methods that form the basis for EP for currently licensed reactor designs as discussed in NUREG-0396, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants." Section A2 is a summary of an evaluation of the spectrum of accidents considered for permanently shutdown reactors and whether the probability and consequences of the accidents may warrant changes in the technical criteria or methods used as the basis for the EP regulations and whether application of these criteria for the permanently shutdown reactors indicate that changes to EP requirements are warranted. Section A3 provides details of the evaluation of the spectrum of spent fuel pool accidents considered for permanently shutdown reactors. The staff's evaluation is summarized below.

A1 Review of NUREG-0396 Rationale, Criteria, and Methods

NUREG-0396, issued in December 1978, presents the results of a study to develop a technical basis for EP. The study was performed by a task force comprising of U.S. Nuclear Regulatory Commission (NRC) and Environmental Protection Agency (EPA) representatives. NUREG-0396 recommended that the objective of EP should be to produce dose savings for a wide spectrum of accidents that could potentially lead to offsite doses in excess of the EPA protective action guidelines (PAGs). The PAGs represent radiation doses that warrant preselected protective actions for the public if the projected dose received by an individual would exceed the PAGs. The PAGs, in essence, correspond to a 1-rem total effective dose equivalent and a 5-rem committed dose equivalent to the thyroid. The NUREG-0396 task force determined that the following three elements needed to be considered in establishing requirements for EP:

A1.1 Review of the Basis for the Size of the Emergency Planning Zone (EPZ)

The most important element to be considered in establishing requirements for EP is the distance from the nuclear power plant over which emergency actions need to be planned. Two areas were identified: (1) a plume exposure pathway EPZ for planning for prompt actions to protect the public and (2) an ingestion pathway zone for planning for actions to prevent radioactive material from entering the food chain. Several rationales were considered for establishing the size of the EPZ. These included risk, probability, cost effectiveness, and accident consequence spectrum. The NUREG-0396 task force chose to base the rationale on a full spectrum of accidents and corresponding consequences tempered by probability considerations. It was the consensus of the NUREG-0396 task force that emergency plans could be based upon a generic distance within which predetermined actions would provide a

dose saving for any such accidents.

The following criteria were used to determine the generic distance for the plume exposure pathway EPZ:

- The EPZ should encompass those areas in which projected dose from design-basis accidents could exceed the EPA PAGs.
- The EPZ should encompass those areas in which consequences of less severe Class 9 (core melt) accidents could exceed the EPA PAGs.
- The EPZ should be of sufficient size to provide for substantial reduction in early severe health effects in the event of the more severe Class 9 accidents.

Detailed planning within the EPZ was expected to provide a substantial base for expanding response efforts should expansion be necessary for those low probability, high consequence events whose effects extend beyond the EPZ.

To determine the areas in which these criteria were met, the NUREG-0396 task force evaluated design-basis accident data from licensees' final safety analysis reports and accident sequence and source term data from NRC document WASH-1400, "Reactor Safety Study" (1975). Specifically, the NUREG-0396 task force calculated (1) the fraction of plants that exceeded PAG doses beyond 10 miles for design-basis accidents, (2) the probability of exceeding various dose thresholds as a function of distance from the reactor, and (3) the benefit of various protective action strategies.

On the bases of these analyses, the NUREG-0396 task force recommended that emergency plans should be developed for an area within a radius of about 10 miles of the reactor for the plume exposure pathway. Figures A1, A2, and A3 illustrate analysis done in NUREG-0396 to support this recommendations

A1.2. Review of the Time-dependent Characteristics of Potential Releases

The time between the initial recognition that a serious accident is in progress and the beginning of a release of radioactive material is important for developing emergency plans, including developing the means for notifying the public of the need for taking protective actions. The NUREG-0396 task force determined that, depending on the type of accident, a wide range of time frames for such releases is possible. The Reactor Safety Study (WASH-1400) reported, for example, that major releases may begin in as short a time as one-half hour to as long as 30 hours after an initiating event. The NUREG-0396 task force concluded that EP requirements should be based on releases that may start as early as 30 minutes following the initiation of an event.

A1.3. Review of the Potential Types of Radioactive Materials Released

In order to specify the characteristics of monitoring instrumentation, develop decision aids to estimate projected doses, and identify critical exposure modes, emergency planners need information on the characteristics of potential radioactive material releases. The NUREG-0396 task force concluded that, since the potential for releases to the environment decreased dramatically when progressing from gaseous materials to volatile solids to non-volatile solids,

emergency plans should focus on the release of gaseous materials and volatile solids, such as noble gases and iodine, respectively.

A2 Evaluation of Rationale, Criteria, and Methods for EP for Permanently Shutdown Reactors

The staff evaluated the potential accident at permanently shutdown reactors to determine if changes to the rationale, criteria, and methods used to determine the EPZ size requirement and changes to EP requirements, based upon the timing and characteristics of potential radioactive material releases, could be justified.

A2.1. Review of the Basis for the Size of the Emergency Planning Zone (EPZ)

The design basis accident for a spent fuel pool is limited to fuel handling accidents which result in the release of radionuclides contained within the gap between the fuel rod and fuel pellet in on fuel bundle. An evaluation of the potential consequences of design basis spent fuel pool accidents indicated that a dose of 1 Rem TEDE would not be exceeded at the site boundary.

Due to the low levels of heat generation by spent fuel decayed over 1 month, core melt accidents are not possible. However if a beyond design-bases accident resulting in the loss of spent fuel pool water for occurred , two types of accidents are possible. A less-severe beyond design basis accident where the fuel heats up to the point where the radionuclides in the gap between the fuel rod and pellet are released due to ballooning and rupture of the fuel rod Zircaloy clad. In addition a more-severe beyond design basis accident can be postulated to occur which involves the rapid oxidation (exothermic reaction) of the Zircaloy clad and resulting release of the much of the less volatile radionuclides contained within the fuel as well as the gap radionuclides.

An evaluation of the less severe beyond design basis accidents indicate that the ....