From: Jason Schaperow
To: cgt
Date: Thu, May 27, 1999 10:46 AM
Subject: Fwd: Re: dose consequences assessment

Attached e-mail message is for your information.

From: James O'Brien
To: Diane Jackson, Jason Schaperow
Date: Thu, May 27, 1999 9:18 AM
Subject: Re: dose consequences assessment

Diane,

I've tried to address your comments and have revised my writeup. It seems that this section could have been used to evaluate where additional calcs should be performed (as was done in part with RES).

I am providing this to RES for there consideration on how it fits with their work.

Jason,
we need to discuss your work and how to integrate with this. By the way I finally got the BNL MACCS files for the 6541work

CC: Vonna Ordaz

4.3.2 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.

4.3.2.1 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)
- time after accident initiation that the plant reaches a General Emergency condition
- evacuation time delay

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. Two inventories used in the dose consequence analysis: (1) All fuel bundles in the pool or (2) only the last discharge of bundles. The decay time considered was 30 days and 90 days. The release fractions were determined for a zirconium fire event using the CORSOR code. Difference scenarios, based upon a combinations of inventory (full pool or last discharge) and decay times (30 days or 90 days), were input into the dose consequence code. A sample of input scenario (and consequence results) is shown in Table 1.

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. As was done in the previous dose consequence studies, difference scenarios, based upon a combinations of inventory (full pool or last discharge) and decay times (12 days or one year), were input into the dose consequence code. A sample of input scenario (and consequence results) for this study is also shown in Table 1.

Atmospheric Dispersion

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).

Population Density

The population density assumed for NUREG/CR-4982 was 100 persons per square mile. The population density assumed for NUREG/CR-5281 was 860 persons per square mile which was based upon the population around the Zion site. 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 (based 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.

Emergency Response

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.

4.3.2.2 Dose Consequence Results

Consequences of the release of radioactive material can be measured in several different manners including prompt fatalities, latent fatalities, or societal dose. The dose consequence results reported in these studies include:

- 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. The results are presented in order to identify the magnitude and type of consequences which were reported for zirconium fire events in these reports. The absolute value is not of primary focus but rather the magnitude of the result. These table was also used, as discussed below, to identify were further calculations should be performed as part of this technical evaluation.

REPORT	SCENARIO DESCRIPTION	CONSEQUENCE MEASURE	RESULT
NUREG/CR-4982	Last Fuel Discharge Decay time 90 days	Societal Dose (out to 50 mile radius)	2.3E6 person-rem
NUREG/CR-5281	Last Fuel Discharge Decay time 90 days	Societal Dose (out to 500 mile radius)	7.97E7 person-rem
NUREG/CR-6451	Last Fuel Discharge Decay time 12 days	Societal Dose (out to 50 mile radius)	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	condemned land	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

The differences between the reported results primarily lie in the assumptions of population density. Notewithstanding these difference, the general conclusion that can be reached is that there are substantial consequences associated with a spent fuel pool fire even. However, these calculations need to supplemented to provide insights into the effectiveness of differenent emergency response actions which may be taken to protect the public. These are described further in the next section.

Is the societal doses for the same areas around the plant? [NO] Why are the numbers for the same parameter so different - which ones are better? [PRIMARILY APPEARS TO BE POPULATION DISTRIBUTION, THEY ARE ALL LARGE SO IT WILL NOT AFFECT THE BOTTOM LINE CONCLUSION] Which one do you or the staff agree with? [NONE OF THE SCENARIOS ADEQUATELY COVER WHAT WE WANTED TO EXTRACT.. THATS WHY ADDITIONAL CALCS WERE PERFORMED] For fatalites - didn't BNL in NUREG/CR-4982 given fatalities that were much lower? [I DIDN'T SEE WERE 4982 REPORTED FATALITIES AS A CONSEQUENCE MEASURE] An explanation of this chart is needed.

4.3.2.3 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.

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. These release fractions were specifically developed for a zirconium fire event in a spent fuel pool, and, therefore a considered to be appropriate for evaluating the consequences of spent fuel pool fire events. However, the previous studies did not describe details of how these fractions were obtained and any associated uncertainties. Further research could be initiated to re-evaluate these release fractions and to understand the uncertainty associated with 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.

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 this generic evaluation. **{FOR A GENERIC STUDY - WHAT WAS THE POP DENSITY or a range of densities THAT YOU THINK IS**

APPROPRIATE - WHAT DID JASON USE?}

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, i.e. people were assumed to be relocated away from deposited radioactive material if the dose they would receive exceeded 25 rem in the first week after the accident). Current EPA guidance (identified in RTM-96) is for the relocation of the population if they would receive 2 rem in a year following deposition of the radioactive material. **{WHAT DOES THE NRC USE - THE 2 REM IS CONFUSING - WHAT DOES IT MEAN?} [RTM-96 TABLE H-1 PROVIDES GUIDANCE THAT THE POPULATION BE RELOCATED IF THE DOSE THEY WOULD RECEIVE FROM DEPOSITED MATERIAL WOULD EXCEED 2 REM IN THE FIRST YEAR]**

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 assumptions utilized are appropriate for current reactors and fuel storage conditions, with the exception of:

(1) the decay time of the radioisotopes (different decay times should be evaluated, e.g. 1 year and 2 years to determine the consequences from facitlities shutdown for this period of time)

(2) the emergency response assumptions (different emergency response scenarios involving partial or full evacution at various times after the event should be considered as well as a change to the relocation criteria)

{WHY???}

In addition further research could be performed to re-evaluate the release fractions assumed for the zirconium fire event and to assess uncertainties in the release fractions.

DO YOU AGREE WITH 6451 ASSUMPTIONS THAT LEAD TO 96000 LATENT FATALIES? I THOUGHT THESE WERE OVER CONSERVATIVE RELEASE FRACTIONS WITHOUT MUST BASIS THAT DROVE THE NUMBERS? [WE HAVE NOT EVALUATED TO RELEASE FRACTIONS... BOTH 6451 AND 4982 USED SIMILAR RELEASE FRACTIONS... SEE BELOW]

SOURCE TERM RELEASE FRACTION ASSUMPTIONS

Chemical Family	Element or Isotope	Release Fraction		
		NUREG/CR-4982	NUREG/CR-5281	NUREG-6451
Noble Gas	Kr, Xe	1	1	1
Halogen	I	1	1	1
Alkali metals	Cs, (BA-137m), Rb	1	1	1
Chalcogens	Te	.02	.02	.02

Alkali earths	Sr, (Y-90), Ba	2e-3	2e-3	2e-3
Transition Elements	Co-58 Co-60 Y-91 Nb-95	.1 .12 .1 .01	.1 .12 .1 .01	2e-5 2e-5 6e-6 6e-6
Miscellaneous	Mo-99	1e-6	1e-6	2e-5
Lanthanides	La,Ce	1e-6	1e-6	6e-6
Transuranics	Np, Ru-106	1e-6	1e-6	2e-5
BASIS for release fractions		CORSOR code using time-temperature histories from SFUEL1W code	CORSOR code using time-temperature histories from SFUEL1W code	NUREG-4982 modified by studies associated with gap inventory and high burnup fuel

ALSO, we are looking at reducing EP sometime down the road - the 12 day estimates are not representative of the problem we are looking at - but since they are the only fire numbers, I guess we have no real choice - I think that should be explicitly stated that the radiological consequences are different at 12 days than 1 year. I kind of talked about it in Section 4.3.1. But since they are using it and you are talking about the report - it should be brought up again. Does any of the work not apply because it was based on operating reactors? [I'VE TRIED TO ADDRESS THIS IN THE WRITEUP]