CT-2093
PDR 3/25/94

SEVERE ACCIDENT SUBCOMMITTEE

PORTLAND, OREGON

SEPTEMBER 22-24, 1993

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The following comments are provided as a follow-up to the Severe Accident Subcommittee Meeting held in Portland, Oregon to discuss severe accident and PRA issues associated with the GE ABWR.

I concur in the attached list of comments prepared by Ivan Catton. In addition, the following comments are provided:

Ex-Vessel Fuel Coolant Interaction (FCI)

Arbitrary amounts of core melt at arbitrary rates are assumed to be released to the containment and are assumed to participate in fuel coolant interaction. Some rationale for the assumed release rates should be given to assure that some sort of bounding calculations have been made. Also, the possibility of intermittent dropping of core debris from the vessel should be considered. With the flooders open, the subsequent masses of melt dropped can serve as a trigger for the material already in the cavity or vice versa.

Core Concrete Interaction (CCI)

During the last fifteen years, NRC and other agencies, such as EPRI, have spent considerable resources to understand and model core concrete interaction. ABWR specific CCI has been modelled parametrically without taking advantage of the available knowledge base. GE should utilize phenomenological models to determine the concrete erosion rate and composition of the core material with time. The concrete erosion rate will in turn determine the drywell pressurization rate.

TO: Tom Kress

FROM: Ivan Catton

ABWR Severe Accident Treatment

Suppression Pool to Wetwell Thermal Coupling

The wetwell airspace will be in thermodynamic equilibrium with the suppression pool surface. This will determine the partial pressure of vapor in the airspace above the pool. The total pressure will be the sum of the vapor pressure and the partial pressure of the non-condensibles. A key factor in determining the pool interface condition is pool thermal stratification. The pool stratification needs to be calculated to allow one to determine the pool effectiveness as a heat sink and to determine how much time it takes to reach the rupture disk set point for activation of the containment overpressure system. Knowing the amount of stratification is also important when considering the impact of an ATWS. This issue needs to be addressed. It has been around for a long time (almost twenty years).

Core on the Floor Calculations

Several aspects of the "core on the floor" calculations were poorly done. First, the upper drywell coupling to the lower drywell via the vents was done as if there were countercurrent flow in each one. This will not be the case. There will be flow up in some and down in others. The heat up of the upper drywell could be quite different. The calculations are done to evaluate the impact on penetrations and on the upper drywell head seals. Another aspect of this problem is the impact of stratification. The calculations are done assuming the upper and lower drywell are completely mixed. This will not be the case. The stratification could be severe and long lasting as the boundaries of the volumes are not good heat conductors. Again this is not a new issue. HDR tests in Germany show stratification and its inherent ability to stay around for a long time. This should be addressed. One should also consider heat up of the upper drywell head by the vessel. If the reactor internals are undergoing a major core degradation process, the upper vessel internals will be heated up as will the upper head. The heat transfer to the drywell head will depend on the heat up process and the thermal characteristics of the head insulation.

In-Vessel FCI

In-vessel fuel coolant interactions will certainly take place. The lower head will always have water in it when the molten core materials exit the core region. A bounding analysis using the TEXAS-II code might be appropriate if it is adequate for treating such problems. As an aside, I think the ACRS should review this code as it is what the staff has based its view of ex-vessel FCIs on. My cursory look left some questions about its arbitrariness. The question here is not α mode failure of the vessel. Rather it is evaluation of the impact on head failure and the resulting lower drywell thermodynamic response, e.g. pressure, lift on the vessel etc..

Direct Containment Heating

The analysis of the impact of direct containment heating was rather incomplete. A number of unnecessary simplifications were made to deal with the containment response (some conservative and maybe some not). The problem need not be difficult. Lumped parameter modeling is appropriate for evaluation of the pressure response and codes like CONTAIN do this rather well. The vessel should be treated as the source and the volumes that need to be modeled are the upper and lower drywells and the suppression pool. GE has the tools to model these processes and should use them. Assumptions about where the core debris go are another matter. The conservative assumptions used in the present analysis are probably acceptable.

Some of the probabilities used in relating the analysis to risk need to be re-visited. In particular, the differences between estimates of the amount of core debris that must be dealt with made by Sol Levy and those by GE need to be discussed.

Wetwell Air Space Depressurization

A number of paths could lead to the suppression pool airspace pressure reaching the COPS actuation value of 90 psig. The airspace could have an airspace non-condensible partial pressure ranging from a lower bound of 14 psi to several atmospheres. As a result the vapor partial pressure will range from a high of 76 psig to a low of three or so atmospheres. The story we heard was confusing; when the blowdown was analyzed, the lowest vapor partial pressure was assumed. The conditions chosen at the time of depressurization should somehow relate to the dominant sequences. I believe the dominant sequence will be the one with the highest vapor pressure as it is the case where most things work as they should. The analysis needed to address carryover, given the initial conditions, was poorly done.

The first part of the analysis deals with the expansion process in the airspace. GE argues that the effective rapid pressure reduction at the water surface is on the order of 7.5 psi. How the water would respond to a 7.5 psi step change in pressure is unclear. When a fluid is suddenly depressurized, it generates vapor explosively and inertial forces govern the pool expansion behavior. GE uses a drift flux approach. Two-fluid modeling as is done in codes like TRAC or RELAP5 would be more appropriate.

The COPS opens a direct line from the contaminated suppression pool to the outside atmosphere. For this reason, I believe an in depth analysis is in order before one can decide a demister or cyclone separator are not needed. The Gunnderemingen (spelling?) plants in Germany have cyclone separators on their containment overpressure system. Are they being super cautious or do they know something we don't?

An Interesting Scenario

The more probable core melt process leads one to believe that all the melt does not come out at once. A small amount could actuate the drywell flood system followed by the rest of the core at a later time. This would most likely yield a coolable debris very early. What, however, happens if a large amount comes out early and a small amount later? Could the small amount trigger a steam explosion that we should worry about?