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SUBJECT: Forwards util comments & recommendations on "BWR Mark I Preliminary Issue Characterization."

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Harold W. Keiser
Vice President-Nuclear Operations
215/770-7502

February 17, 1988

Mr. Hulman, Chief
Severe Accident Issues Branch
Office of Nuclear Regulatory Research
United States Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Hulman:

PP&L has reviewed the document "BWR Mark I Preliminary Issue Characterization" which was transmitted with your letter of January 23, 1988 inviting Paul Hill to attend your BWR Mark I Workshop to be held February 24 through February 26, 1988. We believe that these issues will ultimately affect the BWR Mark II containment, and so we believe that it is appropriate that our views be considered in the course of resolving the issues for the Mark I containment. For this reason we have prepared a response to each of the questions posed in the document cited above. These responses reflect the results of PP&L efforts in the area of severe accident issues over the past several years and are consistent with the various prior documents and presentations by PP&L which have addressed severe accident issues. PP&L has devoted a considerable effort to addressing severe accident issues, and we believe your consideration of our findings and our recommendations is appropriate.

Paul Hill, who requested presentation time as a self nominated speaker on your agenda, will address the topics presented in response to your Questions 1) through 7) on pages 39 and 40 of the document cited above. This limitation is necessary in order to keep within the time constraint to be observed by the self nominated speakers. This topical limitation should not, however, be taken to imply any less interest or concern on the part of PP&L for the additional issues addressed by the questions in your document. We have focussed on these first seven questions on the basis that the concerns and recommendations relating to these questions must first be resolved before the remaining issues can be effectively and properly addressed.

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I hope that the information we have provided will have a beneficial influence on your resolution of all concerns over the adequacy of the BWR pressure suppression containment concept.

Sincerely,

H. W. Keiser

Attachment

PRH/laj

ATTACHMENT

Response to Questions
from
BWR Mark I Preliminary Issue
Characterization, January 21, 1988

Pages 39, 40

1. Question 1)

Are the discussions of phenomenological issues adequate? Are there other important mechanisms which can challenge Mark I containments involving phenomena not encompassed by the identified issues?

Response

The presentation of phenomena seems unbalanced. There is much discussion about phenomena, such as steam explosions, which are ultimately dismissed as unimportant or not significant risk contributors. In the specific case of steam explosions, for example, a decision must be made on whether such a risk is present or not. This is necessary because the operator response to the potential for core melt and vessel failure should be to flood the drywell floor if it is clear that steam explosions would not threaten containment integrity.

This decision must be made at the time when the Emergency Operating Procedures (EOPs) are developed. The issue here is not

> "What is a conservative estimate of the risk from steam explosion?"

in the classical PRA sense, but rather

> "What is the optimal strategy to respond to a threat of core melt and reactor vessel failure?"

so that the EOPs and operator training will assure the most favorable reaction for minimizing plant damage and risk to the public and plant personnel.

This perspective seems to be lost in the NUREG-1150 approach and in the bulk of other contemporary risk assessment studies. To repeat, the focus must be on how to structure procedures and training to minimize damage and risk, not how to derive a conservative estimate of damage and risk. It is essential that recognition of this difference in approach occur and that it be adopted by the NRC and nuclear utilities.

These two approaches frequently lead to very different views of a particular accident sequence and can lead to quite different views on the appropriate response to the threat which the sequence presents.

2. Question 2)

Are the magnitudes of the parameters representing potential containment challenges all included in the ranges identified, or can credible sequences be postulated with values which exceed those included in the issues as discussed?

Response

There is an inordinate tendency in the discussion provided in Section 2 of this document to focus on extending the range of conditions which can be tolerated by the containment. As a result, the accident sequences and phenomena presented in this discussion are excessively conservative and severe.

Operator action to preserve the containment function should be very much a part of the assessment of containment capability. If more attention is directed to operator action to avoid these severe sequences or reduce their severity, the actual risk associated with operation of the plant is almost certainly much less that if primary attention is focussed on the overly severe sequences identified in NUREG-1150 and other contemporary risk assessment documents.

The PP&L experience in performing a realistic risk assessment for the Susquehanna Steam Electric Station has been that attention to the details of the dominant contributors to plant damage has reduced the expected frequency of damage by two decades and the frequency of severe containment challenges which could represent a significant public risk by approximately three decades. This result has been achieved, however, by careful attention to the specific vulnerabilities of the plant and making certain that procedures and training will assure a very high probability of correct operator actions to achieve these reductions. This process involves more detailed attention to the specifics of the event transient timing and the potential for operator failure to accomplish the necessary actions in a timely fashion. This assessment requires consideration of

- the time available for operator actions,
- the quality of symptomatic information available to the operator to prompt the action,
- the extent to which training has sensitized the operator to the critical situations associated with specific plant vulnerabilities.

The result of such studies and attention to procedures and training we believe represents a real reduction in the expected frequency of the very severe accident sequences which can be postulated. We believe it is far better that a nuclear utility devote resources to this process before any major revisions to containment capability are considered. This process will be far more productive and cost effective for true risk reduction, can strongly impact the cost of appropriate revisions to improve containment capability, and can also strongly influence their relative effectiveness.

3. Question 3)

The manifestations of the phenomena can be affected by human actions both prior to the accident and through errors in accident diagnostics and management. Do the identified phenomenological issues imply undue reliance upon favorable maintenance, operation or mitigative behavior. Conversely, are there reasons to assume that any of the phenomenological issues can be further narrowed by reliably predictable human behavior?

Response

In general, PP&L believes that the perceived importance of the phenomenological issues identified are a result of improperly discounting the effectiveness of operator actions backed by effective surveillance and maintenance programs. This approach has, in our opinion, resulted in a failure to recognize the importance of a well trained and disciplined operations staff backed by clear and effective procedures and training specific to the plant, and has inappropriately focussed attention on less effective or overly expensive methods for improvement of containment performance for the expected dominant accident sequences.

PP&L believes that much can be done to influence the phenomenological issues which should be considered. PP&L has identified twelve important operator actions in severe accident response and four analysis assumptions normally used in BWR risk assessments that severely distort the view of the dominant severe accident sequences which should be considered in EOP development and operator training. These sixteen items were identified and discussed in a letter to E. S. Beckjord, Director of Research, in November, 1987. We suggested that these items should be given explicit attention by the NRC and BWR utilities before any direct consideration is given to containment performance related plant modifications. The reason for this preferential consideration is that attention to and accommodation of these sixteen items not only results in a drastic reduction of the calculated frequency of plant damage, but it also has a dramatic impact on the profile of dominant risk sequences. This impact can influence the relative benefit, and cost, of the various containment related modifications that should be considered for operational risk reduction. We strongly recommend that these sixteen items, and perhaps other similar or related items be given consideration before making any decision on modifications intended primarily to improve containment performance.

4. Question 4)

Can any of the phenomena be either precluded or limited in magnitude of challenge to the containment by a feasible addition to or removal from any region of the containment of materials, or by alteration of current maintenance or operation procedures? Are there other phenomena which diminish the challenges?

Response

It is not clear at this time whether or not addition or removal of materials in the containment, or any other containment performance related modification would have a significant favorable impact on overall containment performance. We believe the answer to this question is very strongly plant specific and that it can only be answered by a specific

consideration of the detailed vulnerabilities of the plant. We believe these vulnerabilities are very much dependent on specific design features of a plant with properly developed procedures and training as discussed in answers to the preceding questions. Aside from the sixteen items discussed in the answer to Question 3) above, the presence of steel liner plate on the drywell floor is believed to have a potentially major effect on the threat from core-concrete interactions. The presence of this liner will potentially inhibit the initial release of water vapor from the concrete and result in a drastic reduction in the chemical reaction energy that can be released in the early period of the core debris pour. This delay can, in turn, provide a greater time period for quenching the debris to sufficiently lower temperatures so that these chemical reductions will not occur to an extent sufficient to defeat the quench process.

The presence of this liner may be sufficient to result in a very large reduction in the conditional probability of a core debris pour that cannot be quenched prior to severely threatening containment integrity.

In the same way, more attention to terminating the core damage progression prior to failure of the reactor vessel can very sharply reduce the conditional probability of the core on the floor situation and therefore greatly reduce the threat to the containment. These two issues, and others not discussed here, we believe will result in a drastic revision to the current perception of severe accident risk involving loss of containment integrity.

The influence of the various items involved, however, are believed to be highly plant specific so that a definitive evaluation should be carried out for each plant.

5. Question 5)

Are there separate effects experiments which have the potential for demonstrating low likelihood or limited effect of any of the phenomena?

Response

There are certainly a number of analyses which could directly contribute to the development of procedures which offer the highest likelihood of having a favorable influence on accident sequences to either terminate the sequence or alleviate the severity of the sequence. These analyses include:

- o calculations to determine limits on drywell spray operation for a spectrum of severe accident sequences to reduce drywell temperature, flood the drywell floor, or cool core debris on the drywell floor,

- o calculations to determine the criteria for success in arresting core damage sequences prior to reactor vessel breach for a wide spectrum of core damage sequences, and

- o calculations to determine the criteria for quenching and stabilizing core debris on the drywell floor for a wide spectrum of reactor vessel breach sequences.

It is important, however, that the accident sequences take realistic credit for effective use of available plant equipment by the plant operators. These calculations of sequences should assume that optimal procedures have been developed for the plant analyzed and that operator training is thorough and effective so that failure to utilize plant facilities is dominated by equipment failure rates or realistic time constraints for operator action and not by operator error in following or executing procedures. This approach is essential if proper conclusions are to be drawn regarding optimal response strategies to the most probable severe accident sequences. Development of procedures based on the accident sequences resulting from present day conventional risk assessment assumptions and practice could lead to improper conclusions regarding optimal response strategies.

The analyses recommended do involve a wide variety of physical and chemical phenomena that are poorly understood in terms of hard experimental data to demonstrate the validity of the analytical models and physical data used in the calculations. It would not be justifiable or economically viable to conduct full or even large scale tests to develop the necessary empirical evidence needed to demonstrate the adequacy of current methods or to identify the improvements necessary to current methods. Nevertheless, it should be possible to greatly improve the credibility of current models by careful examination of the analytical representations and fundamental data used, to define separate effects experiments which could be used to reduce the potential for deficiencies in our models and data which could lead to a defective view of the event progressions and the influence of operator induced changes in the conditions which determine the event progression.

At the present time PP&L sees very little indication of a systematic effort to implement this type of evaluation to develop a credible approach to severe accident management on the part of either industry or federal organizations. While such an approach may not produce confidence in the appropriate nature of the response strategies developed in the short term, we believe that it is important that this approach be taken. In the short term we must use the models and data currently available as effectively as we can. It is essential to realize, however, that conservatism in developing an estimate of public risk on the frequency and nature of plant damage may lead to an inappropriate or non-optimal choice of accident response to procedures. Recognition of this distinction is essential in achieving the goal of minimizing the risks associated with nuclear plant operations.

6. <u>Question 6)</u>

Are any of the phenomenological issues related to one another or combinations? If so, how are they related?

<u>Response</u>

There are many complex and direct phenomonological issue relationships which must be considered. As an example the degree of success of stabilizing a core damage sequence prior to reactor vessel failure has a very direct and powerful influence on the importance of core-concrete interaction phenomena if a high degree of core stabilization can be achieved. PP&L believes that optimal Emergency Operating Procedures

backed by effective operator training and relatively low cost plant modifications can result in a very high level of success in this regard for most BWR plants. At Susquehanna we believe the success rate should be well in excess of 90%.

There are numerous other similar relationships which should be considered in the development of optimal EOPs for a plant. These include:

- the relative probability of ex-vessel steam explosion versus drywell floor flooding to reduce core debris threat to the containment,

- the relative probability of loss of containment integrity from drywell spray operation versus the need to reduce containment temperature or flood the drywell floor,

- the relative negative impact of wetwell vent closure before re-introduction of non-condensibles versus the added release associated with extended vent opening,

- and others.

It is these types of interactions which should receive primary attention as opposed to consideration of adverse influence of uncertainties in models and data for individual event sequences. The analyses should be done with consistent and realistic models unless it can be shown that conservatism in treating a given phenomonological uncertainty will not lead to a selection of an unfavorable procedural response to accident sequences.

7. <u>Question 7)</u>

Is the containment response (failure modes, locations of leakage paths and tear locations) to overtemperature/overpressure challenges evaluated for Peach Bottom [44] likely to be similar for all Mark I containments?

<u>Response</u>

While PP&L cannot address the adequacy of analyses for facilities other than Susquehanna, we do believe that dominant severe accident sequences and the specifics of the damage state are surely highly plant specific. The results for one plant should be used only as general guidance for examination of a different plant even when the superficial design features of the plants are identical. The details of construction, equipment installation and configuration, and support system design can have a dramatic impact on the magnitude and nature of dominant accident sequences.

<u>Page 47</u>

8. <u>Question 1)</u>

Do the periods of deinerted operation allowed by technical specification (24 hours before shutdown and 24 hours upon startup) present a sufficient vulnerability to necessitate a reduction?

Response

This issue was not addressed in the Susquehanna IPE (January 1986). We intend to examine the potential impact of this LCO in the first revision to the Susquehanna IPE which is tentatively scheduled for completion in 1988. Our engineering judgement at this time is that this LCO does not represent a significant contributor to increasing the severity of consequences from severe accident sequences.

9. Question 2)

Are the nitrogen supplies provided at Mark I plants sufficient to maintain an inerted atmosphere for long term station blackout scenarios?

Response

Specific analysis has not yet been performed for Susquehanna, but this issue is not expected to represent a problem at Susquehanna.

10. Question 3)

Are the risks of oxygen addition from compressed air supplies used for primary and back-up operation of valves and instrument lines too high? If so, should nitrogen back-up supplies be substituted for oxygen supplies?

Response

Susquehanna uses a nitrogen system for these purposes, and so PP&L has not addressed this issue.

Page 49

11. Question 1)

What are the potential negative impacts of blocking most of the containment spray nozzles (for example on RHR system operation), and providing a crosstie to diesel fire pumps? How can these impacts be ameliorated?

Response

PP&L recognizes this issue as a potential problem area. Our recommendations for this issue are presented in the answer to Questions 5) and 6) on page 40.

12. Question 2)

Fission produce scrubbing is a known advantage of spray use. What quantifiable advantages also could be realized with respect to shell and debris cooling (separately, and in combination with venting, or in combination with venting, core debris control and use of fire sprays in the reactor building)?

Response

The PP&L views on this question are also covered by our response to Question 5) and 6) on page 40.

13. Question 1)

A key question is whether or not there is a net benefit to plant safety derived from venting. Can specific procedures and hardware modifications be developed to demonstrate that a complex severe accident at a Mark I plant is understood enough such that an adequate venting strategy may be developed?

Response

PP&L evaluations of the potential benefits of wetwell venting have shown a significant reduction of containment overpressure failure frequency if wetwell venting capability is provided. In addition we have found that assuring that the PP&L defense in depth criteria are satisfied may require wetwell venting for some accident sequences, although our evaluations and conclusions on this aspect of wetwell venting are not yet final.

On the negative side, however, we find that is is highly likely that modifications to existing equipment will be required in order to assure that vent operation does not result in potentially detrimental loss of equipment or loss of access to critical plant areas. Furthermore, even the most limited modifications to achieve an acceptable level of certainty that vent operation will not result in such loss are expected to be quite expensive and could result in a significant increase in outage time.

Finally our preliminary studies to determine appropriate wetwell vent functional design criteria and operational constraints have indicated that these issues are quite complex and considerable effort to develop a demonstrably acceptable design and the necessary procedures for its use may be required and may involve considerable effort and expense.

Our preliminary findings on this subject for Susquehanna were presented to an NRC team headed by Dr. W. R. Butler during a visit to Susquehanna on February 11, 1987. We recommend reference to the information provided to Dr. Butler and his associates during that visit.

14. Question 2)

Can the potential negative aspects of venting be minimized? How?

Response

The negative aspects of venting can almost certainly be sharply reduced, if not completely eliminated, by providing appropriate design features and by imposing appropriate operational constraints. The specific mix of dominant accident sequences for a plant can have a major impact on the nature of the design features and operational constraints required. The design features in turn can have a dramatic influence on the cost of the wetwell vent and the operational constraints can have significant impact on operator training. It is important that the dominant accident sequences be properly identified in advance so that the financial impact of providing a vent will not be needlessly high and so that the procedures and training are appropriate to the accident sequences judged to be most likely for the plant.

15. Question 3)

Another issue of major concern centers around the pre-accident decision of who has the authority to cause venting to take place? Should the operator be vested with that authority, the utility management, or should a passive system be designed which will provide absolute, invariate action?

Response

PP&L has not yet resolved its views on this issue. At the present time our inclination depend on operator action to open the vent in accordance with approved procedures for the action. It seems very probable that a manual enable function should be provided to allow subsequent vent operation regardless of whether the subsequent operation is passive-automatic or operator initiated.

16. Question 4)

From a design perspective, the question arises as to the need for a safety-grade system. Can a modified vent system that includes non-safety grade components be relied upon just as a safety grade system could?

Response

The interface of the vent system to any existing safety related system must satisfy the existing requirements for such interfaces. It is entirely inappropriate, however, that the usual requirements for safety grade systems, such as redundancy or seismic capability, be imposed on the vent system itself.

There should be assurance that good design and construction practice has been utilized, and there should be some provision to assure that the system would have a high probability of proper operation should it be required during the licensed life of the plant. PP&L has not yet generated a position on what the nature of the provisions to assure these features and to demonstrate adequacy should be.

Page 54

17. Question 1)

Are drywell curbs technically feasible?

Response

PP&L believes that the effectiveness of drywell curbs is highly plant specific, at least for Mark II plants. For Susquehanna, drywell curbs, which could provide additional assurance that critical containment functions would give additional protection against core debris, are believed to be feasible. We have not yet determined that such protection provides significant additional protection against containment failure caused by core debris. We believe that such a finding could only be made after execution of the investigations discussed in Questions 5) and 6) on page 40 have been carried out.

At this time we believe primary attention should be given to core stabilization (prevention of reactor vessel failure) and core debris quench (pre-flooding of the drywell floor). If these actions can be achieved in a high percentage of accident sequences for Susquehanna, then we would see no true benefit from provision of such curbs. Further, we have identified no probable sequences for which defense in depth would require such curbs based on our current expectations for resolution of core damage and core debris phenomena.

In the worst case, we would expect to identify a need for only partial protection from curbs to serve the function of providing additional margin against uncertainties as opposed to a full protection requirement providing primary protection against loss of containment integrity resulting from core debris attack on critical containment components.

18. Question 2)

Are torus room curbs with or without drywell curbs feasible?

Response

Not applicable to Mark II containments.

19. Question 3)

Would curbs in either location interfere significantly with reactor operations? In addition, would curbs in the drywell alter the outcome of accidents within the original design envelop with respect to such topics as blockage of vents and the drywell heat attenuation capability?

Response

This issue has not yet been investigated for Susquehanna with regard to operations. It is highly unlikely that the containment design basis would be in any way influenced however.

20. Question 4)

Several means of protecting drywell concrete from debris attack, for example by covering the floor with a water-porous pebble bed of thoria and alumina, have been suggested. What would be the efficacy and practicality of such measures? Is water in addition to a curb necessary to protect the curb?

Response

At Susquehanna the drywell floor is covered by a steel plate which serves as the leakage barrier between the drywell and the wetwell air space. We believe that the presence of this steel plate will serve to prevent immediate decomposition and release of water vapor or carbon dioxide from the concrete for the debris pour rates expected for accident sequences at Susquehanna. This would prevent the energy of chemical reactions from inhibiting debris quench by water due to film boiling or critical heat flux heat transfer limitations. Further, according to current ORNL models, which we believe have considerable merit, the initial debris pour would include relatively little fission product decay heat energy. For

this reason the quench process would be required to remove only the latent heat of fusion and sensible heat carried by the core debris. The subsequent period of the core debris pour which would contain UO_2 in significant amounts would then be separated from the concrete not only by the steel plate, but also by the initial pour of debris which has been quenched.

This, we believe will also then permit effective quench of the UO_2 material and prevent any significant attack by the melt on the drywell concrete.

For this reason we view water on the drywell floor as the primary means for protection against core debris phenomena and consider barriers to be only a devise that may be needed for partial protection to provide additional margin. The studies which we will carry out, if necessary, to establish the validity of this expectation are only in the preliminary planning stages at this time.

Page 56

21. Question 1)

Are the types of improvements described sufficient to improve ADS reliability?

Response

Susquehanna already has in place additional N_2 bottles to provide for extended operation of ADS. In addition, PP&L is currently in the process of installing cables and connector provisions to allow a mobile 90 Kva generator to be brought in and connected to feed power to the critical 125 VDC battery chargers to assure indefinite availability of critical DC power during Station Blackout sequences.

It is not certain at this time that additional protection for critical electrical cables is required. These cables are already qualified for the extreme conditions which can occur during the design basis accident. PP&L calculations indicate that these conditions will not be exceeded during the accident sequences which are dominant for Susquehanna. There is some possibility that the duration of high temperature conditions could exceed the qualification time limit for some accident sequences or that local temperatures could exceed the calculated values of mean drywell temperatures in critical areas.

The PP&L view on these possibilities is that the appropriate response will be to utilize drywell sprays to reduce drywell temperatures for such cases. At the present time, we are not certain that the specific procedural guidance needed to detect and avoid such conditions in all cases currently exists. We will attempt to develop additional detailed information to address this issue in our planned IPE revision.

22. Question 2)

What are other recommendations?

Response

See the response to Question 1) on page 56.

23. Question 3)

What are the benefits? For example, it increased availability of the ADS system necessary, and will it eliminate the risk from direct containment heating?

Response

For LOCA or reactor vessel failure sequences (direct containment heating) there is no concern over ADS since reactor pressure control is no longer an issue. The reactor vessel will operate at or near drywell pressure regardless of ADS operation.

Concern over ADS operation is related to reactor vessel pressure control to permit vessel injection at lower pressure, to reduce the heat source to the drywell when drywell cooling is lost, and to avoid the possibility of reactor vessel failure at high pressure.

24. Question 4)

What are potential adverse interactions between any of the proposed improvements and existing safety systems?

Response

The only issues which may represent problems are:

- o adverse effects of wetting drywell equipment, and
- o excessive pressure differentials between wetwell and drywell or containment and the reactor building.

We believe critical containment equipment is designed to withstand wetting from two phase blowdown in LOCA and that differential pressures beyond the containment design basis can only occur if venting has significantly depleted the containment design basis non-condensible gas inventory. This last issue must be addressed in design of the wetwell vent and the development of appropriate operational constraints.

25. Question 5)

Are there other improvements that might also be technically feasible to preserve the Mark I containment function in the event of low probability challenges?

Response

PP&L believes that explicit and plant specific attention should be given to assurance that all plant capability to avoid plant damage sequences or minimize their consequences will be utilized, and that the plant specific EOPs and operator training will assure a high probability of successful exploitation of such capability. This assurance must be a first priority in evaluating adequacy of plant performance in severe accident events which are dominant for the plant.

Only after this assurance has been achieved should attention be given to major plant modifications to achieve a reduction in frequency of potentially severe consequence sequences. In all cases, the primary criterion for adequacy should be defense in depth as defined by PP&L. Assurance of defense in depth is believed to be the most effective and credible means of assuring adequacy of plant capability against accident sequences having potentially severe consequences.