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MEMORANDUM FOR: D. F. Ross, Director, Division of Systems Integration

FROM: R. J. Mattson, Director, Division of Safety Technology

SUBJECT: BWR MARK I CONTAINMENT INERTING

The Reliability & Risk Assessment Branch (RRAB) has evaluated the relative impact of inerting Mark I containments from an overall risk standpoint in BWRs based on the results of WASH-1400. We considered events that could lead to a severely degraded core which could generate significant hydrogen but not lead to a core melt. For the high probability accident sequences reviewed, it does not appear that inerting containment would have a significant effect on reducing the overall risk from a BWR plant as discussed in the enclosure. This conclusion must be weighed against the uncertainties in the WASH-1400 methodology and the limited treatment of human errors.

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Enclosure:
Evaluation of Inerting BWR
Mark I Containments

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Enclosure 2

ENCLOSURE

Evaluation of Inerting BWR Mark I Containments

The accident scenarios that are of interest when evaluating the benefits of containment inerting are those that lead to extensive core damage, such that significant amounts of hydrogen are generated before containment failure by mechanisms other than hydrogen combustion. These scenarios are averted core melt accidents probably brought about by the operator restoring partially failed equipment to terminate the accident after extensive core damage has been sustained. Therefore, to evaluate the relative impact of inerting Mark I containments, the BWR accident sequences in WASH-1400 that represent high likelihood of core melt were reviewed.

The BWR scenarios with the highest probability of core melt or transients followed by a failure to scram (ATWS) and transients followed by failure to remove decay heat. As analyzed in WASH-1400, both of these scenarios resulted in containment failure due to excessive steam pressure prior to core melt (and excessive hydrogen generation). Since the purpose of inerting containment is to preclude containment failure by hydrogen combustion, it would appear to be of little benefit for the core melt scenarios with the highest likelihood. However, it must be pointed out that the Peach Bottom reactor was analyzed in WASH-1400, not Vermont Yankee or Hatch (only non-inerting BWR Mark I's), and design differences and the recommended ATWS fix could change the hierarchy of dominant sequences.

The scenarios which could lead to core uncovery where significant amounts of hydrogen could be generated prior to core melt or containment failure are LOCAs where some portion of the ECCS is recovered after having failed for a finite time. The probabilities of core melt LOCA scenarios estimated in WASH-1400 are two orders of magnitude lower than the dominant sequences discussed above. The probability of an averted core melt LOCA would be higher, but in our opinion, still lower than the dominant sequences discussed above.

Other BWR scenarios include events where all high pressure inventory makeup systems are lost and mitigation depends on the availability of low pressure systems or the recovery of the high pressure systems. One of the dominant scenarios is a loss of feedwater (LOFW) event combined with a stuck open relief valve (SORV) and failure of both RCIC and HPCI. This event would be terminated by manual action to depressurize the vessel so low pressure ECCS can inject into the core or recovery of the high pressure systems.

Our estimate of the probability for the LOFW with SORV, failure of HPCI and RCIC, and failure of the operator to manually depressurize the vessel would be the same order of magnitude as the other high risk sequences discussed earlier (ATWS and loss of heat removal capability). The WASH-1400 estimate was considerably lower because of credit for the operator to follow procedures. This scenario was discussed in NUREG-0626 which recommended that automatic depressurization be provided for these kinds of events. Implementation of this recommendation for modifying the initiation logic of the ADS (consistent with Appendix C, NUREG-0660 of the TMI Action Plan) to eliminate the need for manual action to assure adequate cooling would be expected to significantly reduce the probability of core damage from this scenario and hence the need for inerting containment is further reduced.

This assessment is limited by the assumptions used in WASH-1400. The WASH-1400 evaluation did not include beneficial operator action outside of the emergency procedures that could reduce the potential for a complete core melt, but which may have led to extensive core damage with excessive hydrogen generation (where inerting would be beneficial). Similarly, adverse operator actions outside of the emergency procedures that may lead to a degraded core (such as TMI-2) without complete core melt were not considered in WASH-1400. For the events that lead to containment failure prior to core melt such as ATWS and transients with loss of decay heat removal, the possibility of heat transfer through the containment walls which may delay containment failure by overpressure and thus allow a condition of an excessive hydrogen in the containment atmosphere to exist for a finite time were also not considered in WASH-1400. In the WASH-1400 report the ATWS events lead to containment failure by overpressure regardless of H_2 generation. Potential sequences leading to degraded cores following ATWS have not been sufficiently evaluated to determine if inerting would be beneficial. It is our judgment, however, that the high steaming rates into containment associated with ATWS will result in containment failure by overpressure.

Based on our review of high probability core melt scenarios in WASH-1400 for BWRs, it appears that inerting the Mark I containment would have only a small effect on reducing the overall risk for a BWR. This conclusion must be tempered by the uncertainties in the WASH-1400 methodology, including human errors outside of the scope of WASH-1400, such as inappropriate operator action.

Decision Rationale for the Staff's Position on Inerting

On October 18, 1979, Leonard Bickwit, Jr., General Counsel, NRC, wrote a memorandum to the Commission entitled "Adequate Protection of the Health and Safety of the Public." Observations made in that memorandum which are pertinent to the staff's inerting position in the interim rule are as follows:

1. 10 CFR Part 100 has had the effect of requiring incorporation of safety features to prevent the occurrence only of "credible" accidents or to mitigate the consequences of "credible" accidents.[1/]

2. Backfitting first requires achieving an acceptable level of safety, regardless of cost. Further safety improvements then are evaluated considering the value of the added safety as well as the economic or other impacts of the requirement.

For further background, one must consider the Commission's Memorandum and Order of May 16, 1980, in the matter of Three Mile Island No. 1 (CLI-80-16). In this order the Commission admitted the contention of hydrogen control into the restart proceedings, principally because the TMI-2 accident demonstrated that actual ECCS operation (or misoperation) resulted in hydrogen generation greater than that postulated in 10 CFR 50.44. The Commission stated that, if it is determined that

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[1/] The principal reason for adopting the Part 100 approach to "credible" accidents is to provide a reasonable legal and technically justifiable mechanism for limiting debate as to the sufficiency of design; i.e., one is not required to design against accidents that are not "credible." The necessity for such an approach is the clear technical judgment that one can never prevent (i.e., totally prohibit by design) an accident with severe offsite consequences. There will always be a mechanistic analysis that could demonstrate the possibility of such a severe accident, even though the likelihood of such an accident would be extremely small. The process for defining whether an accident is "credible" is to perform judgmental analyses as to the types of accidents against which plants should be designed (i.e., design basis accidents). Extremely low probability events (such as pressure vessel rupture) are deemed, on the basis of engineering analysis, to be "incredible" -- realizing full well that such failures could still conceivably occur. (continued on page 2)

there is a credible loss-of-coolant scenario entailing hydrogen generation, hydrogen combustion, containment breach or leaking, and offsite doses in excess of 10 CFR Part 100 guideline values, then under Part 100 hydrogen control measures beyond 10 CFR 50.44 would be required.

The staff recognizes that the credibility of the above scenario could be argued for some or perhaps even all containments. Such an argument would be based upon the fact that the TMI accident certainly demonstrated the scenario up to, although not including, the point of containment failure. However, an equally good and likely better argument could be made that such a scenario was really "incredible", because the TMI accident did not result in containment breach or leaking.

1/ Once an accident sequence has been judged to be "credible," then conservative, deterministic analyses are performed to evaluate the accident sequences and consequences; and regulatory requirements are imposed so as to:

a. For high probability accidents, require that there be "no fuel damage".

b. Reduce the likelihood of low probability sequences to very low values which could, in the limit, reduce such an accident sequences to an "incredible" status; and

c. Reduce the consequences of low probability, credible accidents to values less than specified in Part 100.

However, in spite of this legalistic approach to licensing, there are still many actions prudently taken by the NRC that serve to mitigate the consequences of accidents legally demmed to be "incredible". Examples of these are: the assumed TID fission product release for analysis of PWR containment spray systems, which includes a spray additive iodine-scrubbing system, while at the same time assuming no core-melt after successful termination of a LOCA by the ECCS; and the requirement for off-site emergency planning out to 10 miles, while at the same time assuming no core melt for a "credible" accident. These examples indicate that there certainly is, and should be, room for prudent regulatory actions within the confines of strict interpretation of 10 CFR Part 100.

This argument would be enforced by the belief that the newly imposed licensing requirements which derive from the many lessons learned from TMI should significantly reduce the likelihood of such a scenario in any event.

However, the staff does not believe it fruitful to debate in this interim rule whether such a scenario is "credible" or "incredible", because there are no established criteria that clearly distinguish between these accident classifications (accidents are better described as a continuum of probabilities and consequences). In this proposed interim rule, the staff prefers to establish reasonable requirements for inerting that are based on a responsible interpretation of the backfit rule; i.e., that there is a spectrum of accidents wherein prudent regulatory actions should be taken, if there is likely a small but cost-effective increase in safety.

Since inerting is only one way to control hydrogen,[2/] the staff believes that the interim rule could contain necessary and sufficient interim requirements to cover inerting without foreclosing the opportunity to examine hydrogen control measures other than inerting in the TMI restart hearing. The staff's position on proposed interim rule for inerting is as follows:

1. BWR Mark I and II containments should be inerted. The decrease in residual risk is small (based on probabilistic analyses), because the likelihood of this accident scenario is one to two orders of magnitude smaller than the dominant core melt/containment failure accident scenarios for BWRs. The persuasive argument for inerting, however, is not the magnitude of risk decrease. It is rather that (1) there are no significant countervailing

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[2/] Purging, repressurization, and recombination being other ways.

safety disincentives, (2) the cost of inerting is small, and (3) there has been substantial satisfactory experience with inerting Mark I containments. Of course, this position could and should be reevaluated in the subsequent, more comprehensive final rulemaking action.

2. Ice condenser containments should not be inerted at this time. Inerting would certainly result in a greater decrease in residual risk (compared to a BWR) from the standpoint of preventing a possible, but still unlikely, hydrogen burn (which would likely result in a containment breach), since a small break LOCA sequence is the dominant contributor to the residual risk from a PWR. However, there are also significant arguments for not inerting. First, inerting would result in an increased personnel hazard, since these containments must be entered frequently during routine operations for maintenance purposes. Second, inerting could lead to a decrease in safety performance of the ice condenser because of increased difficulty in maintenance. Third, inerting is not within proven technology for this type of containment and would have to be thoroughly analyzed and tested (with likely changes in design) before imposing such a requirement. Inerting of ice condenser containments would certainly be an appropriate subject for consideration in final rulemaking, however.

3. Dry containments should not be inerted at this time. While again there would likely be a small increase in safety, any increase would be substantially less than for Mark I or II containments because of the substantially larger containment volumes and the fact that the reinforced concrete containments can probably withstand higher pressures from hydrogen burns. Both of these considerations would permit substantially greater volumes of

hydrogen to be generated. This could still be a subject for further consideration during the final rulemaking, however.