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NUCLEAR UTILITY GROUP
ON EQUIPMENT QUALIFICATION

SUITE 700
1700 SEVENTEENTH STREET, N. W.
WASHINGTON, D. C. 20036
TELEPHONE (202) 857-9817

March 12, 1984

Mr. Nunzio J. Palladino
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Chairman:

The Nuclear Utility Group on Equipment Qualification (Group) wishes to submit these additional views on the Commission's forthcoming rule on hydrogen control requirements for Mark III BWRs and ice condenser PWRs (SECY 83-357). The Group previously submitted two letters to the Chairman, dated October 26, 1983 and December 2, 1983, expressing the view that (1) the rule should adopt a survivability standard rather than a qualification standard chiefly because all testing to date indicates that hydrogen burn conditions are bounded by the conditions associated with design basis events; and (2) that even if the Commission maintains a qualification standard in this rule, its action should not be regarded as a precedent for extending qualification requirements to other events beyond the design basis.

During the Commission briefing on the rule held on November 9, 1983, some questions were also raised about extending the requirements of the hydrogen control rulemaking to PWRs with large dry containments. It appears that some consideration is still being given to extending the rule in this manner. As you know, the rulemaking up to this point has been designed to impose hydrogen control requirements only for Mark III BWRs and ice condenser PWRs. The limitation of the rule to these small containment designs is based on sound technical considerations that have been fully recognized by the Commission Staff. It is our position that an extension of the rule to large dry containments is technically unwarranted and would serve no purpose from the standpoint of public health and safety.

The hydrogen control requirements of the rule have not been imposed on large dry containments for two principal reasons. First, the risk of a hydrogen burn is much lower for large dry

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containments. The reason for this is that a 75% metal-water reaction in a large dry containment is not likely to produce the concentration of hydrogen that is necessary for hydrogen combustion to occur (see transcript of November 9, 1983 Commission briefing, at Tr. 21-24 (remarks of Mr. Butler and Mr. Bernero)). As the Commission Staff pointed out in SECY 83-357 (page 3):

> Because of the greater inherent capability of the dry containment designs to accommodate large quantities of hydrogen (high design pressure and large volume), the staff believes that rulemaking with regard to hydrogen control can be safely deferred pending completion of NRC- and industry-sponsored research.

Although hydrogen combustion did occur at TMI-2, it occurred in a confined area, and the systems and components that must be capable of functioning during and after a hydrogen burn survived (see SECY 83-357, page 3).

Second, the Commission Staff has recognized that the decision on whether to extend hydrogen control requirements to the large dry containments can and should await the completion of the extensive generic research programs now being conducted to determine equipment survivability in large dry containments. As Mr. Mattson explained during the Commission briefing of November 9, 1983 (Tr. 25), "[the generic] analysis would likely be able to show us ways to make conclusions about critical equipment survivability in large dry containments that were much easier to judge, much more efficient to judge, generically than plant-specific." Thus, the establishment of specific requirements for the large dry containments prior to the completion of the generic testing would result in substantial expenditures by industry without any demonstrable benefit to the public health and safety.

We would also submit that any extension of the hydrogen-control requirements to large dry containments may not be done in the context of the present rulemaking. The Commission's Proposed Rule did not contain such requirements for large dry containments. If the Commission were to decide to extend the

rule's requirements to large dry containments, it should either republish the rule for comment in accordance with Section 553 of the Administrative Procedure Act or commence a new rule-making proceeding.

We thank you for the opportunity to express our views on this important matter.

Sincerely,

Nicholas S. Reynolds
Counsel to Nuclear Utility Group
on Equipment Qualification

cc: Commissioner Asselstine
Commissioner Bernthal
Commissioner Gilinsky
Commissioner Roberts

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

DEC 28 1983

MEMORANDUM FOR: Chairman Palladino
Commissioner Gilinsky
Commissioner Roberts
Commissioner Asselstine
Commissioner Bernthal

FROM: William J. Dircks
Executive Director for Operations

SUBJECT: FINAL HYDROGEN CONTROL RULE (SECY-83-357)

The Commission was briefed by the staff on the final Hydrogen Control Rule on November 9, 1983. Following the briefing we received a Staff Requirements memorandum from S. Chilk, dated November 17, 1983 (Enclosure A) and a memorandum from Commissioner Roberts, dated November 17, 1983 (Enclosure B) in which additional comments and questions were submitted. This memorandum provides the staff response to both sets of comments and questions. It is recommended that a decision on this final rule be made expeditiously, since the outcome of several licensing hearings would depend on this decision.

The Chilk memorandum (Enclosure A) contained two comments. In the first comment:

A.1 "Chairman Palladino noted that the proposed rule does not contain provisions for addressing the survivability of equipment in large, dry containments nor does it contain an adequate justification for deferring that issue for consideration at a later date."

Staff Response: The rule, as originally proposed on December 23, 1981, did contain provisions addressing the survivability of equipment in large, dry containments; however, as noted by Chairman Palladino, those provisions were deleted from the proposed final rule.

The justification for deferring the issue to a later date for those plants that have large dry containments was described in SECY-83-357 as follows:

a. The fact that TMI-2 was shut down and maintained in a shutdown condition indicates that essential equipment did generally function following the burn event.

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Contact:
M. Fleishman, RES
443-7616

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b. Design improvements implemented since the TMI-2 accident, as described in NUREG-0737, have served to reduce the likelihood of a degraded core accident.

c. As discussed in Enclosure "I" of the Commission paper (SECY-83-357), there are ongoing NRC- and industry-sponsored research programs which are expected to provide substantially improved understanding regarding the survivability of equipment in a hydrogen combustion atmosphere. These programs are expected to be completed by the end of FY 1984.

There were numerous comments from industry suggesting that the burden of performing the survivability analysis, and possible testing, was unjustified in light of the TMI-2 accident. Further analysis has provided additional justification to defer action on large, dry containments.

The staff has calculated the equipment thermal response to the anticipated containment environment created by a 100% metal-water reaction. The environmental conditions were determined by Bechtel Power Corporation to support the NTCP application for the Pilgrim, Unit 2 Generating Station. Although the staff has not reviewed this analysis and the containment profile did not account for different accident scenarios, the profiles are based on 100% metal-water reaction while the final rule requires that a 75% metal-water reaction be used. The staff's model to calculate the equipment thermal response is not a verified model, but is expected to provide a reasonable answer. The staff has used the same model to calculate the equipment thermal response which was used for the McGuire hearing. Based on this model, the peak internal temperature of a typical pressure transmitter, a heat sensitive component, will be about 272°F. This is based on an initial temperature of 220°F. Hence, even considering the 100% metal-water reaction, the peak internal equipment temperature is lower than the temperature that the equipment heats up to during qualification testing for a LOCA/MSLB (about 300°F to 340°F equilibrium).

Based on the calculations described above, and other evidence including the TMI-2 burn, it is the staff's judgment for large, dry containments that, generally all equipment qualified for DBA environments as required by 10 CFR 50.49, would also be qualified for hydrogen burn environments. This may not apply to some electrical cables. However, TVA has done some additional testing during Sequoyah licensing to demonstrate that these cables will perform their function at much higher temperatures than those experienced during a DBA. These tests satisfied the staff's concerns for the ice condenser plants and provide additional justification for removing the requirement for the large, dry containment plants.

We expect to have a more complete resolution of this issue for the large, dry containments upon completion of the ongoing research programs and analyses of the type described above. The analyses would involve computations for a few prototypical large, dry containments to determine a bounding containment environment which will be used to determine equipment thermal response during and following a hydrogen burn. We would expect to return to the Commission at a later date should this research and analyses show that additional amendments are needed. In the interim we would keep the Commission fully advised in this matter.

A.2 The second comment in the Chilk memorandum indicated that:

> "Commissioner Gilinsky favored revision of the proposed final rule to include a provision that survivability be demonstrated for containments, including large, dry systems, and to require automatic actuation of igniters."

Staff Response: The reply to the first part of this comment has been addressed in the response to Chairman Palladino's comment. With regard to the automatic actuation of igniters, it should be noted that the rule itself has never made any mention of manual or automatic actuation of the igniters. In fact, igniters are not even required. The rule merely requires a hydrogen control system, without specifying the type. If it were desired that an igniter system, if used, should be automatically actuated, this guidance could be placed in the Supplementary Information accompanying the rule. It would then have the same effect as that of a Regulatory Guide. To add a specific requirement for igniters, whether automatic or manual, in the actual rule itself might necessitate going out for another round of public comments since it was not previously proposed.

As discussed in Enclosure "J" of SECY-83-357, the staff has weighed the advantages and disadvantages of manual vs. automatic actuation of the igniters and reaffirmed its position that manual actuation is acceptable. The staff felt that it was a close call either way, but that manual actuation was consistent with Commission policy in other situations where operator action was required and sufficient time and opportunity were present. There was no preponderance of arguments for either approach.

The memorandum from Commissioner Roberts (Enclosure B) contained 7 questions which are responded to individually as follows:

B.1 Have we any quantification for the net safety improvement brought by the rule?

Staff Response: The staff has not quantified the net safety improvement brought by the rule, nor has the rule been evaluated with respect to the proposed safety goals. The rule is related to mitigation of the consequences of degraded core accidents, rather than core melt accidents, though we recognize that it may have some safety benefits for dealing with some core melt accidents. Yet, we cannot readily distinguish accident scenarios leading to only a

degraded condition from those leading to core melt. Up to now the primary technical basis for the rule is engineering judgment that small containments need design improvements to better cope with the hydrogen threat.

At this time, based on the PRA for GESSAR-II submitted by General Electric, it appears that there would be some reduction in the conditional probability of containment failure due to the implementation of a hydrogen control system in Mark III containments; however, the quantification of such a benefit as well as the impact on overall plant safety is still under evaluation. The staff with its contractor, Brookhaven National Laboratory, is currently evaluating these effects in conjunction with our review of the GESSAR-II PRA.

B.2 Please explain the rationale for changing "equipment survivability" to "equipment qualification". Are we changing the design basis now?

Staff Response: In the proposed rule published in the Federal Register of December 23, 1981, an amendment was proposed to paragraph (c) of Section 50.44 of 10 CFR Part 50. Part of that proposed amendment was to add a new subparagraph (3)(v) requiring that systems necessary to establish and maintain safe cold shutdown and containment integrity be provided that are capable of performing their functions during and after being exposed to a hydrogen burn environment. The Supplementary Information accompanying this proposed amendment described a two-step approach to qualifying this equipment. As a first step, the equipment would be demonstrated to meet "survivability" criteria. The second step would require "qualification" of this equipment. A comparison describing the differences between demonstrating survivability and demonstrating qualification was also provided.

Subsequent to the issuance of the proposed rule described above, a final rule addressing environmental qualification of electric equipment, 10 CFR 50.49, was issued. Although 10 CFR 50.49 is only applicable to the qualification of equipment for design basis accident environments, it is the staff's opinion that the requirements are sufficiently general that demonstrating survivability in accordance with the criteria described in the Supplementary Information accompanying the proposed rule published on December 23, 1981, also demonstrates qualification. Therefore, it is the staff's position that a two-step approach to demonstrating qualification for a hydrogen burn environment is no longer necessary, since demonstrating survivability as defined in the proposed amendment provides the same result. The staff is not changing the design basis by taking this position.

It should be noted that results of research and analyses performed by an NRC contractor, by EPRI and by the industry show that the surface temperatures for most electrical equipment will not exceed the surface temperatures achieved during qualification testing for LOCA/MSLB events. Because of this, qualification testing for design basis accidents demonstrates qualification for a hydrogen burn environment for those situations where hydrogen burn analyses show that the equipment surface temperatures are less than those achieved during qualification

testing. Thus far, only one item of equipment, some cable, has required testing specifically to address its ability to function in the burn environment. This additional testing was needed because analyses for hydrogen burn events indicated that the surface temperature would exceed the qualification temperature for LOCA/MSLB events. All such exceptions will be reviewed by the staff on a case-by-case basis.

The staff is now using "qualification" in a broader sense than has been used previously. As discussed on page 12 of Enclosure "F" of SECY-83-357, "qualification" is now viewed, "as the generation and maintenance of evidence using tests and analyses to assure that systems and components will operate on demand to meet system performance requirements." The demonstrations of survivability accepted by the staff for Sequoyah and McGuire without more testing, analysis or documentation are equivalent to demonstrations of qualification for a hydrogen burn event, and the staff does not require any other submittal from the licensees except for the previously identified confirmatory items. Thus, as a practical matter, the staff is using the terms survivability and qualification interchangeably. Therefore, the concerns expressed by the Nuclear Utility Group on Equipment Qualification, in letters to the Chairman dated October 26, 1983 and December 2, 1983, should be alleviated.

B.3 Please summarize the type of analysis which will be required by the rule. Who will review the analysis and on what time frame?

Staff Response: The proposed final amendments to 10 CFR Part 50 would require that the owner of a Mark III or ice condenser plant perform analyses to support the design of the hydrogen control system and to assure the structural integrity of the containment and the ability of certain essential safety systems to function during and after a postulated hydrogen burn. Documented guidance on the type of analyses that would be required is available from a review of the Sequoyah, McGuire and Grand Gulf dockets.

In general, a base case accident sequence will be identified by the licensee or applicant based on consideration of the probabilities of various degraded core accident sequences and on the associated hydrogen threat to containment integrity. The accident sequence will be analyzed, using codes such as MARCH, to determine the hydrogen and steam release to the containment atmosphere. Analyses of the containment pressure and temperature response will be performed for the identified sequence using an appropriate containment computer code, such as the CLASIX code. Key aspects of this sequence will be parametrically varied by the licensee or applicant to determine the impact on containment response. The hydrogen control system analyses reviewed by the staff to date have included containment response analyses for parametric variations in: (1) hydrogen burn criteria; (2) hydrogen release rate; (3) degraded safety system operation; and (4) degraded igniter performance. Acceptability of the containment response is based on a comparison of the calculated peak containment pressure and essential equipment temperatures with the containment pressure capacity and equipment qualification temperatures, respectively.

Containment structural integrity will have to be demonstrated by use of an analytical technique that has been accepted by the staff. The technique could include calculations of the containment ultimate pressure capacity using actual material properties with suitable margins to account for uncertainties in modeling. Another method could include a demonstration that appropriate criteria of the ASME Boiler and Pressure Vessel Code are satisfied, i.e., Service Level C limits for steel containments and Factored Load Category for concrete containments. If there exist applicable analyses done by others, these may be referenced in lieu of new analyses.

Qualification of essential equipment may be demonstrated using a combined approach of analysis and testing. An acceptable thermal analysis would first have to be performed for the containment in order to determine the thermal load on the identified essential equipment during the postulated hydrogen burn. Equipment heat-up will have to be calculated using heat transfer computer codes such as the HEATING5 code developed by Oak Ridge National Laboratory. The thermal response of the essential equipment will then be compared with the thermal response experienced during their qualification testing for design basis accidents. The licensee will be expected to either demonstrate that the qualification thermal response for the design basis accidents envelope the thermal response during a postulated hydrogen burn, or provide separate bases for acceptability, e.g., additional equipment testing performed at predicted hydrogen burn conditions.

It is expected that each licensee or applicant will review its analytical approach with the NRC staff and arrive at a mutually agreeable method for performing the analyses. The staff will conduct a multi-disciplinary review of the licensee's or applicant's analyses. This review will be conducted on a time frame consistent with the scheduled licensing decisions for new plants, or on a mutually agreed upon time frame for operating plants. The scope of the staff's review will be consistent with that completed for the Sequoyah plant.

B.4 To what degree have post TMI requirements reduced the risk of H_2 production for Mark III's and ice condenser PWRs?

Staff Response: The NRC staff has not been able to quantify the risk reduction associated with the post TMI requirements though there is a general belief that a significant improvement has been achieved.

The Bulletins and Orders Task Force published its prioritization of the items it recommended in its final report. These priorities are based on feasibility of accomplishment within given time frames rather than on risk reduction.

Many of the post TMI requirements relate to information available to operators, operator interpretations, training and understanding, and possible operator actions. A quantitative assessment of the reduction of risk in these areas would be subject to very large uncertainties because of the limited human factors data base at this time.

Clearly, if a credible case could be made for substantial risk reduction due to the post TMI requirements, this would have to be taken into consideration in devising further rules. The staff has operated under the assumption that some risk reduction has been effected, but that its exact extent is not quantifiable.

B.5 Will this rule be evaluated after the safety goal evaluation period? Any illumination as to how this rule will fare after the evaluation?

Staff Response: We are presently not using the safety goal in regulatory decisionmaking. In the future, if it is decided to evaluate the NRC regulations in light of the safety goal, then this regulation would be considered as well. A problem that would arise in evaluating this regulation against the safety goal has been mentioned in the reply to question B.1., that is, the safety goal does not distinguish between hazard states leading to a core melt and hazard states that are arrested short of a core melt. If such an evaluation were performed, this regulation would probably fare relatively well, compared to other regulations, because of the low cost involved with installing the igniters.

B.6 How conservative are the hydrogen generation figures called out in the rule?

Staff Response: For severe but recoverable accidents (which stop short of core melt), the staff considers that the quantities of hydrogen specified are conservative, but only by a factor of 2 or less. We find this measure of conservatism for these degraded core accidents to be appropriate and acceptable. It should be noted that for most recoverable accidents, (i.e., DBA's) the hydrogen generation figures are extremely conservative.

For unrecoverable accidents (which proceed to core melt), the figures may not be conservative since larger amounts of metal and even B_4C may become involved in the hydrogen production and there would also be core-concrete reaction products including hydrogen. The matter of unrecoverable accidents is being investigated in conjunction with our ongoing work on severe accidents and any associated regulatory requirements will be considered at a later date.

B.7 In reading the comments, I noted the near unanimity of the industry comments that 75% metal/water reactions is not realistic, yet this value is still adhered to. Why this disparity of views between NRC and the rest of industry? What is the significance? If the net effect is that even with lower, more realistic H_2 releases, the same analysis and qualification would be required, why is there so much disagreement?

Staff Response: The 75% figure was chosen to include a comfortable margin (but less than a factor of 2) over the TMI accident hydrogen production, which is estimated at 40-60%.

Many calculations have shown that it is "impossible" to oxidize more than 20-40% of the clad and still recover cooling. These calculations are oversimplified to the

extent that they do not include operator action or scenario variants that might lead to repeated periods of uncovering and reflooding the core, as is believed to have happened at TMI at least twice.

The staff notes that approximately 45% metal-water reaction without significant core disruption can occur in a simple scenario without reflooding and reuncovering; but this may only happen if feedwater is supplied at a rate just sufficient to permit a very limited oxidation reaction to proceed. The required rate of feedwater introduction is comparable in a BWR 6/Mark III to a single control rod drive water pump if that were the only source of supply. No single rate of feedwater introduction that would lead to 75% oxidation without core slump has been determined, but it is thought that more complex feedwater programs might reach this figure. The margin that has been allowed for these eventualities is not large. Since the rate of hydrogen production is slow under these circumstances, the 75% criterion, when analyzed realistically, may not lead to the most severe challenges to containment in a Mark III. The rule therefore, requires analyses "up to and including 75%", and consideration will be given to the controlling cases at whatever percentage of reaction they occur.

The staff's recent discussions with the Hydrogen Control Owners Group for BWR Mark IIIs have indicated a general acceptance of these principles.

William J. Dircks
Executive Director for Operations

Enclosures:
A - Memo from S. Chilk, dtd 11/17/83
B - Memo from Commissioner Roberts,
dtd 11/17/83

cc: ✓SECY
OGC
OPE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

OFFICE OF THE
SECRETARY

IN RESPONSE, PLEASE
REFER TO: M831109B

November 17, 1983

MEMORANDUM FOR: William J. Dircks, Executive Director
for Operations

FROM: for Samuel J. Chilk, Secretary

SUBJECT: STAFF REQUIREMENTS - DISCUSSION OF HYDROGEN IGNITION SYSTEM AND FINAL RULE, 2:00 P.M., WEDNESDAY, NOVEMBER 9, 1983, COMMISSIONERS' CONFERENCE ROOM, D.C. OFFICE (OPEN TO PUBLIC ATTENDANCE)

The Commission was briefed by staff on the proposed final rule changes to Part 50 on hydrogen control, as outlined in SECY-83-357.

Chairman Palladino noted that the proposed rule does not contain provisions for addressing the survivability of equipment in large, dry containments nor does it contain an adequate justification for deferring that issue for consideration at a later date. Commissioner Gilinsky favored revision of the proposed final rule to include a provision that survivability be demonstrated for containments, including large dry systems, and to require automatic actuation of igniters.

Commissioner Roberts noted that he would submit, in writing, his questions to staff.

The Commission did not take final action on the proposal at this meeting.

cc: Chairman Palladino
Commissioner Gilinsky
Commissioner Roberts
Commissioner Asselstine
Commissioner Bernthal
Commission Staff Offices
PDR - Advance
DCS - 016 Phillips

Rec'd Off. EDO
Date 11-18-83
Time 8:30 a.m.

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ENCLOSURE "A"