ATTACHMENT TO MFN- 084-80

THE BWR PERSPECTIVE ON INTERIM HYDROGEN CONTROL MEASURES

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THE BWR PERSPECTIVE ON INTERIM HYDROGEN CONTROL MEASURES

INTRODUCTION

The TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations[1] and the draft of the NRC Action Plans Developed as a Result of the TMI-2 Accident[2], recommended preparation of a rule change to require the immediate inerting of all Boiling Water Reactor Mark I and Mark II containments. Discussions supporting this recommendation were furnished in an NRC staff position paper (3) which was summarized in a meeting with the NRC Commissioners on March 19, 1980. The General Electric Company believes there is no basis for requiring inerting of Mark I and Mark II containments. This position is based not only on the inherent design features of the BWR, but also on well-defined, historically demonstrated arguments against inerting. General Electric presented this position to the NRC Commissioners on March 19, 1980 and to the Advisory Committee on Reactor Safeguards Ad Hoc Subcommittee on April 2, 1980. This report furnishes detailed comments on the NRC Staff position paper, thereby documenting the bases for General Electric's objection to a requirement for inerting Mark I and II.

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NRC STAFF POSITION PAPER

In Reference 3, the USNRC staff provides information supporting its recommendation to inert all BWR Mark I and Mark II containments. This recommendation is being made in conjunction with a proposal to conduct rulemaking proceedings to develop revised criteria for hydrogen generation and control, and for other aspects of degraded core conditions.[2]

The NRC report contains the following information:

(1) A comparison of various containment design pressures and volumes together with calculated results of hydrogen concentration as a function of percent metal-water reaction for the various reactor and containment types.

(2) The principal contributors to containment pressure increase following onset of a LOCA with substantial metal-water reaction. Identification of three important items that require consideration in establishing the magnitude of hydrogen generation that can be accommodated are noted to include: a) the rate of metal-water reaction, b) the energy storage and removal rates; and c) the resultant accident pressure vs. design pressure.

(3) Estimates of the safety margins between design pressure and failure pressure are made using best estimate yield stress for two PWR containments as a guide.

(4) A section on hydrogen mitigation measures with the principal mitigation approach considered by the staff being containment inerting. Other methods briefly considered include: halon suppressants, filtered-vent systems, hydrogen combustion systems and other methods such as chemical catalysts and gas turbines.

(5) The NRC staff conclusion that operation of Mark I and II containments is justified if they are inerted. Other larger volume containments are found to be acceptable for continued operation and licensing pending further consideration in rulemaking proceedings on degraded cores and hydrogen management.

GENERAL ELECTRIC COMMENTS

It is recognized that the NRC must respond completely to the "lessons learned" from the TMI accident. General Electric and the BWR Owners Group have been working closely and responsively with the USNRC to accomplish that goal. The NRC staff has determined that it is appropriate to recommend inerting prior to the completion of evaluations and considerations which would be a part of the proposed rulemaking proceedings on design features for core-damage and core-melt accidents. The NRC staff position paper(3) provides the information supporting the NRC recommendation. The following paragraphs enumerate the reasons why GE believes immediate actions to inert Mark I and II containments are inappropriate. General Electric strongly believes that a comprehensive evaluation of all the aspects is required prior to the imposition of the demonstrable safety and economic penalties which would result from inerting.

(1) The position paper does not consider the risks associated with inerting.

The position paper considers the acknowledged benefits of inerting as a mitigation measure in Section 5.1, but does not assess any of the adverse consequences which result from inerting. In both the March 19, 1980 meeting with the NRC Commissioners and the April 2, 1980 meeting with the ACRS TMI Ad Hoc Subcommittee, personnel from GE and Yankee Atomic Electric Company made presentations highlighting the risks and benefits. The risks are principally due to the potential safety hazards to plant personnel and to the impact on plant safety attributable to the reduction in containment accessibility and inspection capability. As an example of the former risk, one death occurred in a foreign BWR containment in 1970 when it was thought that the previously-inerted containment had been completely purged. The latter risk was cited by the Atomic Safety and Licensing Appeal Board as being a key concern in the Memorandum and Order of July 11, 1974 which resulted in the ruling ordering the Vermont Yankee plant to operate deinerted.

In the March 19, 1980 presentation to the NRC Commissioners, Yankee Atomic personnel presented information identifying the advantages of the accessibility associated with a non-inerted containment. These include:

1) The ability to quickly locate, evaluate and isolate system leakages.

2) The ability to minimize unnecessary thermal cycles on the reactor systems due to the capability to solve minor problems which, if left unattended, could develop into major equipment malfunctions.

(2) <u>The position paper does not properly consider the benefits of inerting.</u>

Inerting provides protection only against the pressure increase resulting from hydrogen burning and/or detonation. The smaller volume containment designs are, in fact, oxygen-limited, so that an effective upper bound on the amount of hydrogen that can be burned exists. As noted in Reference 4, the quantity of hydrogen that could be burned in a Mark I or Mark II containment would be limited by the available oxygen to less than approximately half the quantity of hydrogen inferred to have been burned in the TMI-2 accident.

Since inerting only addresses one of the containment failure concerns (i.e. a limited range of hydrogen flammability), it has a minimal impact on the reduction in overall reactor risk. This was also the conclusion reached by the NRC Probabilistic Assessment Staff and presented to the ACRS Subcommittee on TMI-2 in October 1979.

The Probabilistic Assessment Staff evaluated a number of event sequences for both BWRs and PWRs, inerted and non-inerted containments, and concluded that inerting appeared to have a small value in reducing overall accident risk. The evaluation also indicated that reducing accident sequence probability (i.e. increasing accident prevention capability) appeared to have equal or greater value. In addition, it was concluded that research on improved safety concepts should be pursued with priority since such concepts appeared to have greater risk reduction impact. This latter conclusion is in agreement with the Lessons Learned Task Force Final Report recommendation[5] to further consider accident prevention and mitigation means in concert with rulemaking on degraded cores and hydrogen management.

(2) <u>The position paper does not consider the superior BWR accident-prevention capability.</u>

The level of safety of the Boiling Water Reactor is established by the design of systems which prevent an accident from producing adverse consequences in concert with the design of systems which mitigate adverse consequences. In the Staff position paper, only accident mitigation is considered. It is General Electric's position that the BWR accident prevention capability precludes the need for additional mitigating capability. A number of the design features unique to the BWR which assure accident prevention are discussed in the following paragraphs.

(a) The BWR provides the plant operator with a <u>direct</u> indication of reactor vessel water level-which is the primary parameter used in assessing core cooling in response to a transient or accident. Figure 1 provides a schematic representation typical of BWR 3 & 4 plants of the range of water level measurement coverage, including the number of level sensors, their relative locations, and the number of indicators and recorders available to the operator.

(b) The BWR is designed with highly redundant water delivery systems to ensure core coolability and to prevent core damage. The typical BWR cooling network includes six high pressure pumps, nine low pressure pumps, and the Automatic Depressurization System. It is important to note that in most instances only one of these fifteen pumps is needed to maintain core coverage or prevent potential core damage due to a transient or a small break accident.* Figure 2 schematically illustrates the feedwater, high pressure coolant injection, reactor core isolation cooling and control rod drive systems and provides typical pumping capacities. Figure 3 illustrates the core spray and low pressure coolant injection systems and their water delivery capabilities. The cooling systems provide diverse phenomenological cooling capability through both core flooding and core spray, and diverse injection locations (feedwater spargers, core spray spargers, recirculation loops and control rod drives).

(c) The BWR provides multiple means to rapidly and easily depressurize the primary system, permitting the operation of the condensate, low pressure coolant injection, and low pressure core spray systems. Figure 4 schemetically illustrates the depressurization system and provides typical time durations to achieve low pressure depending on the depressurization scheme employed.

* For a transient or accident following extended operation at 100% power some plants may require both CRD pumps or, for those plants which are provided with two pumps in each low pressure core spray loop, both LPCS pumps may be needed.

Also shown schematically in Figure 4 are the reactor pressure vessel and safety-relief valve vent lines which provide for the high point venting of the BWR.

(d) The suppression pool provides a large passive heat sink with the capability to handle in excess of ~600 x 10^6 Btu heat load. The suppression pool capability effectively decouples the reactor from the balance of plant for short-term decay heat removal, permitting operations to be fully devoted to reactor inventory maintenance.

(e) The BWR is inherently capable of operating under conditions of natural circulation. Figure 5 schematically depicts the normal natural circulation flowpath from the downcomer through the jet pumps and into the core shroud region. A second natural circulation loop is shown inside the shroud. This loop will exist if the primary natural circulation flow is reduced to a low value following an abnormal transient or a postulated pipe break. Water will flow downward through the core bypass region and into the bottom of the active fuel region through the normal bypass leakage paths. This inherent BWR design feature prevents significant hydrogen generation by providing cooling whenever water inventory is available.

(4) The position paper does not recognize significant BWR-PWR distinctions.

In specifying the amount of metal-water reaction or hydrogen generation, important differences in BWR vs. PWR event sequences and core heatup are neglected. In considerations of rate of metal-water reaction in Section 3.1 of the paper it is stated that an unlimited amount of steam in the core is assumed in order to maximize zirconium-steam reaction rate, but the evaluation neglects the associated steam cooling, a very effective mode of heat transfer, in making this assessment. In Section 3.3, the assumption is made that core uncovery occurs immediately after blowdown and remains uncovered until the entire core approaches the melting point of Zircaloy. While clearly bounding, these assumptions are entirely unrealistic (for example, there is enough liquid stored in the reactor pressure vessel that core uncovery would not occur for ~45-60 minutes following scram for a loss of feedwater event even if no makeup systems were available).

In performing assessments of containment capability the PWR failure pressures are assumed to be approximately three times design pressure based on the evaluation of two PWR containments used as a guide. No BWR containment integrity evaluations were performed. Instead the failure pressure was arbitrarily assumed to be a factor of two higher than the design pressure, thereby penalizing the BWR containments at the outset of the comparison. The BWR evaluations should be performed with factors reflecting actual BWR containment capability. (It is expected that the BWR factor is in excess of 2.5.)

(5) The Staff position paper utilizes arbitrary acceptance limits in concluding that inerting is required for Mark I and II.

In Section 3.3.1 the Mark I containment was found to exceed twice design pressure with a metal-water reaction of approximately 9%. Other containment designs were evaluated, and in the limiting case found to exceed three times design pressure with a metal water reaction of 25%. In prescribing inerting for Mark I and II but not for other containment designs, it appears that the staff has found a 25% metal-water reaction rate acceptable but 9% not acceptable. There is no evident basis for these determinations.

(6) The position paper imposes containment inerting as the sole mitigation approach.

The Staff has recommended that containment inerting be imposed as the only acceptable mitigative action. No other options are provided in the recommendation for other alternatives to provide mitigation. In order to provide a balanced consideration of all the available alternatives, evaluations should be performed as indicated in the Lessons Learned Task Force Final Report[5] which recommends the orderly consideration of improvements to both accident prevention and mitigation design features.

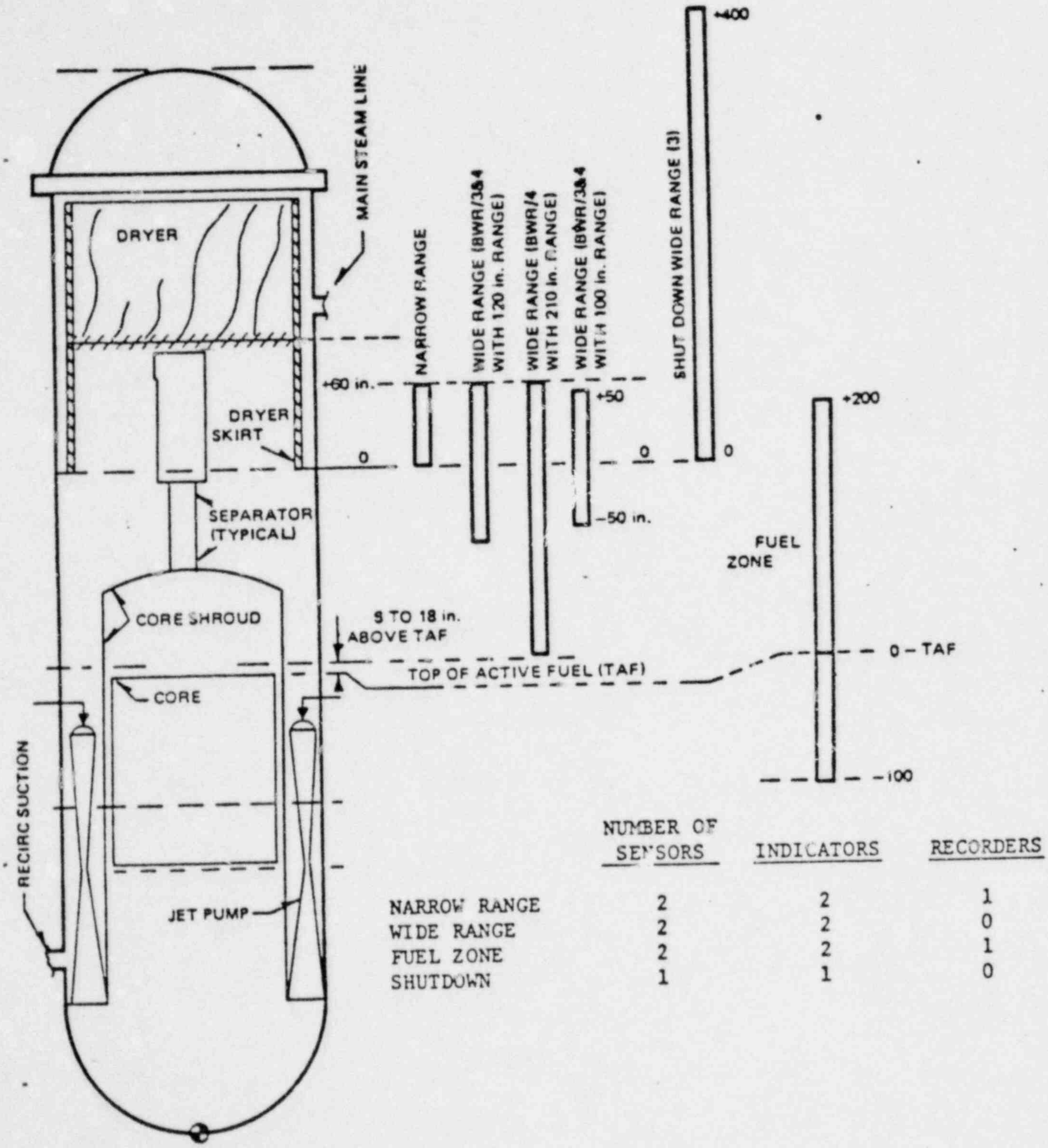
CONCLUSION

It is General Electric's position that substantial hydrogen generation is effectively prevented in a BWR due to its unique inherent design features. General Electric believes that inerting BWR Mark I and II containments is unnecessary and is not recommended due to its risks to plant personnel and reduction in operational safety. Furthermore, General Electric strongly disagrees with the NRC staff position paper in the evaluation of the risk and benefits associated with containment inerting, the lack of BWR accident prevention capability recognition, and the treatment of BWR-PWR differences. The staff proposal to arbitrarily prescribe acceptance criteria resulting in the inerting recommendation doesn't consider other accident prevention/ mitigation approaches.

It is General Electric's recommendation that detailed evaluations to address the overall issue of hydrogen control requirements be established through a disciplined process, such as the rulemaking procedures on design features for core-damage and core-melt accidents recommended by the TMI-2 Lessons Learned Task Force. General Electric feels strongly that actions to inert Mark I and II containments in advance of such actions would be premature and counterproductive to safety.

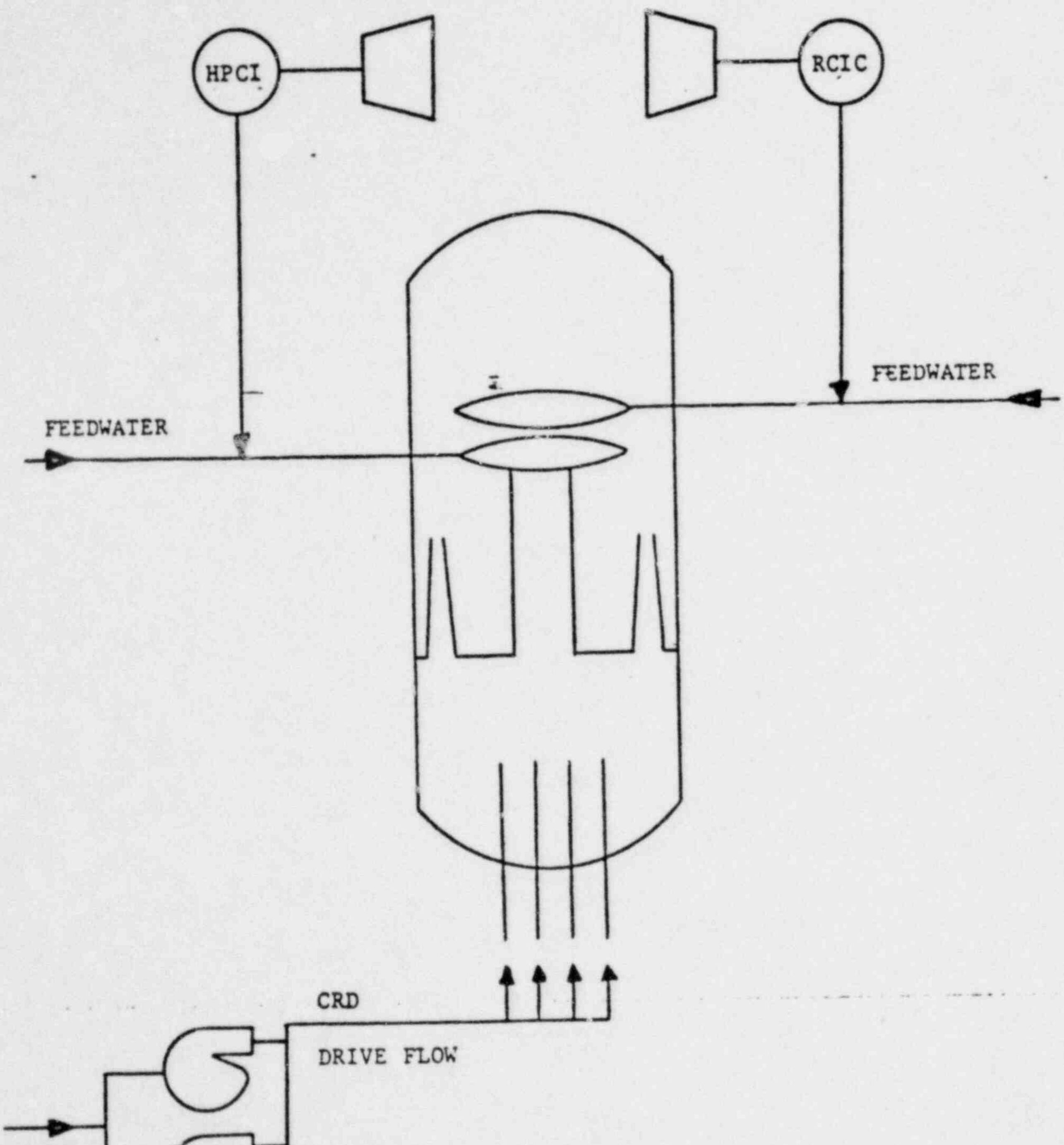
FIGURE 1

TYPICAL REACTOR VESSEL LEVEL RANGE COVERAGE
(BWR/3&4 PLANTS)



	NUMBER OF SENSORS	INDICATORS	RECORDERS
NARROW RANGE	2	2	1
WIDE RANGE	2	2	0
FUEL ZONE	2	2	1
SHUTDOWN	1	1	0

TYPICAL BWR/3,4 HIGH PRESSURE WATER DELIVERY SOURCES

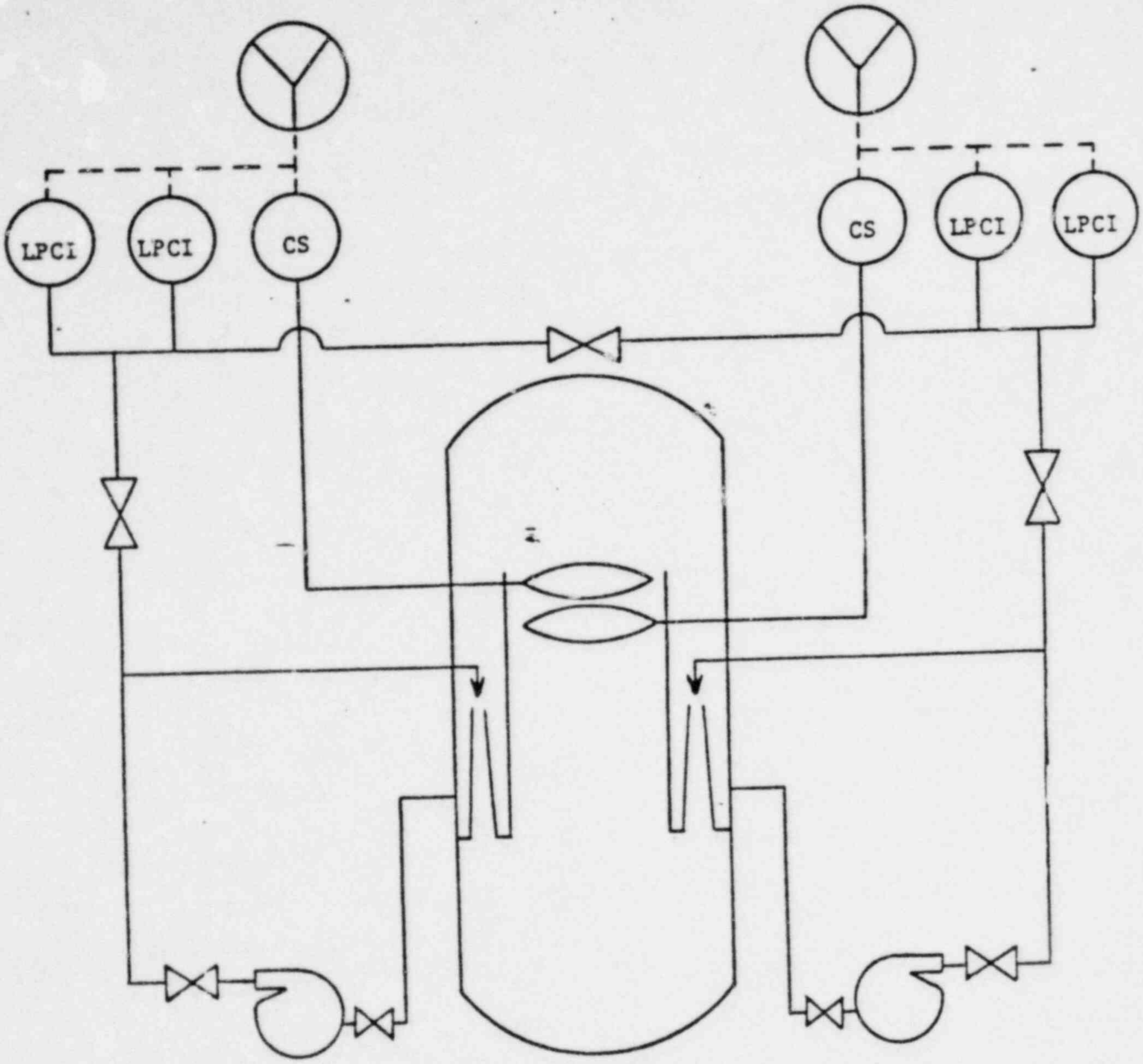


CAPACITIES

FEEDWATER		30000	GPM (2HP pumps; 3LP pumps)
HPCI		5600	GPM
RCIC		600	GPM
CRD	To	250	GPM

FIGURE 2

TYPICAL BWR/3,4 LOW PRESSURE WATER DELIVERY SOURCES



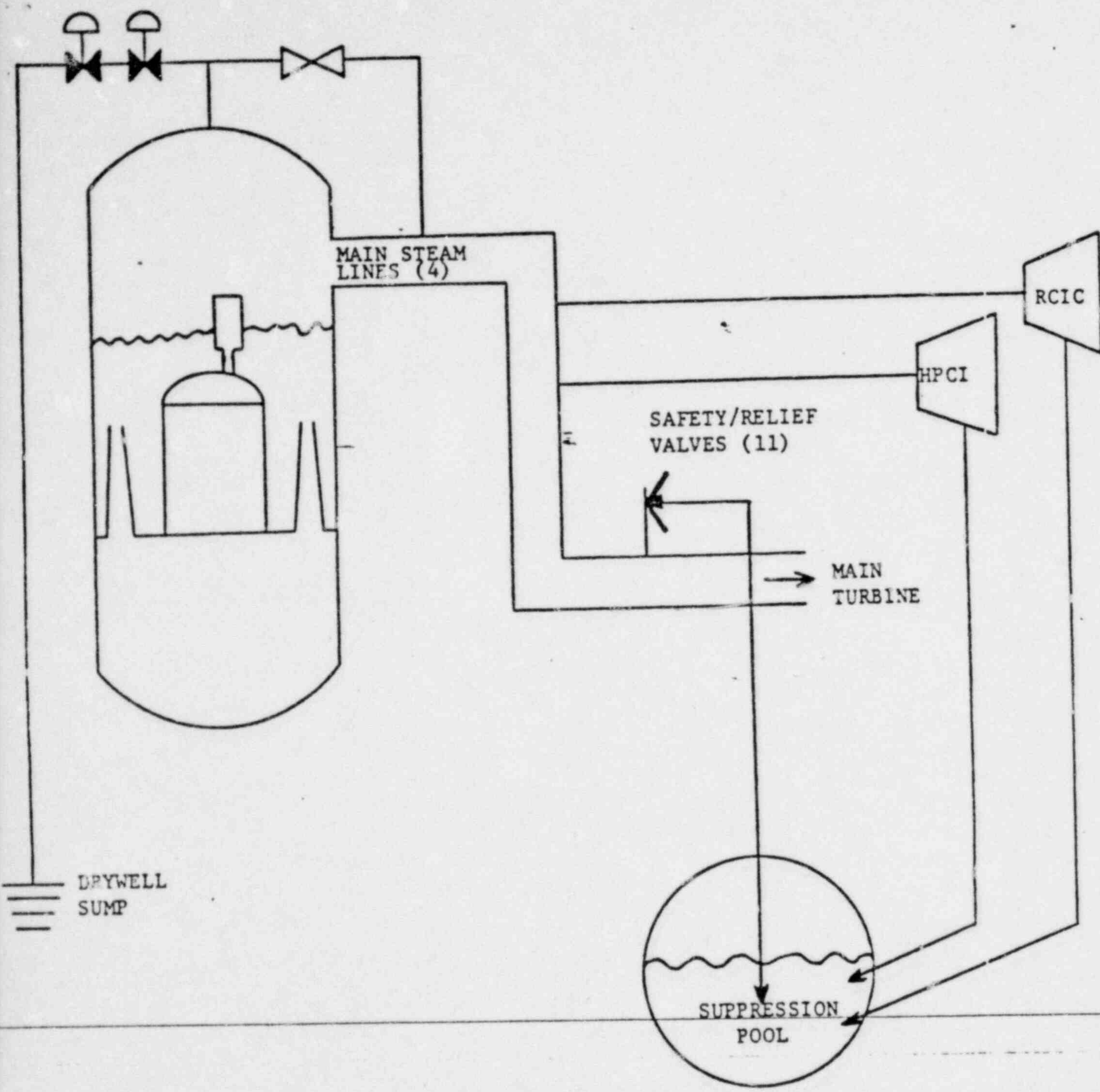
CAPACITIES

CORE SPRAY 4500 GPM PER SYSTEM
2.45 GPM MIN PER BUNDLE
LPCI 14,500 GPM/3 PUMPS

FIGURE 3

FIGURE 4

TYPICAL BWR VENTING AND DEPRESSURIZATION SCHEMES



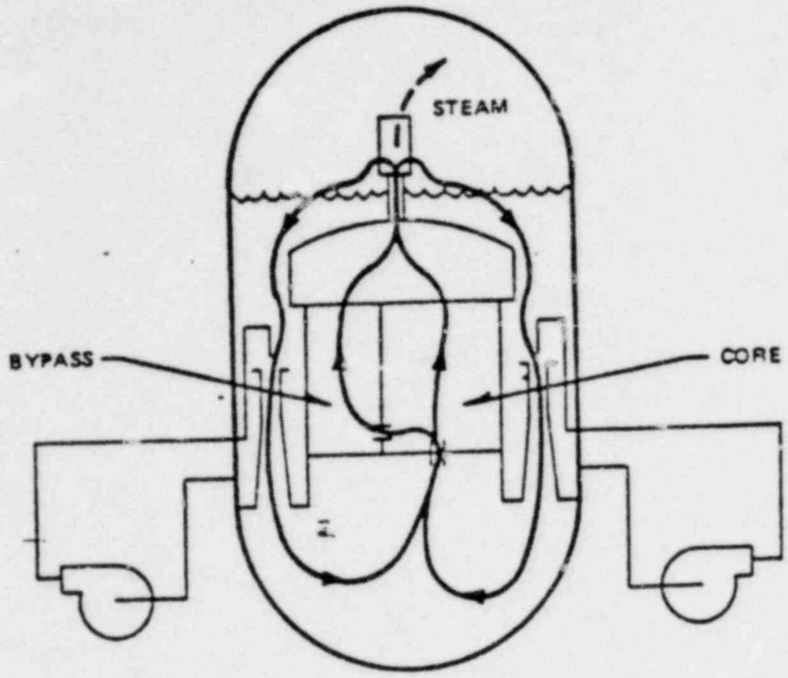
TYPICAL TIME TO LOW PRESSURE:

MAIN TURBINE/CONDENSER	> 10 MIN
S/RVs (INCLUDES ADS)	≥ 5 MIN
HPCI	≥ 3 HR

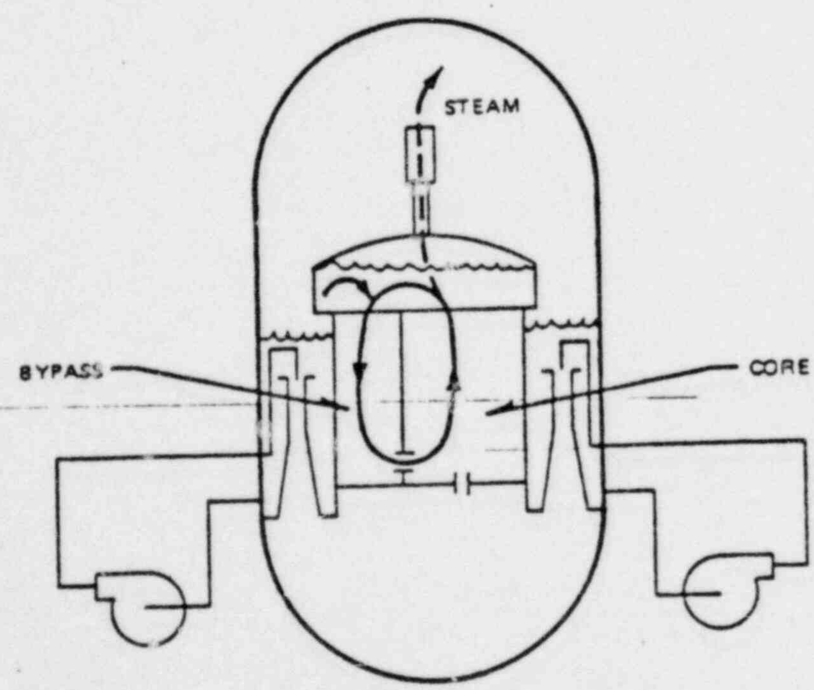
ENERGY ABSORPTION OF SUPPRESSION POOL ~ 6 HOURS OF DECAY HEAT

FIGURE 5

TYPICAL BWR NATURAL CIRCULATION



A. NORMAL NATURAL CIRCULATION



B. INTERNAL LOOP CIRCULATION

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<u>REFERENCES</u>

1. "TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations," NUREG-0578, July 1979.

2. "NRC Action Plans Developed as a Result of the TMI-2 Accident," NUREG-0660 (Draft).

3. Denton, H. R., Memorandum for the Commissioners, subject: Proposed Interim Hydrogen Control Requirements for Small Containments, SECY-80-107, February 22, 1980.

4. Wooten, R. O. et.al., "Analysis of the Three Mile Island Accident and Alternative Sequences," NUREG-CR-1219, January 1980.

5. "TMI-2 Lessons Learned Task Force Final Report," NUREG-0585, October 1979.

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MFN-0100-80

May 20, 1980

Richard P. Denise
Acting Assistant Director for Reactor Safety
Division of Systems Safety
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Denise:

SUBJECT: RESPONSE TO COMMISSION REQUEST ON INTERIM HYDROGEN CONTROL MEASURES

References:
1) Denise, R. P. letter to A. Philip Bray, April 8, 1980
2) Sherwood, G. G. letter to J. F. Ahearne, "The BWR Perspective on Interim Hydrogen Control Measures", April 21, 1980

Reference 1 indicated that in the meeting with the NRC Commissioners on March 19, 1980, General Electric was requested to provide its views on Mark I and II containment inerting, including any calculations which differ from those provided by the NRC staff in the memo SECY-80-107, "Proposed Hydrogen Control Requirements for Small Containments". General Electric's response was provided in the Reference 2 memorandum which furnished comments on the NRC staff memo, thereby documenting the bases for GE's objection to a requirement for interting Mark I and II containments.

It was noted in Reference 1 that the staff was not aware of any fundamental disagreement between the results of GE's calculations and those of the staff on hydrogen concentrations and hydrogen combustion in a noninerted BWR containment building. If it is postulated that significant quantities of hydrogen are generated as a result of a severe accident, the GE calculations of resulting containment pressures do not differ significantly from those of the staff.

However, GE believes that the superior BWR accident prevention capability would prevent the occurrence of a core uncovery event and the attendant

Enclosure 5

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core heatup and generation of hydrogen. The GE BWR accident prevention capabilities were highlighted in Reference 2. Other fundamental GE disagreements with the staff position are enumerated in detail in Reference 2 and include:

1. The lack of consideration of the risks associated with inerting.

2. The improper assessment of the benefits of inerting.

3. The lack of recognition of significant BWR unique distinctions.

4. The use of arbitrary acceptance limits in considering an inerting requirement for Mark I and II.

5. The recommendation of inerting as the only acceptable mitigating approach.

It has been General Electric's recommendation that detailed evaluations to address the overall issue of hydrogen control requirements be established through a disciplined process, such as the rulemaking procedures on design features for core-damage and core-melt accidents recommended by the TMI-2 Lessons Learned Task Force. General Electric feels strongly that actions to inert Mark I and II containments in advance of such actions would be premature and counterproductive to safety.

Very truly yours,

R H Buchholz for

Glenn G. Sherwood, Manager
Safety and Licensing Operation

GGS:mm/1608-09

cc: W. R. Butler
H. R. Denton
R. J. Mattson