MARK III CONTAINMENT
HYDROGEN CONTROL OWNERS GROUP

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HGN-055

Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. Robert Bernero

Dear Mr. Bernero:

SUBJECT: Evaluation of SBO and ATWS Contributions to Hydrogen Generation Events

REFERENCE: Letter HGN-040 from S. H. Hobbs to Mr. R. Bernero dated 7/12/85

By the referenced letter the Hydrogen Control Owners Group (HCOG) transmitted Revision 3 to the Hydrogen Control Program Plan. In that revision HCOG indicated that a qualitative discussion concerning the omission of Anticipated Transients Without Scram (ATWS) and Station Blackout (SBO) Events as Hydrogen Generation Event (HGE) initiators would be submitted to the NRC. The HCOG position is based on the low probability of either event leading to recoverable degraded core accidents which threaten containment integrity due to hydrogen combustion. Attached is this discussion. This letter constitutes closure of Subtask 1.6 and therefore completes Task 1 of the HCOG Program Plan.

This submittal was compiled by HCOG from the best information available for submittal to the Nuclear Regulatory Commission. The submittal is believed to be complete and accurate, but it is not submitted on any specific plant docket. The information contained in this letter and its attachments should not be used for evaluation of any specific plant unless the information has been endorsed by the appropriate member utility. HCOG members may individually reference this letter in whole or in part as being applicable to their specific plants.

Very truly yours,

Sam H Hobbs

MJM/SHH:vog
Attachment

cc: (See Next Page)

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EVALUATION OF SBO AND ATWS CONTRIBUTIONS TO HYDROGEN GENERATION EVENTS

The Hydrogen Control Owners Group (HCOG) completed Task 1.4 (Reference 1), Most Probable Accident Scenario, in late 1982 and early 1983. Recently however, Station Blackout (SBO) and Anticipated Transient Without Scram (ATWS) accident sequences have received increased attention as possible Hydrogen Generation Event (HGE) initiators. In this evaluation, HCOG is providing clarification as to why ATWS and SBO are not likely HGE precursors based on their relatively low core melt frequency contributions to events leading to hydrogen combustion containment failure (HCCF).

For the purposes of this evaluation, station blackout at a BWR Mark III plant is defined as a complete loss of offsite AC power and onsite AC emergency diesel generation capability, including the HPCS diesel generator. ATWS is defined as a failure to achieve reactor subcriticality following a transient initiating event.

The Reactor Safety Study Methods Application Program (RSSMAP) (Reference 2), identified event sequences which could lead to HCCF without considering the operation of the hydrogen ignition system. Because of this, the RSSMAP results are not biased by the effects of the hydrogen ignition system and are therefore appropriate for selecting the most probable HGE precursor on which to base the hydrogen ignition system design. The RSSMAP was conducted to apply the methodology developed in the Reactor Safety Study to an additional group of plants with the objective of identifying risk dominating accident sequences for a broader group of reactor designs. The GGNS is typical of all BWR Mark III plants which are similar in system design and was chosen by RSSMAP for this reason. Since GGNS is typical of all BWR Mark III plants, results from the GGNS RSSMAP are applicable to all BWR Mark III plants currently under construction (Perry, Clinton, and River Bend).

Based on RSSMAP results for GGNS, HCOG contends that SBO and ATWS core melt frequency contributions to the total core melt frequency from accident sequences leading to containment failure due to hydrogen burning are sufficiently low that these sequences need not be considered as probable precursors to recoverable HGEs.

RSSMAP identified nine dominant accident sequences at GGNS which lead to containment failure from one of the following three modes: steam explosion, hydrogen combustion, or overpressure caused by gas generation. These nine sequences represent more than 90% of the total core melt frequency at GGNS. Detailed MARCH analyses were performed for each dominant accident sequence in order to determine the containment failure mode for the sequence.

Figure 1 shows the total core melt frequency contribution for each containment failure mode. Total core melt frequency at GGNS due to all accident sequences is 3.7×10^{-5}/R-Yr. Containment failure due to hydrogen combustion sequences accounts for only about 3% of this total. This 3% contribution is further broken down by its SBO contribution in Figure 2.

Figure 2 depicts the relative contribution of SBO and non-SBO cut sets to core melt frequencies of accident sequences leading to containment failure from hydrogen combustion. As can be seen in Figure 2, three dominant accident sequences were identified (T_1PQE, T_{23}PQE AND T_1QUV) of which two (T_1PQE AND T_1QUV) had SBO cut sets.

Both of these RSSMAP sequences involving SBO also require concurrent mechanical failure of the Reactor Core Isolation Cooling (RCIC) system in order for the sequence to proceed to core melt. Without this RCIC system failure, core melt and subsequent hydrogen generation would not occur. Given that the RCIC system does fail, the T_1PQE sequence has a 4.1% SBO contribution and the T_1QUV has a 6.4% contribution. The combined SBO contribution from both sequences is 4.5% of the total core melt frequency of accident sequences resulting in hydrogen combustion containment failure. Since this is a small fraction of the total, it is not considered a probable HGE precursor.

The turbine driven RCIC pumps at Mark III plants have been shown to be capable of supplying makeup water for at least seven hours after SBO. If it is assumed that an SBO sequence occurs without concurrent failure of the RCIC system, then at least seven hours would be available for all Mark III plants to recover AC power (onsite or offsite) before RCIC failure and subsequent core melt occurs. A review of industry operating experience through 1983 shows that only one loss of offsite power at a U. S. nuclear plant has remained unrecovered for more than seven hours (Reference 3). In the unlikely event that an SBO did last longer than seven hours, and the RCIC system failed, the incremental probability of recovering from the SBO prior to reaching a severely melted core would be small. Even though this event sequence was not considered in RSSMAP, its core melt frequency contribution is very small and therefore is not considered a probable HGE precursor. Conversely, event sequences containing a stuck open relief valve (SORV) contribute 33% of the total core melt frequency from events leading to HCCF.

In order to assess the effect of hydrogen release and combustion in the drywell and on drywell equipment, HCOG is also analyzing a drywell break scenario in addition to a SORV scenario even though the drywell break has no hydrogen combustion containment failure contribution. For this analysis, HCOG selected a small drywell break initiating event due to its relatively high frequency compared to a large drywell break. RSSMAP identified one dominant accident sequence involving a small drywell break (SI). This event sequence contributes about 13% of the total core melt frequency at Grand Gulf whereas no dominant accident sequences involving large drywell breaks were identified by RSSMAP.

Of the nine dominant accident sequences identified for GGNS, only one involved an ATWS ($T_{23}C$). Following the failure to scram, reactor power is assumed to equilibrate at approximately 30%. The resulting heat rejection to the suppression pool is calculated to be greater than the heat removal capacity of the RHR system. This causes the containment to overpressurize and fail in less than 2 hours. Containment failure then leads to Emergency Core Cooling System (ECCS) failure and core melt due to suppression pool boiling and subsequent pump cavitation. Although this accident sequence contributes about 15% to the GGNS total core melt frequency, the predicted mode of containment failure for the sequence is not from hydrogen combustion, but from over-pressurization due to gas generation. This ATWS sequence has no contribution to containment failure from hydrogen combustion and therefore need not be considered as a plausible HGE. Other ATWS sequences were considered by RSSMAP, however their contributions to core melt frequency are insignificant compared to this dominant ATWS accident sequence.

It is acknowledged that the majority of the data base utilized in the GGNS RSSMAP study was compiled as part of the Reactor Safety Study and that since that time a considerable amount of additional plant specific data has been collected which would change individual cut set frequencies and therefore dominant accident sequence frequencies. It is likely that SBO contributions to HGE at Mark III plants would decrease if up to date information were used as evidenced by the fact that RSSMAP uses a relatively high SBO frequency of $9.6x10^{-6}$/R-Yr.

However, this conservatively high SBO frequency may be offset by other non-conservative data or assumptions used by RSSMAP. Overall results and conclusions obtained from RSSMAP relative to SBO and ATWS contributions to recoverable HGE are therefore expected to remain valid and are applicable to current BWR Mark III plants.

Reference 1: HCOG Program Plan

Reference 2: Reactor Safety Study Methodology Applications Program (RSSMAP): Grand Gulf #1 BWR Power Plant NUREG/CR-1659/Vol. 4 of 4

Reference 3: Losses of Offsite Power at U. S. Nuclear Power Plants: All Years through 1983, NSAC/80

FIGURE 1

GGNS Containment Failure Modes

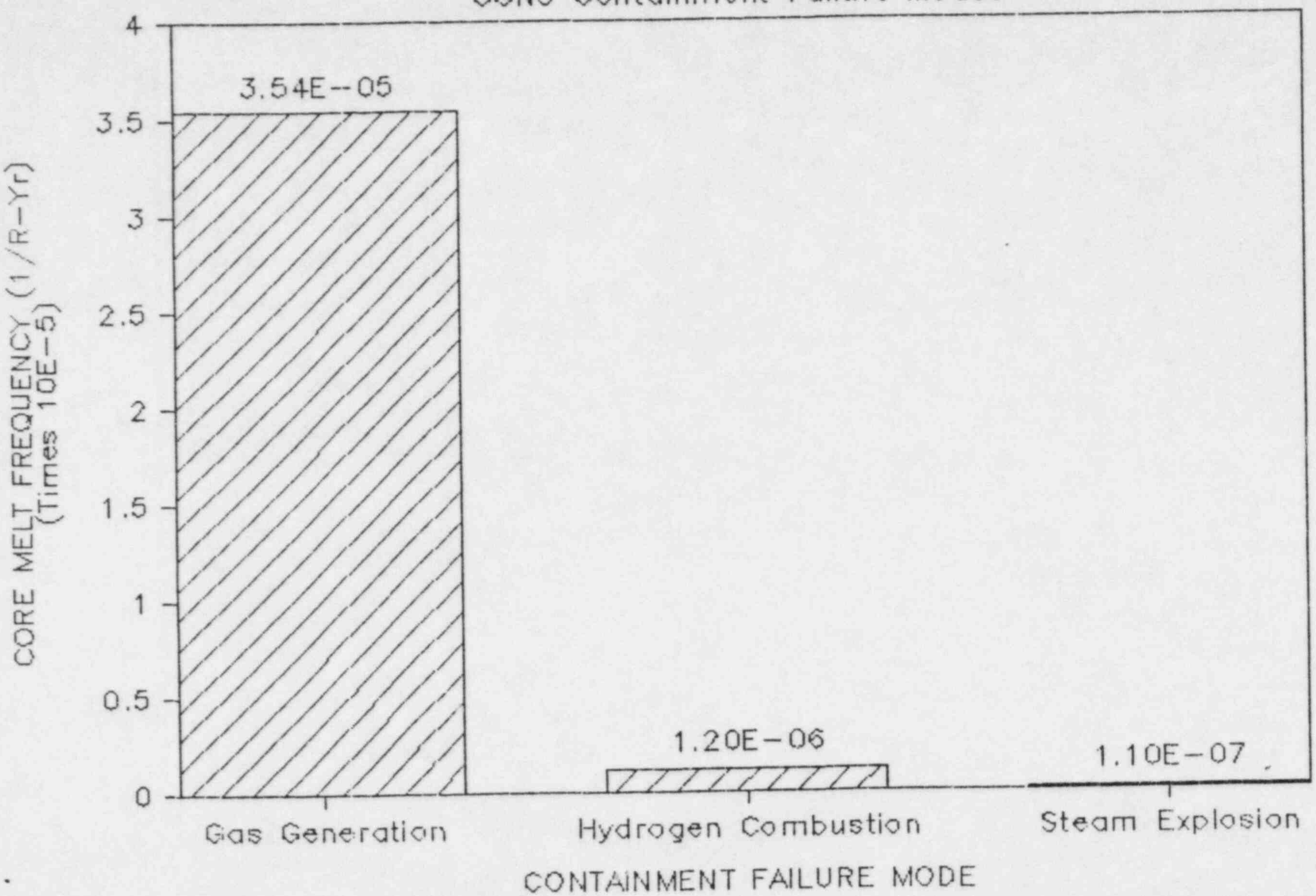
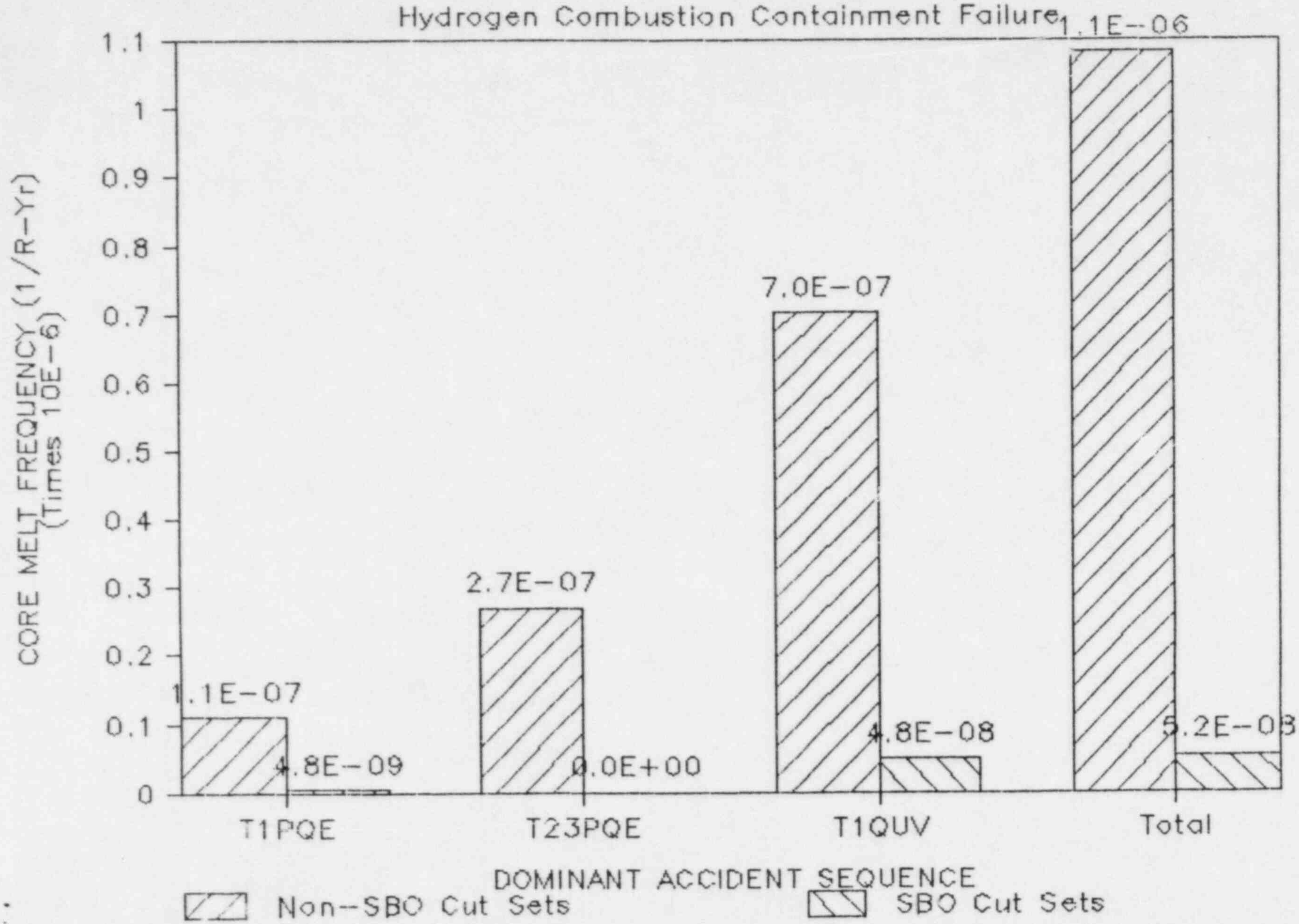


FIGURE 2



Hydrogen Combustion Containment Failure
CORE MELT FREQUENCY (1/R-Yr)
(Times 10E-6)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1.1E-07
4.8E-09
2.7E-07
0.0E+00
7.0E-07
4.8E-08
1.1E-06
5.2E-08
T1PQE
T23PQE
T1QUV
Total
DOMINANT ACCIDENT SEQUENCE
Non-SBO Cut Sets
SBO Cut Sets