MARK III CONTAINMENT
HYDROGEN CONTROL OWNERS GROUP
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HGN-122-NP

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

Attention: Document Control Desk

References:

1) Letter from J.R. Langley to R. Bernero, "Revision 2 to the Hydrogen Control Owners Group Combustible Gas Control Emergency Procedure Guideline and Supporting Appendices", HGN-110, dated December 1, 1986

2) Letter from J.R. Langley to NRC Document Control Desk, "Revision 3 to Mark III Combustible Gas Control Emergency Procedure Guideline", HGN-122, dated July 8, 1988

Subject: Revision 3 to Mark III Combustible Gas Control Emergency Procedure Guideline

The Hydrogen Control Owners Group (HCOG) has revised the Mark III Combustible Gas Control Emergency Procedure Guideline (CGC EPG) which was submitted to the NRC in Reference 1. HCOG's revision of the Mark III CGC EPG resulted from continuing HCOG reviews of this guideline, as well as discussions with the NRC staff. Attachment 1 contains HCOG's resolution of NRC comments on the Mark III CGC EPG. Revision 3 to the Mark III CGC EPG is provided in Attachment 2. The enclosed revision to the guideline and its appendices supercedes, in total, the information submitted in Reference 1. As noted in the enclosed revision of the EPG, the format has also been modified to promote integration with Revision 4 of the BWR Owners Group EPGs.

Due to the revisions in the Mark III CGC EPG, Appendix B has correspondingly been revised. Attachment 3 to this letter consists of a revised Appendix B.

Attachment 4 to this letter consists of Appendix C to the Mark III CGC EPG. Appendix C identifies the methodology used in calculating the hydrogen deflagration overpressure limit (HDOL) curve. Example calculations and the resulting HDOL curve have also been provided in Attachment 5.

In response to NRC questions in the October 22, 1986 HCOG/NRC meeting, the HCOG has developed vent path selection guidelines for use in the Mark III CGC EPG. These guidelines are contained in Appendix D to the Mark III CGC EPG and are provided as Attachment 6.

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The attached document is the non-proprietary version of Reference 2 and is submitted in accordance with 10 CFR 2.790. The proprietary information contained in Reference 2 has been omitted from this document.

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,

J.R. Langley
Project Manager

JRL/jlw

Attachment

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Attachments to
<u>HGN-122-NP</u>

Attachment 1	Resolution of NRC Open Items and Summary of Revisions to Mark III Combustible Gas Control Emergency Procedure Guideline (CGC EPG)
Attachment 2	Revision 3 to Mark III Combustible Gas Control Emergency Procedure Guideline
Attachment 3	Appendix B to Mark III Combustible Gas Control Emergency Procedure Guideline - Technical Justification For Steps in The CGC EPG
Attachment 4	Appendix C to Mark III Combustible Gas Control Emergency Procedure Guideline - Calculational Procedure for Hydrogen Deflagration Overpressure Limit (HDOL)
Attachment 5	Example Calculation of HDOL
Attachment 6	Appendix D to Mark III Combustible Gas Control Emergency Procedure Guideline - Vent Path Selection Guidelines

Attachment 1 to HGN-122-NP

Resolution of NRC Open Items and Summary of Revisions to Mark III Combustible Gas Control Emergency Procedure Guideline

I. NRC OPEN ITEMS

The NRC has identified several open items associated with the HCOG Mark III Combustible Gas Control Emergency Procedure Guideline (CGC EPG) during meetings between the HCOG and the NRC. HCOG's responses to the comments are provided in this section. A synopsis of each comment along with the HCOG resolution is provided below.

1. **ITEM:**

The HCOG needs to determine if the igniters should remain energized regardless of hydrogen concentration in containment if it can be confirmed that the igniters have been continuously operating. The NRC has suggested that the HCOG consider this change.

HCOG RESOLUTION:

The proposed change to the Mark III CGC EPG would make the requirement for securing operation of the igniters based on containment hydrogen concentration consistent with existing guidance on securing igniters based on drywell hydrogen concentration. Current guidance indicates that the drywell igniters should not be deenergized if the igniters have been continuously operating since the drywell hydrogen concentration exceeded the deflagration overpressure limit. The basis for this guidance is that during drywell break events, all oxygen in the drywell will be purged due to the blowdown of steam from the reactor coolant pressure boundary break. Thus, even if hydrogen is released into the drywell due to core damage, the atmosphere will be inert due to both the absence of oxygen and the high concentrations of steam. In this situation, a high hydrogen concentration is not indicative of conditions which could lead to containment or drywell structural failure. Since the containment and drywell igniters are powered from the same circuit, the Mark III CGC EPG recommends that all igniters remain energized rather than securing all igniters based on high drywell hydrogen concentration. The EPG recommendations are based on the comparatively low risk from leaving the drywell igniters energized in an inert environment and the high risk associated with securing igniters in the containment.

The HCOG has concluded that if the containment becomes steam inerted during an event in which the containment igniters are energized, and hydrogen production causes the containment hydrogen concentration to exceed the deflagration overpressure limit, it would be prudent for the operator to leave the igniters energized. This conclusion was based in part upon additional discussions with HCOG's hydrogen combustion experts (Dr. Bernard Lewis and Mr. Bela Karlovitz) who indicated that as the containment is de-inerted, combustion would occur locally if the igniter system remains energized, as opposed to occurrence of a large global deflagration. The local combustion of hydrogen would not be expected to present a significant pressure challenge to the containment structural integrity. Therefore, since keeping the igniters energized is expected to reduce the threat of hydrogen combustion containment failure, the third operator Contingency Action on page 1 of the guideline has been modified to reflect this revision.

2. **ITEM:**

Step PC/H-2 in the Mark III CGC EPG involves venting the containment to remove small amounts of hydrogen if the resulting radioactive release would not exceed releases permitted by plant Technical Specifications. The NRC has questioned if the operator may initiate containment venting at inappropriate points in accidents which involve core damage.

HCOG RESOLUTION:

This step was most recently discussed with the NRC in a June 23, 1988 HCOG-NRC meeting. In this meeting, the HCOG reaffirmed their position that venting the containment is an acceptable and prudent operator action under conditions of both low radiation (i.e., less than technical specification allowable limits) and a hydrogen concentration above the minimum detectable limit (i.e., typically 0.5 percent). Appendix B to this guideline describes the basis for this step as follows:

> "This step provides for normal venting and purging operations if small amounts of hydrogen are detected in the drywell or containment. This statement requires that vent and purge operations only be initiated if the radioactivity release rate due to these operations is expected to remain below the site release rate LCO presented in the plant technical specifications. This prevents any unnecessary radioactivity release in excess of technical specification limits.
>
> Since the EPGs are based on a symptomatic approach, Step PC/H-2 would allow normal venting and purging as long as the plant release rate is maintained within technical specification limits. It is expected that an accident severe enough to result in significant hydrogen generation would result in venting release rates in excess of technical specification limits."

Step PC/H-2 also includes a caution statement which directs the operator not to override high containment radiation isolation interlocks to initiate venting. The inclusion of this caution statement provides adequate direction to the operator to resolve the NRC's concern that the operator could initiate containment venting with higher radiation levels present in the containment.

In discussing this step with the HCOG, the NRC indicated that similar discussions have recently been held with the BWROG's Emergency Procedures Committee on Revision 4 of the generic EPGs. While a final resolution of the 0.5 percent vent step has not been reached, the NRC is reevaluating their basis for requesting that this step be deleted. In light of this, and the fact that the HCOG considers the subject step to be appropriate, the HCOG agreed to the following: 1) retain PC/H-2 in the Mark III Mark III CGC EPG in its Revision 3; and 2) modify the generic Mark III Mark III CGC EPG at a later date, if necessary, to be consistent with the BWROG's approved generic Mark III CGC EPG.

3. **ITEM:**

Step PC/H-4.2 in the Mark III CGC EPG requires the operator to utilize the backup containment hydrogen purge if the hydrogen recombiners are ineffective in controlling hydrogen concentrations. The operator is directed not to complete this step if the resulting release rate would exceed the offsite release rate which requires an alert. The NRC questions if there is a potential that the operator may initiate venting at an inappropriate point in an accident.

HCOG RESOLUTION:

HCOG's position has been that this step was an important part of the operator's options to respond to the event. If the recombiners were not controlling hydrogen concentration and there was a relatively low level of radiation present, it was considered prudent to direct the operator to initiate the backup hydrogen purge in order to reduce the potential for the hydrogen concentration to reach the HDOL.

However, the HCOG acknowledges that the backup hydrogen purge system is a low flow system (typically 50 scfm) which can provide only a marginal contribution in reducing the hydrogen volume within the containment. This marginal benefit is offset by the risks posed by a vent path that could fail open during the postulated accident scenarios. Therefore, the HCOG has deleted Steps PC/H-4.2 (initiate backup purge system) and PC/H-4.4 (secure backup purge system) from the Mark III CGC EPG.

4. **ITEM:**

The NRC has suggested that the drywell mixers should be activated if containment HDOL is being approached. This would help to dilute the containment hydrogen concentration through mixing the drywell airmass with the containment air. Energizing the mixing compressors would help to delay the need for venting the containment irrespective of offsite release rate when the containment deflagration overpressure limit is reached.

HCOG RESOLUTION:

Background:

This issue was addressed at length during the June 23, 1988 HCOG-NRC meeting. In discussing the appropriateness of using the drywell mixing system to provide a mechanism for dilution of a high containment hydrogen concentration, the original design intent of the mixing system was considered. In reviewing this issue, the HCOG committed to summarize, in this submittal, the design philosophy of the Mark III drywell mixing system.

In researching the design intent of the drywell mixing systems, system description documents and/or Final Safety Analysis Report descriptions were reviewed for each of the four Mark III facilities. In all four facilities, the accident sequence for which the drywell mixing system was designed, was the same. The subject accident sequence was a loss of coolant accident (LOCA) in which the vessel water inventory and any hydrogen gas produced as a result of the LOCA are introduced into the drywell. (The hydrogen gas is postulated to result from metal-water reaction, radiolysis, and aluminum and/or zinc corrosion.) In order to reduce the drywell hydrogen concentration, a system was installed to remove hydrogen from the smaller drywell volume and dilute it with the larger containment volume. This accomplishes the following objectives: 1) reduction of drywell hydrogen concentration; 2) introduction of hydrogen into a large airmass where the concentration would increase more slowly; and 3) introduction of hydrogen to the volume with recombiners where it can be consumed.

While the specific design configurations of the drywell mixing system at each of the four HCOG plants varies, the design philosophy was the same. This is further supported by the design flow rates of the various systems which vary from less than 500 cfm to approximately 1,000 cfm. These flow rates can provide a rapid turnover of the drywell air volume, but provide a very slow mechanism for turning over the containment air volume.

Detailed Response:

The HCOG maintains that a procedure step for starting the hydrogen mixing system in cases where the containment hydrogen concentration is approaching the HDOL is not warranted. The technical basis for this position includes several considerations: 1) the effect of pressurizing (or repressurizing) the drywell during event recovery; 2) the containment atmosphere dilution rate associated with mixing system operation; 3) the potential for hydrogen ignition due to operation of the hydrogen mixing system; and, 4) the difficulty inherent in providing meaningful direction to the operator. Each of these considerations is discussed below.

Pressurization of Drywell:

As discussed in the June 23, 1988 HCOG-NRC meeting, operation of the drywell mixing system in two of the four HCOG plants can lead to drywell pressurization. This pressurization would result in a "high drywell pressure" isolation signal which would significantly encumber the recovery actions that must be taken by the operator. In these plants, only a limited number of scenarios could be postulated wherein operation of the drywell mixing system could even be considered as a potential dilution mechanism. Prior to addressing these sequences, other sequences will be identified and briefly addressed to indicate why mixing system operation could not be considered as an option in delaying venting.

In order to reduce containment hydrogen concentration via mixing system operation, the hydrogen concentration in the drywell would have to be significantly lower than in the containment. However, significant differences between drywell and containment hydrogen concentrations may be precluded by volume interchange through the drywell vacuum breakers if the two volumes were not at similar pressures. For scenarios where containment pressure and hydrogen concentration are high, vacuum breaker operation would result in some movement of hydrogen out of the containment and into the drywell. For these cases, interchange of the atmospheres via the mixing system would provide, at best, only a limited additional equalization mechanism. Therefore, the dominant condition in which mixing system operation might be considered as a potential benefit is one in which both the drywell and containment pressures are low, with high hydrogen concentration in containment, and low concentration in the drywell.

Such conditions (i.e., low drywell and containment pressures with a high hydrogen concentration in the containment and a low concentration in the drywell) could be postulated during recovery from a hydrogen generation event. For those cases where a degraded core has been recovered, and drywell and containment pressures are low, both the low reactor water level and high drywell pressure LOCA signals should be clear.

Initiation signals for operable emergency core cooling system (ECCS) would, therefore, not exist. Thus, recovery would be in progress, and containment cooling and/or decay heat removal modes of ECCS should be in operation. In this case, pressurization of the drywell by operation of the mixing systems would cause re-initiation of the LOCA (i.e., high drywell pressure) signal. There are multiple detrimental effects associated with this situation. These include load shedding and resequencing of any systems operating on the emergency diesel generators, a sealed-in signal which would bypass the Residual Heat Removal heat exchanger for a period of 10 minutes, and isolation of valves and systems being used for recovery which would not otherwise be isolated. Examples of significant problems caused by a LOCA signal during recovery from accidents/transients include:

(1) During recovery, operators will be removing decay heat from the core using the shutdown cooling mode of the residual heat removal (RHR) system. The operators will also be removing decay heat from the containment/suppression pool using the suppression pool cooling mode of RHR. Upon receipt of a LOCA signal, the cooling modes of RHR will be isolated and the RHR will initiate in the injection mode (LPCI) automatically. Since the LPCI mode takes priority, suppression pool water will be pumped to the RPV, the RHR heat exchanger bypass will open, and the majority of the core and containment heat removal capability will be lost.

(2) If the diesel generators are supplying power, the LOCA signal will initiate load shedding and sequencing. Loads will be stripped from the bus (all equipment that consitutes significant 4160V load) and sequenced back on in the LOCA priority. This could include the de-energization of instrument air system with no short term re-energization because the LOCA priority signal gives preference to emergency core cooling systems (ECCS).

In the June 23, 1988 meeting, NRC personnel acknowledged that the disadvantages of requiring mixing system operation as a containment dilution mechanism may outweigh the advantages under certain conditions. However, this position encompassed only those sequences in which an isolation signal does not exist at the time of mixing system actuation. The NRC did consider operation of the mixing system a prudent operator action if a drywell isolation signal was energized at the time of mixing system actuation. In response to this, the HCOG indicated that a high hydrogen concentration within the containment would be indicative of core reflood, and most probably, event termination. In this case, the operator would have already implemented or would be postured to implement whatever actions would be necessary to actuate the drywell coolers with the intent of reducing drywell pressure and clearing the isolation signal (e.g., bypass interlocks). This action would be prudent since it would support subsequent operator actions destined to ensure long term core cooling and event recovery.

The actuation of the drywell mixing system would be a counterproductive action since it would result in a very limited dilution contribution (see following discussion), while delaying the need to vent only marginally, and locking in the high drywell pressure isolation signal. For these reasons, and those discussed below, actuation of the drywell mixing system is not considered a prudent operator action under the assumed conditions and has not been incorporated into the Mark III .ark III CGC EPG.

Dilution Rate:

The goal of adding a step to the guideline which would require the operator to initiate the drywell mixing system during the subject hydrogen generation event is to reduce the containment hydrogen concentration and defer the need to initiate containment venting. This step would require the operator to initiate the mixing system if containment conditions indicated that the igniters and recombiners were not adequately controlling the hydrogen concentration. The mixing system would then be initiated to offset the increasing hydrogen concentration and delay the time at which HDOL would be reached and containment venting would be initiated to safeguard containment integrity.

While the HCOG agrees with the goal of this step (i.e., defer the need to vent), it is apparent that the design of the mixing system does not support this objective. In reviewing the appropriateness of including this step into the Mark III CGC EPG, the HCOG examined the rate at which the containment concentration would decrease due to the operation of the mixing system. As noted earlier, the designs of the mixing systems in the four U.S. Mark III plants vary significantly. In developing a "best case" estimate, the HCOG member plant with the highest compressor flow rate (i.e., 1,000 cfm) was evaluated. This plant has drywell and containment volumes of approximately 270,000 ft^3 and 1,400,000 ft^3, respectively. At a flow of 1,000 cfm, the entire drywell volume could be turned over in about 4.5 hours. This would support the design intent of the system which is to transfer a potentially threatening gas volume out of the drywell and into the containment.

However, assuming a hydrogen concentration of zero percent in the drywell and 5 volume percent in the containment at the time that the purge compressors are initiated, the hydrogen concentration would decrease to a minimum of only 4.6 volume percent at the end of a two hour period. This assumes a compressor flow rate of 1,000 cfm, and demonstrates the limited benefit realized by operating this system with the intent of reducing the hydrogen concentration in the containment.

Therefore, while this system very efficiently performs its design function of moving hydrogen from the drywell to the containment, it is equally inefficient in reducing containment hydrogen concentration even when given in excess of two hours. For this reason, the HCOG does not consider inclusion of the requested drywell mixing system actuation step to be warranted.

Implementation:

In addition to the three considerations discussed above, a final consideration also deserves attention. This involves the ability to realistically implement the subject mixing system step in a manner that provides clear, definitive direction to the operator. The conditions under which the hydrogen mixing system would be operated are: 1) existing high drywell pressure isolation signal; and 2) inability of igniters and recombiners to control hydrogen concentration to levels less than HDOL. The first condition is definitive and easily determined by an operator, though the desirability of creating conditions that would result in a continuous isolation signal is low as discussed previously. The second condition would require the HCOG to identify a hydrogen concentration at which to initiate the drywell mixing system. The subject hydrogen concentration would be defined as being below the HDOL, while being above the hydrogen concentration at which hydrogen igniters and recombiners provide an effective mechanism for hydrogen control. This latter consideration of a hydrogen concentration above a minimum value would allow for optimum utilization of the primary hydrogen control tools, i.e., igniters and recombiners, prior to actuation of a secondary hydrogen control system (i.e., mixing systems).

A definitive means of implementing this guideline is not clear, and due to the potentially conflicting and/or confusing direction to the operator that may result, the HCOG again feels inclusion of this step in the Mark III CGC EPG is unwarranted.

Conclusion:

Therefore, the HCOG has concluded that the disadvantages of operating the drywell mixing system significantly outweigh the advantages, and the HCOG has elected not to incorporate this step into the Mark III Mark III CGC EPG.

5. **ITEM:**

The NRC has suggested that HCOG consider revising step PC/H-5 in the Mark III CGC EPG. The proposed modification would involve initiating containment sprays before the igniters, recombiners and drywell mixing compressors are secured. The NRC suggested that operation of the containment sprays may reduce the containment pressure sufficiently so that the hydrogen concentration is below the deflagration overpressure limit. This might eliminate the need to secure the igniters, recombiners and hydrogen mixing system compressors.

HCOG RESOLUTION:

The HCOG could not identify any sequences when actuation of containment sprays prior to de-energizing the igniters, recombiners and mixing compressors would have adverse consequences. The HCOG concurred with the NRC that actuating containment sprays might decrease the containment pressure sufficiently to drop the containment conditions below the deflagration overpressure limits. The HCOG, therefore, has implemented this suggestion.

6. **ITEM:**

In the October 22, 1986 meeting, the NRC requested the HCOG to provide a general set of guidelines that could be used by the individual utilities in identifying and prioritizing vent paths for use in containment venting operations.

HCOG RESOLUTION:

The HCOG has developed the requested vent path selection guidelines and has enclosed them as Appendix D to the Mark III CGC EPG. (See Attachment 7 to this transmittal.) These guidelines were developed to delineate all factors which must be considered when hydrogen gas could be vented from the containment. These concerns are presented in Appendix D with no priority or hierarchy to ensure the consideration of each of the concerns during vent path selection.

II. OTHER PROCEDURE REVISIONS

In addition to the procedure revisions delineated in the responses to the NRC's open items, several other revisions have been incorporated into Revision 3 of the Mark III Combustible Gas Control Emergency Procedure Guideline (Mark III CGC EPG). The more notable revisions and the basis for each are briefly summarized below.

a. Purpose/Entry Conditions

In accordance with the BWR Owners Group EPGs, both a "Purpose" statement and "Entry Conditions" have been incorporated in Revision 3 of the Mark III CGC EPG. The entry conditions utilize vessel water level, and containment and drywell hydrogen concentration as parameters which govern entry into this EPG.

b. Step PC/H-2.2

In Revision 2 to the Mark III CGC EPG, Step PC/H-2.2 was accompanied by a reference to Caution 22 of the BWROG EPGs. Since this caution statement has been deleted in Revision 4 of the generic BWROG EPGs, the caution has been incorporated into Step PC/H-2.2. This format is consistent with that used in Revision 4 EPGs. [A similar revision was incorporated at Step PC/H-6.1.]

c. Step PC/H-4.1.1

In order to ensure the hydrogen recombiners do not initiate a threatening deflagration when they are energized, Step PC/H-4.1.1 was revised to include consideration of the HDOL prior to recombiner operation. A similar addition was made in Steps PC/H-4.2 and PC/H-10 which govern operation of the recombiners.

d. Step PC/H-5

This step has been resequenced to provide spray actuation prior to both reaching HDOL and the de-energizing of igniters and mixing systems. (See NRC Open Item 5 discussion.) In addition, it has been revised to incorporate the operator caution previously provided by reference to Caution 18. The current format is consistent with that used in the Revision 4 BWROG EPGs.

e. Contingency On PC/H-6

In order to minimize the period of the containment venting operation, a contingency has been added prior to Step PC/H-6 to secure vent and purge activities once the hydrogen concentration maintained below the HDOL. This step is prudent since at the time the hydrogen concentration drops below the HDOL, the threat posed by hydrogen concentration to the containment structural integrity has been mitigated.

f. Step PC/H-6

Consistent with the revision to the third operator Contingency Action, this step has been modified to clarify the conditions under which the igniters are to be secured. (See the discussion associated with NRC Open Item 1.)

g. Contingency On PC/H-8

Step PC/H-8 is intended to remove residual concentrations of hydrogen from the containment during recovery operations. To ensure that the relocation of hydrogen from the drywell to the containment does not result in a hydrogen concentration which approaches HDOL, the subject contingency was added. While this scenario is of low probability, this step reflects the proper operator action to be taken from a symptomatic perspective.

Attachment 2 to HGN-122-NP

Revision 3

To

Mark III Combustible Gas Control

Emergency Procedure Guideline

PURPOSE]3

The purpose of this guideline is to specify actions for controlling]3
hydrogen concentrations in Mark III containments and drywells in]3
order to maintain containment integrity and equipment survivability.]3

ENTRY CONDITIONS]3

The entry conditions for this guideline are any of the following:]3

- RPV water level below [-164 in. (top of active fuel)] or cannot]3
  be determined.]3

- Primary containment or drywell hydrogen concentration reaches]3
  [0.5% (minimum detectable hydrogen concentration)].]3

OPERATOR ACTIONS

PC/H Monitor and Control
Hydrogen Concentrations

If while executing the following steps:

- The hydrogen monitoring system is or becomes unavailable,
  sample the drywell and primary containment for hydrogen
  in accordance with [sampling procedure].]3

- Drywell hydrogen concentration cannot be determined to be below the (Hydrogen Deflagration Overpressure Limit) and it cannot be determined that the igniters have been continuously operating since the drywell hydrogen concentration exceeded the [lowest hydrogen concentration that can support a deflagration], secure and prevent operation of the igniters.

- Primary containment hydrogen concentration cannot be
  determined to be below the (Hydrogen Deflagration
  Overpressure Limit), and it cannot be determined that]3
  the igniters have been continuously operating since the]3
  containment hydrogen concentration exceeded the [lowest]3
  hydrogen concentration that can support a deflagration],]3
  then secure and prevent operation of hydrogen mixing
  systems, recombiners, and igniters and, irrespective of
  the offsite radioactivity release rate, vent and purge
  the primary containment in accordance with [steps
  PC/H-5.1 and PC/H-5.2] until the primary containment
  hydrogen concentration can be determined to be below the
  (Hydrogen Deflagration Overpressure Limit).

PC/H-1 When RPV water level is below [-164 in. (top of active]3
fuel)] or cannot be determined, but only if primary containment hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit) and the drywell hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit), operate hydrogen igniters.

PC/H-2 When primary containment or drywell hydrogen concentration reaches [0.5% (minimum detectable hydrogen concentration)] but only if the site radioactivity release rate is expected to remain below the site release rate LCO, vent and purge the primary containment to restore and maintain primary containment and drywell hydrogen concentration below [0.5% (minimum detectable hydrogen concentration)] as follows:

> If while executing the following step the site radioactivity release rate reaches the site release rate LCO, isolate the primary containment vent and purge.

PC/H-2.1 Refer to [sampling procedure]

> Isolation interlocks related to high containment radiation should not be overridden to allow containment venting.

PC/H-2.2 Vent the primary containment in accordance with the
[procedure for containment venting] defeating isolation]3
interlocks, if necessary. If the primary containment]3
cannot be vented, vent the drywell to atmosphere in accordance with the [procedure for containment venting].

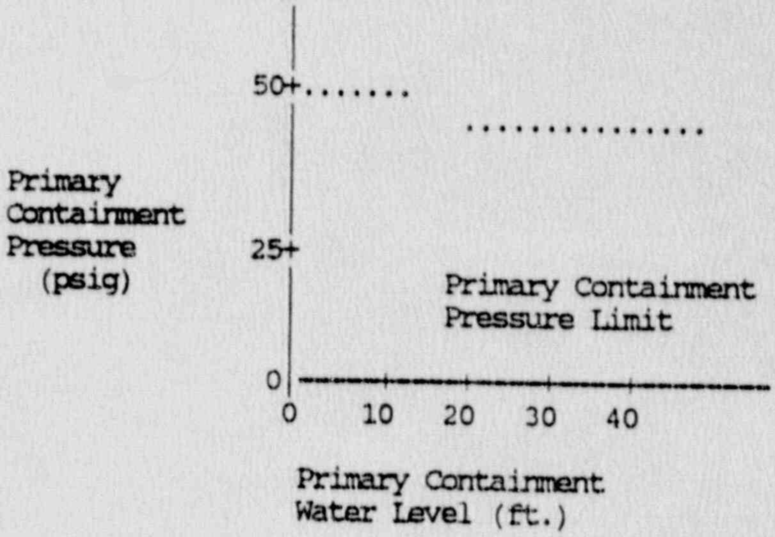
PC/H-2.3 If the primary containment or the drywell can be vented, initiate and maximize the containment and drywell purge.

Execute [steps PC/H-3 and PC/H-4] concurrently

PC/H-3 Monitor and control hydrogen concentration in the drywell.

PC/H-3.1 When drywell hydrogen concentration reaches [0.5% (minimum detectable hydrogen concentration)] if primary containment hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit), and drywell hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit), operate hydrogen igniters.

PC/H-3.2 Before drywell hydrogen concentration reaches [4% (lowest hydrogen concentration which can support an upward flame propagation)] but only if [RPV pressure is below the Primary Containment Pressure Limit] and primary containment hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit), operate the drywell hydrogen mixing systems.



PC/H-3.3 Continue in this procedure at [step PC/H-5].

PC/H-4 Monitor and control hydrogen concentration in the primary containment.

PC/H-4.1 When primary containment hydrogen concentration reaches [1% (minimum hydrogen concentration for recombiner operation or minimum detectable hydrogen concentration, whichever is higher)]:

1. If primary containment hydrogen concentration is below [6% (maximum hydrogen concentration for recombiner operation or the lowest hydrogen concentration which can support a deflagration, whichever is lower) and the (Hydrogen Deflagration Overpressure Limit)], then place hydrogen recombiners in service.
2. If primary containment hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit) and if the drywell hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit), operate hydrogen igniters.

PC/H-4.2 When primary containment hydrogen concentration reaches [6% (maximum hydrogen concentration for recombiner operation or the lowest hydrogen concentration which can support a deflagration, whichever is lower) or the (Hydrogen Deflagration Overpressure Limit)], secure hydrogen recombiners.

PC/H-5 When primary containment hydrogen concentration reaches (Hydrogen Deflagration Overpressure Limit) and [primary containment pressure is above 1.7 psig (Mark III Containment Spray Initiation Pressure Limit)], initiate containment sprays (using only those RHR pumps not required to assure adequate core cooling by continuous operation in the LPCI mode).

> If while executing the following step the primary containment hydrogen concentration can be restored to and maintained below the (Hydrogen Deflagration Overpressure Limit), secure containment vent and purge.

PC/H-6 When primary containment hydrogen concentration reaches the (Hydrogen Deflagration Overpressure Limit) and it cannot be determined that the igniters have been continuously operating since the containment hydrogen concentration exceeded [6% (the lowest concentration which can support a deflagration)], secure the igniters and drywell hydrogen mixing systems, then irrespective of the offsite radioactivity release rate, vent and purge the primary containment to restore and maintain the primary containment hydrogen concentration below the (Hydrogen Deflagration Overpressure Limit) as follows:

PC/H-6.1 Vent the primary containment in accordance with [procedure for containment venting] defeating isolation interlocks, if necessary.

PC/H-6.2 If the primary containment can be vented, initiate and maximize containment purge.

PC/H-7 If primary containment hydrogen concentration cannot be restored and maintained below the (Hydrogen Deflagration Overpressure Limit), then irrespective of whether adequate core cooling is assured, if primary containment pressure is above [1.7 psig (Mark III Containment Spray Initiation Pressure Limit)], initiate containment sprays.

> If while executing the following step the containment hydrogen concentration reaches [the (Hydrogen Deflagration Overpressure Limit)], secure the drywell hydrogen mixing system.

PC/H-8 When primary containment hydrogen concentration can be restored and maintained below the (Hydrogen Deflagration Overpressure Limit), and drywell hydrogen concentration is above [0.5% (minimum detectable hydrogen concentration)] and [RPV Pressure is below the Primary Containment Pressure Limit], operate the drywell hydrogen mixing systems.

PC/H-9 When primary containment hydrogen concentration can be restored and maintained below the (Hydrogen Deflagration Overpressure Limit), and drywell hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit), operate the hydrogen igniters.

PC/H-10 When primary containment hydrogen concentration can be
restored and maintained below [6% (maximum hydrogen
concentration for recombiner operation or the lowest
hydrogen concentration which can support a
deflagration, whichever is lower) and the (Hydrogen]3
Deflagration Overpressure Limit)], and hydrogen]3
concentration is above [1% (minimum concentration for
recombiner operation)], operate the hydrogen
recombiners.

Attachment 3 to HGN-122-NP

Appendix B

Technical Justification for Steps in the Mark III Combustible Gas Control Emergency Procedure Guideline

SECTION 8, PRIMARY CONTAINMENT CONTROL

OPERATOR ACTIONS]3

PC/H Monitor and control hydrogen and oxygen concentrations.]3

DISCUSSION: (Figure B-7.8)

The hydrogen control section of the Primary Containment Control Guideline specifies actions for controlling hydrogen concentrations in Mark III containments and drywells. This procedure applies only to those plants with Mark III containments.

A variety of components and systems, as described below, have been installed in the Mark III containment to control hydrogen produced from a wide range of accidents. Excessive accumulations of hydrogen could result in deflagrations which would cause overpressurization of containment, structural damage to containment, or failure of vital equipment located in the containment which would be required in a
post-burn environment. The equipment (e.g., hydrogen igniters and]3
recombiners) which has been installed will prevent deflagrations]3
which could threaten either containment integrity or equipment]3
survivability for the majority of the accident sequences.

The methods and systems used to control hydrogen in Mark III containment plants are varied. The preferred method of control for small amounts of hydrogen utilizes normal venting and purging operations, provided radiation release rates are below technical specification limits. Under post LOCA conditions which lead to moderate hydrogen production, this is not expected to be practical. For this reason, Mark III plants were designed with hydrogen recombiners to control hydrogen in the containment, and drywell hydrogen mixing systems to force hydrogen from the drywell into containment.

As a redundant method to containment hydrogen control by recombiners,]3
Mark III plants are equipped with a backup containment hydrogen purge]3
system. This system is used to control containment hydrogen in the event of recombiner malfunction or inability to control hydrogen accumulation. The Mark III containment plants also utilize a hydrogen igniter system to control the amounts of hydrogen which could be produced by degraded core accidents. The igniters are used to control hydrogen concentration in the containment and drywell by
ignition of hydrogen at low concentrations. This procedure actuates]3
the igniter system as early as possible in conditions which could lead to significant hydrogen production during degraded core accidents. This assures that combustion of hydrogen will occur at the lowest possible hydrogen concentration, which will accordingly limit overpressure resulting from possible combustion.

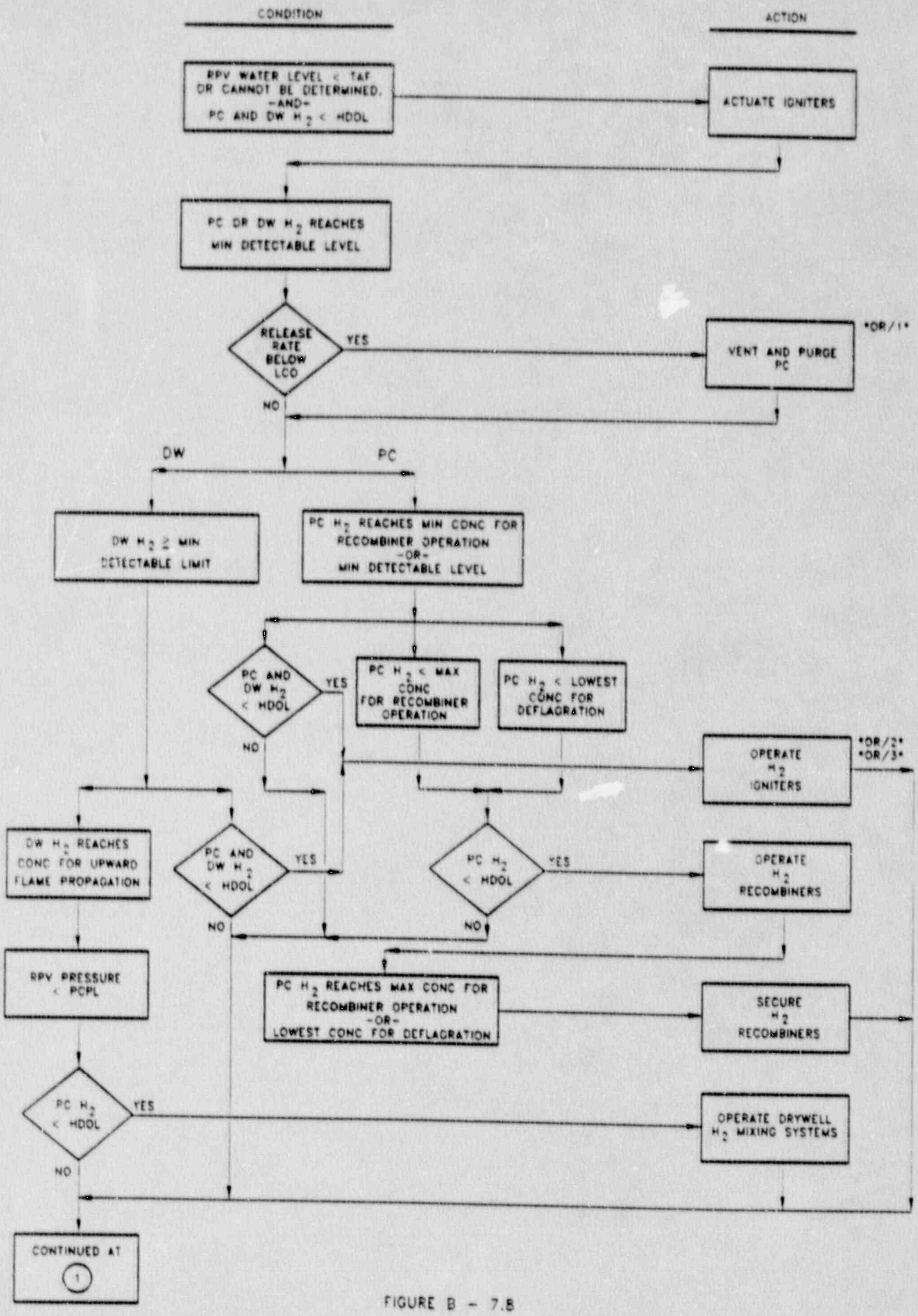


FIGURE B - 7.8

OPERATOR ACTIONS FOR PRIMARY CONTAINMENT HYDROGEN CONTROL

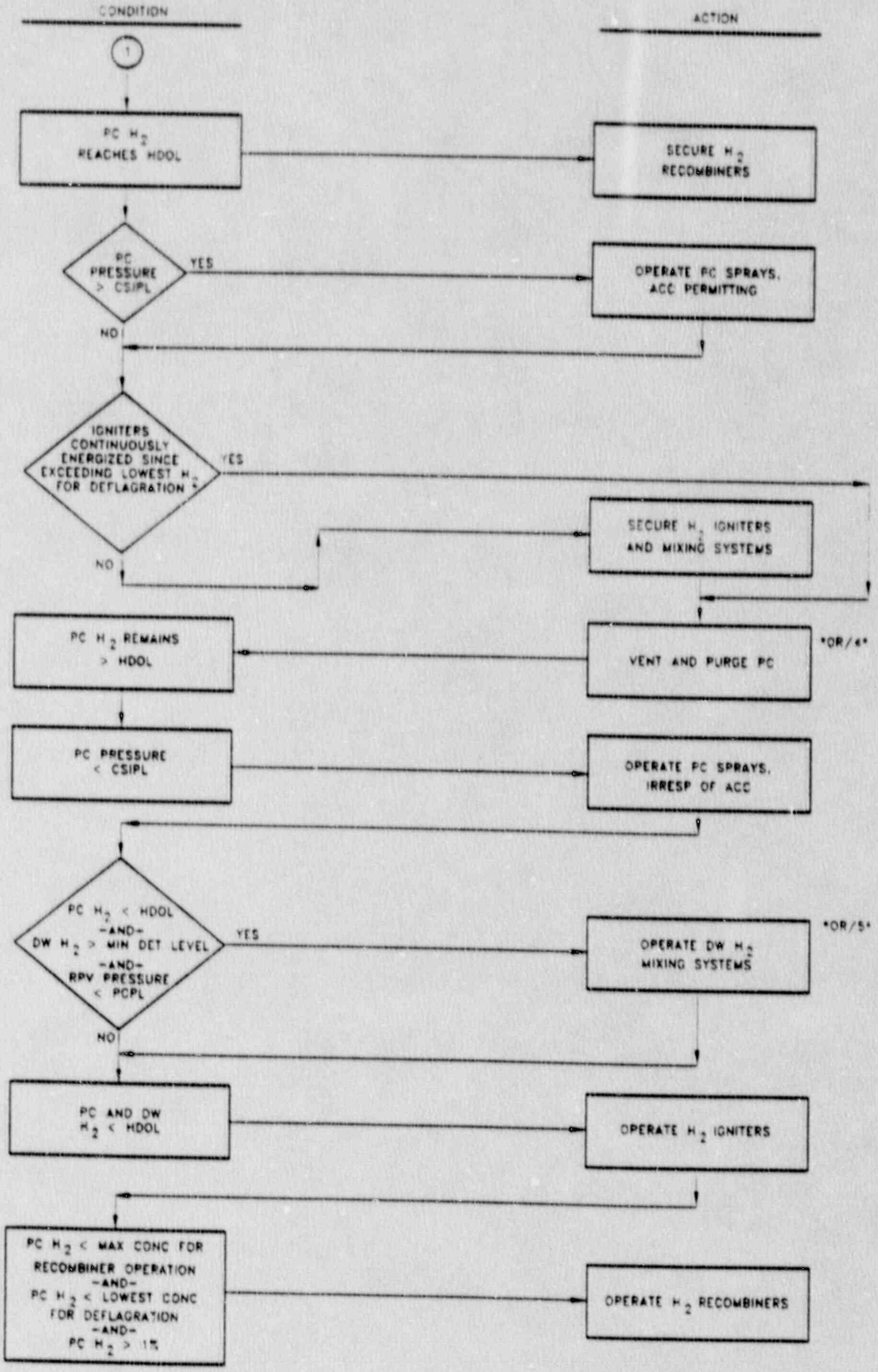


FIGURE B - 7.8

OPERATOR ACTIONS FOR PRIMARY CONTAINMENT HYDROGEN CONTROL
(CONTINUED)

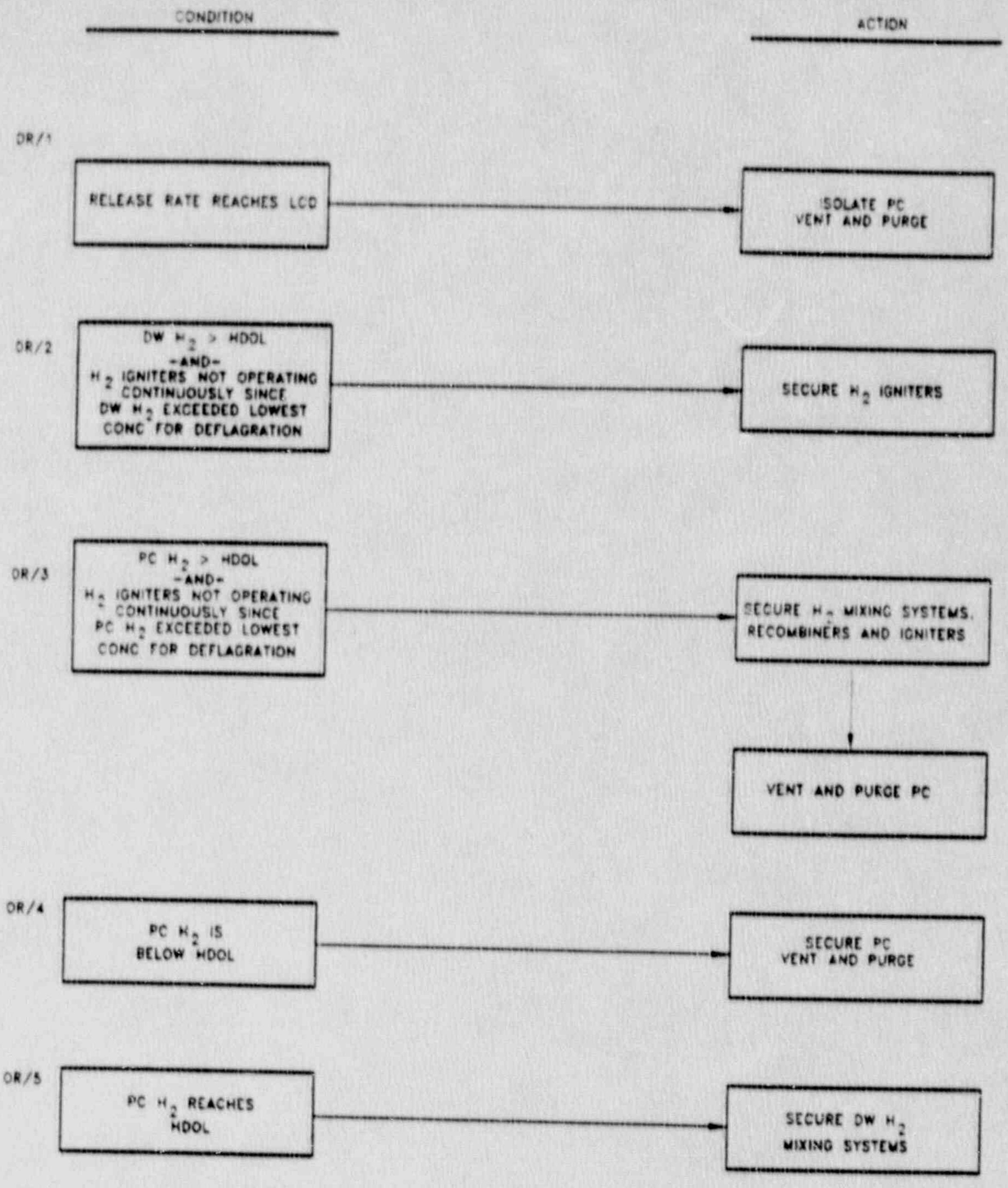


FIGURE B - 7.8

OPERATOR ACTIONS FOR PRIMARY CONTAINMENT HYDROGEN CONTROL
(CONTINUED)

If the hydrogen igniters, hydrogen recombiners and the backup containment hydrogen purge do not effectively control containment
hydrogen, then this procedure subsequently directs the operator to]3
initiate venting of the containment. If deflagrations in containment]3
which could threaten subsequent loss of containment integrity are possible, then containment venting is pursued regardless of resulting offsite radioactive release rates.

An overview of operator actions specified in the Mark III Combustible]3
Gas Control Emergency Procedure Guideline is presented in Figure]3
B-7.8.]3
]3

ENTRY CONDITIONS]3

The entry conditions for this guideline are any of the following:]3

- o RPV water level below [-164 in. (top of active fuel)] or cannot]3
  be determined.]3
- o Primary containment or drywell hydrogen concentration reaches]3
  [0.5% (minimum detectable hydrogen concentration)].]3

Discussion: The entry conditions have been chosen in order to give]3
the operators sufficient time to preclude hydrogen combustion]3
containment failure resulting from a hydrogen generation event. It]3
has been calculated that there would be a minimum of 10 minutes]3
available between the time when the RPV water level reaches the top]3
of active fuel and the time when significant hydrogen production]3
begins. This will provide the operators with sufficient time to]3
mitigate the consequences of hydrogen generation. The entry]3
condition based on primary containment or drywell hydrogen]3
concentration addresses the most directly monitored condition related]3
to hydrogen control.

OPERATOR ACTIONS (PC/H)

PC/H Monitor and Control Hydrogen Concentrations]3

If while executing the following steps:

- The hydrogen monitoring system is or becomes unavailable, sample the drywell and primary containment for hydrogen in accordance with [sampling procedure].]3

- Drywell hydrogen concentration cannot be determined to be below the (Hydrogen Deflagration Overpressure Limit) and it cannot be determined that the igniters have been continuously operating since the drywell hydrogen concentration exceeded the [lowest hydrogen concentration that can support a deflagration], secure and prevent operation of the igniters.

- Primary containment hydrogen concentration cannot be determined to be below the (Hydrogen Deflagration Overpressure Limit), and it cannot be determined that the igniters have been continuously
  operating since the containment hydrogen concentration exceeded]3
  the [lowest hydrogen concentration that can support a]3
  deflagration], then secure and prevent operation of hydrogen]3
  mixing systems, recombiners, and igniters and irrespective of]3
  the offsite radioactivity release rate, vent and purge the primary containment in accordance with [steps PC/H-6.1 and PC/H-6.2] until the primary containment hydrogen concentration can be determined to be below the (Hydrogen Deflagration Overpressure Limit).

Discussion: These contingent actions are applicable throughout the entire hydrogen control procedure and should be entered and executed whenever conditions match those described in the contingent actions. If conditions are appropriate, more than one of the contingent actions will be executed concurrently. In general, these contingent actions are intended to define operator actions when hydrogen concentrations are unknown, but are believed to be significant. In order for significant amounts of hydrogen to be generated, reactor pressure vessel water level must drop significantly below the top of active fuel (TAF) level for some period of time. The further the level drops below the TAF, and the longer it remains there, the greater the potential that hydrogen production will occur. The plant unique parameters that are used to define when hydrogen concentrations have reached threatening levels are the containment and drywell hydrogen deflagration overpressure limit (HDOL). Appendix C of the hydrogen control guideline gives the technical description of these limits and the derivation of their calculational procedures.

The purpose of the HDOL curves is to assure that the postulated combustion of hydrogen and oxygen in containment (or drywell) will not result in a sufficiently high overpressure that will structurally fail the primary containment or adversely affect the integrity of the drywell. The containment curve is a plot of hydrogen concentration versus containment initial pressure. Higher concentrations of hydrogen result in a larger pressure increase during combustion. As initial containment pressure increases, the margin to the failure pressure decreases, and as concentration increases, there is more hydrogen in the volume to burn. Both factors result in decreasing the allowable concentrations as the pre-combustion containment pressure increases. The drywell HDOL identifies the maximum allowable hydrogen precombustion concentration for any initial pressure.
The drywell HDOL is based on protecting drywell integrity as]3
well as containment structural integrity.]3

The first contingent action requires sampling of the drywell and primary containment for hydrogen in accordance with plant procedures if the hydrogen monitoring system becomes unavailable. The usefulness of sampling information is dependent upon plant conditions and is subject to the operator's discretion. For example, in situations where it is known that adequate core cooling exists (i.e., due to core recovery, significant amounts of hydrogen are no longer being generated) and conditions are stable, sampling information can be used to determine hydrogen concentration and to assure that the HDOL limit is not exceeded. If the igniter system is functioning as designed, then the hydrogen concentration in the containment, for example, should be relatively constant regardless of hydrogen production rate since the igniter system maintains hydrogen concentrations below 6% globally. Conversely, if adequate core cooling does not exist, then the hydrogen concentration may be increasing. Since some lag time is inherent in obtaining and analyzing samples, sample results should be used judiciously. Even though some time lag is associated with this step, sampling provides useful information on hydrogen accumulation trends in the unlikely event that the igniters are not operating, if conditions allow several samples to be taken. The operator will, therefore, combine the results of sampling information with an assessment of plant conditions when deciding what actions are appropriate.

The second and third contingent actions are applicable if the]3
operator cannot determine that the drywell and/or containment]3
hydrogen concentration are below the drywell or containment]3
HDOL, as appropriate. The contingent actions require that the]3
operator secure the igniters, provided he cannot determine that
the igniters have been in continuous operation from the time

time that the hydrogen concentration exceeded the minimum
concentration which could support a deflagration. The third
contingent action would also necessitate the de-energization of]3
the recombiners and mixing systems under the same]3
preconditions. The intent of this contingent action is to
prevent a deflagration in the drywell and/or containment which]3
would threaten either drywell or containment integrity. The use]3
of the minimum concentration that can support a hydrogen]3
deflagration as a contingency limit provides a margin between]3
this limit and the applicable HDOL. This margin allows the]3
operator to have sufficient time to respond to an event where]3
the igniter power supply and/or core reflood capability has been]3
lost, with subsequent recovery of both. Sequences can be]3
postulated in which recovery of a reflood source may cause]3
hydrogen concentrations to quickly rise above the minimum]3
deflagration limit before it can be determined if the igniters]3
have been continuously operating. In this case it would be]3
prudent to secure the igniters prior to reaching the HDOL, and]3
this can only be accomplished by establishing a contingency]3
limit that provides a margin to the HDOL.]3

If the igniters have been in continuous operation above the
minimum hydrogen concentration which can support a deflagration
and hydrogen is continuing to accumulate, then the drywell
and/or containment atmosphere is potentially steam inert or]3
oxygen starved. Recovery from these conditions would be]3
supported by spray operation (i.e., gradual steam condensation)]3
and/or vent/purge operations (i.e., introduction of additional]3
oxygen). Continued igniter operation under these conditions]3
will not jeopardize either the drywell or containment since
either no deflagrations will occur or combustion is occurring
continually, using available oxygen to consume the hydrogen. In
this case, continued operation of the igniters prevents the
buildup of oxygen in sufficient quantity to allow combustion of
the total amount of hydrogen in the drywell and/or containment]3
at once and, therefore, prevents the resultant large pressure
rise which could threaten drywell or containment structural
integrity.

Similarly, for a steam inert condition, continued igniter]3
operation will not jeopardize the drywell or containment]3
structural integrity since combustion would be prevented by the]3
high steam fraction. Continuous operation of the igniters would]3
ensure that combustion would occur locally, instead of globally,]3
as the steam fraction is gradually reduced by subsequent spray]3
operation. This mode of combustion (i.e., localized in lieu of]3
global) prevents the large pressure rise that could result from]3
a global deflagration that would threaten drywell or containment]3
structural integrity.]3

If, however, continuous igniter operation cannot be verified and
the operator cannot determine that the drywell and/or]3
containment hydrogen concentration is below the applicable HDOL,]3
then the igniters should be secured.]3

Hydrogen control procedure Steps PC/H-6.1 and PC/H-6.2 are used
to control and proceduralize the venting and purging
operations. Appendix D of the combustible gas control guideline]3
lists general guidelines for hydrogen control vent path]3
selection.]3

]3

PC/H-1 When RPV water level is below [-164 in. (top of active]3
fuel)] or cannot be determined, but only if primary]3
containment hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit) and the drywell hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit), operate hydrogen igniters.

Discussion: Operation of the hydrogen igniters is designed to prevent hydrogen accumulation by ignition of any hydrogen at the lowest concentrations. If conditions exist which could lead to significant hydrogen production, it is desirable to actuate the igniter system as early as possible to control hydrogen accumulation. This step provides for operation of the igniters if RPV water level cannot be determined to be above the top of active fuel (TAF). With RPV level at or above TAF, significant hydrogen generation cannot occur. However, as RPV level decreases to below TAF, conditions increasingly favorable for the production of hydrogen will exist.

Operation of the igniters is conditional upon a containment hydrogen concentration being below the containment HDOL and a drywell hydrogen concentration below the drywell HDOL. Operation of the igniters with containment hydrogen concentrations above the containment HDOL is prohibited since a deflagration and the resulting pressure increase under these conditions could overpressurize containment. Similarly, a deflagration in the drywell with the drywell HDOL exceeded could damage drywell or containment integrity.

PC/H-2 **When primary containment or drywell hydrogen concentration reaches [0.5% (minimum detectable hydrogen concentration)] but only if the site radioactivity release rate is expected to remain below the site release rate LCO, vent and purge the primary containment to restore and maintain primary containment and drywell hydrogen concentration below [0.5% (minimum detectable hydrogen concentration)] as follows:**

Discussion: This step provides for normal venting and purging operations if small amounts of hydrogen are detected in the drywell or containment. This statement requires that vent and purge operations only be initiated if the radioactivity release rate due to these operations is expected to remain below the site release rate LCO presented in the plant technical specifications. This prevents any unnecessary radioactivity release in excess of technical specification limits.

Since the EPGs are based on a symptomatic approach, Step PC/H-2 would allow normal venting and purging as long as the plant release rate is maintained within technical specification limits. It is expected that an accident severe enough to result in significant hydrogen generation would result in venting release rates in excess of technical specification limits.

> If while executing the following step, the site radioactivity release rate reaches the site release rate LCO, isolate the primary containment vent and purge.

Discussion: With only minimal amounts of hydrogen in the containment and/or the drywell there is no threat to vital equipment or containment integrity; therefore, continuation of venting which would result in exceeding the site radioactivity release rate LCO is unwarranted.

PC/H-2.1 **Refer to [sampling procedure]**

Discussion: This step provides for the performance of sampling for airborne contaminants prior to venting operations to assure release rates can be expected to remain below the site radioactivity release rate LCO.

Isolation interlocks related to high containment radiation should not be overridden to allow containment venting.

PC/H-2.2 Vent the primary containment in accordance with the [procedure for containment venting] defeating isolation interlocks, if necessary. If the primary containment cannot be vented, vent the drywell to atmosphere in accordance with the [procedure for containment venting].]3]3

Discussion: This step initiates the venting of containment in accordance with normal plant venting procedures to reduce containment and drywell hydrogen concentration. If the containment cannot be vented, this step provides for establishing venting of the drywell to atmosphere. Besides reducing drywell hydrogen accumulation, venting the drywell to atmosphere will reduce primary containment hydrogen accumulation when combined with the establishment of a containment to drywell to atmosphere flow path.

In performing this step, some isolation interlocks may have to be defeated to accomplish the vent and purge operations. However, the operator is cautioned not to override any interlocks which pertain to high containment radiation in order to minimize the offsite radiological release.]3]3

PC/H-2.3 If the primary containment or the drywell can be vented, initiate and maximize the containment and drywell purge.

Discussion: Maximization of the containment purge will maximize the primary containment atmosphere turnover, thereby maximizing containment hydrogen removal. Similarly, maximizing drywell purge will maximize removal of hydrogen from the drywell.

If the containment cannot be vented, but drywell venting to atmosphere can be accomplished, maximizing containment purge will increase containment pressure and cause the drywell vacuum breakers to open, thereby establishing a path into the drywell through which venting to atmosphere can be accomplished.

Execute [Steps PC/H-3 and PC/H-4] concurrently

PC/H-3 Monitor and control hydrogen concentration in the drywell.

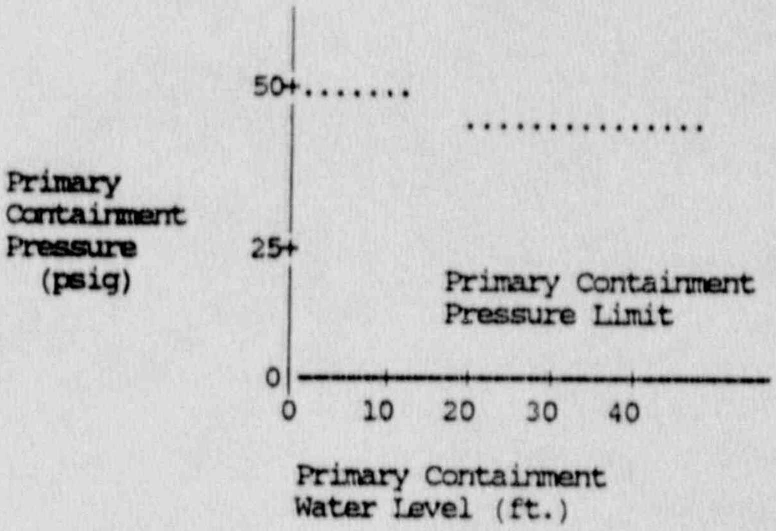
Discussion: Execution of Steps PC/H-3 and PC/H-4 are performed concurrently to assure both the containment and the drywell are monitored for hydrogen accumulation. Step PC/H-3 provides for the response to a drywell hydrogen accumulation.

PC/H-3.1 When drywell hydrogen concentration reaches [0.5% (minimum detectable hydrogen concentration)] if primary containment hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit), and drywell hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit), operate hydrogen igniters.

Discussion: This step provides for initiation of the igniters as soon as hydrogen is detected in the drywell, if they have not already been actuated as a result of Step PC/H-1 or PC/H-4.1.2. Operation of the igniters should only be initiated, however, if the containment hydrogen concentration is below the HDOL and the drywell hydrogen concentration is below its HDOL. As explained in the bases for Step PC/H-1, operation of the igniters when the HDOL is exceeded could challenge primary containment or drywell integrity.]3]3

Since actuation of the igniter system results in the simultaneous actuation of igniters in both the drywell and the primary containment, monitoring of primary containment hydrogen concentration is required to assure its HDOL is not exceeded.

PC/H-3.2 Before drywell hydrogen concentration reaches [4% (lowest hydrogen concentration which can support an upward flame propagation)] but only if [RPV pressure is below the Primary Containment Pressure Limit] and primary containment hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit), operate the drywell hydrogen mixing systems.]3



Discussion: This step provides for operation of the drywell hydrogen mixing systems prior to drywell hydrogen concentration reaching the range where deflagrations may occur. Initiation of the drywell mixing systems is called for to transfer hydrogen from the drywell to the primary containment volume, and thereby reduce the drywell hydrogen concentration below the level where hydrogen combustion might occur.

Operation of the drywell hydrogen mixing systems is conditional upon hydrogen concentration in the primary containment. In the plant specific case where the drywell hydrogen mixing systems permit direct communication between the drywell and containment without forcing non-condensibles through the suppression pool, use of the drywell mixing systems is conditional upon RPV pressure.

Since operation of the drywell mixing systems involve operation of rotating equipment located in the containment, they may provide an ignition source in the containment. For this reason, initiation of the drywell mixing systems are conditional upon primary containment hydrogen concentration being below the primary containment HDOL.

For those plants whose drywell mixing systems allow direct communication between containment and drywell atmospheres without forcing non-condensibles through the suppression pool, an additional condition must be met prior to initiation of the drywell mixing systems. This condition requires that RPV pressure be below the Primary Containment Pressure Limit. This restriction prevents direct blowdown of the reactor vessel to containment by bypassing the pressure suppression pool; an occurrence which could threaten primary containment if the postulated pipe break were large enough and reactor pressure were high enough. In order to preclude this occurrence, RPV pressure is required to be below the Primary Containment Pressure Limit. This assures that RPV pressure is low enough that any blowdown which might bypass the suppression pool will not threaten containment integrity.

PC/H-3.3 Continue in this procedure at [step PC/H-5]

Discussion: Once operation of the drywell mixing systems has been initiated, if conditions permitted initiation, the operator is instructed to continue in the procedure at Step PC/H-5. The actions associated with these steps are conditional only upon containment hydrogen concentration. If drywell hydrogen accumulation were to continue until the drywell HDOL is reached, then the contingent action described in the beginning of this procedure relating to the continuous operation of the hydrogen igniter system applies.

PC/H-4 Monitor and control hydrogen concentration in the primary containment.

Discussion: Monitoring of containment hydrogen concentration is provided for by this step. It is performed concurrently with monitoring of drywell hydrogen concentration, as provided for in Step PC/H-3.

PC/H-4.1 When primary containment hydrogen concentration reaches [1% (minimum hydrogen concentration for recombiner operation or minimum detectable hydrogen concentration, whichever is higher)]:

1. If primary containment hydrogen concentration is below [6% (maximum hydrogen concentration for recombiner operation or the lowest hydrogen concentration which
can support a deflagration, whichever is lower) and the]3
(Hydrogen Deflagration Overpressure Limit)], then place]3
hydrogen recombiners in service.

2. ....

Discussion: This step provides for the actuation of the hydrogen recombiners to control hydrogen accumulation in the containment. Actuation of the recombiners is contingent upon the containment hydrogen concentration being high enough to allow recombiner operation, but not higher than either the lowest hydrogen concentration which can support a deflagration (or the maximum hydrogen concentration for recombiner operation, if it is lower)
or the Hydrogen Deflagration Overpressure Limit. At the point]3
where recombiner operation is prohibited, the heat produced]3
inside the recombiner can damage the recombiner internals. A]3
deflagration inside the recombiner could also damage the]3
recombiner internals, or the recombiner itself could initiate a]3
deflagration.]3

PC/H-4.1 When primary containment hydrogen concentration reaches [1% (minimum hydrogen concentration for recombiner operation or minimum detectable hydrogen concentration, whichever is higher)]:

1 .....

2. If primary containment hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit) and if the drywell hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit), operate hydrogen igniters.

Discussion: As described in the bases for Steps PC/H-1 and PC/H-3.1, the igniters are actuated as early as possible to control hydrogen accumulation. This step provides for the actuation of the igniters if hydrogen is detected in the containment, provided that the primary containment hydrogen concentration is below the containment HDOL, and provided that drywell hydrogen concentration is below the drywell HDOL. The drywell HDOL is considered since actuation of the hydrogen igniter system simultaneously actuates the igniters in the drywell and the primary containment. These conditionals protect containment integrity as described in the bases for step PC/H-1.]3

]3

PC/H-4.2 When primary containment hydrogen concentration reaches [6%]3
(maximum hydrogen concentration for recombiner operation or
the lowest hydrogen concentration which can support a
deflagration, whichever is lower) or the (Hydrogen]3
Deflagration Overpressure Limit)], secure hydrogen]3
recombiners.

Discussion: This step provides for securing the hydrogen
recombiners when hydrogen concentration reaches a level where a
deflagration can occur, or a level where the energy released by
the recombination of hydrogen threatens continued operability of
the recombiners. This step also assures that the recombiners]3
will be secured if a potential exists for the recombiners to]3
initiate a deflagration which could result in overpressurization]3
of the containment.]3

PC/H-5 **When primary containment hydrogen concentration reaches (Hydrogen Deflagration Overpressure Limit) and [primary containment pressure is above 1.7 psig (Mark III Containment Spray Initiation Pressure Limit)] initiate containment sprays (using only those RHR pumps not required to assure adequate core cooling by continuous operation in the LPCI mode).**

Discussion: This step has been included to assure that the containment sprays are actuated in a timely manner. It is anticipated that the sprays will be operating by this point in time due to guidance provided by the containment pressure control guideline. However, it is prudent to include this step to ensure they are actuated. As discussed below, spray operation during an accident that involves hydrogen production provides both a containment pressure control benefit, as well as a scrubbing benefit prior to initiation of venting operations.

As noted above, initiation of containment sprays will reduce containment pressure. Since the final deflagration pressure is the sum of initial containment pressure and the pressure rise caused by the deflagration of the hydrogen in containment, lowering the initial containment pressure via spray operation will result in a lower peak pressure during any deflagration. Thus, reducing containment pressure may, depending on the hydrogen concentration, keep the containment in a condition below the HDOL (and preclude the need to vent) even though the hydrogen concentration has not changed. Initiation of containment sprays will also provide some additional scrubbing of fission products, thereby reducing offsite dose if venting is still required.

Initiation of containment sprays is contingent upon a containment pressure above the Mark III Containment Spray Initiation Pressure Limit. This limit specifies the lowest containment pressure at which containment sprays may be initiated without exceeding the design negative pressure of the containment. This conditional requirement assures that the containment will not be challenged due to negative pressure in the containment resulting from spray initiation.

Since RHR pumps are used for containment spray, the caution incorporated into the text of this step is included to assure that any RHR pump required for continuous LPCI operation to provide adequate core cooling is not diverted from the LPCI mode to the containment spray mode. Diverting any RHR pump which is required to assure adequate core cooling is not justified since the venting and purging operations which follow this step may be able to eliminate the threat to containment without the use of

containment sprays. Also, operation of the sprays alone may not]3
be effective in keeping the containment below the HDOL depending]3
on hydrogen concentration. Diverting resources from providing]3
adequate core cooling under this condition may only serve to]3
increase hydrogen production.

If while executing the following step the primary containment hydrogen concentration can be restored to and maintained below the (Hydrogen Deflagration Overpressurization Limit), secure containment vent and purge.

Discussion: When primary containment hydrogen concentration can be reduced and maintained below the containment HDOL, this caution calls for venting and purging operations to be halted. This caution is appropriate since the threat to containment structural integrity from a deflagration in the containment has been eliminated.

PC/H-6 When primary containment hydrogen concentration reaches the (Hydrogen Deflagration Overpressure Limit) and it cannot be determined that the igniters have been continuously operating since the containment hydrogen concentration exceeded [6% (the lowest hydrogen concentration which can support a deflagration)], secure the igniters and drywell hydrogen mixing systems, then irrespective of the offsite radioactivity release rate, vent and purge the primary containment to restore and maintain the primary containment hydrogen concentration below the (Hydrogen Deflagration Overpressure Limit) as follows:

Discussion: Since a deflagration which occurs with hydrogen concentration at or above the HDOL could result in containment pressures exceeding the ultimate pressure capacity of the primary containment, once the containment HDOL is reached, primary containment integrity can no longer be assured. For this reason, possible ignition sources related to hydrogen control systems, i.e., the hydrogen igniters and the drywell mixing systems, are secured if in operation. In situations where loss of containment is threatened, containment venting is initiated regardless of release rates. This is preferable to a containment failure which may result in uncontrollable releases.

However, as discussed under "Operator Actions" above, there may]3
be conditions when the hydrogen increases above the HDOL and it]3
may be prudent to maintain the igniters energized. As noted in]3
this step, these conditions would arise when it can be confirmed]3
that the igniters have been operating since the containment]3
hydrogen concentration exceeded the lowest hydrogen concentration]3
which can support a deflagration. A continuing increase in the]3
containment hydrogen concentration would be indicative of a steam]3
inert or oxygen starved environment. Recovery from these]3
conditions would be supported by spray operation (i.e., gradual]3
steam condensation) and/or vent/purge operations (i.e.,]3
introduction of additional oxygen).]3

For an oxygen starved condition, continued igniter operation will]3
not jeopardize either the drywell or containment since either no]3
deflagrations will occur or combustion is occurring continually,]3
using available oxygen to consume the hydrogen. In the latter]3
case, continued operation of the igniters prevents the buildup of]3
oxygen in sufficient quantity to allow combustion of the total]3
amount of hydrogen in the drywell and/or containment at once and,]3
therefore, prevents the resultant large pressure rise which could]3
threaten drywell or containment structural integrity.]3

Similarly, for a steam inert condition, continued igniter]3
operation will not jeopardize the drywell or containment]3
structural integrity since combustion would be prevented by the]3
high steam fraction. Continuous operation of the igniters would]3
ensure that combustion would occur locally, instead of globally,]3
as the steam fraction is gradually reduced by subsequent spray]3
operation. This mode of combustion (i.e., localized in lieu of]3
global) prevents the large pressure rise that could result from a]3
global deflagration that would threaten drywell or containment]3
structural integrity.]3

In reviewing this step and the actions that should be taken prior]3
to and in response to it, the operator should consider the]3
desirability of opening inboard ECCS valves and MOVs prior to]3
reaching HDOL. This consideration arises due to the potential]3
for a spurious ignition of hydrogen which could result from]3
operation of motor-operated valves during periods when hydrogen]3
concentration exceeds the applicable HDOL.]3

PC/H-6.1 Vent the primary containment in accordance with [procedure]3
for containment venting], defeating isolation interlocks, if]3
necessary.]3

Discussion: This step provides for the initiation of containment venting to reduce hydrogen concentration in the containment. As discussed in Step PC/H-6, this is warranted because of the threat to containment integrity posed by hydrogen
deflagration. The caution incorporated into the text of this]3
step is included due to the possibility of having to defeat]3
isolation interlocks to accomplish this step.

PC/H-6.2 If the primary containment can be vented, initiate and]3
maximize containment purge.

Discussion: Once the vent path is established, the containment purge is maximized, thus obtaining the maximum hydrogen concentration reduction in containment.

PC/H-7 If primary containment hydrogen concentration cannot be
restored and maintained below the (Hydrogen Deflagration]3
Overpressure Limit), then irrespective of whether adequate
core cooling is assured, if primary containment pressure is
above [1.7 psig (Mark III Containment Spray Initiation
Pressure Limit)], initiate containment sprays.]3
]3

Discussion: If containment venting and purging operations are
unable to restore and maintain the hydrogen concentration below
the HDOL and containment sprays have not been initiated in Step
PC/H-5 because of the caution, only one additional measure
remains to be taken in order to reduce the threat to]3
containment. This step requires that, irrespective of whether]3
adequate core cooling is assured, containment sprays should be
initiated, provided containment pressure is above the Mark III
Containment Spray Initiation Pressure Limit.

As discussed in step PC/H-6, a deflagration with hydrogen]3
concentrations above the containment HDOL could lead to the loss of containment integrity. With the loss of containment integrity, uncontrollable releases would occur. Containment sprays should be actuated at this point regardless of whether or not adequate core cooling has been assured in order to provide whatever reduction in containment pressure is possible and to maximize scrubbing of fission products if containment failure occurs.

Initiation of containment sprays is the only remaining action
which will reduce or minimize the threat to containment from
hydrogen deflagration. Initiation of the sprays is, however,
still contingent upon containment pressure exceeding the Mark
III Containment Spray Initiation Pressure Limit, since omission]3
of this requirement could also threaten containment integrity
due to excessive negative pressure.

]3
]3
If while executing the following step, the primary]3
containment hydrogen concentration reaches the]3
(Hydrogen Deflagration Overpressurization Limit),]3
secure the drywell hydrogen mixing system.]3
]3
]3

PC/H-8 When primary containment hydrogen concentration can be restored and maintained below the (Hydrogen Deflagration Overpressure Limit), and drywell hydrogen concentration is above [0.5% (minimum detectable hydrogen concentration)], and [RPV Pressure is below the Primary Containment Pressure Limit], operate the drywell hydrogen mixing systems.

Discussion: This step allows reactivation of the drywell hydrogen mixing systems to enhance event recovery. Requiring containment hydrogen concentration to be maintained below containment HDOL is appropriate since the drywell hydrogen mixing systems could serve as a potential ignition source in the containment. This step also requires a minimum hydrogen concentration in the drywell prior to initiating the drywell mixing systems. This is required since actuation of the mixing systems would not be beneficial unless hydrogen is present in the drywell.

The caution statement, however, acknowledges that by moving]3
hydrogen from the drywell to the containment, the containment]3
hydrogen concentration can increase. Therefore, to ensure that]3
the event recovery intent of this procedure does not result in a]3
condition that could threaten containment integrity, the caution]3
statement requires the operator to secure the drywell hydrogen]3
mixing system when the containment HDOL is reached.]3

An additional plant-specific requirement is included for those plants whose drywell mixing systems allow direct communication between containment and drywell atmospheres without forcing non-condensibles through the suppression pool. This requirement ensures that RPV pressure is below the Primary Containment Pressure Limit prior to mixing system operation and is discussed in the bases for step PC/H-3.2.

PC/H-9 When primary containment hydrogen concentration can be restored and maintained below the (Hydrogen Deflagration Overpressure Limit), and drywell hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit), operate the hydrogen igniters.]3

Discussion: This step provides for re-initiation of the hydrogen igniters to aid in controlling hydrogen concentration. As explained in the bases for Step PC/H-1, hydrogen igniter operation is contingent upon a drywell hydrogen concentration below the drywell HDOL and a containment hydrogen concentration below the containment HDOL.

PC/H-9 When primary containment hydrogen concentration can be restored and maintained below the (Hydrogen Deflagration Overpressure Limit), and drywell hydrogen concentration is below the (Hydrogen Deflagration Overpressure Limit), operate the hydrogen igniters.]3

Discussion: This step provides for re-initiation of the hydrogen igniters to aid in controlling hydrogen concentration. As explained in the bases for Step PC/H-1, hydrogen igniter operation is contingent upon a drywell hydrogen concentration below the drywell HDOL and a containment hydrogen concentration below the containment HDOL.

PC/H-10 When primary containment hydrogen concentration can be
restored and maintained below [6% (maximum hydrogen
concentration for recombiner operation or the lowest
hydrogen concentration which can support a deflagration,
whichever is lower) and the (Hydrogen Deflagration]3
Overpressure Limit)], and hydrogen concentration is above]3
[1% (minimum concentration for recombiner operation)],
operate the hydrogen recombiners.

Discussion: This step operates the hydrogen recombiners when
containment hydrogen concentration has been reduced to a level
where the recombiners can be operated without damage, but is
above the minimum concentration required for recombiner
operation, thus reducing the heat load in containment.
Recombiners should not be operated if the containment conditions]3
remain above the HDOL because the recombiners might initiate a]3
deflagration which could threaten containment integrity.]3

Attachment 4 to HGN-122-NP

Appendix C to Mark III Combustible Gas Control Emergency Procedure Guideline

Calculational Procedure For Hydrogen Deflagration Overpressure Limit (HDOL)

1.1 Technical Description and Derivation of the Calculational Procedures

1.1.1 General

The Hydrogen Deflagration Overpressure Limit (HDOL) curve is constructed by calculating the pressure increases resulting from burning various concentrations of uniformly mixed hydrogen, air and steam in the containment or drywell volumes. Each pressure increase is related to the pressure capacity of the primary volumes to get a relationship (the HDOL) between the initial pressure and the maximum hydrogen concentration that can be ignited without potential overpressurization of the volumes.

The use of the term "containment" in Appendix C is defined as the sum of the free volume of the wetwell, intermediate and upper containment volumes.

The calculational procedures are divided into two sections: containment HDOL and drywell HDOL.

1.1.2 HDOL

The purpose of the HDOL curve is to assure that the postulated combustion of hydrogen and oxygen in the containment or drywell will not result in an overpressurization that will structurally fail the containment. The containment HDOL curve is a plot of hydrogen concentration versus containment initial pressure.]3 The drywell HDOL is not presented as a curve but rather as a hydrogen concentration limit that will allow a non-threatening burn of hydrogen.

The containment initial pressure has taken into account the increase in pressure as a result of assuming that the hydrogen has been added to a sealed containment. Since the hydrogen concentration is a percent of the volume and the densities of the enclosed gases are related to the initial pressure of the containment, the amount of hydrogen present increases as the initial pressure increases for equal volume percentages of hydrogen. Likewise, as initial containment pressure increases, the margin to the failure pressure decreases. Both of these factors result in decreasing the allowable concentrations as the pre-combustion containment pressure increases.

The pressure increase from a burn results from the heating of the atmosphere to high temperatures. The maximum pressure occurs within 3 to 30 seconds, depending on hydrogen and steam concentrations. Following the burn, the atmosphere loses its energy to the heat sinks in the containment and the pressure decays to near the initial pre-burn pressure. The pressure decay occurs within a few minutes.

The calculational procedure, which can be completed algebraically or graphically, determines the allowable initial pressure in the primary containment for various hydrogen concentrations. The procedure was developed by analyzing the pressure rise that would result from burns with various initial conditions utilizing a detailed combustion computer code. The calculated maximum pressures are compared with the ultimate capacity of the primary containment to obtain a relationship between the permissible initial pressure and the maximum hydrogen concentration that can be ignited without containment overpressurization. Since the pressure rise is a function of hydrogen and steam concentrations, the allowable initial pressure also depends on these concentrations. The methods employed to determine the HDOL do not require the operator to know what the steam concentration is.

Using the CLASIX-3 computer code, pressure and temperature transients are calculated for varying hydrogen and steam concentrations utilizing appropriate initial conditions for the containment. The threshold for burning hydrogen is between 4% and 6%, therefore, combustion transients are calculated for 6, 8, 10 and 13 percent hydrogen by volume, with varying steam concentrations from 0 to 50 percent.

1.1.3 Combustion Computer Code

The computer code used to calculate the pressure and temperature increases is the CLASIX-3 code. CLASIX-3 is a Westinghouse proprietary code. The CLASIX-3 code is a Mark III containment modification to the original CLASIX code that was developed to perform hydrogen combustion analysis for an ice-condenser containment. CLASIX-3 is a multivolume containment code which calculates the containment pressure and temperature response in the separate compartments (i.e., drywell, wetwell, containment). CLASIX-3 has the capability to model features of the systems unique to a Mark III containment (including the suppression pool, refueling pool, vacuum breakers, and drywell purge system) while tracking the distribution and effects of the atmosphere constituents (i.e., oxygen, nitrogen, hydrogen and steam). The code also has the capability of modeling containment sprays and structural heat sinks. The burning of hydrogen is calculated in the code with provisions to vary the conditions under which hydrogen is assumed to burn and conditions at which the burn will propagate to other compartments.

In performing CLASIX-3 calculations for the HDOL, the containment or drywell is assumed to have a uniformly mixed concentration throughout its volume. Ignition initiates a deflagration and the flame front propagates throughout the volume. The duration of energy release is controlled by the burn time, an input parameter. The other critical input parameters for deflagration type burns are the initial hydrogen, air and steam or water vapor concentrations. The fraction of hydrogen burned and the initial hydrogen concentration determine the amount of energy released. The peak pressure and temperature are related to the amount of hydrogen burned, the burn duration, the initial steam concentration, and the atmosphere turbulence. The decay of the peak pressure and temperature is related to the energy of combustion being transferred from the hot gases into the heat sinks within the containment or drywell.

1.2 Input Parameters and Physical Constants

$P_{C_{ULT}}$ Best estimate of the actual maximum pressure the primary containment can withstand

$P_{C_{ULT}}$ = ____________ psia

h_H Hydrogen enthalpy as a function of temperature at P = 14.696 psia. See Table 1]3

V_{DW} Drywell free volume

V_{DW} = ____________ ft^3

V_C Containment net free volume (wetwell, intermediate and upper containment volumes)

V_C = ____________ ft^3

$T_{DW_{LCO}}$ Drywell LCO temperature (Limiting Condition of Operation temperature from plant tech. specs.)

$T_{DW_{LCO}}$ = ____________ ^oF

$T_{C_{LCO}}$ Containment LCO temperature prior to air/steam/hydrogen addition (Limiting Condition of Operation temperature from plant tech. specs.)

$T_{C_{LCO}}$ = ____________ ^oF

P_{DW} Normal operating drywell pressure

P_{DW} = ____________ psia

P_C	Containment pressure prior to air/steam/hydrogen addition
	P_C = ________________ psia
T_H	Temperature of hydrogen when released through the suppression pool. T_H will be the peak suppression pool temperature during blowdown of a Design Basis Accident (DBA).]3
	T_H = ________________ ^oF
R_a	Gas constant for air
	R_a = 53.33 ft-lbf/lbm-^oR
M_H	Molecular weight of hydrogen
	M_H = 2.016 lbm/lbm-mole
M_a	Molecular weight of air
	M_a = 28.97 lbm/lbm-mole
C_{P_H}	Constant pressure specific heat of hydrogen
	C_{P_H} = 3.42 Btu/lbm-^oR
C_{P_a}	Constant pressure specific heat of air
	C_{P_a} = 0.24 Btu/lbm-^oR
$P_{D_{SLB}}$	Peak drywell pressure due to steam line break
	$P_{D_{SLB}}$ = ________________ psid
$P_{D_{RLB}}$	Peak drywell pressure due to recirculation line break
	$P_{D_{RLB}}$ = ________________ psid
HDOL $\%H_{2_{MAX}}$	The maximum hydrogen concentration which can be safely burned as defined by the HDOL.
x_H	Molar fraction or percent by volume of hydrogen.
x_S	Molar fraction or percent by volume of steam.

x_a	Molar fraction or percent by volume of air.
S_{DBA}	Average slope of the rise in differential pressure versus time in the drywell of a Design Basis Accident.
S_{CLX}	Average slope of the rise in differential pressure versus time in the drywell as determined by CLASIX-3 code simulated drywell hydrogen burns.
P_o0%	Maximum initial pressure for a safe hydrogen burn at the maximum hydrogen concentration allowed in the containment volume by the HDOL.

1.3 Containment Volume Assumptions

a. The gases are uniformly mixed in containment when combustion occurs.

b. No sprays or fans are operating during combustion.

c. Containment is at the saturated atmosphere temperature (i.e., relative humidity = 1) for all cases where the steam concentration is greater than zero.

d. The Technical Specification Limiting Condition for Operation (LCO) is used for the initial containment temperature prior to the addition of steam and noncondensibles to the containment. Initial containment pressure is one atmosphere.]3

e. Combustion durations vary with hydrogen and steam concentrations. Combustion times as a function of hydrogen concentration are based on the large volumetric burns conducted at the Nevada Test Site.

f. Before combustion initiation, the containment is assumed to be pressurized due to a loss of coolant accident (LOCA) in the drywell by additional air equivalent to the drywell air mass at drywell LCO temperature. The addition is above and beyond the air, steam, and hydrogen existing in containment at atmospheric conditions. This containment atmosphere generates a more limiting pressure environment during a hydrogen burn.]3]3

g. For cases with no steam in the atmosphere, hydrogen is assumed to enter the containment at 150°F, corresponding to the anticipated suppression pool temperature, and equilibrate with the air without heat transfer to the structures.

1.4 Calculational Procedure for the Containment HDOL

Using the assumptions listed in Section 1.3 and input listed in Section 1.2, calculate the HDOL containment pre-combustion initial conditions. The procedure (enumerated in Sections 1.4.1 and 1.4.2) is repeated for each combination of hydrogen (x_H) and water vapor (x_s) concentration listed in Table 2. Record P_o and T_o in Table 2. Section 1.4.3 describes the calculation of the containment HDOL.

1.4.1. Calculation of Initial Conditions for Cases with No Steam

The cases with no steam assume that the initial containment pressurization is due to addition of noncondensibles, i.e., hydrogen release to containment and air carryover from the drywell.

a. Calculate the initial air masses in the drywell and containment and determine the total air mass, m_a.]3

$$m_{a_{DW}} = \frac{P_{DW} V_{DW} * 144}{R_a (T_{DW_{LCO}} + 460)}$$

$m_{a_{DW}}$ = ______________ lbm

$$m_{a_C} = \frac{P_C V_C * 144}{R_a (T_{C_{LCO}} + 460)}$$

m_{a_C} = ______________ lbm

$$m_a = m_{a_{DW}} + m_{a_C}$$

m_a = ______________ lbm

b. Using the hydrogen volume fractions at zero steam concentration from Table 2, calculate the hydrogen mass in containment.

$$m_H = \frac{x_H}{(1 - x_H)} * m_a \frac{M_H}{M_a}$$

m_H = ______________ lbm

c. Determine the total mass of noncondensibles in containment.

$$m_T = m_a + m_H$$

m_T = ______________ lbm

d. At T_H determine the enthalpy of hydrogen from Table 1.

h_H = ______________ Btu/lbm]3

e. Enter air enthalpies at drywell and containment LCO temperatures (use reference temperature of absolute zero).]3]3

@ $T_{DW_{LCO}}$ = ______________ $(T_{DW_{LCO}}+460)\,^{\circ}R$

$h_{a_{DW}}$ = ______________ Btu/lbm

@ $T_{C_{LCO}}$ = ______________ $(T_{C_{LCO}}+460)\,^{\circ}R$

h_{a_C} = ______________ Btu/lbm

f. Calculate the specific heat of the noncondensible mixture in containment.

$$C_P = \frac{1}{m_T}\left(m_a C_{P_a} + m_H\, C_{P_H}\right)$$

C_P = ______________ Btu/lbm-°R

g. Calculate the containment pre-combustion initial temperature, assuming no heat transfer from the noncondensibles to the structures.

$$T_o = \frac{m_{a_{DW}}\, h_{a_{DW}} + m_{a_C}\, h_{a_C} + m_H\, h_H}{m_T\, C_P}$$]3

T_o = ______________ °R

h. Calculate the containment pre-combustion initial pressure as a result of noncondensible addition.

$$P_o = \left(1 + \frac{x_H}{(1-x_H)}\right) * \left(\frac{m_a R_a T_o}{V_C * 144}\right)$$

P_o = ________________ psia

i. Repeat steps (b) - (h) for each combination of air/hydrogen concentrations (at zero steam content) in Table 2. Convert T_o to degrees Fahrenheit and enter P_o and T_o in the appropriate boxes in Table 2.

1.4.2 Calculation of Initial Conditions for Remaining Cases

For the remaining cases, the containment is heated due to the addition of steam from the suppression pool. A saturated atmosphere is assumed.]3

a. Estimate the containment temperature, and calculate the air partial pressure.

T_{C_i} = ________________ °R

$$P_{a_i} = \frac{m_a R_a T_{C_i}}{V_C * 144}$$

P_{a_i} = ________________ psia

b. Using the volume fractions from Table 2, calculate the air volume fraction.

$$x_a = 1 - x_s - x_H$$

x_a = ________________

c. Calculate the steam partial pressure and the corresponding saturation temperature from the steam tables.

$$P_{s_i} = \frac{x_s P_{a_i}}{x_a}$$

P_{s_i} = ________________ psia

$T_{SAT_i}(P_{s_i})$ = ________________ °F

d. Using $T_{SAT_i}(P_{s_i})$ as the new estimate of the containment temperature, repeat steps (a) - (c) n-times until convergence (n is generally 3 or 4).

$$T_o = T_{SAT_n}(P_{s_n})$$

T_o = _______________ °F

P_{s_n} = _______________ psia

e. Calculate the pre-combustion initial containment pressure.

$$P_o = \frac{P_{s_n}}{X_s}$$

P_o = _______________ psia

f. Enter P_o and T_o in the appropriate box in Table 2.

Repeat steps (a) - (e), using a new estimate of containment temperature and new values of X_s and X_H.

1.4.3 Calculation of Containment HDOL

a. The CLASIX-3 code must be run (for each case) to determine the maximum pressure (P_f) for insertion in Table 2.

b. Plot each peak pressure (P_f) versus its corresponding initial pressure (P_o) on Figure 1. Draw the lines of constant initial hydrogen concentration.

c. Plot the ultimate containment capacity ($P_{C_{ULT}}$ psia) on the P_f axis of Figure 1, and at that point extend a line horizontally across the graph.

d. Draw a line through the points of zero steam concentration. Mark the point where this line intersects the $P_{C_{ULT}}$ horizontal line, and record P_o on the horizontal axis for this point. This point, $P_o0\%$, will be used later in this section to determine the maximum percent of hydrogen concentration allowable, $\%H_2max$.

e. For a line of constant hydrogen concentration, determine the slope. This may be done graphically, using any two points on the line, or by establishing the slope from a linear regression fit of the points (P_o, P_f) in Table 2.

f. Pick any point (P_{o_1}, P_{f_1}) on a line of constant hydrogen concentration. The critical initial pressure for that concentration is

$$P_{o_{CRIT}} = \frac{P_{C_{ULT}} - P_{f_1}}{SLOPE} + P_{o_1}.$$

g. Convert $P_{o_{CRIT}}$ values to psig. Tabulate $P_{o_{CRIT}}$ in Table 3. Repeat steps 1.4.3. (e) and (f) for each line on Figure 1.

h. Plot x_H versus $P_{o_{CRIT}}$ on Figure 2 to define the HDOL curve.

i. The HDOL curve is extrapolated to an allowable pressure value]3
of P_o which is equal to 10 psig below the $P_{C_{ULT}}$ value.]3
(This 10 psig margin is provided to mitigate the consequences]3
of a deflagration that could potentially occur at the maximum]3
pressure as defined by the HDOL.) At a P_o value equal to 10]3
psig below $P_{C_{ULT}}$, draw a vertical line from the HDOL curve]3
to the horizontal axis. The right side of the HDOL curve is]3
defined by this vertical line.]3

j. Plot P_o0% from 1.4.3.d on the horizontal axis. Draw a vertical line from the horizontal axis to the HDOL curve. Draw a horizontal line left from the intersection of the vertical line and the HDOL curve to the vertical axis. The intersection of the horizontal line with the vertical axis (hydrogen
concentration) defines HDOL %H_2max, the maximum hydrogen]3
concentration which can be safely burned.

k. In summary, the HDOL curve is defined by the horizontal line from a point at HDOL %H_2max on the vertical axis to a point defined by the coordinates (P_o0%, %H_2max), from there along a curve drawn through points whose coordinates are (P_{CRIT},
x_H), and ending at P_o equals $P_{C_{ULT}}$ minus 10 psig, where]3
a vertical line to the horizontal axis defines the curve.

1.5 Assumptions for the Drywell HDOL

a. Prior to the postulated burn, containment and drywell pressurization results only from addition of steam and/or noncondensible gases.

b. The gases are uniformly mixed in the drywell when combustion occurs.

c. The suppression pool level has been raised by an upper pool dump for those plants which utilize an upper pool dump.

d. The Technical Specification Limiting Condition for Operation (LCO) is used for the initial temperature prior to the addition of steam and additional noncondensibles to the drywell. Initial drywell pressure is one atmosphere (14.7 psia).]3

e. Drywell is at the saturated atmosphere temperature (i.e. relative humidity = 1) for all cases where the steam concentration is greater than zero.

f. Combustion durations vary with hydrogen and steam concentrations. Combustion times are based on the large volumetric burns conducted at the Nevada Test Site.

g. The drywell HDOL will be exceeded when either of two criteria are met:

   1) The hydrogen burn peak differential pressure P_f, between the drywell and containment, exceeds the peak differential pressure for either a main steam line or recirculation line break.

   2) The rate of change of pressure with respect to time between the drywell and containment is greater than the rate of change due to the higher rate of either a main steam line or recirculation line break.

   The first criterion limits the maximum pressure due to a hydrogen burn to that of a Design Basis Accident (DBA). Main steam or recirculation line breaks are the most severe DBAs for which the drywell must maintain its functional integrity during and following the peak transient pressure. These accidents include the worst single failure which leads to maximum drywell pressure.

   The second criteria is premised on limiting the rate of pressure rise of a hydrogen burn to that of a DBA because of the potential resulting suppression pool swell and pool dynamic effects on containment and drywell structures.

h. The differential pressure between the drywell and containment is initially zero.]3

1.6 Calculational Procedure For the Drywell HDOL

The procedure involves two calculations. The first defines the HDOL by determining the critical initial pressure and the second defines the allowable rate of change of drywell differential pressure with respect to time. The calculations are then compared to determine the drywell HDOL.

Using the assumptions listed in Section 1.5 and input from Section 1.2, calculate the HDOL drywell precombustion initial conditions T_o and P_o. The procedure is repeated for each combination of hydrogen, steam and air concentration listed in Table 4. Record]3
P_o and T_o in Table 4.

1.6.1 Calculation of Initial Conditions for Cases with No Steam.

The cases with no steam assume that the initial drywell pressurization is due to addition of hydrogen to the drywell.

a. Calculate the initial air masses in the drywell.

$$m_{a_{DW}} = \frac{P_{DW}\, V_{DW} * 144}{R_a\,(T_{DW_{LCO}} + 460)}$$

$m_{a_{DW}}$ = _______________ lbm

b. Using the hydrogen volume fractions at zero steam concentration from Table 4, calculate the hydrogen mass in the drywell.

$$m_{H_{DW}} = \frac{x_H}{(1 - x_H)} * m_{a_{DW}} \frac{M_H}{M_a}$$]3

$m_{H_{DW}}$ = _______________ lbm]3

c. Determine the total mass of noncondensibles in the drywell.

$$m_{T_{DW}} = m_{a_{DW}} + m_{H_{DW}}$$]3

$m_{T_{DW}}$ = _______________ lbm]3

d. At $T_{DW_{LCO}}$ determine the enthalpy of hydrogen from Table 1.]3

$h_{H_{DW}}$ = _______________ Btu/lbm]3

e. Enter air enthalpies at drywell LCO temperature.

@ $T_{DW_{LCO}}$ = _______________ $(T_{DW_{LCO}} + 460)\,^{o}R$

$h_{a_{DW}}$ = _______________ Btu/lbm

f. Calculate the specific heat of the noncondensible mixture in drywell.

$$C_p = \frac{1}{m_{T_{DW}}} \quad (m_a C_{p_a} + m_{H_{DW}} C_{p_H})$$

C_p = ______________ Btu/lbm-oR

g. Calculate the drywell pre-combustion initial temperature, assuming no heat transfer from the noncondensibles to the structures.

$$T_o = \frac{m_{a_{DW}} h_{a_{DW}} + m_{H_{DW}} h_{H_{DW}}}{m_T C_p}$$

T_o = ______________ ^oR

h. Calculate the drywell pre-combustion initial pressure as a result of noncondensible addition.

$$P_o = \left(1 + \frac{x_H}{(1-x_H)}\right) * \left(\frac{m_{a_{DW}} R_a T_o}{V_{DW} * 144}\right)$$

P_o = ______________ psia

i. Repeat steps (b) - (h) for each combination of air/hydrogen concentrations (at zero steam content) in Table 4. Enter P_o and T_o in the appropriate boxes in Table 4.

Note: P_o is also used for the initial pre-combustion pressure for the containment since it is assumed that the differential pressure across the drywell is equal to zero.]3

1.6.2 Calculation of Initial Conditions for Remaining Cases.

For the remaining cases, the drywell is heated due to the addition of steam. A saturated atmosphere is assumed.

a. Estimate the drywell temperature, and calculate the air partial pressure.

T_{DW_i} = ____________ °R

$$P_{a_i} = \frac{m_{a_{DW}} R_a T_{DW_i}}{V_{DW} * 144}$$

P_{a_i} = ____________ psia

b. Using the volume fractions from Table 4, calculate the air volume fraction.

$$x_a = 1 - x_s - x_H$$

x_a = ____________

c. Calculate the steam partial pressure and the corresponding saturation temperature from the steam tables.

$$P_{s_i} = \frac{x_s P_{a_i}}{x_a}$$

P_{s_i} = ____________ psia

$T_{SAT_i} (P_{s_i})$ = ____________ °F

d. Using $T_{SAT_i}(P_{s_i})$ as the new estimate of the drywell temperature, repeat steps (a) - (c) n-times until convergence (n is generally 3 or 4).

$$T_o = T_{SAT_n} (P_{s_n})$$

T_o = ____________ °F

P_{s_n} = ____________ psia

e. Calculate the pre-combustion initial drywell pressure.

$$P_o = \frac{P_{s_n}}{x_s}$$

P_o = ____________ psia

f. Enter P_o and T_o in the appropriate box in Table 4.

Repeat steps (a) - (e), using a new estimate of drywell temperature and new values of x_s and x_H.

1.6.3 Calculation of First Criterion - Peak Differential Pressure Limit

The peak differential pressure between the drywell and the containment due to the combustion of hydrogen in the drywell cannot be allowed to exceed the peak differential pressure due to a main steam line or recirculation line break in the drywell. Differential pressures are used to simplify the calculations. This section outlines the procedure for determining the HDOL according to this criterion.]3

a. The CLASIX-3 code must be run for each drywell case (P_o and T_o pair) in Table 4 to determine the maximum pressure (P_f) for insertion into Table 4.

b. Compare the difference of P_f - P_o for each case with the higher peak differential pressure ($P_{DW_{MAX}}$) between the drywell and containment of either a main steam line or recirculation line break.

   1) If for any given hydrogen concentration (x_H) the differences of P_f - P_o for any of the varying steam concentration cases (x_s) is greater than $P_{DW_{MAX}}$, then the drywell HDOL is defined as being exceeded at that steam concentration (x_s), and cases for a lower concentration of hydrogen should be examined.

   2) If for a given hydrogen concentration (x_H) the differences of P_o - P_f for any one of the varying steam concentration cases (x_s) are less than $P_{DW_{MAX}}$ then the drywell HDOL is defined as allowing burns up to and including x_H.]3

c. Place the limiting hydrogen concentration (x_{H_I}) as determined by the first criterion in Table 6.

d. Sections 1.6.3 (a) and (b) define the HDOL according to the first criterion, but the second criterion as defined in Section 1.6.4 must also be met for the HDOL to be specified completely.

1.6.4 Calculation of Second Criterion - Allowable Rate of Change of Differential Pressure

The rate of change of pressure with respect to time due to the combustion of hydrogen in the drywell cannot exceed the rate of change of pressure due to the greater of either a main steam line or recirculation line break. Differential pressures are used. The following steps outline the procedure for determining the drywell HDOL as defined by the second criterion.

a. Drywell to containment differential pressure time histories for a main steam line and a recirculation line break must be obtained for this calculation.

b. CLASIX-3 hydrogen burn differential pressure time histories]3
are obtained from Step 1.6.3.a.]3

c. Comparisons between rates are made by first determining average slopes.

1) The maximum average slope (S_{DBA}) of an FSAR Design]3
Basis Accident (DBA) due to a main steam line or]3
recirculation line break is determined by the]3
following:

a) The differential pressure versus time curve for the DBA line break that has the maximum peak pressure will be used to establish the allowable rate of change.

b) The rate of change of the chosen curve is defined
as the maximum slope of the linear approximation]3
to the maximum pressure rise portion of the curve
which imparts the majority of the momentum to the
suppression pool.

c) Place the slope (S_{DBA}) in Table 5.

2) The average slope (S_{CLX}) of the rise in differential pressure versus time as determined by the CLASIX-3 simulated drywell hydrogen burns for various concentrations of hydrogen and steam as listed in Table 4 is determined by:

$$S_{CLX} = \frac{P_f - P_o}{t_f - t_o}$$

where:

P_o = Initial (time=0) pressure (psia)

P_f = Maximum pressure (psia)]3

t_o = Initial time (time=0)

t_f = Time of occurrence of the maximum pressure.

Place the slopes for each case in Table 5.

3) Compare S_{CLX} for each case with S_{DBA}.

a) If for a given hydrogen concentration (x_H) any one of the S_{CLX} of the varying steam concentration cases (x_s) is greater than S_{DBA}, then the drywell HDOL is defined as being exceeded at that steam concentration (x_s) and cases for a lower concentration of hydrogen should be examined.

b) If for a given hydrogen concentration (x_H) all S_{CLX} for the varying steam concentration cases (x_s) are less than S_{DBA}, then the drywell HDOL is defined as allowing burns up to and including x_H.

c) Place the limiting hydrogen concentration ($x_{H_{II}}$) as determined by the second criterion in Table 6.

1.6.5 Calculation of Drywell HDOL

The drywell HDOL is determined by comparing the two limiting hydrogen concentrations (x_{H_I} and $x_{H_{II}}$) calculated in Sections 1.6.3 and 1.6.4.]3

a. If x_{H_I} and $x_{H_{II}}$ differ in value, the drywell HDOL is the lesser of the two.

b. If x_{H_I} and $x_{H_{II}}$ have the same value, the drywell HDOL has the same value as the two.

c. Place the drywell HDOL as determined from 1.6.5 (a) or (b) in Table 6.]3

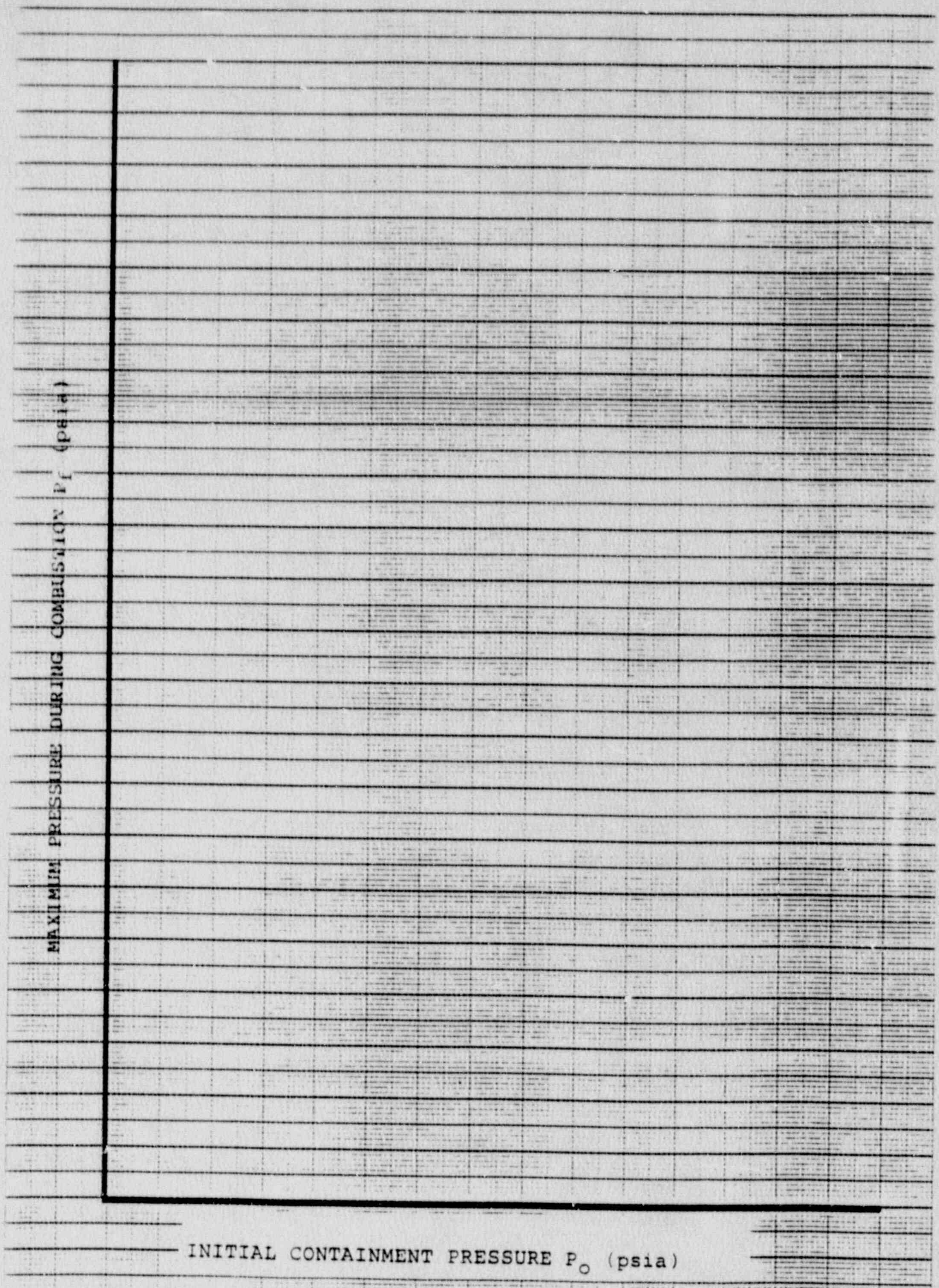

MAXIMUM PRESSURE DURING COMBUSTION P_f (psia)
INITIAL CONTAINMENT PRESSURE P_o (psia)

FIGURE 1

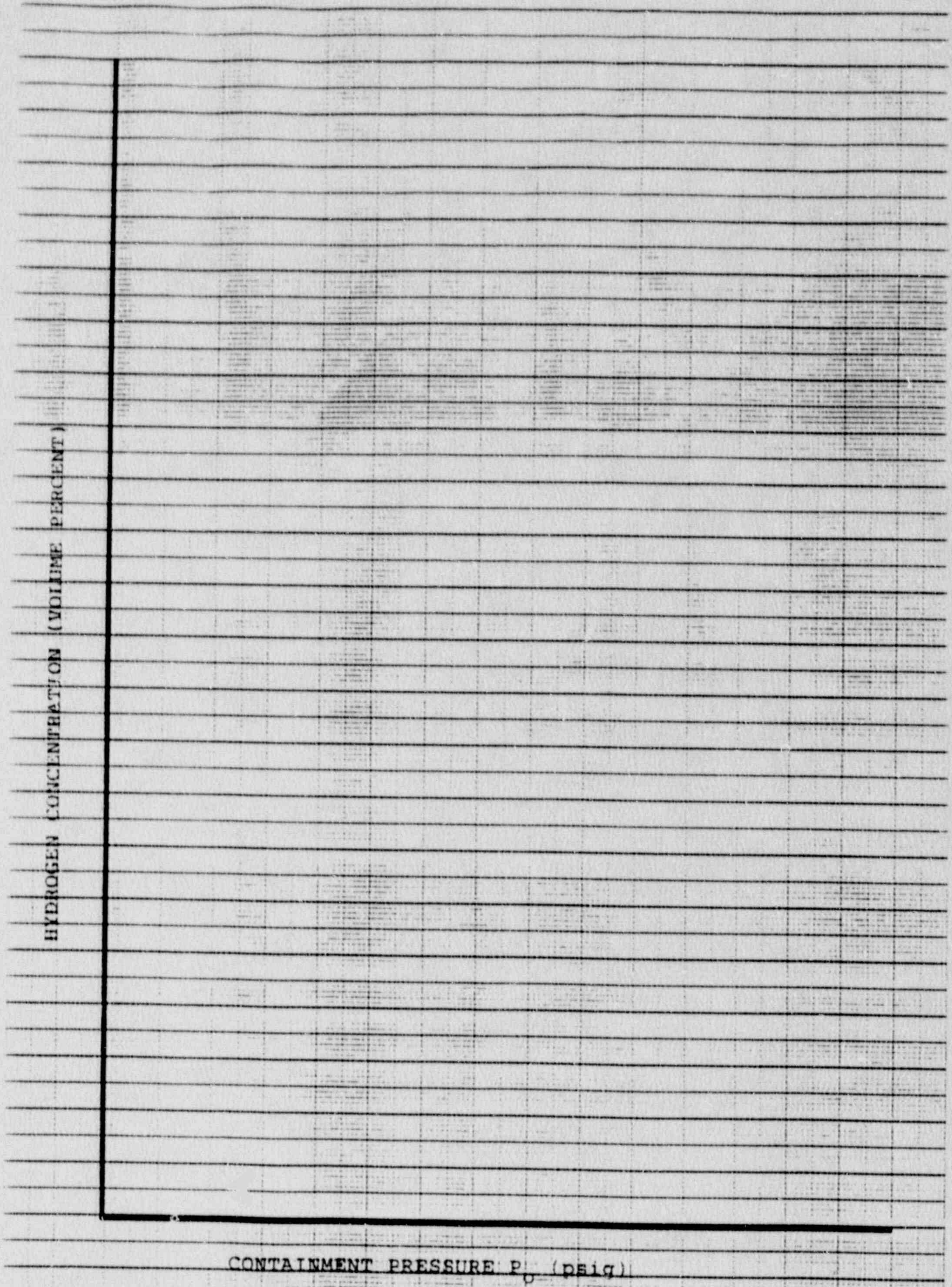


Figure 2. Mark III Containment HDOL Curve

TABLE 1

HYDROGEN ENTHALPY

(Normal Hydrogen at 14.696 psia)

Temperature (°R)	h_H (Btu/lbm)
520	1750.164
540	1818.473
560	1887.054
580	1955.666
600	2024.463
650	2196.779
700	2369.521

]3

Reference: "NASA SP-3089", Table C-2C, p.116.]3

TABLE 2

INITIAL CONDITIONS AND RESULTS OF CLASIX-3 CALCULATIONS FOR THE CONTAINMENT MODEL

	%VOL STEAM — x_S	0	5	15	30	50	
x_H							
%Vol H_2							
	T_o (F)						
	P_o (psia)						
6	P_f (psia)						
	%H_2 Burned						]3
	Burn Time (Sec)						]3
	T_o (F)						
	P_o (psia)						
8	P_f (psia)						
	%H_2 Burned						]3
	Burn Time (Sec)						]3
	T_o (F)						
	P_o (psia)						
10	P_f (psia)						
	%H_2 Burned						]3
	Burn Time (Sec)						]3
	T_o (F)						
	P_o (psia)						
13	P_f (psia)						
	%H_2 Burned						]3
	Burn Time (Sec)						]3

TABLE 3

CONTAINMENT HDOL CURVE DATA

PRE-COMBUSTION HYDROGEN CONCENTRATION	MAXIMUM ALLOWABLE INITIAL PRESSURE
x_H (volume percent)	$P_{o_{CRIT}}$ (psig)
6	
8	
10	
13	

TABLE 4
INITIAL CONDITIONS AND RESULTS OF CLASIX-3 CALCULATIONS FOR THE DRYWELL MODEL

	%VOL STEAM -- x_S	0	5	15	30	50
x_H %Vol H_2						
6	T_O (F)					
	P_O (psia)					
	P_{MAX} (psid)					
	%H_2 Burned					
	Burn Time (Sec)					
8	T_O (F)					
	P_O (psia)					
	P_{MAX} (psid)					
	%H_2 Burned					
	Burn Time (Sec)					
10	T_O (F)					
	P_O (psia)					
	P_{MAX} (psid)					
	%H_2 Burned					
	Burn Time (Sec)					
13	T_O (F)					
	P_O (psia)					
	P_{MAX} (psid)					
	%H_2 Burned					
	Burn Time (Sec)					

TABLE 5

AVERAGE SLOPES

Main steam line break S_{DBA} ____________________

Recirculation line break S_{DBA} ____________________

CLASIX-3 HYDROGEN BURN AVERAGE SLOPES S_{DBA}]3

x_S	6% x_H S_{DBA}	x_S	8% x_H S_{DBA}	]3
0		0		
5		5		
15		15		]3
30		30		]3
50				]3

x_S	10% x_H S_{DBA}	x_S	13% x_H S_{DBA}	]3
0		0		
5		5		
15		15		
30		30		

TABLE 6

DRYWELL HDOL

I. Maximum hydrogen concentration (x_H) from first criterion (Section 1.6.3)

x_{H_I} = ____________ %

II. Maximum hydrogen concentration (x_H) from second criterion (Section 1.6.4)

$x_{H_{II}}$ = ____________ %

Drywell HDOL = ____________ % Volume H_2]3

Attachment 5 to HGN-122-NP

Example Calculation of
Hydrogen Deflagration Overpressure Limit (HDOL)

[Attachment 5 has been deleted due to the proprietary nature of the input information. The attachment's text was a repeat of Appendix C (i.e., Attachment 4), with CLASIX-3 information used to create the generic HDOL curve.]

Attachment 6 to HGN-122-NP

Appendix D to the Mark III Combustible Gas Control Emergency Procedure Guideline

Vent Path Selection Guideline

1.0 GENERAL GUIDELINES FOR HYDROGEN CONTROL VENT PATH SELECTION

There are two circumstances for which containment venting would be necessary. These are: 1) increasing containment pressure, and 2) increasing hydrogen concentration. In both cases, venting is a procedure carried out to avert potential loss of containment integrity.

Purging and venting may be used to control the hydrogen concentration in the containment and drywell by either maintaining the concentration below or reducing the concentration below specified limits during a core damage event. Hydrogen gas will be produced as the core degrades and will be released into the containment or drywell atmosphere, depending on the event. To prevent damage to the containment and the enclosed equipment as a result of hydrogen burning, Mark III containments provide a hydrogen ignition system which is manually initiated when needed. The venting and purging operations would be used to control events in which relatively small quantities of hydrogen have been generated, and in which negligible radioactivity releases would be involved. In addition, venting and purging would also be used as a backup to the hydrogen recombiners for events with relatively low radiation releases. If the event progresses in such a way that the hydrogen concentration is above the hydrogen deflagration overpressure limit (HDOL), containment venting would be used to reduce the pressure and the amount of combustible gas in containment. The containment may then be purged to further reduce the amount of combustible mixtures so that hydrogen ignition may be safely initiated. However, venting should be considered even if purge capability does not exist, since containment pressure and hydrogen concentration may be reduced to levels acceptable for safe hydrogen ignition.

The Combustible Gas Control Emergency Procedures Guideline (CGC EPG) provides specific guidance to operators concerning both the conditions under which containment venting can be implemented as a precautionary step, and the conditions under which venting is required to preclude hydrogen combustion events that could potentially result in containment failure. In order to implement the associated venting steps in the CGC EPG, guidelines have been developed which support the selection of a vent path. These guidelines are discussed below. The development of plant specific emergency operating procedures (EOPs) should consider these guidelines when defining plant unique vent paths in their EOPs.

The discussion below provides general vent path selection guidelines which may be used to assess vent path acceptability based on the potential consequences of using the vent path. Examples of adverse consequences are hydrogen combustion outside containment, airborne radioactivity release, exposure of components at discharge point to the containment atmosphere, and high radiation exposure rates. The potential for such adverse consequences are primarily dependent upon the following factors: vent intake point, line size, pressure carrying capability, filtering capability, vent valve actuation, vent discharge routing outside containment, and the vent discharge point. Vent paths should be selected to minimize the adverse consequences of venting.

Containment vents of all sizes should be selected prior to considering drywell vents since venting from the containment assures suppression pool scrubbing of potential fission products. Vent paths which are filtered should be favored over those that are not filtered. Vent pathways that are piped should be favored over those with ducting due to their higher pressure carrying capability.

The vent discharge route should be evaluated to determine potential vent line rupture locations. Critical equipment, required personnel access, and the potential consequences of a rupture in those areas should be evaluated. For example, if a vent line rupture were to occur in a confined area with no ventilation or inadequate ventilation, hydrogen concentrations may build to a combustible mixture resulting in hydrogen combustion. If critical equipment was in this area, it could fail due to the resulting thermal environment. Even if a hydrogen combustion did not occur, the harsh environment created by the rupture could result in the loss of critical equipment due to high temperatures or high radiation.

Access along the vent line route could be restricted due to external radiation fields which may result from either shine from the vent path enclosure or airborne radioactivity discharged from the vent at the vent path's termination point or rupture point. Therefore, the potential consequences of local radioactivity should also be evaluated.

Lastly, the discharge point for each vent path should be selected based on an evaluation of the critical equipment which could be exposed to the containment atmosphere at or near the discharge point. The need to operate and/or access this equipment should be considered. In addition, the equipment installed at or near the discharge point should be reviewed to determine if actuation of the equipment could present a possible spurious ignition source to any hydrogen entrained in the vented gases. In assessing the potential hydrogen combustion threat, the volume of the enclosure discharged to, as well as the operability of any ventilation should be noted to support the determination of any hydrogen buildup concerns.

In addition to hydrogen effects, it would also be advantageous to evaluate the vicinity of the discharge point to determine if it provided a fission product retention benefit.

The following section provides a summary of the vent path selection guidelines discussed above.

2.0 SUMMARY OF HYDROGEN CONTROL VENT PATH SELECTION GUIDELINES

Vent Intake Point	- Select wetwell vents before drywell vents (provides suppression pool scrubbing of accompanying fission products).
Vent Line Size	- The size of a potential vent path should be evaluated considering both its ability to promptly exhaust the containment atmosphere and the effect on offsite dose if isolation components were assumed to fail.
Pressure Carrying Capability	- Vent pathways that are piped should be favored over those with ducting due to their higher pressure carrying capability.
Filtering Capability	- Vent paths that are filtered should be favored over those that are not filtered. This especially applies to the drywell vents which do not benefit from pool scrubbing. An example of a filtered vent path would be the standby gas treatment system. For filtered vent paths, the effect of filter plugging should be considered. In addition, the vent path should be examined to determine if any heaters or other potential ignition sources are present in the path.
Vent Valve Operability	- The vent path isolation valves should be reviewed to confirm that they are capable of opening and closing when exposed to the maximum differential pressure that could exist in the line. Vent paths should also be selected considering their potential for initiating combustion. A review should be performed to assure that the actuation of a valve to open the vent path will not serve as an ignition source. That is, it may be desirable to select a path whose isolation valve operators are sealed to prevent steam intrusion. This seal would provide a significant barrier to the intrusion of hydrogen into the operator housing where low energy sparks would be possible.

Vent Valve Power Supply - To ensure the availability of the vent path, DC powered isolation valves should be preferred choice. If not available, valves powered from AC buses with onsite (e.g., diesel) backup power supplies should be selected.

Vent Discharge Routing Outside Containment - Vent paths should be favored that have minimal potential effects on equipment and personnel access. The vent line route should be reviewed to determine the proximity of equipment required to function during the postulated accident, personnel access requirements, the location of any weak points in the vent line, and the potential consequences of a rupture at these points. The potential consequences of a rupture should be evaluated based on such factors as:

(a) room size

(b) ventilation

(c) access requirements

(d) critical equipment

(e) compartment pressure capability (e.g., consider whether room has open doorways or closed doors, etc.)

(f) ignition sources

For example, a rupture in a confined area with no ventilation could allow the hydrogen concentration to build to combustible levels. The effects of compartment overpressure and over-temperature should be considered. Also a rupture could result in potentially unacceptable concentrations of local airborne radioactivity. In addition, the effect of the potentially high steam fraction and elevated temperature that could result due to the discharge of the containment atmosphere should be considered when evaluating component operability.

Vent Discharge Point	- Vent discharge points should be evaluated based on equipment located near the vent discharge point. In addition, the effects of discharging potentially radioactive elements into the area should be considered. The potential consequences of venting to a specific location should be evaluated similar to the rupture described above.
Pathway Availability	- Assure that the selected pathway is available when required by considering the following: power available to vent valves, need for jumpering isolation logic, manual actions required prior to venting, affect of pressure surges due to rapid opening of vent valves in vent path, evaluation of fire damper operation in vent pathway.
Control Room Habitability	- Evaluate releases and release points to determine if the impact on control room habitability is consistent with TMI Action Plan III.D.3.3.
Preparation For Venting	- Identify early operator actions to be taken so that venting can be accomplished prior to exceeding the HDOL. Establish access restrictions during venting.
Offsite Doses	- If using a vent path other than a normal release point, or if vent path failure would produce unmonitored releases, consider the need to monitor releases and provide data to the emergency operations facility (EOF).