ASSESSING THE IMPACT OF THERMAL/HYDRAULIC UNCERTAINTY ON AP600 PRA SUCCESS CRITERIA

Introduction and Background

The NRC has asked that Westinghouse perform an assessment of the potential that the AP600 probabilistic risk assessment (PRA) success criteria could be significantly affected by uncertainty in the prediction of the thermal/hydraulic (T/H) performance of passive systems. Specifically, the NRC has requested that Westinghouse demonstrate that any potential impact on core damage due to such T/H uncertainty is significantly smaller than the core damage frequency due to hardware failures and human error.

The NRC is asking that Westinghouse demonstrate that sequences which have been labeled as success, as a result of the extensive success criteria modeling efforts performed for the PRA, remain as success sequences even when reasonable T/H uncertainty is accounted for. An approach has been formulated to address this issue which will demonstrate that, for all success sequences, one of the following is true: the success criteria are robust with respect to T/H uncertainties such that there is sufficient margin to core damage with the existing success criteria (the preferred outcome); or, if inclusion of T/H uncertainty does affect the success of a given sequence, the effect on the results of the PRA is not significant. This approach complements, not replaces, the systematic approach to definition of success criteria which Westinghouse has already undertaken for the PRA, in support of which over 400 computer analyses have been performed. This effort is being performed for AP600 in order to address an NRC concern that T/H uncertainty may be more important for passive plants than for evolutionary plants since the driving heads for core cooling flow are not provided by pumps.

This evaluation is new and unique in its application to PRA, so it is possible that the approach that is outlined in the following paragraphs will require some modification as the assessment proceeds. To avoid unnecessary delays or rework that could result if a portion of the process requires modification, the tasks have been defined to include several progress review and test points, so that the NRC has an opportunity to review and comment on results at intermediate stages, and so that the approach can be tried first on a limited set of sequences with a subset of T/H parameters. Then the rest of the evaluation can proceed, with any necessary modifications identified from the test case.

The list of tasks to be performed for the T/H uncertainty assessment was provided to the NRC in reference 1. The assessment generally involves: selection of the sequence success criteria to be evaluated including the effects of T/H uncertainty; identification of important T/H parameters and selection of bounding values; analysis of the sequence success criteria

with T/H uncertainty included: and an evaluation of any resulting effect of T/H uncertainty on the PRA results. This document is the deliverable for assessment Task 2, "Prepare Program Definition and Binning Criteria with Examples." Task 2 is defined as follows.

> The objective of Task 2 is to document the approach Westinghouse presented on April 20, 1995 to the NRC for addressing T/H uncertainty and to provide a description and an example of the binning process that will be used to reduce the number of sequences that must be examined. The criteria Westinghouse plans to use for binning of sequences and for justifying the bounding sequence selection will be provided to the NRC for review and comment with an example. This will demonstrate how the Westinghouse approach relates to the NRC Margins Approach to resolving the issue of passive system reliability.

The remainder of this document is organized as follows. First, a discussion of the technical basis involved in the assessment of T/H uncertainties on the PRA success sequences is presented, along with a set of definitions of terms appropriate to this assessment. Next, a discussion of the preliminary criteria to be used for any binning of sequences, and for justifying that bounding of sequences has been properly performed, is presented. Examples of binning and bounding are provided within this discussion. Finally, the steps in the NRC "Risk-Based Margins Approach for Passive System Performance Reliability Analysis," as presented by the NRC to Westinghouse on April 20, 1995, are discussed to demonstrate how this approach coincides with the NRC Margins approach. This document does not address issues specific to the identification and selection of T/H parameters or values, or to the analysis of the sources and effects of uncertainties; these are the subjects of later tasks.

Technical Bases

The AP600 PRA provides a prediction of the ability of the plant and operators to prevent and/or mitigate severe accidents. This prediction is a function of the uncertainties in assessing the probabilities of success and failure for the various systems and actions. Uncertainty in hardware and human reliability is addressed explicitly in the PRA. There is also uncertainty in the analyses performed to define the success criteria for the various event sequences. This analytical, or thermal/hydraulic, uncertainty is not readily addressed explicitly within the PRA.

For the AP600, the NRC and Westinghouse have agreed to employ a "margins" approach to assessing the impact of T/H uncertainty on the PRA results. In this approach, the effect of T/H uncertainty on the various PRA success criteria is examined to show that the success criteria are conservative, even when this uncertainty is included. Defining parameters and criteria conservatively is not normally done in a PRA, in order to provide insights into the more likely plant and operator responses to different accident scenarios The use of a bounding method precludes any need to quantify T/H reliability and simplifies the overall process.

Thermal/hydraulic reliability has been defined (reference 2) as "the probability that a sequence involving one or more passive systems will not lead to core damage due to failures associated with uncertainties in the T/H performance of passive systems." This assumes that an assessment of the effect of T/H uncertainty on the success criteria can be used to address T/H reliability concerns.

Objective of this Assessment. The objective of this assessment is to show that the success criteria for sequences involving passive systems, as defined through a systematic and conservative process for the PRA, are not sensitive to uncertainties in the prediction of plant T/H performance .

Definitions. In the discussions that follow, a number of terms are used to denote specific meanings. These are defined as follows

A *modeled sequence* is any combination of equipment operation or operator action successes or failures shown explicitly on one of the event trees (Figures 4-1 through 4-26) of the AP600 PRA (reference 3).

A *bounded sequence* is any combination of equipment operation or operator action success or failures not explicitly shown on the event trees of the AP600 PRA, but with consequences which are less severe than, and therefore, bounded by, one of the modeled sequences. *Bounding*, in general for this assessment, refers to the process of determining that the effects of a parameter of interest (e.g., a sequence, or a system success criterion, or a sequence success criterion) for a set of similar scenarios may be measured by examining the effects of a scenario shown to have the greatest effect within the set.

A *success criterion (for a given sequence)* is defined as the set of criteria of each of the various systems required to function for success of the sequence (i.e., no core damage). The following is an example of the *success criterion for path 2 of the medium Loss of Coolant Accident (LOCA) event tree*, Figure 4-2 of the PRA (repeated here as Figure 1): injection from 1 out of 2 core makeup tanks (CMTs) AND opening of 2 out of 4 automatic depressurization system (ADS) Stage 4 valves AND opening of check valves in 1 out of 2 in-containment refueling water storage tank (IRWST) injection lines AND opening of valves in 1 out of 4 recirculation lines. There is one sequence success criterion for each success path in the PRA; these are summarized in Table 6-2 of the PRA.

A *success criteria baseline case* is one for which the T/H modeling includes the effects of the following:

- o minimum injection (typically 1 CMT or 1 accumulator and 1 line of IRWST injection);
- o the worst break location and break size for the event category;
- o failure of containment isolation (which is limiting for IRWST injection); and
- o the longest credited operator action time (where applicable).

Any *baseline case* is conservative, since it bases modeled sequence success on a bounded sequence which includes multiple worst-case assumptions, and whose probability of occurrence thus falls within the "tail" of the distribution of probabilities of all sequences represented by the modeled sequence.

Binning is a process in which initiating events or event sequences are grouped together and analyzed as if they were a single event. These events must be similar with respect to characterstics such as plant reactivity and thermal/ hydraulic response, system or operator response, sequence timing, or end results. Each bin is represented by a success criteria baseline case.

Preliminary Criteria for Sequence Selection, Bounding and Binning

Because of the large number of scenarios modeled in a PRA, it is not practical to consider each individually. However, as noted in the definitions for binning and bounding, similar scenarios can be examined together, and this has been done in constructing the AP600 PRA event tree models. The following paragraphs discuss the manner and extent to which success criteria selections will be made for the assessment of T/H uncertainty.

Success Criteria Based on Design Basis Analyses. Certain success criteria are defined from analyses performed using design basis analysis codes and modeling assumptions. Such analyses already incorporate allowances to account for uncertainties, including T/H uncertainties, sufficient to support the bounding nature of the results. As a result, sequence success criteria based on design basis analyses need not be evaluated in this assessment of the impact of T/H uncertainty on the PRA results, because of the conservative nature of those analyses.

Success Criteria Involving Operation of Active Systems. Some sequences involve operation of active systems (either in addition to or instead of passive systems) for success. Examples of active systems modeled in the PRA include main and startup feedwater, and normal residual heat removal. The primary issue being addressed in this assessment is T/H uncertainty related to passive systems, and it is not necessary to address uncertainty in sequences involving active systems, for the following reasons.

Thermal/hydraulic uncertainty has not been an issue relative to success criteria for active systems. The nature of active systems is that success criteria for preventing core damage depend strongly on whether or not the hardware operates, and less on the specific conditions under which the hardware operates during a sequence. Thus, the thermal/hydraulic uncertainty associated with predicting the performance of active systems, which typically involve the use of pumps, turbines, and so forth for motive power, can be reasonably estimated and bounded by analyses.

For sequences in which passive systems and active systems are modeled, the passive system would be operating under less challenging conditions than in passive-only sequences. Therefore, the effect of T/H uncertainty for active/passive sequences would be less than for passive-only sequences.

Also, for any success path in the PRA in which an active system is modeled, there is an equivalent success path involving only passive systems. Thus, if the active/passive system success path were determined to result in failure rather than success, the sequence would continue with the backup passive system, potentially resulting in success. An example of this can be seen in medium LOCA sequences 1 and 2 (see Figure 1). Sequence 1 involves success of CMT injection (a passive system) and normal RHR (an active system). If this sequence were to somehow be determined to be unsuccessful as a result of failure of the normal residual heat removal system (RNS), the result would not be core damage, but rather a different scenario (in this case sequence 2), in which, if RNS fails, success can be achieved if ADS operates to depressurize the RCS and IRWST gravity injection and recirculation (passive functions) operate to provide RCS inventory control and core cooling. For these reasons, it is only necessary to examine the passive-only sequences in order to evaluate the impact of T/H uncertainty.

<u>Potential Adverse Passive/Active System Interactions</u>. The above justification for examining only sequences without active systems relies in part on the absence of any significant adverse active/passive system interactions. The operation or failure of active systems will not adversely affect the operation of passive systems. Further, the operation of additional equipment beyond the minimum required for success of a sequence (i.e., 2 CMTs instead of 1, or 1 CMT and 1 accumulator instead of 1 CMT only) will not lead to a worse (i.e., higher peak core temperature) transient. Such potential system interactions have been and are being examined. Documentation of the results of these assessments will be documented separately from the T/H uncertainty assessment. No significant adverse interactions have been identified. Should these ongoing examinations identify an adverse interaction with potential impact on this T/H uncertainty assessment, it will be addressed .

<u>Binning of Success Criteria</u>. To the extent possible, binning of success criteria for the purposes of evaluating the effects of T/H uncertainty will utilize the binning already performed in setting up the PRA event tree models. Bins defined in the PRA event trees include the various LOCA categories and transients. From the standpoint of minimizing the number of success criteria to be evaluated, it may be appropriate to combine some of the LOCA and/or transient criteria, making use of the extensive set of success criteria analyses performed to date to provide the necessary justifications for the combined bins. Any further binning will be done on the basis of the success criteria already defined in the PRA.

An example can be seen by referring to Table 1, which summarizes the initial set of success criteria to be considered for bins for the T/H uncertainty assessment. (These criteria are taken from PRA Table 6-2.) The success criteria for success sequence number 2 (for medium LOCA) and sequence number 4 (for intermediate LOCA) are the same. Thus, it may be beneficial to consider these two in a single bin. The analyses for this combined bin would then need to cover a range of conditions appropriate to both the medium LOCA and the

intermediate LOCA break sizes, locations, and so forth. Similarly, considering the success criteria for success sequence number 6 (small LOCA) and sequence number 8 (transient with failure of decay heat removal) in a single bin may be appropriate, based on similar plant behavior in these sequences.

As another example, within the transient event categories, the passive success criteria for most of the transient initiating events include sequences involving CMT case CM2AB, ADS case ADA, gravity injection case IW2AB, and recirculation case RECIRC. All such sequences could be considered to be a single bin for the purpose of assessing the impact of T/H uncertainty, since, once decay heat removal is lost following a transient, the plant response for any sequence with the same set of success criteria is essentially independent of the initiating event.

These binning examples are, at this stage of the assessment, preliminary, and for illustrative purposes only. In general, the initial set of success criteria bins to be considered for this assessment is the set of passive-only baseline success criteria for success criteria other than those based on design basis analyses, that were developed for the PRA. This initial set is presented in Table 1. It is an initial set at this time because it is possible that, as the assessment progresses, cases may be identified that are similar enough such that one can be bounded by another, as discussed in the preceding paragraphs. For such cases in which success criteria are to be combined into a single bin, justification for the binning would be provided as part of the final assessment documentation. A more clearly defined set of bins will be defined in conjunction with Tasks 4 and 5 of this assessment.

Success Criteria Bounding. As stated in the definitions provided for modeled and bounded sequences, each modeled sequence represents several bounded sequences. The success criterion assigned to a modeled sequence is therefore required to be appropriate for all associated bounded sequences. The selection process for baseline case success criteria (per Task 3 of this assessment) has been defined in a manner such that the baseline case success criteria for a modeled sequence bounds the success criteria for each bounded sequence. This is achieved by using conservative assumptions such as minimum injection sources (e.g., 1 of 2 CMTs or 1 of 2 accumulators, 1 of 2 IRWST injection paths, 1 of 2 recirculation paths), as well as longest credited operator response time, and worst break size and location in the baseline success criteria. Thus, any given success criterion is based on the "bottom-most" bounded sequence, which, in the absence of adverse system interactions, produces the highest peak core temperature for the modeled sequence.

Since the initial set of success criteria bins includes one bin for each sequence (considering the various transients together), the amount of bounding to be done is limited to the individual bins. For example, for medium LOCA, there would be bins for the passive-only success paths on the medium LOCA event tree. These are the paths labeled MLO-OK2 (path 2) and MLO-OK4 (path 8) on Figure 1. If these paths were expanded to show the bounded sequences, the result would be as shown in Figure 2. (For the purposes of T/H Uncertainty Task 2, Figure 2 is illustrative only.) All paths on Figure 2 labeled MLO-OK2 represent bounded sequences, that is, sequences bounded by path 2 on Figure 1. Similarly, all paths on Figure 2 labeled MLO-OK4 represent sequences bounded by path 8 on Figure 1.

Table 1 lists the initial set of sequences that have been identified as being bounded by the various baseline success criteria. This listing is preliminary at this time for the same reasons as discussed under binning.

Assessment of the Impact of T/H Uncertainty on Bounded Sequences. If a modeled success criterion can be shown to be successful by analyzing its baseline case with the effects of T/H uncertainty included, then the analysis will have demonstrated, for that particular modeled sequence and for its associated bounded sequences, that T/H uncertainty does not affect the PRA results. If a modeled success criterion cannot be shown to be successful by analyzing the baseline case with the effects of T/H uncertainty included, then additional analysis is required.

For the latter case, the approach calls for finding a less restrictive set of hardware failures for which the criterion succeeds. As an example, if the baseline success criterion for modeled sequence MLO-OK4 (see Figure 1) could not be shown to be successful with T/H uncertainties included, an approach similar to the following would be followed. (Note that modeled sequence MLO-OK4 includes the 16 bounded success sequences, which are also labeled MLO-OK4, between sequences 88 and 118 on Figure 2.)

The baseline success criterion for MLO-OK4 is based on conditions represented by the bottom-most, and therefore, most restrictive, success path (sequence 114), i.e., no CMT, ADS case ADQ, 1 accumulator, 1 IRWST injection line, and 1 recirculation line. Several options exist regarding specification of alternative hardware configurations for success with T/H uncertainty included. These include (and are not limited to) the following: requiring 2 IRWST injection paths rather than 1 (but retaining the existing criteria for ADS, accumulators, and recirculation), which would result in paths 106, 107, 113, and 114 being failure paths; requiring 2 accumulators rather than 1 accumulator (but retaining the existing criteria for ADS, IRWST, and recirculation), which would result in paths 110, 111, 113, and 114 being failure paths; or requiring more ADS valves than specified in case ADQ (but retaining the existing criteria for accumulators, IRWST, and recirculation), which would keep paths 103,104, 106, 107, 110, 111, 113, and 114 as success paths, but at a lower success frequency. Another possibility would be to credit containment isolation, which would increase injection performance. (Note that, on Figure 2, paths with successful containment isolation are not shown explicitly, since Figure 2 assumes failed isolation at the first branch point. Sequence 1 on Figure 2 in fact represents 117 success and failure sequences with success criteria generally less restrictive than those for sequences 2 through 118. Note also that paths with less T/H uncertainty are not shown, since Figure 2, for this assessment, assumes worst T/H uncertainties.)

Any of these options results in the availability of additional injection flow with increased likelihood of success (which would be confirmed with additional analysis). The options could be tried one at a time, working up from the bottom of the tree, until success was achieved. However, it is expected the selection can be made based on knowledge of plant performance with various configurations for the particular initiating event.

Once it is determined which bounded sequences are affected by modifying the hardware

availability assumptions, an assessment of the significance of the impact on PRA core damage frequency can be made by examining the bounded sequences that changed from success to failure or for which the success frequency changed. For example, suppose that it were shown that changing from ADS criterion ADQ (which is 2 of 4 ADS Stage 4 valves) to 3 of 4 ADS Stage 4 valves resulted in success. Then if there is an effect on core damage frequency, it would be from the difference between the contribution of bounded sequences 93, 94, 97, 100, 102, 105, 108, 109, 112, 115, 116, 117, and 118 (i.e., the failure paths) with the 3 out of 4 ADS Stage 4 criterion and with the 2 out of 4 ADS Stage 4 criterion, for the conditions of most limiting T/H uncertainty. If the difference in the failure probabilities for both of these ADS criteria is sufficiently small, then it can be reasonably stated that the effect of this change on the PRA results is not significant, and the analysis will have demonstrated that, for that particular modeled sequence and for its associated bounded sequences, the effect of T/H uncertainty does not affect the PRA. If the assessment requires moving up through the bounded sequences so far that it cannot be reasonably stated that the effect of the change on the PRA results is not significant, then it may be necessary to revise that PRA success criterion and determine the impact of the change on the PRA.

Correspondence to NRC Margins Approach

The approach to assessing the impact of T/H uncertainty on the PRA results as outlined in the preceding paragraphs generally follows the NRC Margins approach.

A binning process will be used as described in this Task 2 deliverable, based on the existing PRA event sequences. The bounding sequence (i.e., the sequence for which the highest peak core temperature will occur) for each bin will be used; sequence frequency cutoffs will not be used. The binning will be finalized in conjunction with Task 5 and documented in Task 10 of the T/H Uncertainty Assessment.

Identification of sources of uncertainty associated with the T/H performance of passive systems will be done through Tasks 4, 5, 6, and 7 of the T/H Uncertainty Assessment. Identification of "large impact" variables is not anticipated, since all identified sources of T/H uncertainty will be addressed. A systematic process will be used to identify sources of uncertainty.

Analysis of available margin to core damage will be performed for the bounding sequence for each bin, in Tasks 9 and 10 of the T/H Uncertainty Assessment. Bounding values will be used for the identified uncertainty variables.

If, for any bin, the analyses fail to show margin to core damage, a different set of hardware success criteria will be selected for the bin (corresponding to a different bounded sequence) such that margin to core damage can be shown. If this can be shown to result in an insignificant change to the PRA results, then there is no impact of T/H uncertainty on the success criterion for the bin. If there is a significant impact on sequence core damage frequency as a result of selecting a different bounded sequence to represent the bin, this will be addressed for the PRA.

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Table 1 Initial Set of Success criteria to be Considered for Bins for T/H Uncertainty Assessment

Initiating Event or Category	Success Sequence ID	Success Seq.#	Success Criteria	Bounded Success Sequences
Medium LOCA CMT Line Break SI Line Break	MLO-OK2 CMT-OK2 SIL-OK1	1	1 of 2 CMTs, ADS case ADM, 1 of 2 IRWST injection lines, 1 of 4 IRWST recirculation lines	MLO-OK1 CMT-OK1
	MLO-OK4 CMT-OK4 SIL-OK2	2	ADS case ADQ, 1 of 2 accumulators, 1 of 2 IRWST injection lines, 1 of 4 IRWST recirculation lines	MLO-OK3 CMT-OK3
Intermediate LOCA (Including consequential LOCA due to stuck open pressurizer safety valve)	NLO-OK2	3	RCP trip, 1 of 2 CMTs, ADS case ADM, 1 of 2 IRWST injection lines, 1 of 4 IRWST recirculation lines	NLO-OK1
	NLO-OK4	4	ADS case ADQ, 1 of 2 accumulators, 1 of 2 IRWST injection lines, 1 of 4 IRWST recirculation lines	NLO-OK3

Table 1 Initial Set of Success criteria to be Considered for Bins for T/H Uncertainty Assessment

Initiating Event or Category	Success Sequence ID	Suc-cess Seq.#	Success Criteria	Bounded Success Sequences
Small LOCA (Including consequential small LOCAs due to RCS Leak, SGTR, PRHR tube rupture, transients)	SLO-OK2 SGR-OK4	5	RCP trip, 1 of 2 CMTs, 1 PRHR heat exchanger, ADS case ADS, 1 of 2 IRWST injection lines, 1 of 4 IRWST recirculation lines	SLO-OK1 SGR-OK3
	SLO-OK2' SGR-OK2'	6	RCP trip, 1 of 2 CMTs, 0 PRHR heat exchanger, ADS case ADA, 1 of 2 IRWST injection lines, 1 of 4 IRWST recirculation lines	SLO-OK1' SGR-OK1'
	SLO-OK4 SGR-OK6	7	0 or 1 PRHR heat exchanger, ADS case ADT, 1 of 2 accumulators, 1 of 2 IRWST injection lines, 1 of 4 IRWST recirculation lines	SLO-OK3 SGR-OK5

Table 1 Initial Set of Success criteria to be Considered for Bins for T/H Uncertainty Assessment

Initiating Event or Category	Success Sequence ID	Suc-cess Seq.#	Success Criteria	Bounded Success Sequences
Steam Generator Tube Rupture	SGR-OK2	8	Main steam flow isolation, steam generator overfill protection, RCP trip, 1 of 2 CMTs, 1 PRHR heat exchanger	---
Transients with failure of decay heat removal	TRA-OK5	8	RCP trip, 1 of 2 CMTs, 0 PRHR heat exchanger, ADS case ADA, 1 of 2 IRWST injection lines, 1 of 4 IRWST recirculation lines	TRA-OK4
	TRA-OK7	9	0 PRHR heat exchanger, ADS case ADT, 1 of 2 accumulators, 1 of 2 IRWST injection lines, 1 of 4 IRWST recirculation lines	TRA-OK6
Loss of Offsite Power	LSP-OK5	10	1 of 2 CMTs, 0 PRHR heat exchanger, ADS case ADAL, 1 of 2 IRWST injection lines, 1 of 4 IRWST recirculation lines	LSP-OK4
	LSP-OK7	11	0 PRHR heat exchanger, ADS case ADT, 1 of 2 accumulators, 1 of 2 IRWST injection lines, 1 of 4 IRWST recirculation lines	LSP-OK6

Table 1 Initial Set of Success criteria to be Considered for Bins for T/H Uncertainty Assessment				
Initiating Event or Category	**Success Sequence ID**	**Suc-cess Seq.#**	**Success Criteria**	**Bounded Success Sequences**
Station Black out	SBO-OK2	12	1 of 2 CMTs, 0 PRHR heat exchanger, ADS case ADAB, 1 of 2 IRWST injection lines, 1 of 4 IRWST recirculation lines	---
	SBO-OK3	13	0 PRHR heat exchanger, ADS case ADT, 1 of 2 accumulators, 1 of 2 IRWST injection lines, 1 of 4 IRWST recirculation lines	---
Main Steamline Break	SLB-OK6	14	RCP trip, 1 of 2 CMTs, 0 PRHR heat exchanger, ADS case ADA, 1 of 2 IRWST injection lines, 1 of 4 IRWST recirculation lines	SLB-OK5
	SLB-OK4 SLB-OK8	15	ADS case ADT, 1 of 2 accumulators, 1 of 2 IRWST injection lines, 1 of 4 IRWST recirculation lines	SLB-OK3 SLB-OK2 SLB-OK1 SLB-OK7
Anticipated Transients Without Scram (with failure of boration or stuck open pressurizer safety valve decay heat removal)	ATW-OK3 ATW-OK6	16	RCP trip, 1 of 2 CMTs, ADS case ADW, 1 of 2 IRWST injection lines, 1 of 4 IRWST recirculation lines	ATW-OK2 ATW-OK5

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Figure 1 Medium LOCA Event Tree from AP600 PRA
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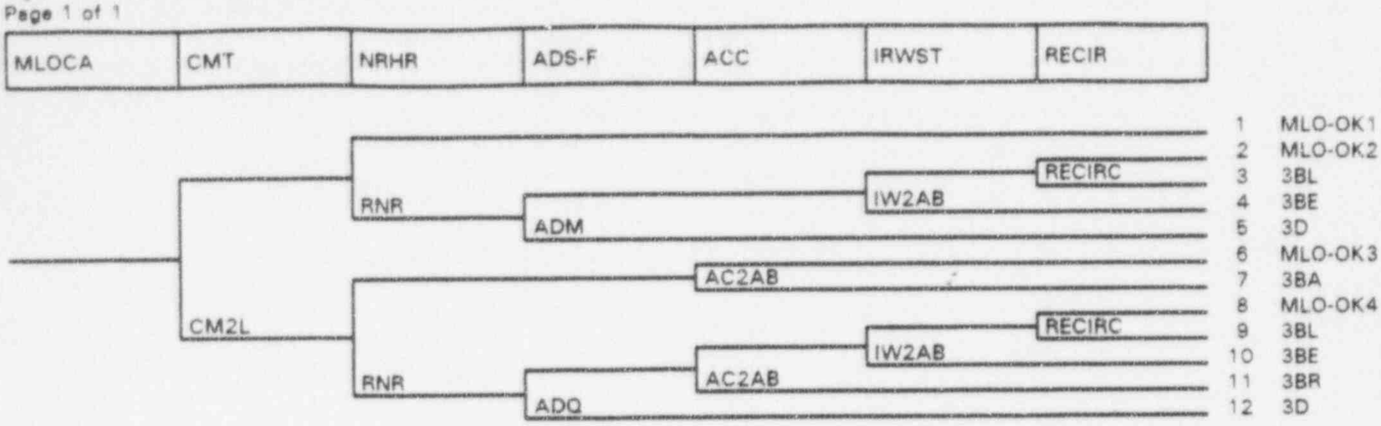

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Fig. 1 Medium LOCA Event Tree from AP600 PRA
List of top events

Event	Description
MLOCA	MEDIUM LOCA EVENT OCCURS
CMT	RCP TRIP, AND ONE OR BOTH CORE MAKEUP TANKS INJECT
NRHR	1 OR 2 TRAINS OF NORMAL RHR IN INJECTION MODE
ADS-F	FULL DEPRESSURIZATION WITH ADS (CASE ADM/ADQ OR BETTER)
ACC	1 OR 2 ACCUMULATORS INJECT
IRWST	1 OR 2 LINES OF IRWST INJECTION
RECIR	1 OR 2 LINES OF WATER RECIRCULATION

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Fig.2 Example AP600 Medium LOCA Event Tree with Passive Paths Expanded
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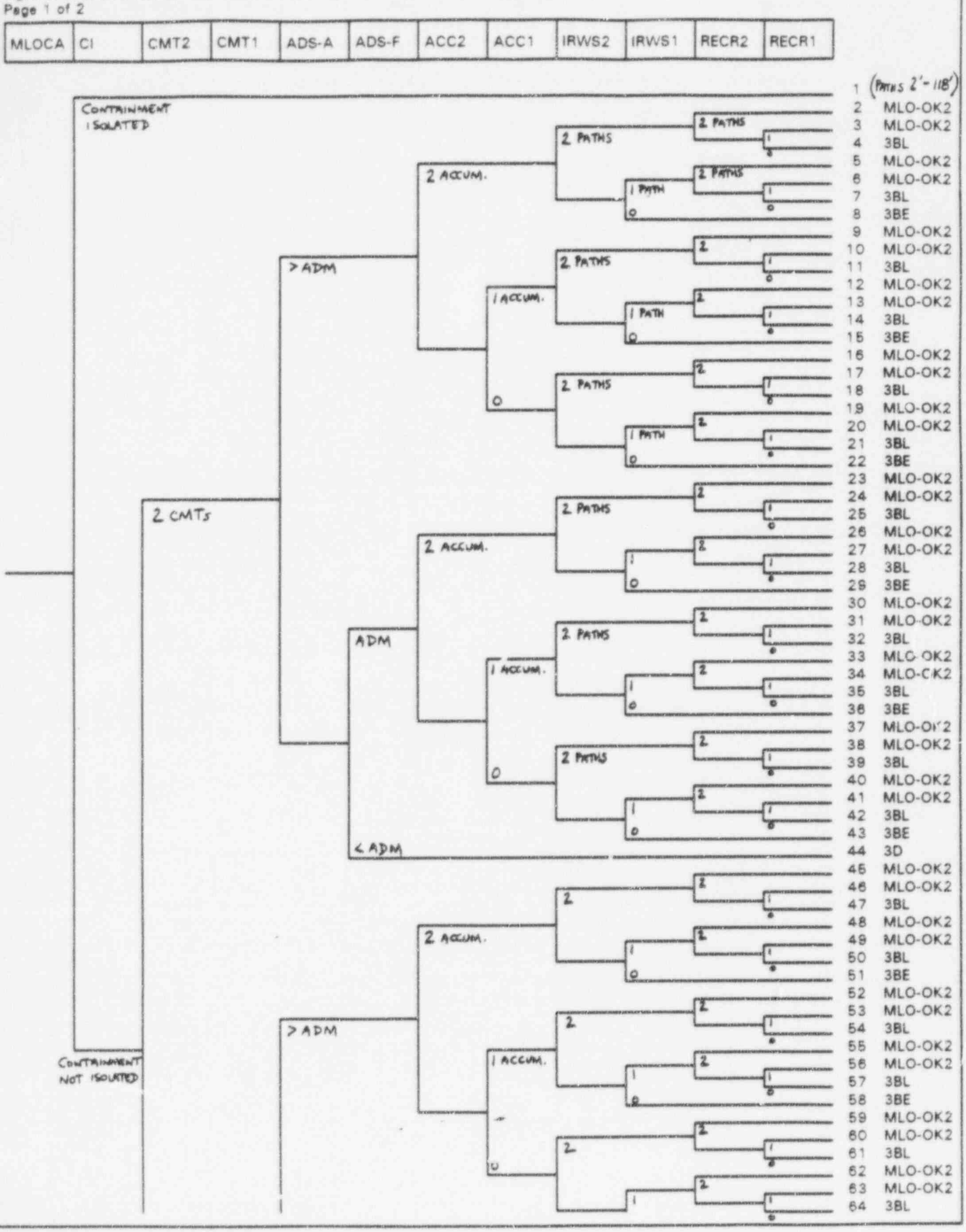

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Fig.2 Example AP600 Medium LOCA Event Tree with Passive Paths Expanded
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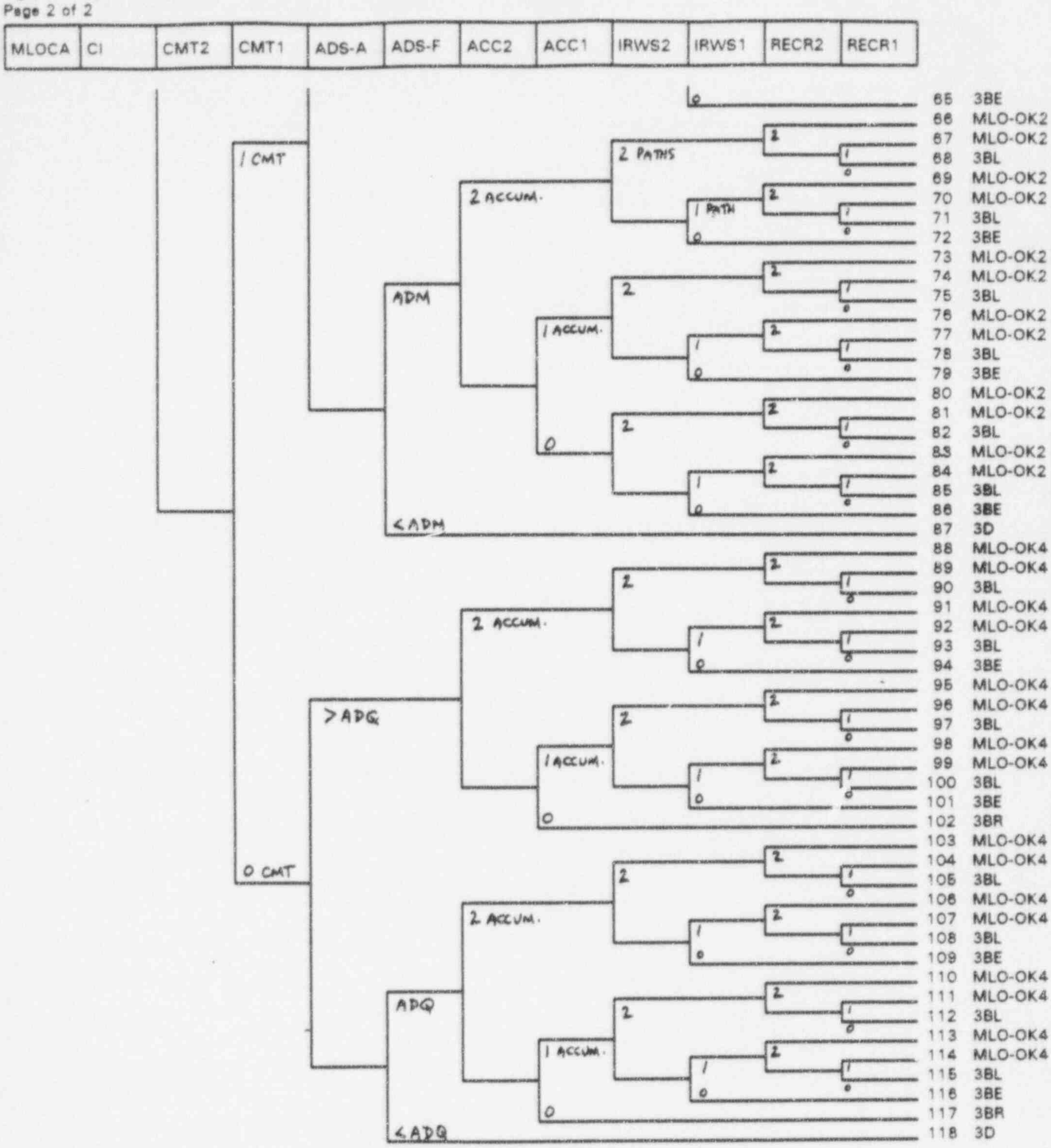

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Fig.2 Example AP600 Medium LOCA Event Tree with Passive Paths Expanded
List of top events

Event	Description
MLOCA	MEDIUM LOCA EVENT OCCURS
CI	CONTAINMENT ISOLATION
CMT2	RCP TRIP AND BOTH CORE MAKEUP TANKS
CMT1	RCP TRIP AND ONE CORE MAKEUP TANK
ADS-A	FULL DEPRESSURIZATION, ALL ADS VALVES OPERATE
ADS-F	FULL DEPRESSURIZATION BY ADS
ACC2	BOTH ACCUMULATORS
ACC1	ONE ACCUMULATOR
IRWS2	GRAVITY INJECTION FROM BOTH LINES
IRWS1	GRAVITY INJECTION FROM ONE LINE
RECR2	TWO PATHS OF WATER RECIRCULATION TO RPV
RECR1	ONE PATH OF WATER RECIRCULATION TO RPV

References

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2. *Passive System Performance eliability Analysis in Advanced Reactor Designs --- Approach and Implementation Issues*, NRC Probabilistic Safety Assessment Branch presentation at March 30, 1995 NRC/Westinghouse meeting on AP600 Thermal-Hydraulic Performance.

3. *AP600 Probabilistic Risk Assessment*, Revision 3, February 28, 1995.