August 22, 1995

APPLICANT: Westinghouse Electric Corporation

FACILITY: AP600

SUBJECT: SUMMARY OF MEETING TO DISCUSS THE ISSUE OF PASSIVE SYSTEM RELIABILITY FOR THE DESIGN OF THE AP600

On September 15, 1994, representatives of the Nuclear Regulatory Commission and Westinghouse Electric Corporation met to discuss the issue of passive system reliability for the design of the AP600. Attachment 1 is a list of the attendees. Attachment 2 is a copy of the slides presented by Westinghouse.

Westinghouse discussed their proposed approach to addressing passive system reliability, including discussion of their definition of event sequence success criteria and how they were using the MAAP code to model the success criteria. Westinghouse indicated that the examples provided during the presentation were preliminary, and for illustrative purposes only.

The staff indicated that, conceptually, Westinghouse's approach to addressing this issue appeared acceptable, but that it needed to discuss the details of the implementation to ensure its adequacy. Issues the staff identified included success criteria acceptability, acceptability of the number of nodes Westinghouse intended to apply, definition of adequacy of margin, identification of "trigger points" to require closer evaluation of a sequence, appropriateness of inputs to the MAAP calculations, and appropriateness of operator action times assumed in the evaluations.

It was agreed to hold meetings approximately monthly to track the status of Westinghouse's efforts.

original signed by:

Thomas J. Kenyon, Project Manager
Standardization Project Directorate
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Docket No. 52-003

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As stated

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PASSIVE SYSTEM RELIABILTIY
ATTENDANCE SHEET
SEPTEMBER 15, 1994

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BRIAN MCINTYRE	WESTINGHOUSE
TOM KENYON	NRC/NRR/PDST
RALPH CARUSO	NRC/NRR/SASG
ADEL EL-BASSIONI	NRC/NRR/SPSB
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DEBRA OHKAWA	W RISK & RELIABILITY
JIM SCOBEL	W RISK & RELIABILITY
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BOB PALLA	NRC/DSSA/SPSB

Attachment 1

AP600 Probabilistic Risk Assessment

Discussion of Progress in Defining Success Criteria for Revision 2

Westinghouse Presenters:
Debra Ohkawa
Barry Sloane

Westinghouse/NRC Meeting
Rockville, Md.

September 15, 1994

Attachment 2

Agenda

- Discuss Current Status of Definition and Documentation of Event Sequence Success Criteria
- Discuss Current Status of MAAP Code Modeling for Success Criteria
- Obtain Early Feedback on Approach Taken

Objectives

- Ensure that a success criterion is defined and documented for each case on the event trees
- Understand how interactions among systems modeled in the event trees impact success criteria
- Ensure that event tree structure reflects the system success criteria for each event tree
- Ensure that appropriate uncertainties are accounted for in defining success criteria

Key Steps in Defining Success Criteria

- Identify Assumptions and Any Existing Bases for Each Event Tree Case
- Systematically Identify System Interactions for Success Paths
- Identify Appropriate Tools for Defining Each Success Criterion
- Perform Analyses to Define Best Estimate Success Criteria
- Systematically Identify Uncertainties that can Affect Success Criteria
- Document Success Criteria, Adjust Event Tree Logic if Necessary

Structure of Documentation

- PRA Report Rev. 2 will have two sections related to Level 1 Success Criteria:
  - Section 6 - Level 1 Success Criteria
    - Defines and explains the assumptions and corresponding bases for the event tree models
    - Identifies and explains combinations of passive and active systems included in the models
  - Section 7 - Documentation of MAAP and Other Analyses for Success Criteria
    - Presents analyses supporting success criteria other than design basis
    - Establishes applicability of MAAP results, including sensitivities and uncertainties

Summary of Section 6

- Define Acceptance/Success Criteria for Critical Safety Functions
- Discuss Important Modeling Assumptions of the Event Trees and Identify
  - Success Criteria and Bases for Safety Functions for Each Main Event Category (Transients, small LOCA, ...)
  - Timing-Related Criteria and Bases
  - System Interactions Implicit in Models, and Associated Success Criteria and Bases
  - Case-Specific Success Criteria and Bases for Each Case of Each Event Tree Top Event
- Provide Information in Response to Success Criteria Questions Asked During Review of PRA Rev.0

AP600 PRA - Revision 2

6.0 EVENT TREES TOP EVENTS SUCCESS CRITERIA FOR INTERNAL EVENTS AT POWER

TABLE OF CONTENTS

General Tools for Defining Success Criteria Bases

- o Design Basis Analyses, where
  - Conservatisms do not affect conclusions
  - Success Criteria cannot be otherwise refined
- o MAAP Analyses Using MAAP 4.0
- o Other Best Estimate Analyses (ATWS, Large LOCA)
- o Engineering Calculations
- o Engineering Judgement Based on Relevant Experience or Data

Identify Assumptions and Bases for Specific Cases

- Each event tree top event can have one or more "Cases" depending on event sequence

- For each case, the Success Criteria section of the PRA will identify:
  - requirements for success
  - mission time
  - assumed actuation dependencies
  - time available for modeled operator actions
  - specific bases for the above
  - initiating events the case applies to
  - sequence-related information:
    - pertinent prior system successes/failures
    - impact of success or failure
    - subsequent requirements for success

Table 6.4-1
Summary of Event Tree Top Events Success Criteria
(Internal Initiating Events at Power Cases)

CASE NAME	TOP EVENT NAME	EVENT TREES	SUCCESS CRITERIA	MANUAL ACTIONS	DEPENDENCIES AND MODELED ACTUATIONS	MISSION TIME	BASIS
CIL Containment Isolation, power recovered or DG operate after LOOP	CI	TE	At least one isolation valve in each penetration closed.	Credit given for manual closure of valves if automatic actuation fails. [Operator Actions: CIT-MAN01]	Automatic actuation via PMS (high containment pressure S signal), or DAS (high ctmt. temperature)	24 hours	D 6.4.10
CIP Containment Isolation, following LOCA or SGTR	CI	A,S1,S1C, S1S, S2,S2S, S2P,SL,V2	At least one isolation valve in each penetration closed.	Credit given for manual closure of valves if automatic actuation fails. [Operator Actions: CIP-MAN01, CIP-REC01]	Automatic actuation via PMS (high containment pressure S signal), or DAS (high ctmt. temperature)	24 hours	D 6.4.10
CISB Containment Isolation, failure to recover offsite power after LOOP	CI	TE	At least one isolation valve in each penetration closed.	Credit given for manual closure of valves if automatic actuation fails. [Operator Actions: CIT-MAN01]	Automatic actuation via PMS (high containment pressure S signal), or DAS (high ctmt. temperature)	24 hours	D 6.4.10
CIT Containment Isolation, following transient	CI	TT,TR, TF1,TF2, TC,TFX, TP, TS, TCW, TSW, TCA,TFA	At least one isolation valve in each penetration closed.	Credit given for manual closure of valves if automatic actuation fails. [Operator Actions: CIT-MAN01]	Automatic actuation via PMS (high containment pressure S signal), or DAS (high ctmt. temperature)	24 hours	D 6.4.10

Table 6.4-1
Summary of Event Tree Top Events Success Criteria
(Internal Initiating Events at Power Cases)

CASE NAME	TOP EVENT NAME	EVENT TREES	SUCCESS CRITERIA	MANUAL ACTIONS	DEPENDENCIES AND MODELED ACTUATIONS	MISSION TIME	BASIS
COND Main Condenser and full steam dump	CV	TT, TR, TF1, TF2, TFX, TP, TCW	8 out of 8 steam dump valves open to accommodate full secondary side steam load to condenser **AND** At least 1 out of 2 Circulating Water trains operates to maintain condenser vacuum.	None.	Automatic PLS control of steam dump, FW & circ. water trains	24 hours.	6.4.14
COND1 Main condenser and secondary heat removal path via steam dump	WPR	V2	1 out of 4 steam dump valves open for secondary heat removal **AND** At least 1 out of 2 Circulating Water trains operates to maintain condenser vacuum.	Credit given for manual steam dump valves adjustment. [Operator Actions: CIB-MAN01, DUMP-MAN01]	Automatic PLS control of steam dump, FW & circ. water trains	24 hours.	6.4.15
FWF Main Feedwater	QM	TF1	1 out of 2 feedwater trains (condensate pump, FW booster pump, FW pump, FW reg. valves) from deaerator storage tank to 1 out of 1 steam generator.	None. [Operator Actions: (TCB-MAN01)]	None. (Automatic control via PLS)	24 hours.	D 6.4.21
FWT Main Feedwater	QM	TT, TR, TP, TCW	1 out of 2 feedwater trains (condensate pump, FW booster pump, FW pump, FW reg. valves) from deaerator storage tank to 1 out of 2 steam generators	None. [Operator Actions: (TCB-MAN01)]	None. (Automatic control via PLS)	24 hours.	D 6.4.21

Table 6.4-1
Summary of Event Tree Top Events Success Criteria
(Internal Initiating Events at Power Cases)

CASE NAME	TOP EVENT NAME	EVENT TREES	SUCCESS CRITERIA	MANUAL ACTIONS	DEPENDENCIES AND MODELED ACTUATIONS	MISSION TIME	BASIS
IW1A Gravity Injection	G	S1S	IRWST injection into the RCS through 1 out of 2 check valve paths (with 2 out of 2 check valves open per path) in 1 out of 1 intact Gravity Injection line.	None.	None.	24 hours.	D 6.4.22
IW2AB Gravity Injection	G	TT,TR, TF1,TF2, TC,TFX, TP,TS, TCW,TSW, TCA,TE, TSLD, TSLU,TSOV A,S1,S1C, S2,S2S, S2P,SL, V2,TFA	IRWST injection into the RCS through 1 out of 2 check valve paths (with 2 out of 2 check valves open per path) in 1 out of 2 Gravity Injection lines.	None.	None.	24 hours.	D 6.4.22

Table 6.4-1
Summary of Event Tree Top Events Success Criteria
(Internal Initiating Events at Power)

Key to Table 6.4-1 BASIS column entries:

C = Calculated value
M = MAAP analysis
D = Design Basis, per SSAR or other document
O = Other specific justification
E = Engineering judgment
T = Other transient analysis

Numbers in BASIS column indicate Success Criteria Notebook subsection number in which additional details are provided.

Example Sections From AP600 Rev. 2 Success Criteria Notebook

6.4.10 CONTAINMENT ISOLATION

This top event represents containment isolation following various initiating events for scenarios in which long term core cooling is being accomplished by gravity injection and recirculation (following either: a transient event with failure of secondary side cooling, successful full RCS depressurization, and failure of normal RHR; or a loss of RCS inventory event with successful full RCS depressurization and failure of normal RHR). Containment isolation in such cases is necessary for prevention of water inventory depletion with potential long-term core damage. If containment isolation fails, the possibility of recovery of containment integrity or cooling using spent fuel pool inventory is evaluated.

CIL CONTAINMENT ISOLATION

Loss of Offsite Power, TE

This case is used for a loss of offsite power event with power recovery or availability of the diesel generator.

The success criterion is:

One isolation valve closed in each containment penetration.

Credit is given for manual actuation if automatic actuation fails.

Mission time is 24 hours. The time available for operator action is XXX minutes.

Basis for Success Criteria:

SSAR Chapter 15.
???

Example Sections From AP600 Rev. 2 Success Criteria Notebook

CIT CONTAINMENT ISOLATION

Transients TT, TF, TM, TP, TS, TCW, TSW, TCA, TFA

This case is used for transients following loss of decay heat removal but with successful RCS depressurization and gravity injection.

The success criterion is:

One isolation valve closed in each penetration.

Credit is given for manual actuation if automatic actuation fails.

Mission time is 24 hours. The time available for operator action is XXX minutes.

Basis for Success Criteria:

SSAR Chapter 15.
???

Example Sections From AP600 Rev. 2 Success Criteria Notebook

6.4.14 STEAM DUMP AND MAIN CONDENSER FOR FEEDWATER AVAILABILITY

This top event represents availability of steam dump (turbine bypass) to the main condenser as a heat sink following a transient. If this function is successful, it provides a supply for continued main feedwater for secondary side cooling (if the initiating event did not involve a loss of main feedwater), and also a backup supply, in addition to the condensate storage tank, for startup feedwater. If this function fails, the probability of a stuck open secondary relief valve is evaluated, and the only source for startup feedwater is the condensate storage tank. In order to allow for a total loss of load, the success criteria for this event require availability of all steam dump valves.

COND STEAM DUMP AND MAIN CONDENSER AVAILABLE FOLLOWING TRANSIENT

Transients TT, TR, TF1, TF2, TFX, TP, TCW

The success criterion is:

8 out of 8 steam dump valves open
AND
Condenser availability, including 1 out of 2 circulating water pumps supplying the condenser with cooling water.

Credit is given only for automatic steam dump actuation.

Mission time is 24 hours.

Basis for Success Criteria:

SSAR

Table 6.4-2
Summary of Success Criteria for Operator Actions and Mission Times

OPERATOR ACTION IDENTIFIER	USED IN EVENT TREE CASES	AVAILABLE OPERATOR RESPONSE TIME (MINUTES)	REFERENCE/BASIS
ADN-MAN01	AD1, ADB, ADC, ADF, ADL, ADN, ADQ, ADR, ADT, ADY, ADZ, ADLS, ADNS, ADTS, ADNLT, ADQLT, ADTLT	30	
ADN-REC01	ADNLT, ADQLT, ADTLT	30	
ATW-MAN01	CO, CSBOR1	1	
ATW-MAN03	CE	1	
ATW-MAN04	CO	2	
CCB-MAN01	CSAUXS, CSBOR1, CSLOCA, CSP, RNP, RNR, RNP2, RNT2	30	
CIA-MAN01	CIA		
CIB-MAN00	CIB, CSAUXS	30	
CIB-MAN01	CIB, COND1		
CIP-MAN01	CIP	180	
CIP-REC01	CIP		
CIT-MAN01	CIL, CISB, CIT	300	
CMN-MAN01	CM1A, CM2AB, CM2L, CM2P, CM2SL, CMBOTH, CM2AM, CM2AMP, CM2LLT	30	
CMN-REC01	CMBOTH, CM2LLT		
CVN-MAN00	CSAUXS	30	
CVN-MAN02	CSBOR1	60	
DUMP-MAN01	COND1	30	
FWN-MAN02	SFM, SFW, SFW1, SFWT	30	
FWN-MAN03	SFWP	30	
HPM-MAN01	PRB, PRL, PRP, PRS, PRT, SFM, SFW, SFW1, SFWP, SFWT	30	
IWN-MAN00	IW2A	60	
LPM-MAN01	AD1, ADB, ADC, ADF, ADL, ADN, ADR, ADT, ADY, ADZ, CM2AB, CM2SL, RCSL, RCT, ADNLT, ADTLT	30	
LPM-MAN02	ADQ, CM1A, CM2L, CM2P, ADQLT, CMBOTH, CM2LLT	20	
LPM-MAN03	AD1A, ADA, ADAB, ADAL, ADRA, ADS, ADV	15	
LPM-MAN04	ADM	15	

Table 6.4-2
Summary of Success Criteria for Operator Actions and Mission Times

OPERATOR ACTION IDENTIFIER	USED IN EVENT TREE CASES	AVAILABLE OPERATOR RESPONSE TIME (MINUTES)	REFERENCE/BASIS
LPM-MAN05	ADALS, ADAS, ADLS, ADNS, ADSS, ADTS, CM2AM, CM2AMP, PRM, PRMP	60	
LPM-REC01	ADNLT, ADQLT, ADTLT, CMBOTH, CM2LLT		
PRI-MAN01	PRI	35	
PRI-MAN02	PRI1	15	
PRN-MAN01	PRT	30	
PRN-MAN02	PRB, PRL, PRP, PRS	30	
PRN-MAN03	CSP	>120	
RCN-MAN01	RCSL, RCT	30	
REN-MAN02	RECIRB, RECIRC, RECIRP,RNP, RNR	>60	
REN-MAN03	IWF	160	
RHN-MAN01	RNP, RNR	30	
RHN-MAN02	RNP2	120	
RHN-MAN03	RNT2	120	
SFN-MAN00	IWTM	>120	
SGHL-MAN01	SGHL	30	
SWB-MAN02	CSAUXS, CSBOR1, CSLOCA, CSP, RNP, RNR, RNP2, RNT2	30	
SWB-MAN02N	RNC2	30	
SWN-MAN01	CSAUXS, CSBOR1, CSLOCA, CSP, RNP, RNR, RNP2, RNT2	30	
TCB-MAN01	FWF, FWT	30	
VLN-MAN01	VLH	120	
VWN-MAN01	VLH	60	
VWN-MAN02	VLH	60	
ZON-MAN01		30	

Summary

- AP600 PRA Revision 2 Success Criteria Documentation Will Be Thorough and Scrutable

- Success Criteria and Bases Will Be Clearly Defined for All Event Tree Cases

- Important System Interactions Will Be Addressed and Documented

STATUS REPORT ON MAAP ANALYSES TO SUPPORT AP600 LEVEL 1 SUCCESS CRITERIA

September 15, 1994

Debra Ohkawa
Westinghouse Electric Corporation

Major Points of Discussion

- MAAP Limitations and Criteria
- MAAP analyses
  - Purposes
  - Approach
  - List of Cases
- Documentation of MAAP Analyses
- MAAP-Related RAIs

Review of August 1 Meeting

- Approach to MAAP analyses was outlined, but few details had been developed

- "Promises" included:

  - Will evaluate system interactions
  - Will consider sensitivity analyses
  - Will include thorough documentation in the PRA

- Example sensitivity cases were provided for a medium LOCA base case:

  - RCS depressurization rate
  - RCS depressurization time
  - Accumulator availability (1 vs 2)
  - IRWST injection rate

Summary of MAAP4 Application Meeting (Sept 8)

- Presentations made on the MAAP4 models
  - T/H models
  - Passive plant models
  - In-vessel models
  - Ex-vessel models
- T/H and Severe Accident Parameter Benchmarks were presented
- The majority of the benchmarks and MAAP user's guidance is based on MAAP3.0B
- For success criteria applications, MAAP4 is similar to MAAP3.0B with the following improvements:
  - Pressurizer and surge line model
  - More detailed core model

MAAP LIMITATIONS

- GUIDANCE FROM THE FOLLOWING SOURCES IS BEING USED:

  - EPRI TR-100167, "RECOMMENDED SENSITIVITY ANALYSES FOR AN INDIVIDUAL PLANT EXAMINATION USING MAAP 3.0B"

  - FIN L-1499, "MAAP 3.0B CODE EVALUATION FINAL REPORT," BROOKHAVEN NATIONAL LABORATORY, OCTOBER 1992.

  - EPRI TR-100743, "MAAP PWR APPLICATION GUIDELINES FOR WESTINGHOUSE AND COMBUSTION ENGINEERING PLANTS," JUNE 1992.

- ALTHOUGH ABOVE GUIDANCE IS BASED ON MAAP3.0B, THE T/H RECOMMENDATIONS AND CONCLUSIONS ARE GENERALLY APPLICABLE TO MAAP4

- WE RECOGNIZE THAT MAAP WAS ORIGINALLY WRITTEN FOR SEVERE ACCIDENT ANALYSES, AND THERE ARE LIMITATIONS WHEN APPLIED TO PRE-CORE DAMAGE SCENARIOS

- MAAP WILL NOT BE USED FOR:

  - ATWS
  - LARGE LOCAs

RECOMMENDATIONS FROM EPRI TR-100167 (IPE RECOMMENDATIONS)

MAAP PARAMETERS IN NATURAL CIRCULATION MODEL, AFFECTING DETERMINATION OF SUCCESS CRITERIA			
VARIABLE	SUGGESTED VALUE	DESCRIPTION	RECOMMENDED SENSITIVITIES
VFSEP	0.6	VOID FRACTION AT WHICH PRIMARY SYSTEM NATURAL CIRCULATION STOPS	NO SENSITIVITIES RECOMMENDED
HTSTAG	850 W/M²/K	HEAT TRANSFER COEFFICIENT BETWEEN NATURALLY CIRCULATING WATER AND SURFACE OF SG TUBE	NO SENSITIVITIES RECOMMENDED
FAOUT	0.3	FOR COUNTER-CURRENT FLOW CALCULATIONS, FRACTION OF TUBES CARRYING FLOW AWAY FROM HOT LEG	NO SENSITIVITIES RECOMMENDED
IEVNT (208)		EVENT CODE TO SIGNIFY THAT PUMP SUCTION VOLUMES CLEAR	
FFRICR	APPROX 0.1	FRICTION FACTOR FOR AXIAL FLOW IN CORE	NO SENSITIVITIES RECOMMENDED.
FFRICX	0.25	FRICTION FACTOR FOR CROSS FLOW IN CORE	NO SENSITIVITIES RECOMMENDED
FWHL	0.115	COEFFICIENT USED TO CALCULATE HOT LEG COUNTER-CURRENT FLOW	NO SENSITIVITIES RECOMMENDED.
NSAMP	10	COEFFICIENT USED TO SMOOTH OUT NUMERICAL OSCILLATIONS IN CORE-UPPER PLENUM NATURAL CIRCULATION FLOW	NO SENSITIVITIES RECOMMENDED.
FCDBRK	0.7	DISCHARGE COEFFICIENT FOR PRIMARY SYSTEM BREAK	NO SENSITIVITIES RECOMMENDED
TCLMAX	1200 K	CLAD TEMPERATURE AT WHICH CLAD RUPTURE AND GAP RELEASE OCCURS IF NOT ALREADY COMPUTED FROM CLAD STRAIN MODEL	NO SENSITIVITIES RECOMMENDED

Notes:
- AP600 MAAP parameter file is consistent with the suggested value for each variable
- IEVNT 208 does not apply to AP600 because there are no loop seals

RECOMMENDATIONS FROM BROOKHAVEN REPORT

"... IN GENERAL, MAAP IS ADEQUATE FOR PREDICTING THERMAL-HYDRAULIC BEHAVIOR PRIOR TO CLAD DAMAGE UNLESS CERTAIN THERMAL-HYDRAULIC CONDITIONS ARE ENCOUNTERED. THESE ARE:"

- THE BREAK LOCATION GIVES RISE TO A QUASI-STEADY STATE TWO-PHASE FLOW CONDITION.

- THE REACTOR HAS NOT SCRAMMED (FUEL STORED ENERGY WILL NOT BE RELEASED).

- CLAD TEMPERATURE IS ABOVE 1200 K. (THIS IS BASED ON MAAP3.0B ONE NODE MODEL, WHICH MAY CAUSE MAAP TO UNDERPREDICT THE CLAD HEATUP RATE ONCE CLAD OXIDATION POWER EXCEEDS DECAY POWER)

"THE REVIEW CONFIRMED THAT THE UTILITIES SHOULD NOT USE MAAP FOR DETERMINING SUCCESS CRITERIA AFTER CLAD DAMAGE (E.G., TO DETERMINE WHETHER OR NOT A CORE CAN BE SUCCESSFULLY REFLOODED AFTER EXTENSIVE FUEL MELTING HAS OCCURRED)."

Recommendations from EPRI TR-100743 (Application Guidelines)

- Provides summary of experience, cautions and recommended sensitivity calculations for:
  - Loss of Feedwater
  - Small LOCA
  - Medium and Large LOCA
  - Steam Generator Tube Rupture
  - Main Steamline Break
- Specific recommendations will be presented later, with the discussion of the initiating event groups

Criteria for MAAP Analyses

- If the top of the core remains covered with water, the case will be considered "success"; however, if there is core uncovery, the results will be examined more closely

- Definition of core damage [EPRI Utility Requirements Document, Volume III, ALWR Passive Plant, Chapter 1, Appendix A]:

    A fuel cladding temperature of 2200°F [1477 K] or higher is reached in any node of the core as defined in a best-estimate thermal-hydraulic calculation

- Clad oxidation begins at 1490°F [1083 K], and the heatup of the core will be at a much faster rate

    - Therefore, any base case results that exceed 1100 K will be examined more closely to determine the validity of the results

- Peak temperature used from MAAP is based on hottest <u>core</u> node, not hottest <u>clad</u> node

    - At the start of the transient, the MAAP peak temperature will overestimate the PCT by more than 260°F (400 K)

    - By 500 seconds after reactor trip, the difference is on the order of tens of degrees

PURPOSES OF MAAP ANALYSES

- IDENTIFY BREAK SIZES THAT DEFINE EACH GROUP OF INITIATING EVENTS

- TO CONFIRM SUCCESS OF EVENT TREE PATHS THAT HAVE NOT BEEN CONFIRMED BY DESIGN BASIS, HAND CALCULATIONS, OR ENGINEERING JUDGEMENT

- TO EXAMINE SYSTEM INTERACTIONS

- TO DETERMINE SENSITIVITY TO UNCERTAINTIES

  - PASSIVE SYSTEM PERFORMANCE
  - MAAP

- TO FIND IF THERE ARE ANY "CLIFFS" DUE TO UNCERTAINTIES AND MODELLING LIMITATIONS

- BOUNDING OPERATOR ACTION TIME LIMITS TO SUPPORT HUMAN RELIABILITY ANALYSIS

Support of Human Reliability Analysis

- The determination of minimum operator action times is not expected to be sensitive to variations in the MAAP models
  - Minimum operator action times are used in the human reliability analysis to determine shaping factors for the human error probabilities (HEP)
    - The time available is only one factor that is used in determining the stress level
    - For the recovery shaping factor, the difference between time to perform a set of actions and the minimum time window generally has a large margin
  - Using this methodology, human error probability is not expected to be significantly impacted by MAAP code sensitivities
- The margin between the minimum time available, as predicted by MAAP4, to perform a set of actions and the time required to perform the set of actions will be reviewed to identify any cases where variations in the MAAP prediction might impact the HEP results
  - MAAP sensitivities will only be performed if the evaluation shows that the HEP may be impacted

MAAP Case Definition Process

- Success criteria that have not been confirmed with other basis were reviewed to determine how they are used in the event trees:
  - Initiating event
  - System Assumptions, such as
    - ADS
    - CMT
    - Accumulator
    - PRHR
    - NRHR
    - IRWST injection / recirculation
    - SG Feedwater
- Table on following viewgraph shows a summary of this effort for ADS success criteria that need further analytical basis

PRELIMINARY

REVIEW OF EVENT TREES
ADS SUCCESS CRITERIA VS. THE APPLICABLE INITIATING EVENTS

Name	System Assumptions				Initiating Events					
	ADS	ACC/ CMT	PRHR	IRWST or NRHR	Trans	SGTR	Very SLOCA	SLOCA	MLOCA	ATWS
ADRA	(3)	CMT	--	NRHR	x					
ADR	(3) - M	ACC	--	NRHR	x					
ADB/ ADL/ ADT	(1) - M	ACC	--	Either	x					x
ADAB/ ADAL/ ADA	(1)	CMT	--	Either	x	x	x	x		x
ADC	(1) - M	ACC	--	Either		x	x	x		
ADN	(2) - M	ACC	PRHR	Either		x	x	x		
ADS	(2)	CMT	PRHR	Either		x	x	x		
ADV	(4)	CMT	PRHR	NRHR		x	x	x		
ADZ	(4) - M	ACC	PRHR	NRHR		x	x	x		
ADM	(2)	CMT	--	IRWST					x	
ADQ	(2) - M	ACC	--	IRWST					x	

ADS Depressurization:

(1) 3 out of 4 Stage 2 and 3
OR
2 out of 4 Stage 4 (with 1 out of 6 in Stage 1,2,3 as permissive)

(2) 3 out of 4 Stage 2 and 3
OR
2 out of 4 Stage 4

(3) 1 out of 6 stage 1,2,3

(4) 1 out of 10 stage 1,2,3,4

M Manual actuation

c:\wp\ap600\veqcase.tab

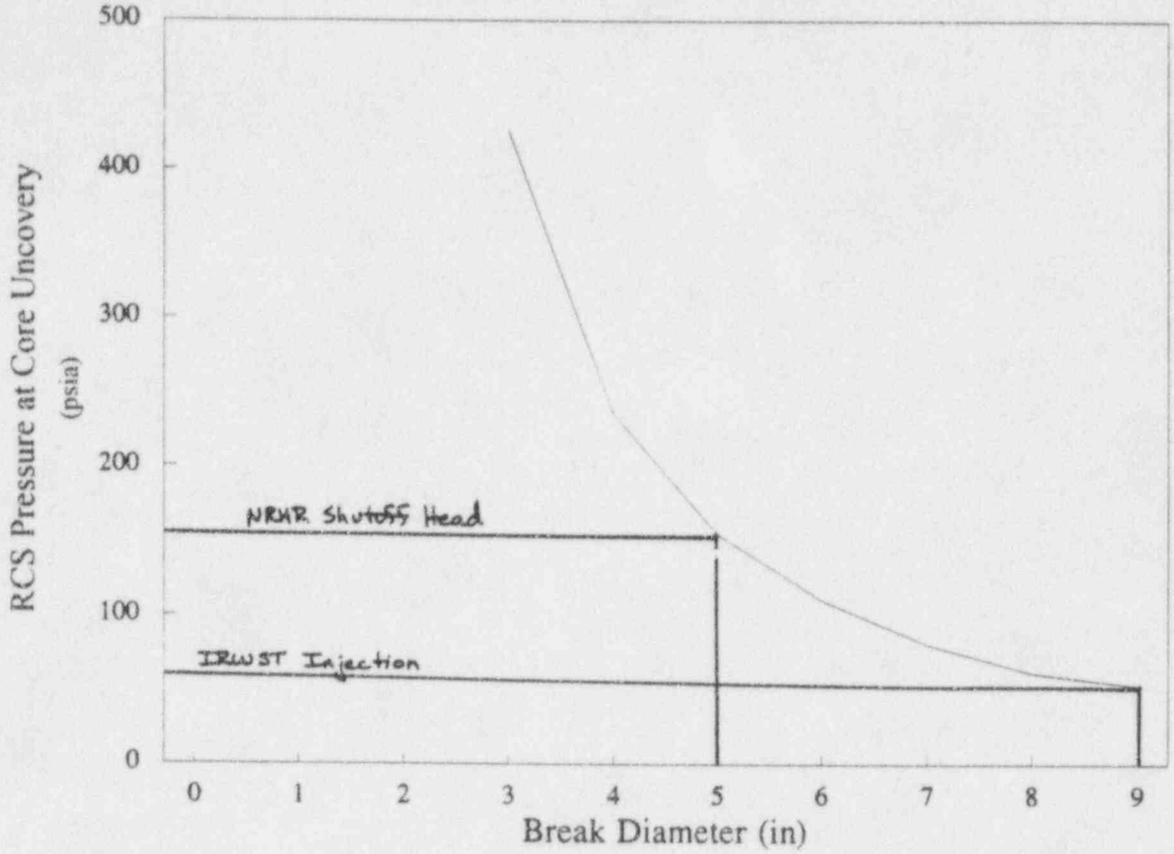
Case Definition

Large LOCA:	A break large enough to allow IRWST gravity drain without ADS actuation
Medium LOCA:	A break large enough to allow NRHR injection without ADS actuation
Small LOCA:	A break large enough that the CVS is not sufficient and ADS is required to allow NRHR injection
Very SLOCA:	A break where the CVS makeup flow cannot maintain the pressurizer level but is sufficient for RCS cooling
SGTR:	Steam generator tube ruptures
Transients:	All non-LOCA initiating events

Break Size Determination

- MAAP is being used to determine the break sizes that define each break category (large LOCA, medium LOCA, etc.)
- Break size is primarily used to determine initiating event frequency for the different LOCA categories
  - For AP600 there are relatively few different line sizes
  - The line sizes are grouped into large, medium, small and very small piping
  - For each pipe size there is a probability that the pipe can experience a large, medium, or small LOCA
  - Using this methodology, initiating event frequency for each LOCA category is not significantly impacted by MAAP code sensitivities

PRELIMINARY



Assumptions Throughout MAAP Analyses

- Breaks are modelled on the cold leg
- The runs are terminated after IRWST injection has recovered the core
  - In the longterm, recirculation is assumed to function, and is not confirmed with MAAP analysis
- NRHR is not modelled in MAAP, and design requirements will "complete" the MAAP analysis
- The Passive Containment Cooling System is assumed to operate
  - This minimizes the containment pressure, which delays the gravity drain of the IRWST
- Reactor coolant pumps trip on CMT actuation signal
- No SG feedwater is injected
- The MAAP parameter model has been reviewed to ensure that the actuation logic of the protection systems is consistent with the latest design

Medium LOCA Cases

<u>EPRI Application Guidelines</u>

- Benchmarking experience includes small end of medium LOCA size spectrum
- Caution that accumulator discharge is isothermal so that the discharge rate will be overpredicted
- No specific sensitivities are recommended

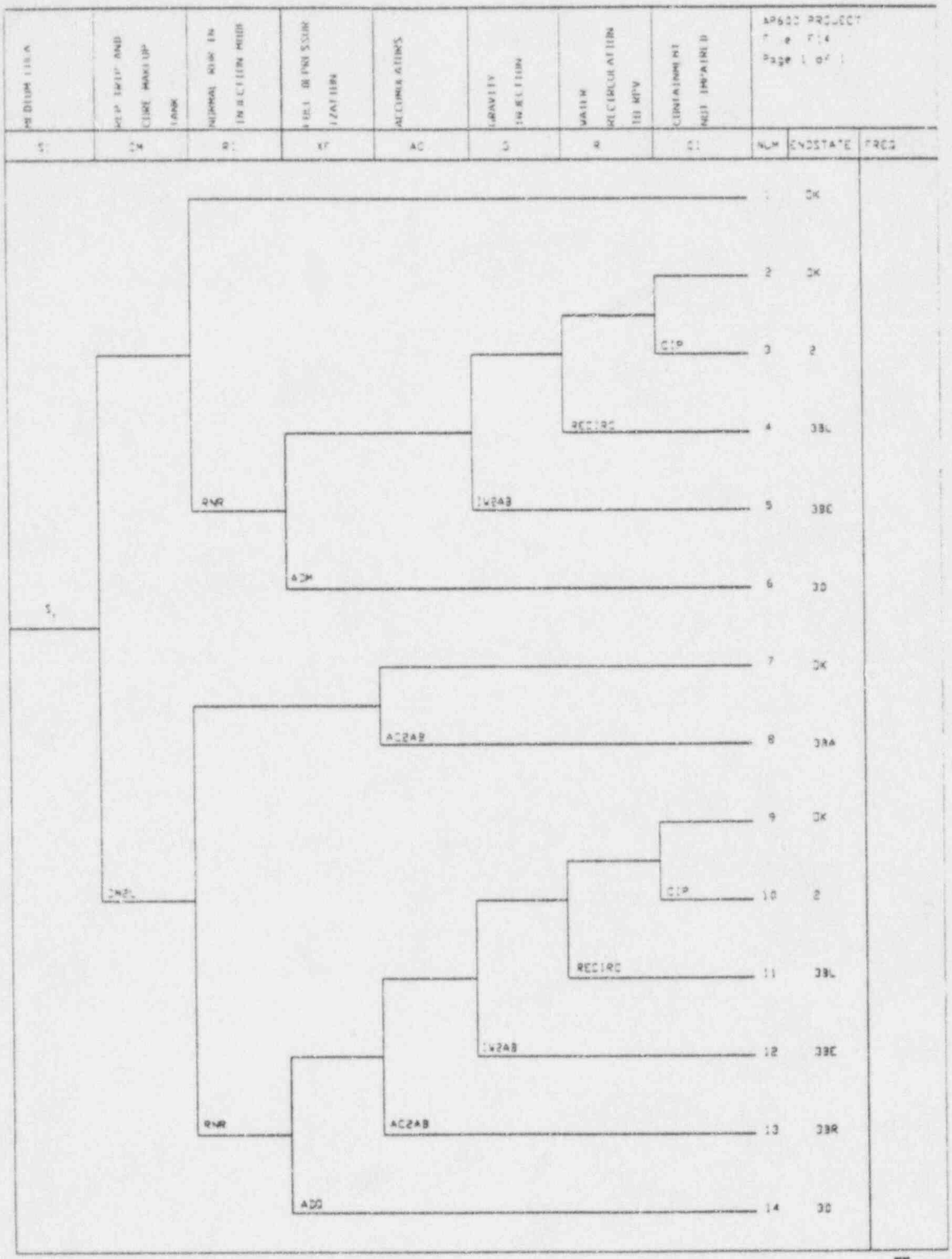


Figure F-14

Medium Loss of Coolant Accident Event Tree

PRELIMINARY

MAAP Medium LOCA Cases												
Case	Equipment Assumptions									Case Type		Comments
	ADS					CMT	ACC	PRHR	IRWST	Base	Sens	
	1	2/3	4	M	Delay							
1	-	3	-	-	-	1	-	-	1 line	x		All base cases are run to ensure that gravity drain from the IRWST provides a long term heat sink
2	-	-	2	-	-	1	-	-	1 line	x		
3	-	3		M	10 m		1	-	1 line	x		
4	-	-	2	M	10 m		1	-	1 line	x		
5						2	-	-	1 line		x	Water injection sens; use worst ADS conditions from Case 1 - 2
6						2	2	-	1 line		x	
7					20 m	-	1	-	1 line		x	Operator action time sens; use worst ADS conditions from Case 3 - 4
8					5 m	-	1	-	1 line		x	
9									1 line		x	ADS valve area sens; use worst case from Case 1 - 4
10									1 line		x	IRWST injection rate sens; use worst case from Casc 1 - 4
11									1 line		x	Break size sensitivity; use worst of Case 1 - 4
12												PCCS Sensitivity
13												VFSEP Sensitivity

SMALL LOCA CASES

EPRI APPLICATION GUIDELINES

- EXTENSIVE EXPERIENCE WITH MAAP BENCHMARKING AGAINST SEMISCALE, MIST, RELAP, RETRAN, TMI

- CAUTIONS

  - BE AWARE OF ISOTHERMAL ACCUMULATOR DISCHARGE, WHICH HAS BEEN KNOWN TO CAUSE "AUTOC ΓALYTIC ACCUMULATOR DISCHARGE"

  - WATCH OUT FOR CASES WITH ANOMALOUS GAS OR WATER FLOW THROUGH THE PRESSURIZER PORV (THIS CONCERN HAS BEEN "FIXED" IN MAAP4)

  - BE AWARE THAT THE RESULTS MAY BE SENSITIVE TO BREAK SUBCOOLING

- RECOMMENDED SENSITIVITIES

  - MAXIMUM CONDENSATION "EFFICIENCY" ASSUMED ON ECCS WATER (MAAP PARAMETER FCDDC)

  - VFSEP, ALTHOUGH SENSITIVITY STUDIES INVOLVING A LIMITED NUMBER OF SEQUENCES HAVE NOT SHOWN ANY PRONOUNCED SENSITIVITIES

  - OPERATOR ACTIONS THAT AFFECT TIMING OF INJECTION AND RCS DEPRESSURIZATION

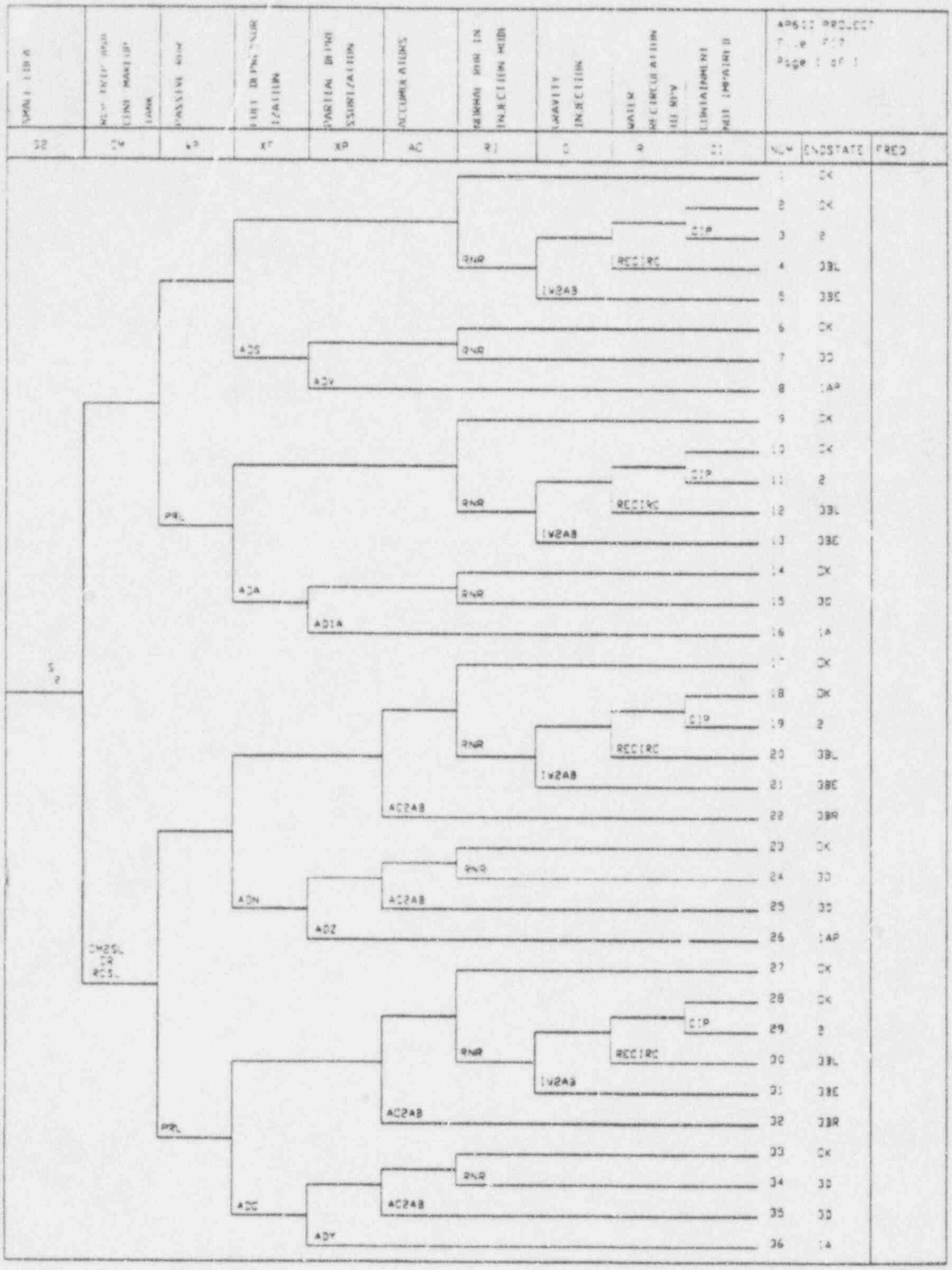


Figure F-17

Small Loss of Coolant Accident Event Tree

PRELIMINARY

MAAP Small LOCA Cases												
Case	Equipment Assumptions									Case Type		Comments
	ADS					CMT	ACC	PRHR	IRWST	Base	Sens	
	1	2/3	4	M	Delay							
1	-	3	-	-	-	1	-	-	1 line	x		All base cases with full depressurization are run to ensure that either 1) gravity drain from the IRWST, or 2) NRHR provides a long term heat sink.
2	1	-	2	-	-	1	-	-	1 line	x		
3	-	1	2	-	-	1	-	-	1 line	x		
4	-	3	-	-	-	1	-	Yes	1 line	x		
5	-	-	2	-	-	1	-	Yes	1 line	x		
6	-	3	-	M	10 m	-	1	-	1 line	x		
7	1	-	2	M	10 m	-	1	-	1 line	x		
8	-	1	2	M	10 m	-	1	-	1 line	x		
9	-	3	-	M	10 m	-	1	Yes	1 line	x		
10	-	-	2	M	10 m	-	1	Yes	1 line	x		
11						2	-				x	Water injection sens; use worst scenario from Case 1 - 5
12						2	2				x	
13					20 m	-	1				x	Operator action time sens; use worst scenario from Case 6 - 10
14					5 m	-	1				x	
15									1 line		x	ADS valve area sens; use worst scenario from Case 1 - 10
16									1 line		x	IRWST injection rate sens; use worst scenario from Case 1 - 10
17									1 line		x	Break area sens; use worst scenario from Case 1 - 10

PRELIMINARY

MAAP Small LOCA Cases												
Case	Equipment Assumptions									Case Type		Comments
	ADS					CMT	ACC	PRHR	IRWST	Base	Sens	
	1	2/3	4	M	Delay							
18	1	-	-	-	-	1		Yes	-	x		All base cases with partial depressurization are run to ensure that NRHR provides a long term heat sink
19	-	1	-	-	-	1	-	Yes	-	x		
20	-	-	1	-	-	1	-	Yes	-	x		
21	1	-	-	M	10 m	-	1	Yes	-	x		
22	-	1	-	M	10 m	-	1	Yes	-	x		
23	-	-	1	M	10 m	-	1	Yes	-	x		
24						2	-	-	-		x	Water injection sens; use worst ADS conditions from Case 18 - 20
25						2	2	-	-		x	
26					20 m	-	1	-	-		x	Operator action time sens; use worst ADS conditions from Case 21 - 23
27					5 m	-	1	-	-		x	
28											x	ADS valve size sens; use worst conditions from Case 18 - 23
29											x	Break area sens; use worst conditions from Case 18 - 23

Transients (Loss of Feedwater)

EPRI Application Guidelines

- experience with MAAP is generally quite good
- Cautions
  - Monitor PORV flow for anomalies if pressurizer nearly solid (This concern has been "fixed" in MAAP4)
- Recommended Sensitivities
  - Consider variations in operator actions, including RCP trip and reactor trip

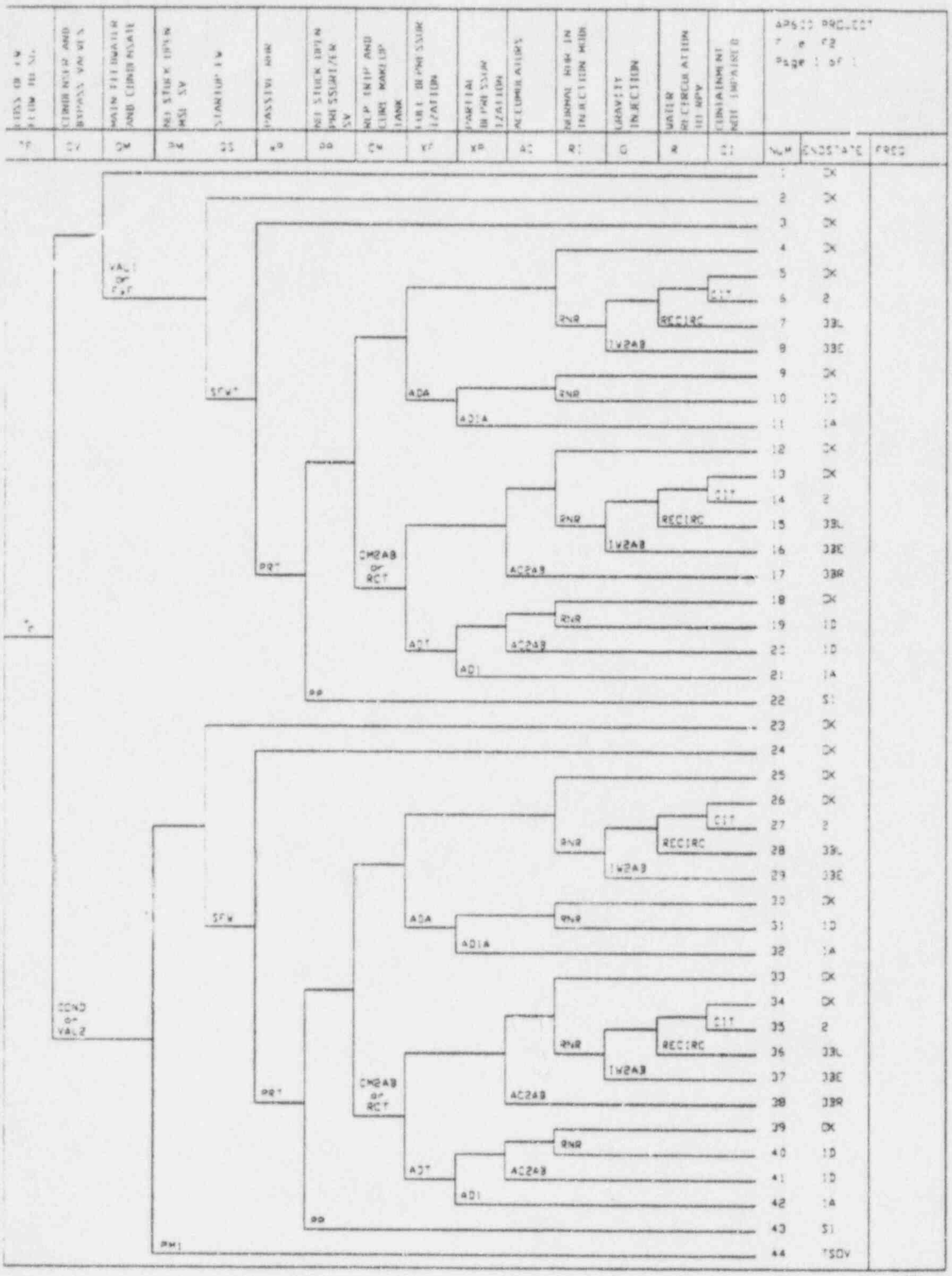


Figure F-2

Loss of Feedwater Flow Event Tree

PRELIMINARY

MAAP Transient (Loss of Feedwater) Cases

Case	Equipment Assumptions									Case Type		Comments
	ADS					CMT	ACC	PRHR	IRWST	Base	Sens	
	1	2/3	4	M	Delay							
1	1	-	-	-	-	1	-	-	-	x		All base cases with partial depressurization are run to ensure that NRHR provides a long term heat sink
2	-	1	-	-	-	1	-	-	-	x		
3	1	-	-	M	10 m	-	1	-	-	x		
4	-	1	-	M	10 m	-	1	-	-	x		
5						2	-	-	-		x	Water injection sens; Use worst ADS conditions from Case 1 - 2
6						2	2	-	-		x	
7					20 m	-	1	-	-		x	Operator action time sens; Use worst ADS conditions from Case 3 - 4
8					5 m	-	1	-	-		x	
9											x	ADS valve area sens; use worst case from Case 1 - 4
10	-	3	-	-	-	1	-	-	1 line	x		All base cases with full depressurization are run to ensure that either 1) gravity drain from the IRWST, or 2) NRHR provides a long term heat sink
11	1	-	2	-	-	1	-	-	1 line	x		
12	-	1	2	-	-	1	-	-	1 line	x		
13	-	3	-	M	10 m	-	1	-	1 line	x		
14	1	-	2	M	10 m	-	1	-	1 line	x		
15	-	1	2	M	10 m	-	1	-	1 line	x		
16						2	-	-	1 line		x	Water injection sens; Use worst ADS conditions from Case 10 - 12
17						2	2	-	1 line		x	
18					20 m	-	1	-	1 line		x	Operator action time sens; Use worst ADS conditions from Case 13 - 15
19					5 m	-	1	-	1 line		x	
20									1 line		x	ADS valve area sens; Use worst Case 10 - 15

PRELIMINARY

MAAP Transient (Loss of Feedwater) Cases												
Case	Equipment Assumptions									Case Type		Comments
	ADS					CMT	ACC	PRHR	IRWST	Base	Sens	
	1	2/3	4	M	Delay							
21									1 line		x	IRWST injection sens; Use worst of Case 10 - 15

Documentation of Results

- Results from all cases will be summarized in tables
  - Sequence timing information
    - Reactor trip
    - CMT actuation
    - ADS Actuation (Each stage)
    - PRHR Actuation (duration, if applicable)
    - CORE UNCOVERY (duration)
    - IRWST Injection
  - Peak core temperature, if core uncovers
- Key output parameters from selected cases will be shown in plots
  - RCS Pressure
  - RCS Water Level
  - Core Temperature
  - IRWST Injection rate

Results of Medium LOCA Cases								
Case	Description of Case	Time of Actuation						Max Core Temp
		Rx Trip	CMT	ADS	PRHR	Core uncovers	IRWST	
1	1 CMT, Stage 2/3 ADS							
2	1 CMT, Stage 4 ADS							
3	1 Acc, Stage 2/3 ADS (Manual)							
4	1 Acc, Stage 4 ADS (Manual)							
5	2 CMTs							
6	2 CMTs, 2 Accs							
7	Longer manual actuation of ADS							
8	Shorter manual actuation of ADS							
9	ADS valve area reduced							
10	IRWST injection rate smaller							
11	Break size larger							

MAAP-Related RAIs

- There were several RAIs relative to how MAAP analyses were used to support the Level 1 success criteria

- These RAIs are being considered as the MAAP analyses are redone

- RAIs can be categorized as concerns with:

    - Missing justification of success criteria (440.180a, 440.182, 440.184, 440.186a, 440.187)

    - Mis-match of analysis assumptions with success criteria they "support" (440.180b, 440.182B, 440.186B)

    - Lack of consideration of all the cases (Combinations of CMT and accumulator availability in 440.185)

    - Discrepancy with licensing basis results (440.187)

SUMMARY

- THE PROCESS OF DEFINING MAAP CASES HAS BEEN DEVELOPED TO ENSURE THAT:
  - THERE IS CONSISTENCY BETWEEN THE SUCCESS CRITERIA AND THE ASSUMPTIONS IN THE SUPPORTING ANALYSIS
    - APPLICABLE INITIATING EVENTS ARE CONSIDERED
    - INTERACTION OF OTHER SYSTEMS IS CONSIDERED
  - MAAP UNCERTAINTIES ARE CONSIDERED
  - PASSIVE SYSTEM UNCERTAINTIES ARE ADDRESSED
- DOCUMENTATION OF THE MAAP RESULTS WILL BE THOROUGH AND TRACEABLE