Session C-11: Level 2 PSA of Nuclear Power Plants I

Paper #170

The Development of Simplified LERF Estimation Model of ABWR

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PSAM 9
Kwoloon Shangri-la Hotel, Hong Kong, China
22 May 2008

Outline

- Introduction
- Containment Event Tree
- Thermal-Hydraulic Calculation
- LERF Event Tree
- Result and Conclusion

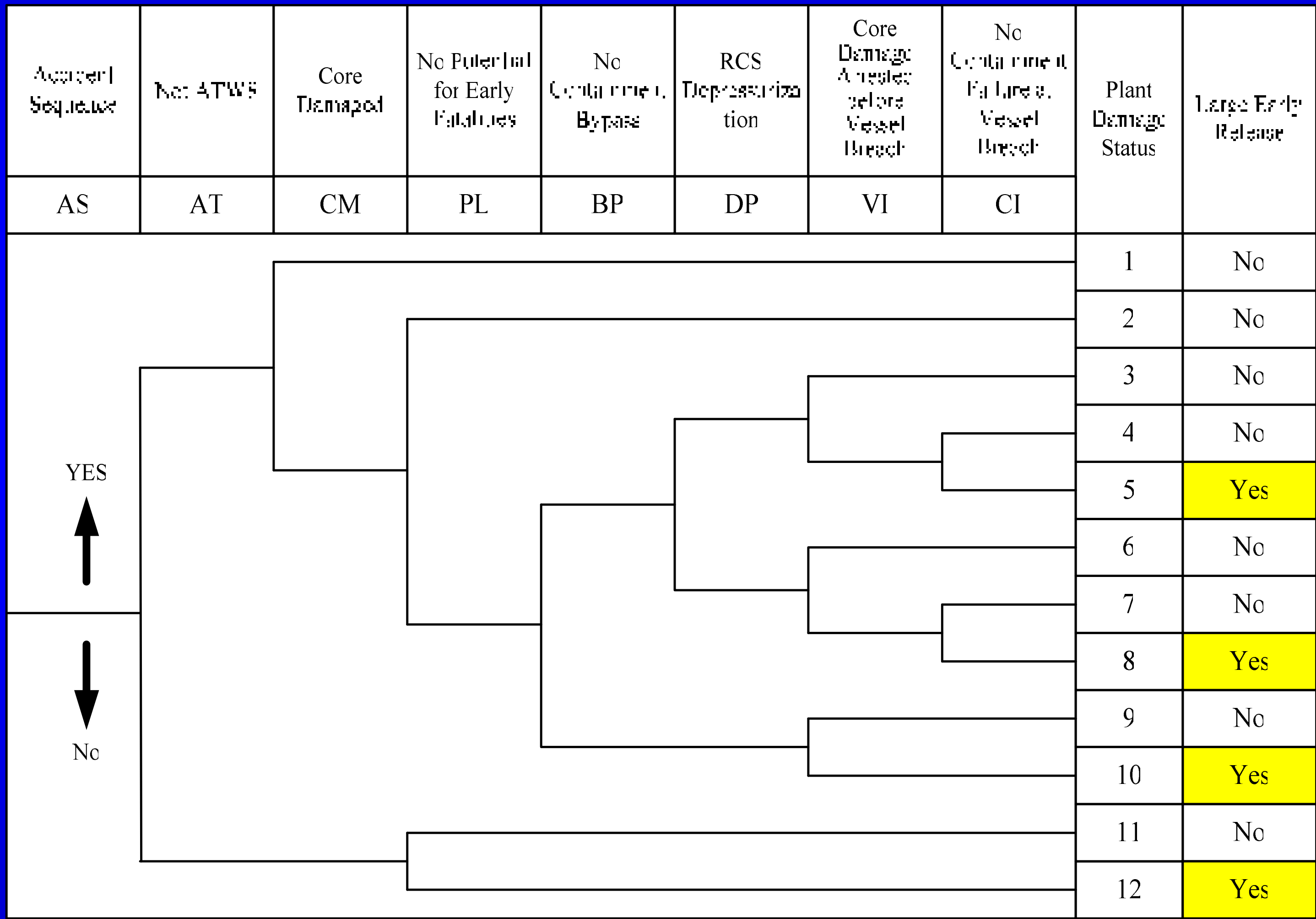
Introduction

- **NUREG/CR-6595**
  - Simplified approach for LERF estimation from Level-1 PSA results
  - Containment event tree for each type of containment
  - Probability of containment failure of specific plant configuration
- **Following the approach of NUREG/CR-6595 to identify large early release sequences of ABWR containment**
  - Consider unique design and plant operating procedure of ABWR
  - Develop containment event tree of ABWR
  - Develop LERF event trees for ABWR
  - Identify large early release sequences from LERF event trees
  - Estimate LERF from large early release sequences

Containment Event Tree

- **Issues that may be important when identifying large early release sequences of ABWR**
  - ATWS
  - Late containment failure
  - Containment integrity
  - RCS depressurization
  - Core damage arrested before vessel breach
  - Water on drywell floor
  - Venting after vessel breach
  - Containment failure at vessel breach

Containment Event Tree



Containment Failure Rate

- Key design parameters of different containment

Design Parameter	Mark I	Mark II	Mark III	ABWR
Pressure Suppression	Yes	Yes	Yes	Yes
Number of Barriers	2	2	3	2
Volume (million ft3)	0.4	0.5	1.6	0.5
Heat Capacity (billion BTU)	1.7	1.3	1.3	1.3
Design Pressure (Psig)	62	45	15	45
LOCA Pressure (Psig)	44	42	9	39

- ABWR containment design is very close to that of Mark II containment
- Containment failure probability used for Mark II containment is recommended

Thermal-Hydraulic Calculation

- **MAAP run of large break LOCA event**
  - Double-ended feedwater line break
  - Disable all coolant injection, containment spray and passive flooder
  - Core uncovered at 115 seconds after LOCA
  - Reactor vessel failed at 4.6 hours after LOCA
  - Containment failed at 17.8 hours after LOCA
- **ABWR containment design can effectively prevent large early release without any containment spray if the containment was not bypassed**
- **Containment spray is not considered in ABWR containment event tree**

Thermal-Hydraulic Calculation

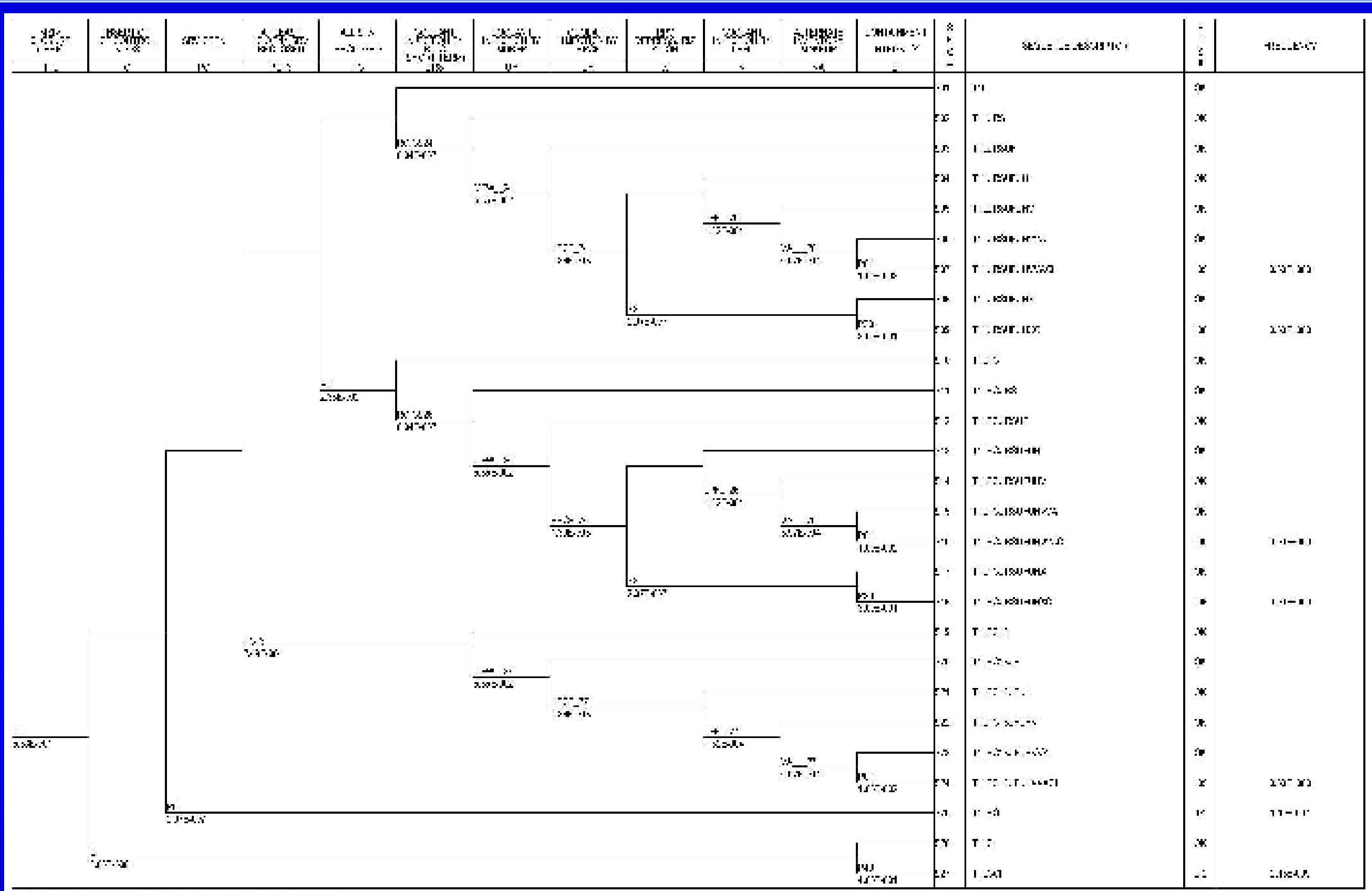
- **The estimation of time to vessel failed**
  - Time available for operator to recover coolant injection
  - 9 typical plant status were selected to perform MAAP run

Initiating Event	System Status	Time to vessel failed
Large LOCA	-	280 Min
Intermediate LOCA	-	293 Min
Small LOCA	With RCIC	13 Hr
Small LOCA	Without RCIC	314 Min
MSIV Closure	All SRV closed, with RCIC	9.6 Hr
MSIV Closure	All SRV close, without RCIC	212 Min
MSIV Closure	One SRV stuck open, with RCIC	10.2 Hr
MSIV Closure	One SRV stuck open, without RCIC	280 Min
MSIV Closure	2 or more SRVs stuck open	270 Min

LERF Event Tree

- Develop LERF event tree for each initiating event of Level-1 PSA
- Take credit for the recovery of ECCS and the alternate cooling methods
- Major concerns while developing LERF event tree
  - Sequences with control rods fail to insert into the core
  - Possible alternate core cooling methods
  - Effects of RCIC operation after initiating event
- Identify large early release sequences in LERF event tree
- Quantify large early release sequences
- LERF will be the frequency summation of all large early release sequences in all LERF event trees

Example LERF Tree



Results and Conclusions

- LERF is significant lower than traditional BWR
- The installation of passive flooder has significant effect to prevent large early release
- Three independent ECCS divisions design of ABWR can significant improve the reliability of core cooling
- Alternate core cooling methods has significant effect in preventing large early release
  - Fire water pump with its own diesel generator
  - Motor-driven feedwater pump
  - Transferring water from condensate storage tank