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Scenario Development for Accident Management Rulemaking

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December 12, 2013

Background

- The following information is being provided to support the regulatory basis for the rulemaking on filtering strategies
- Expands on information provided in past public meetings to focus attention on dominant contributors to core damage as discussed in SRM-SECY-12-0157
- Definition of “base case” only for rulemaking purpose

General Assumptions

- All cases start with ELAP
- Order EA-13-109 capability assumed to be in place
  - Vent line sizes:
    - Wetwell: 16”
    - Drywell: 12”
    - Base case K = 10 or discharge coefficient (Cd) = .3
- EPG/SAG Rev 3 assumed to be in place
- FLEX assumed to be in place for both pre-core and post-core damage, as justified for Alternative.
- Initial RCIC flow rate of 600 gpm. RPV level control via throttling of RCIC steam supply.
- Vessel breach timing is calculated by code
- Assume drywell leakage based on gas temperature > 700 °F (0.1 ft2)
  - Consider impact on filter alternatives – pressure drop in filter path will control leakage rate

Initial RPV Pressure Control

- 10 minutes – control between 800-1000 psig using single SRV
- 1 hour – begin controlled depressurization at 80°F/hr
- Control pressure between 200-400 psig to maintain adequate steam flow to RCIC turbine

Scenario/Alternative-Specific Assumptions

- MSL rupture simulating a LOCA – assumed break size 6” dia.
  - Calculated in MELCOR
  - Assumed in MAAP based on MELCOR timing
- SRV seizure (full open) – assume single valve fails open to pool
  - Calculated in MELCOR
  - Assumed in MAAP based on MELCOR timing
  - Could investigate sensitivity to partially open SRV
- Debris cooling provided by 500 gpm injection to RPV or drywell (expect to perform sensitivity analysis)
- Head flange leakage simulating Fukushima-type accident (SOARCA methodology); venting in this case assumed not initiated in time or it is ineffective in preventing overpressure; equipment and human reliability issue.

Scenario/Alternative-Specific Assumptions

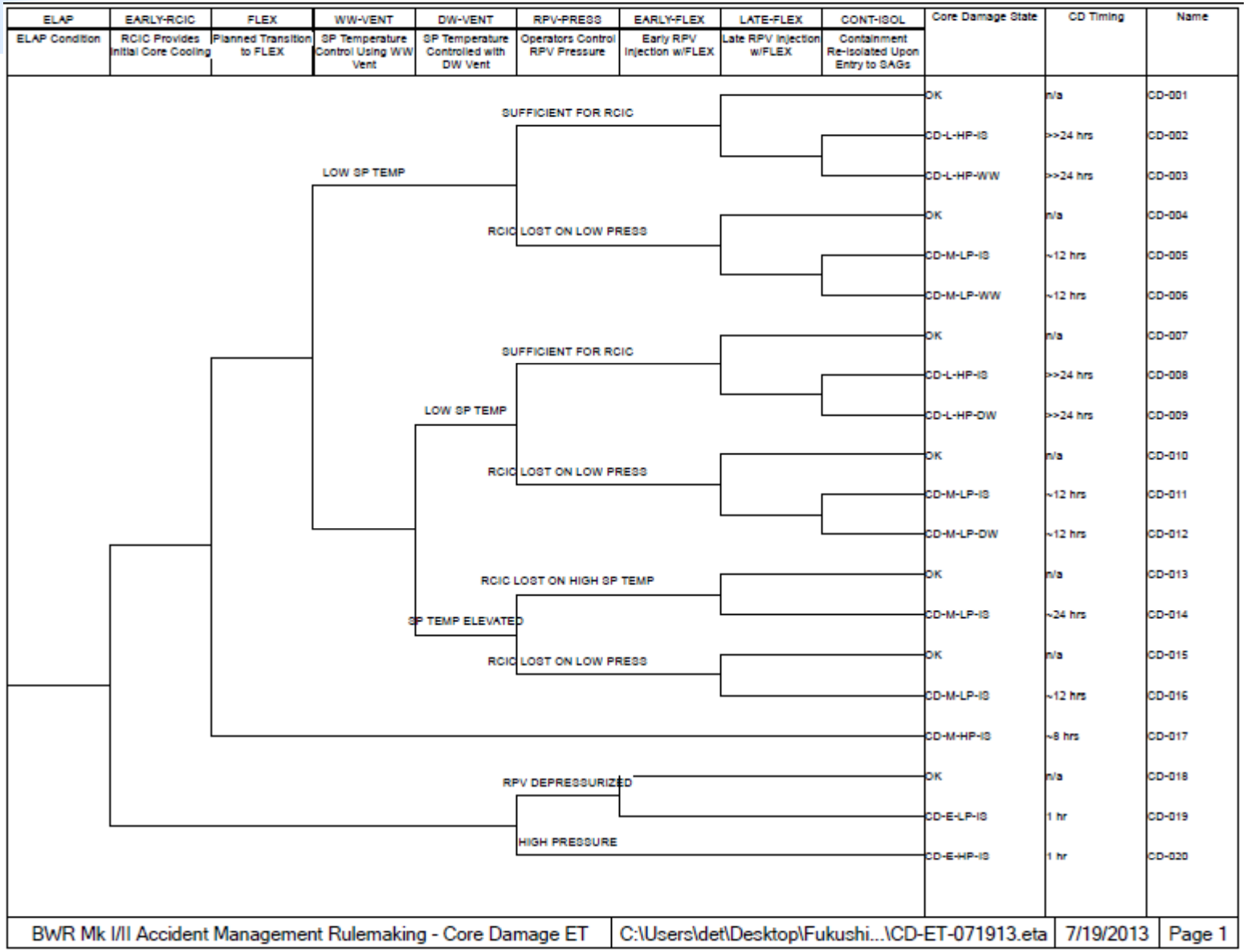
- Procedures for use of Containment Vent
  - Prior to core damage, anticipatory venting to maintain low SP temperature for RCIC and maintain pressure suppression function (PSP) - vent opened at 15 psig and no cycling.
  - Upon entry into SAG (minimum steam cooling level) vent closed unless required to maintain pressure suppression function – venting pressure of 30 psig (PSP)
  - Upon vessel breach – venting pressure of 60 psig (PCPL) unless previously vented to maintain PSP, then continue venting based on PSP.
  - Vent cycling cases – 10 psid control band (applies to both PSP and PCPL)
  - Closure of wetwell vent at pool level > 21’ above bottom of torus (consistent with plant-specific procedures)
  - Sensitivity case to investigate depressurization prior to isolation of wetwell vent (creates margin for future containment pressurization)

Potential Alternatives to Analyze

1. Base Case
   - FLEX injection to RPV, EA-13-109, Rev. 3 EPG/SAGs
2. External RPV Water Injection Point
   - 2A. Option 1 plus external injection point to RPV
   - 2B. Option 2A plus WW/DW vent cycling
   - 2C. Option 2B plus water management to prevent the need for DW venting
3. External DW Water Injection Point
   - 3A. Option 1 plus external injection point to DW
   - 3B. Option 3A plus WW/DW vent cycling
   - 3C. Option 3B plus water management to prevent the need for DW venting
4. Small Filter[1] (30 kg aerosol loading, 250kw decay heat)
   - Option 3A plus small filter
5. Large Filter[1] (199 kg aerosol loading, 1mw decay heat
   - Option 3A plus large filter

Note 1: From Sept 19, 2013 public meeting

Core Damage Scenario Development



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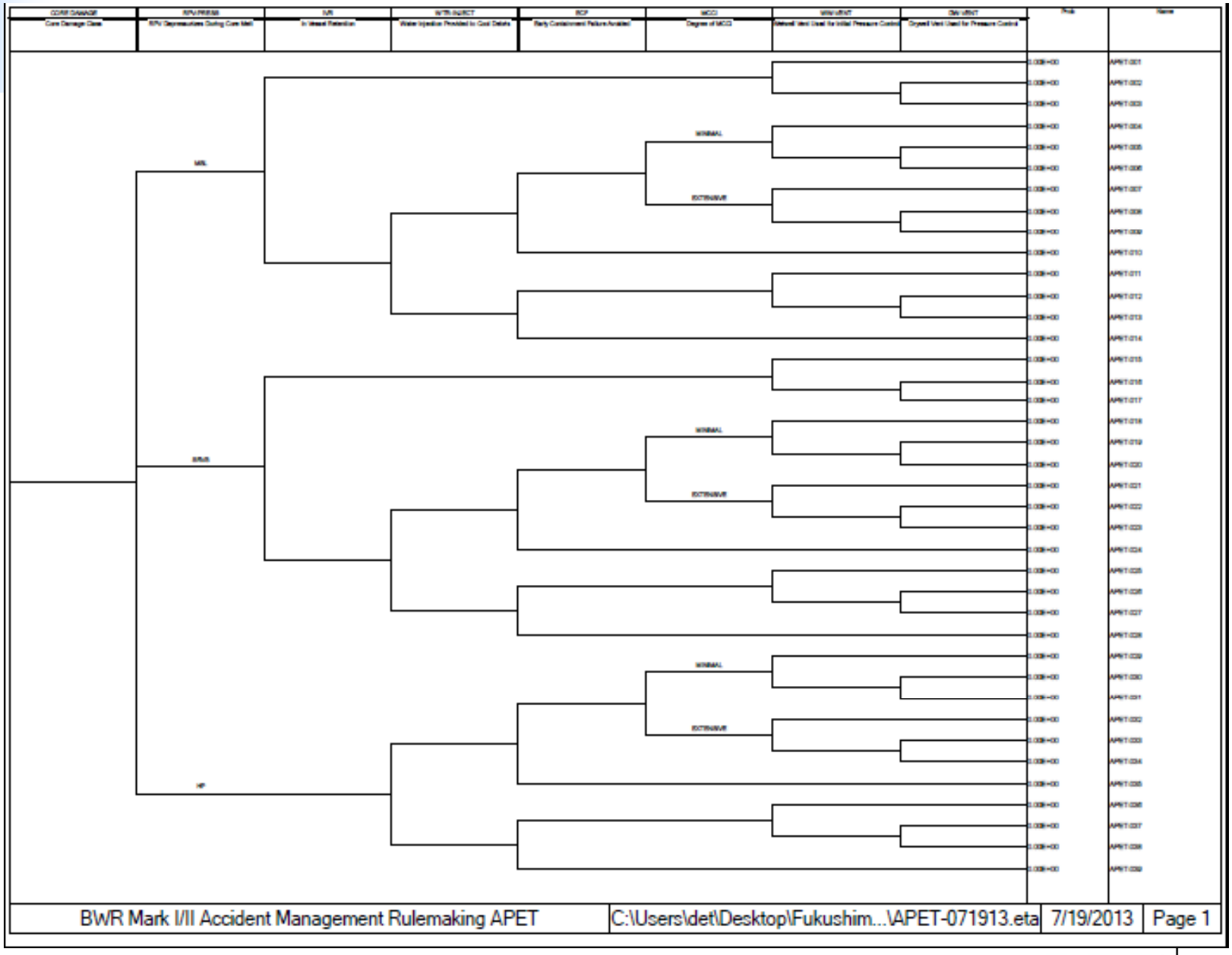
Core Damage Top Events

- ELAP
  - Total loss of offsite and onsite AC/DC power
- EARLY-RCIC
  - RCIC available to operate initially
- FLEX
  - FLEX implementation successful for injection pump and DC power for pressure control
- WW-VENT
  - Wetwell vent successful for extended RCIC operation
- DW-VENT
  - Drywell vent successful for extended RCIC operation
- RPV-PRESS
  - Operators successfully control RPV pressure to extend RCIC operation
- EARLY-FLEX
  - For scenarios with failure of EARLY-RCIC, FLEX implementation late aftereloss of RCIC able to prevent core damage
- LATE-FLEX
  - For scenarios with success of EARLY-RCIC and FLEX, FLEX implementation late after loss of RCIC able to prevent core damage
- CONT-ISOL
  - If venting was performed prior to core damage, this node addresses the successful closure of that vent path upon entry into the SAGs

Accident Progression Event Tree



APET Top Events

- RPV-PRESS
  - This node addresses the potential for either an SRV seizing open or creep rupture of the main steam line during the core damage phase of the accident. The split fractions will be influenced by the entry condition for RPV pressure as defined by the core damage state.
- IVR
  - Should injection be provided to the RPV after the onset of core damage but prior to vessel breach, there is some likelihood that vessel breach can be avoided.
- WTR-INJECT
  - Water injection into the RPV or into the drywell is considered here. The injection is either available prior to vessel breach or following vessel breach. Defined by alternative being considered.
- ECF
  - This event evaluates the potential for early drywell failure as a result of vessel breach and the discharge of core material into containment. Without water injection, the likelihood of liner melt through (LMT) is considered high. This node can also address the potential for containment failure resulting from high pressure melt ejection.
- MCCI
  - For cases with successful injection of water into containment, this event evaluates the potential for core debris quenching, thereby stopping the molten core concrete interaction.
- WW-VENT
  - Wetwell venting is initially used for containment pressure control
- DW-VENT
  - If the wetwell vent fails to operate, the drywell vent will be used for containment pressure control.

Preliminary Dominant Sequences – Core Damage[1]

Note 1: From August 14, 2013 public meeting

- CD-019: RCIC Fails Early, Operator ED, FLEX Late/Unavail
  - Fails at t=0
- CD-017: RCIC Succeeds Early, FLEX (DC power) unavailable
  - No DC charging early and RCIC fails at 4 hours
- CD-020: RCIC Fails Early, No ED, FLEX ineffective
  - Fails at t=0
- CD-002: RCIC Succeeds Early, RPV pressure control and Anticipatory Venting Succeeds, FLEX fails late, Containment vent re-isolated
  - Represented by RCIC failure at 16 hrs.
- CD-016: RCIC Succeeds Early but trips due to failure to control pool temperature, FLEX fails
  - RCIC trips when suppression pool temperature > 230 °F

These 5 end states capture 95% of total CDF

Preliminary Dominant Sequences – Release

- Base Case
  - SRV seizure, Dry, LMT
  - MSL failure, Dry, LMT
  - High pressure melt, Dry, LMT
- Alternatives
  - SRV seizure, In-Vessel retention, WW venting
  - SRV seizure, MCCI, WW venting
  - MSL failure, MCCI, WW venting
  - SRV/MSL, MCCI, WW venting, LMT (represented by base case)

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