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Mark I and Mark II BWRs Containment Venting Systems

Guidance for Order EA-13-109 and Accident Management Rulemaking

July 11, 2013

Japan Lessons Learned

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Agenda

- Introductions
- Opening remarks
- Schedules
- NRC presentation – Filtering strategies for BWR Mark I and Mark II containments rulemaking
  - Backfitting
  - General Rulemaking
  - Event Tree Modifications
  - MELCOR Calculation Matrix
- NEI/Industry presentation – Filtering strategies for BWR Mark I and Mark II containments rulemaking
- NEI/Industry presentation – Guidance development
- Public questions and comments

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Schedule - ISG

- ISG issuance endorsing NEI 13-02 – October 2013
- ACRS Full Committee – October 3, 2013 (Tentative)
- ACRS Sub Committee – Sept. 18, 2013 (Tentative)
- ISG public comment period ends – Sept. 18, 2013
- ISG issued for public comment – August 19, 2013
- ISG draft completion target – August 9, 2013
- Public and industry interactions – June to August 2013

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Schedule - Rulemaking

- Technical basis for rulemaking – March 2014
- Proposed rule – March 2015
- Final rule – March 2017

NRC Presentation – Filtering strategies for BWR Mark I and Mark II containments rulemaking

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Backfitting

Backfitting Rule (10 CFR 50.109)

- Requires a Backfit Analysis (10 CFR 50.109(a)(3)) if an exception does not apply under 10 CFR 50.109(a)(4):
  - Ensuring Adequate Protection
  - Defining/Redefining Adequate Protection
  - Compliance

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The Parts of a Backfit Analysis

- 2-step process, where the first step must be satisfied continue to the next step:
- First step: Is the regulatory action a **substantial increase** in the overall protection to public health and safety or common defense and security?
  - **Substantial Safety Enhancement**
- Second step: Is the regulatory action cost-justified (cost-beneficial)?
- If the regulatory action satisfies both parts of the process it is a **cost-justified substantial safety enhancement**

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What is a Substantial Safety Enhancement?

- Only looks at the benefits of the regulatory action
- Can be quantitative and/or qualitative
  - Safety Goal Quantitative Health Objectives (QHO)
  - Risk to people (person-rem)
    - No minimum set to determine what is “substantial”
  - Qualitative issues (e.g., defense-in-depth,
  - security)

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Substantial Safety Enhancement – Filtering Strategies

- Staff in SECY-12-0157 provided a justification of a conditional containment failure probability
- Industry provided a "Margin to the Safety Goal QHOs" at a previous public meeting
  - Could be considered as a determination/justification of a substantial safety enhancement

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Substantial Safety Enhancement - Pertinent Commission Direction

- SRM-SECY-93-086
  - Commission will consider both quantitative and qualitative discussions in determination of a substantial increase to public health and safety
- SRM-SECY-12-0157
  - Directed staff, independent of the Filtering Strategies Rulemaking, to seek guidance from the Commission on the use of qualitative factors in a notation vote paper
- SRM-SECY-12-0110
  - Commission found that the current backfitting framework is good and should not be changed in relation to Economic Consequences

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Cost-Justification – Pertinent Commission Direction

- Based on 10 CFR 50.109(c)
- NUREG/BR-0058, Rev. 4 and NUREG/BR-0158
  - Allows both quantitative and qualitative discussions
- Includes all benefits and costs (probability-weighted)
  - All health benefits
  - All health detriments (increased exposure from implementation)
  - Implementation and operation of the regulatory action (Industry and NRC costs)
  - Onsite and offsite property damage
  - Other non-health factors

General Rulemaking

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Performance Measures

- SRM directs evaluation of several performance measures
  - Decontamination factor
    - "Strategies that result in a DF greater than 1000 are considered viable."
  - QHO Margin (see 6/26/2013 presentation)
  - Equipment and procedure availability similar to thos required to implement 10 CFR 50.54(hh)
    - Example: BWROG Tabletop performance goals
    - How does this relate to QHO Margin? Same result?
  - Others under consideration

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Alternatives

- Severe accident capable dry well flood added to alternatives
  - FLEX for before core damage only, no role after core damage
- All alternatives assume severe accident capable dry well and wet well vents

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Industry Plans

- Staff requests update of industry plans for:
  - Analyses to support evaluation of performance measures
  - Definition of severe accident conditions
  - Severe accident event tree/fault tree
  - Treatment of uncertainties
  - Alternatives
    - Cost of alternatives
  - Mark II

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Industry Plans (Cont.)

- Will work continue on:
  - Filtering strategies water management
    - Achieve high decontamination (> 1000 DF) while not blocking wet well vent
    - BWROG Tabletop insights
  - Use of dry well spray for decontamination
  - New equipment
    - Automated cycling vent valve
    - Instrumentation to determine vessel breach and to support auto vent valve cycling after breach

Event Tree Modifications

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Overview

- Computation of Δrisk and risk contributors
- E/T modifications
  - Credit for portable pump (e.g., FLEX) to prevent core damage and vessel breach
  - More detailed examination of operator actions and their dependencies
- Questions:
  - FLEX success criteria?
  - Details of the filtering strategy (vent cycling)?
  - What HRA model to use (needs to represent ex-control actions following core damage)?
  - Treatment of dependent operator actions?
  - Battery depletion time? Sequence timing?
  - How to credit containment flooding? Can FLEX be used to flood the containment?
  - Data (frequencies and probabilities)?

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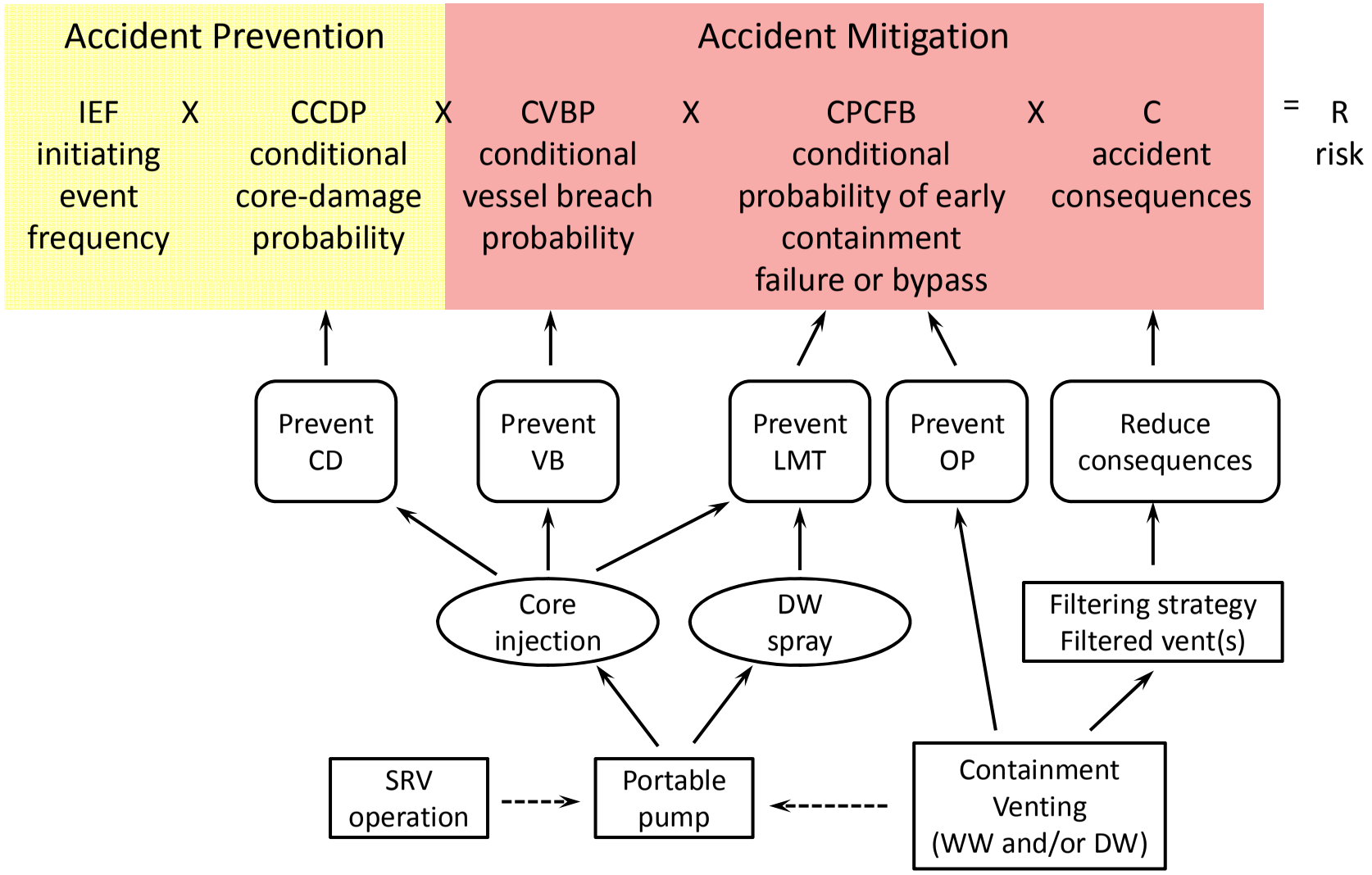
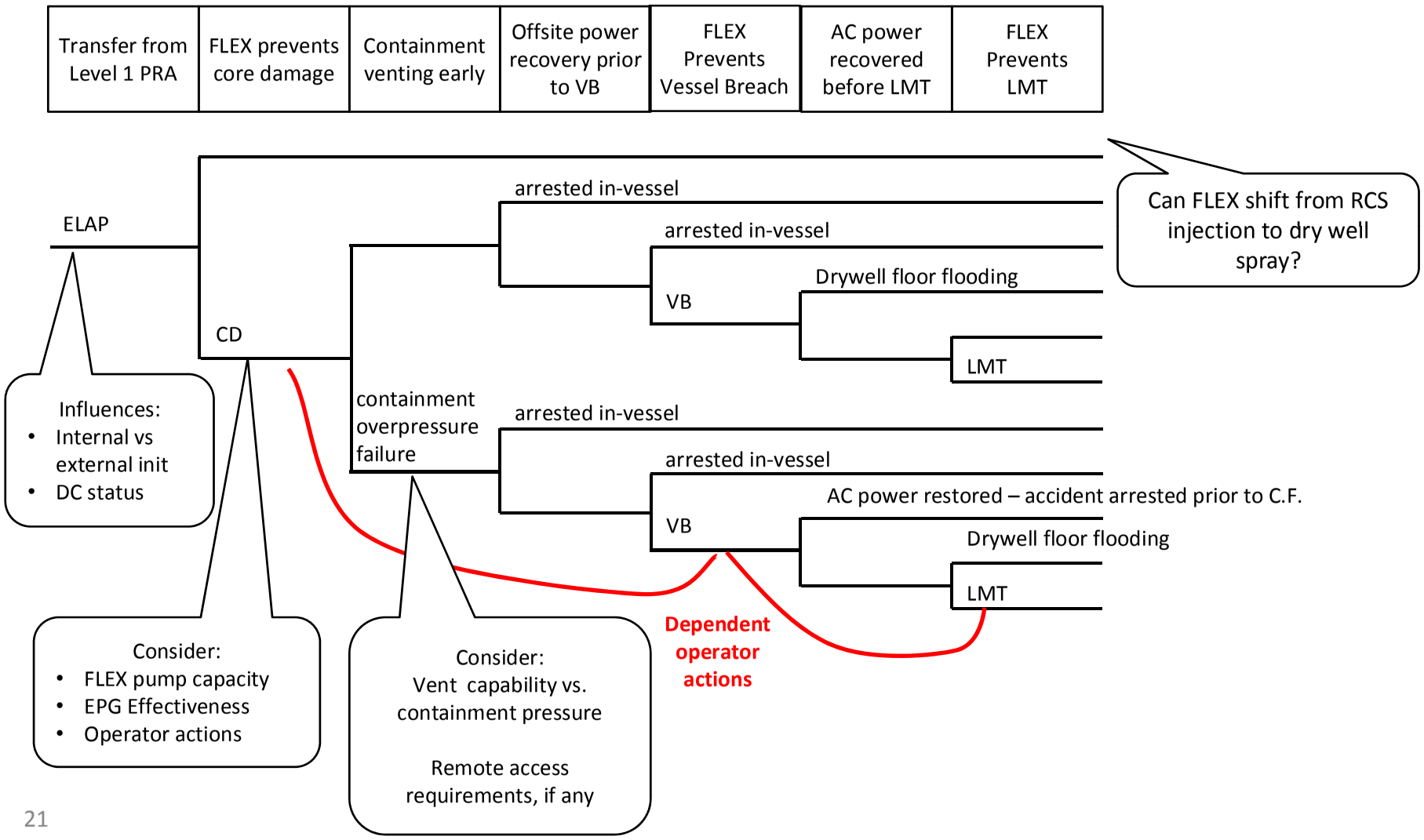
Impact of Alternatives on Risk



Preliminary Event Tree



MELCOR Calculation Matrix

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Consideration of Analysis Options

- RCIC operation
  - RCIC duration: 16 hr., 4 hr., 0 hr.
  - Flow rate: 600 gpm (or EPG/SAG specification, if any)
- RPV depressurization and vessel injection (?)
  - Reliability of vessel injection under SA condition
  - Injection source, capacity, and effectiveness
- Drywell spray
  - Spray actuation time: @RCIC stop, @ vessel breach, other (?)
  - Spray flow rate: 500 gpm, variation (if any)
- Containment venting
  - Vent sizing: variable between wetwell and drywell, same
  - Vent cycling criteria: (PCPL)/(PCPL-15), other (if any)?
  - Transition from WW to DW venting: SP high water level, other (?)
  - Early venting option: criteria (?)
- Duration of transients: 72 hours, other (?)

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MELCOR Calculation Matrix

Case Description	Input Parameters	Case 1	Case 2	Case 3	Case 4	Case 5
Main Steam Line Creep Rupture	RCIC failure (hr.)	16	4	0	16	4
	Drywell spray actuation	@ RCIC failure	@ RCIC failure	@ vessel breach	@ vessel breach	@ vessel breach
	Drywell spray flow rate (gpm)	500	500	500	500	500
	Wetwell vent cycling	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)
	Drywell vent cycling	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)
	Run time (hr.)	72	72	72	72	72

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MELCOR Calculation Matrix

Case Description	Input Parameters	Case 6	Case 7	Case 8		
Main Steam Line Creep Rupture	RCIC failure (hr.)	16	16	16		
	Drywell spray actuation	16	16	@ vessel breach		
	Drywell spray flow rate (gpm)	500	500	500		
	Wetwell vent cycling	(PCPL)/ (PCPL-15)	Early venting	Early venting		
	Drywell vent cycling	No cycling	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)		
	Run time (hr.)	72	72	72		

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MELCOR Calculation Matrix

Case Description	Input Parameters	Case 9	Case 10	Case 11	Case 12	Case 13
Vessel Breach	RCIC failure (hr.)	16	4	16	16	16
	Drywell spray actuation	16	4	@ vessel breach	16	16
	Drywell spray flow rate (gpm)	500	500	500	500	500
	Wetwell vent cycling	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	Early venting
	Drywell vent cycling	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	none	(PCPL)/ (PCPL-15)
	Run time (hr.)	72	72	72	72	72

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MELCOR Calculation Matrix

Case Description	Input Parameters	Case 14	Case 15	Case 16	Case 17	
SRV failure	RCIC failure (hr.)	16	4	16	16	
	Drywell spray actuation	16	4	@ vessel breach	16	
	Drywell spray flow rate (gpm)	500	500	500	500	
	Wetwell vent cycling	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	Early venting	
	Drywell vent cycling	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	
	Run time (hr.)	72	72	72	72	

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MELCOR Calculation Matrix

Case Description	Input Parameters	Case 18	Case 19			
Containment overpressure failure (e.g., head flange leakage)	RCIC duration (hr)	16	4			
	Drywell spray actuation time (hr.)	16	4			
	Drywell spray flow rate (gpm)	500	500			
	Venting					
	Run time (hr.)	72	72			
	RCIC duration (hr)	16	4			

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MELCOR Calculation Matrix

Case Description	Input Parameters	Case 20	Case 21	Case 22		
Containment bypass (e.g., liner melt-through)	RCIC duration (hr)	16	4	16		
	Drywell spray actuation time (hr.)	@ vessel breach	@ vessel breach	@ vessel breach		
	Drywell spray flow rate (gpm)	500	500	500		
	Wetwell venting	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	Early venting		
	Drywell venting	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)	(PCPL)/ (PCPL-15)		
	Run time (hr.)	72	72	72		

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Assumptions and Notes

- All cases start with ELAP; SACV capability assumed to be in place as are FLEX and other EPG/SAG features; FLEX for pre-core damage only
- MSL rupture simulating a LOCA - assumed break size 6" dia.
- RCIC quits at battery depletion; RCIC flow rate of 600 gpm assumed based on existing information
- Vessel breach timing is calculated
- Assumed value of 500 gpm subject to revision based on industry's EPG/SAG
- Assumed 16" wetwell vent line; vent cycling assumed with vent opening at PCPL and closing at (PCPL-15); subject to revision based on EPG/SAG
- Early venting and vent cycling strategy explored at lower pressure limits
- Assumed 12" drywell vent line; wetwell to drywell transition @ suppression pool high water level, if needed
- Vent cycling assumed with vent opening at PCPL and closing at (PCPL-15); subject to revision based on EPG/SAG
- Drywell vent once opened, assumed late in the transient, remains open
- Both stochastic failure and thermal seizure of SRVs to be considered
- Head flange leakage simulating Fukushima-type accident; venting in this case assumed not initiated in time or it is ineffective in preventing overpressure; equipment and human reliability issue
- Matrix shown is representative of Mark I calculations; identical or substantially similar effort is anticipated for Mark II.

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Abbreviations

- ACRS – Advisory Committee on Reactor Safeguards
- CER – Cumulative Effects of Regulation
- DW – Drywell
- EPG – Emergency Procedure Guidelines
- GPM – gallons per minute
- PCPL – Primary Containment Pressure Limit
- RCIC – Reactor Core Isolation Cooling
- SA – Severe Accident
- SAG – Severe Accident Guidelines
- SP – Suppression Pool
- WW – Wetwell

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NEI/Industry Presentation
Filtering Strategies for Mark I and Mark II Containments Rulemaking

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NRC Presentation
Guidance Development

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Scope and Purpose

- Design and operation of vents (SACV) in beyond design-basis core damage conditions
- Includes conditions created in a sequence of events leading to core damage
- Most extreme conditions of temperature, pressure (includes hydrogen, CCI), radiation determined by analysis of severe accidents that include reactor vessel breach, main steam line rupture, and SRV failure
- SACV primary mission is to protect the dry well head gasket from failure

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BWROG Generic Insight

- "Evaluations of containment limiting pressure and the ability to raise it by improving limiting component capability may be appropriate"
  - "This evaluation should include uncertainties associated with containment structural response

BWROG Tabletop 2/5/2013 Slide 36

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NEI Presentation

Guidance Development

(Chapter 1, “Introduction” and Chapter 4.2, “Vent Operation and Monitoring,” NEI 13-02)

(*Draft Only*)

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Questions & Discussion