U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Filtering Strategies Rulemaking Public Meeting

April 30, 2014

Purpose

- Provide status of the rulemaking effort
- Discuss extension of regulatory basis, proposed rule, and final rule
- Discuss intended process for this rulemaking
- Discuss regulatory analysis and backfitting process
- Provide information requests and received from industry
- Path Forward

Agenda

9:00am – 9:10am	Welcome, introductions, and logistics
9:10am – 9:45am	Schedule and process of rulemaking
9:45am – 10:00am	Comments on schedule and process
10:00am – 10:15am	Break
10:15am – 11:45am	Industry presentation on drywell venting
11:45am – 12:00pm	Comments on industry presentation
12:00pm – 1:00pm	Lunch
1:00pm – 2:30pm	Presentation of NRC technical analysis
2:30pm – 2:45pm	Break
2:45pm – 4:45pm	Presentation of industry technical analysis
4:45pm – 5:00pm	Closing remarks

Announcements

- Category 2 Public Meeting
  - Comments during presentations should be only on the material being presented
  - General public comments are provided at the end of the morning and afternoon
- This meeting is being transcribed
- Teleconference Number:
  - 800-316-9414; passcode: 29256
- Webinar:
  - https://www1.gotomeeting.com/register/657553096

Announcements

- Please make sure to say your name before you make a statement for the transcriber
- Introductions around the room
- If you are on the telephone, please introduce yourself now and send an email to Aaron.Szabo@nrc.gov confirming your attendance

Public Meeting Summaries and Related Documents

- April 18, 2014 letter to ERIN from NRC/RES on MACCS input code (ML14108A261)
- March 26-27, 2014 (ML14093A098)
- January 2014 phone call between NRC/NRR and NEI (ML14035A156)
- December 12, 2013 (ML13357A794)
- November 12, 2013 NEI workshop presentation (ML13337A500)

Public Meeting Summaries and Related Documents (cont'd)

- November 6, 2013 (ML13324A953)
- September 19, 2013 (ML13277A332)
- August 14, 2013 (ML13238A328)
- July 11, 2013 (ML13211A395)
- June 26, 2013 (ML13203A074)
- June 13, 2013 (ML13199A216)

Tentative Extension to Regulatory Basis, Proposed Rule, and Final Rule

- Approved by EDO, with Commission
- Previous Due Dates:
  - Regulatory Basis: December 19, 2014
  - Proposed Rule: December 19, 2015
  - Final Rule: March 19, 2017
- New Due Dates:
  - Draft Regulatory Basis: December 2014
  - Regulatory Basis: September 19, 2015
  - Proposed Rule: September 19, 2016
  - Final Rule: December 19, 2017

Reason for Extension

- Delays in receiving information from industry
  - Receiving information in relation to developing core damage and accident progression event trees (specifically, access to BWROG EPG/SAG Rev 3)
  - Ground rules regarding sequence definition for the MELCOR runs
- To note, NRC will now further develop BWR Mark II containment analysis
  - No separate development of event trees for Mark II containments or Isolation Condensers

Regulatory Basis Dates

- Begin Concurrence: October 2014
- Draft Regulatory Basis: December 2014
- Comment Period (45 days): January – February 2015
- Final Regulatory Basis: September 2015

General Process

- Present Draft Regulatory Basis for formal public comment
  - Includes Regulatory Analysis and Backfitting
  - Tentative meeting with ACRS during public comment period
  - Tentative public meeting(s) during public comment period
- Provide Final Regulatory Basis as Information paper to Commission
  - Directed by SRM-SECY-12-0157
  - Will use information from public comment period to inform final regulatory basis
  - Tentative meeting with ACRS
  - No formal comment period provided

General Process (cont'd)

- Begin development of proposed rule based on final regulatory basis document
  - Continue with periodic public meetings
  - Development of draft regulatory guide (white papers to be provided through process)
  - Development of proposed rule language (draft rule language will be provided through process)
  - Development/modification of regulatory analysis and backfitting for proposed rule
  - Submit proposed rule to Commission for vote

Regulatory Analysis Process

- Event trees are developed using Probabilistic Risk Assessment (PRA)
  - Determines dominant sequences based on hypothetical event and facility
- MELCOR Analysis
  - Develops releases based on reference BWR Mark I and reference BWR Mark II
- MACCS Analysis
  - Uses source terms from MELCOR analysis
  - Will use various locations to develop reference consequences for BWR Mark I and Mark II
- MACCS analysis consequences are then probability-weighted consequences for a reference BWR Mark I and Mark II
  - Both complete risk and conditional risk assuming core damage

Regulatory Analysis Process (cont'd)

- The reference plants do not represent any specific plants within the United States, but are hypothetical generic plants that are representative of the plants being reviewed
  - A low, best estimate, and high estimate will be developed based on the information
  - Information from plants are used to develop assumptions but the end result does not represent a specific plant
- Information is then put into the regulatory analysis to develop a representation of the BWR Mark I and Mark II containments for determination of potential regulatory actions

Backfitting Process

- Any proposed action from this rulemaking would be deemed a backfit under 10 CFR 50.109(a)(1)
- Step 1: Is the regulatory action necessary to ensure Adequate Protection of public health and safety?
  - If yes, the regulatory action may be taken regardless of cost
  - If no, proceed to Step 2
- Step 2: If not, is the regulatory action provide a substantial increase in protection of public health and safety?
  - If yes, proceed to Step 3
  - If no, the regulatory action should not be taken
- Step 3: Is the regulatory action cost-beneficial?
  - If yes, the regulatory action meets the criteria of 10 CFR 50.109
  - If no, the regulatory action should not be taken

Information Received

- E-portal access and public meeting (closed) on BWROG's EPG/SAG Rev 3 in late March
  - March 12, 2014 BWROG letter (ML14072A160)
- General cost estimates and ranges
  - September 19, 2013 public meeting
- Insights for development of PRA event trees and ground rules for MELCOR sequences
  - Public meetings from July – December 2013
- Performance criteria
  - Public meetings in July – September 2013

Requests for Information

- Detailed cost estimates of options
  - Request for information by: **May 31, 2014**
  - Preliminary cost information provided at previous public meeting
  - Non-proprietary detailed cost information expected early May
- Changes to SAMGs due to filters and filtration strategies
  - Request for information by: **May 31, 2014**
  - Any addition or reduction of action necessary
  - Instrumentation requirements

Requests for Information (cont'd)

- Major assumptions related to BWROG's EPG/SAG Rev 3 that are required to be publicly available
  - Request for information by: **June 30, 2014**
  - Staff finalizing list of information necessary to be made public
  - Anticipatory venting
  - Steam cooling level vent
  - Venting pressure upon vessel breach
  - Control band for vent cycling
  - Closure of wetwell vent
  - TSC interactions post core damage

Requests for Information (cont'd)

- Plant-specific information:
  - Request for information by: **July 31, 2014**
  - Staff is developing template spreadsheet for information required
  - Requesting all plants with names scrubbed that fill out each sheet

Request for Information (cont'd)

- Mark II Containment Information:
  - Request for information by: **May 31, 2014**
  - Drawings that provide reactor sump locations, dimensions, and floor shape, including distance from floor to elevation where spillover into downcomers begin
    - Used to develop generic MELCOR analysis and sensitivities
    - Will use current MELCOR analysis if no information is provided
  - Number of safety relief valves, including opening and closing pressures
  - Steam explosion probability
  - Restrictions for water level in drywell

Path Forward

- Continue MELCOR and MACCS analysis for BWR Mark I and Mark II containments
  - Including sensitivities, when appropriate
  - Planned public meeting after receiving detailed information on Mark II containments
- Independent review of industry cost information
- Continue development of performance goals, measures, etc.
- Follow-up meeting on BWROG EPG/SAG Rev 3 specifically relating filtering strategies rulemaking

Contact Information

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MELCOR Preliminary Information

April 30, 2014

Regulatory Analysis Options

- Option 1: EA-13-109, EPG/SAG Rev 3, anticipatory venting, RPV pressure control
- Option 2A: Option 1 plus injection to RPV via an external injection point
- Option 2B: Option 2A plus WW/DW vent cycling
- Option 3A: Option 1 plus injection to drywell via an external injection point
- Option 3B: Option 3A plus WW/DW vent cycling
- Option 4: Options 1 -3 above plus a small external filter
- Option 5: Options 1-3 above plus a large external filter

MELCOR Analysis Background Information

- Builds upon information exchange between the industry and the NRC at previous public meetings
- General assumptions same or substantially similar to those used by the industry
- Complies with SRM for SECY-12-0157
- Alternatives/options considered for regulatory analysis are largely consistent with those used by the industry
- Some differences between staff's CDET and APET evaluation and those of the industry

MELCOR Analysis Assumptions (6/11/13 and 12/12/13)

- RCIC operation
  - Suction from SP (option for suction from CST/SP)
  - Flow rate 600 gpm
  - RPV level control via throttling of RCIC
- RPV pressure control
  - Initial pressure control in 800 – 1000 psig band
  - Controlled depressurization after one hour
  - Subsequent pressure control in 200 – 400 psig band for continued RCIC operation

MELCOR Analysis Assumptions (6/11/13 and 12/12/13)

- Containment venting
  - Anticipatory venting prior to core damage
  - Upon entry into SAG vent closed; reopens at PCPL (60 psig) – option to reopen at PSP considered
  - Transition from WW to DW venting at SP high water level (21’ above bottom of torus)
  - Vent cycling in (PCPL)/(PCPL-10) band; option with PSP considered
  - Vent sizing consistent with industry assumptions

MELCOR Analysis Assumptions (6/11/13 and 12/12/13)

- RPV injection
  - 500 gpm injection into core from an external source; option to study flow rate sensitivity
  - Injection at vessel breach; option to inject prior to vessel breach (e.g., RPV water level 2/3rd core height)
- Drywell injection
  - 500 gpm injection into drywell from an external source
  - Injection at vessel breach
  - MELCOR considers initial buildup of water in the drywell from nominal leakage

MELCOR Analysis Assumptions

- All MELCOR cases start with an ELAP
- Order EA-13-109 capability assumed in place
- EPG/SAG Rev 3 assumed in place
- FLEX assumed in place both pre- and post-core damage; functionality of FLEX may vary
- Possible end states of accident progression: liner melt-through, MSL rupture, head flange leakage, seal or other leakage – all consequential to environmental release
- 72-hour transient

MELCOR Calculation Matrix

Case	Description	Staff Option	Industry Equivalence
1	EA-13-109, EPG/SAG Rev. 3, FLEX in place; RCIC suction from SP until failure (SP temperature exceeding 230^{o}F); anticipatory early venting and RPV pressure control in effect; containment vent isolated upon entry into SAG and re-opens at PCPL; SRV fails by overheating; low pressure vessel failure and subsequent liner melt-through	1	Option 1 CD-016
7	As in Case 1 with core injection initiating at vessel breach; low pressure vessel failure; containment vent isolated upon entry into SAG and re-opens at PCPL; liner melt-through and possibly basemat failure avoided	2A	Option 2A CD-016
10	As in Case 7 but initially venting through wetwell and switching to drywell at wetwell vent closure (pool level 21 feet above torus bottom)	2A	Option 2A CD-016
18	As in Case 14; initially venting through wetwell at PCPL and cycling in 10 psid band , then switching at wetwell vent closure to drywell vent cycling in 10 psid band	2B	Option 2B CD-016

MELCOR Calculation Matrix

Case	Description	Staff Option	Industry Equivalence
21	As in Case 1 with drywell injection starting at vessel breach; low pressure vessel failure; containment vent (wetwell) isolated upon entry into SAG and re-opens at PCPL; liner melt-through and basemat failure possibly avoided	3A	Option 3A CD-016
32	As in Case 21; initially venting through wetwell and cycling in 10 psid band then switching at wetwell vent closure to drywell vent cycling in 10 psid band	3B	Option 3B CD-016
2	As in Case 1 but SRV does not fail; no MSL creep rupture and RPV fails at high pressure; subsequent liner melt-through	1	No industry equivalence
3	As in Case 1 except RCIC fails early (prior to FLEX alignment and initiation of anticipatory early venting); containment vent isolated at entry into SAG and re-opens at PCPL; MSL creep rupture	1	Option 1 CD-017
5	As in Case 1 but RCIC suction initiating from CST and transitioning later to SP; extends RCIC operation time; otherwise, identical to Case 1	1	Option 1 CD-002

MELCOR Calculation Matrix

Case	Description	Option	Industry Equivalence
6	As in Case 1 except vent re-opens at PSP instead of at PCPL	1	Option 1 CD-016
13	As in Case 7 but RCIC suction initiating from CST and transitioning later to SP; extends RCIC operation time; otherwise, identical to Case 1	2A	Option 2A CD-002
14	As in Case 7 with wetwell vent opening at PCPL and cycling in 10 psid band	2B	Option 2B CD-016
24	As in Case 21; initially venting through wetwell and switching to drywell at wetwell vent closure (pool level 21 feet above torus bottom), if needed	3A	Option 3A CD-016
27	As in Case 21 with wetwell vent opening at PCPL and cycling in 10 psi band	3B	Option 3B CD-016
41	As in Case 7 but RCIC failing early; containment vent isolated upon entry into SAG and re-opens at PCPL; MSL rupture may precede vessel breach thus resulting in high pressure failure	2A	Option 2A CD-017

MELCOR Calculation Matrix

Case	Description	Option	Industry Equivalence
42	As in Case 10 but RCIC failing early; initially venting through wetwell and switching to drywell at wetwell vent closure (pool level 21 feet above torus bottom); , MSL rupture may precede vessel breach thus resulting in high pressure failure	2A	Option 2A CD-017
43	As in Case 21 but RCIC failing early; containment vent isolated at entry into SAG and re-opens at PCPL; wetwell venting; drywell injection at vessel breach; however, MSL rupture may precede vessel breach thus resulting in high pressure failure	3A	Option 3A CD-017
44	As in Case 24 but RCIC failing early; initially venting through wetwell and switching to drywell at wetwell vent closure; MSL rupture may precede vessel breach	3A	Option 3A CD-017
45	RCIC suction from SP until failure (SP temperature exceeding 230^{o}F); no anticipatory venting or RPV pressure control; drywell injection at vessel breach; drywell venting at PCPL	Variation of 3A	No industry equivalence
46	As in Case 45 but initially wetwell venting at PCPL then switching to drywell at wetwell vent closure	Variation of 3A	No industry equivalence

MELCOR Results (Preliminary)

Case	Option	Cs (RF) @ 72 hours	Cs (DF = 1/RF)	I (RF) @ 72 hours	DC battery (hr)	Early venting (opn/cls) (hr)	RCIC failure (hr)	SRV failure (hr/# cycles)	MSL failure (hr)	WW venting (opn/cls) (hr)	DW venting (opn/cls) (hr)	LH fails (hr)	FLEX 500 gpm (stop @ hr)	Liner failure (hr)
No Water Injection														
1	1	2.42E-02	41	9.95E-02	72	10.7/12.8	9.6	16.0 (50)	-	16.7/-	-	24.3	-	31.8
5	1	5.51E-03	181	5.49E-02	72	11.4/19.8	16	23.2 (54)	-	24.6/-	-	31.4	-	39
6	1	2.76E-02	36	2.43E-01	72	10.7/12.8	9.6	16.0 (50)	-	14.5/-	-	22.8	-	30.6
3	1	6.75E-02	15	2.71E-01	4	-	4	-	9.85	9.85/-	-	15.8	-	18.8
Water injection at LH failure (Stop Injection at WW level of 21 ft)														
7	2A	5.93E-03	169	5.76E-02	72	10.7/12.8	9.6	16.0 (50)	-	16.7/-	-	24.3	RPV (42.7)	-
14	2B	3.98E-03	251	4.30E-02	72	10.7/12.8	9.6	16.0 (50)	-	16.7/...	-	24.6	RPV (37.3)	-
21	3A	1.07E-02	93	6.70E-02	72	10.7/12.8	9.6	16.0 (50)	-	16.7/-	-	24.3	DW(41.8)	-
27	3B	3.41E-03	293	4.12E-02	72	10.7/12.8	9.6	16.0 (50)	-	16.7/...	-	24.6	DW (36.6)	-
41	2A	1.86E-02	54	1.29E-01	4	-	4	-	9.85	9.85/-	-	15.8	RPV(31.9)	41.8
43	3A	2.07E-02	48	1.51E-01	4	-	4	-	9.85	9.85/-	-	15.8	DW(31.5)	41.3
Water injection at LH failure (Maintain Injection & Switch to DW venting at WW level of 21 ft)														
10	2A	5.55E-03	180	5.34E-02	72	10.7/12.8	9.6	16.0 (50)	-	16.7/42.8	57.7/-	24.3	RPV	-
18	2B	3.69E-03	271	3.92E-02	72	10.7/12.8	9.6	16.0 (50)	-	16.7/30.1	39.3/...	24.6	RPV	-
24	3A	9.42E-03	106	5.41E-02	72	10.7/12.8	9.6	16.0 (50)	-	16.7/42.0	58.1/-	24.3	DW	-
32	3B	3.09E-03	324	3.65E-02	72	10.7/12.8	9.6	16.0 (50)	-	16.7/35.5	36.6/...	24.6	DW	-
42	2A	1.60E-02	63	9.10E-02	4	-	4	-	9.85	9.85/31.9	39.7/-	15.8	RPV	-
44	3A	1.66E-02	60	9.15E-02	4	-	4	-	9.85	9.85/31.5	45.3/-	15.8	DW	-

MELCOR Results (Preliminary)

- RPV/DW water injection increases the overall Cs decontamination factor (decrease in release fraction by up to about an order of magnitude)
  - Release is still continuing beyond 72 hours for cases without water injection
  - Containment water level control does not significantly impact releases
  - RPV injection appears to be more efficient in reducing the release
- WW/DW vent cycling results in highest decontamination factor
  - Significant number of cycles appears to be required

MELCOR Results (Preliminary)

- Direct release into the Drywell (MSLB) can increase the Cs release by a factor of ~2
  - Potential for drywell head failure and leakage (leading to hydrogen combustion in the reactor building) even if venting is actuated
  - RPV/DW water injection can increase the overall Cs DF by a factor of ~4
  - For these cases SRV failure was disabled, but there is a good chance that SRV is stuck open before MSLB
- Water management options show a range of overall Cs DF between approximately 100-300
  - MACCS analysis will highlight the consequence differences
- Additional sensitivity calculations will be pursued

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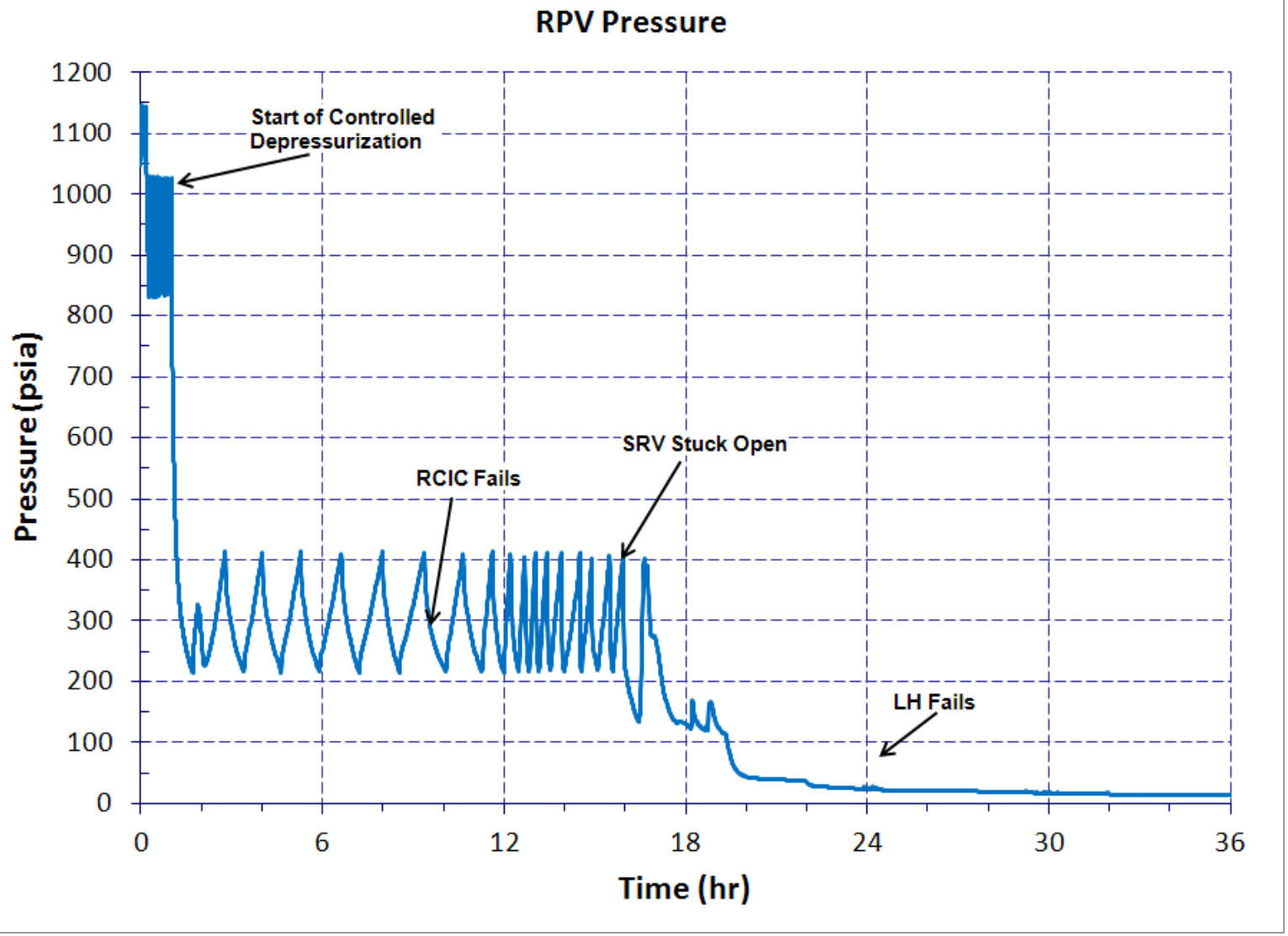
Backup Slides

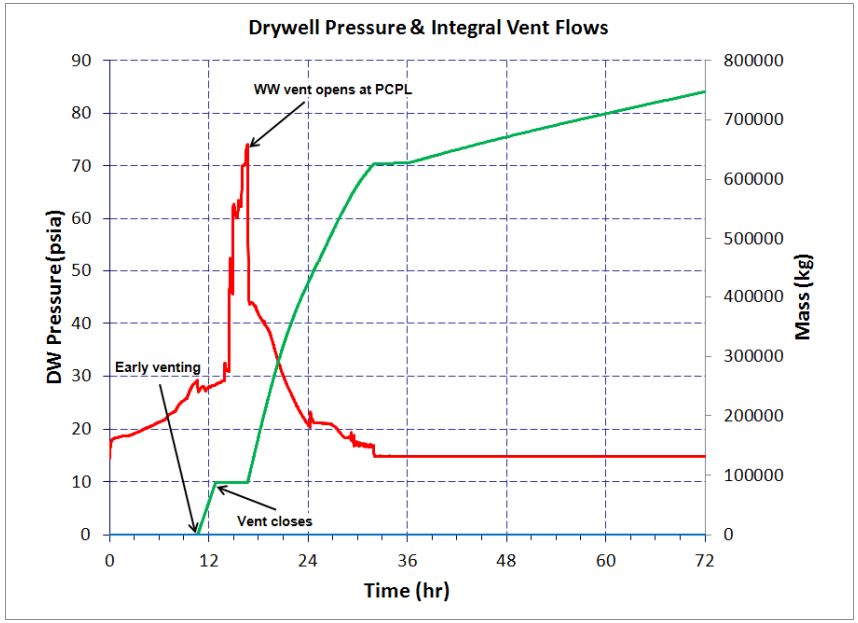
April 30, 2014

MELCOR Results (RPV Pressure Control)

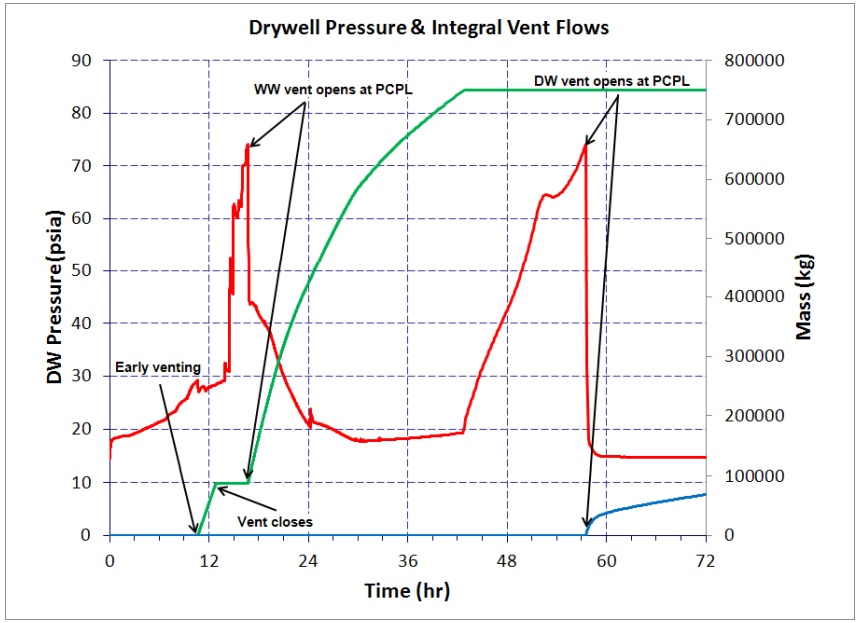


MELCOR Results (WW/DW Pressure Control)

Case 1
(no injection)

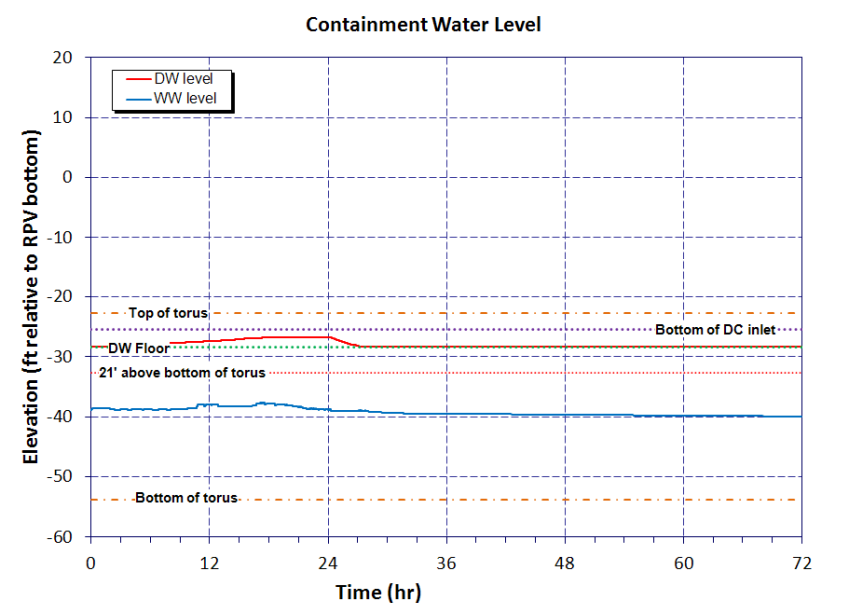


Case 10
(RPV injection)
(no WW level control)

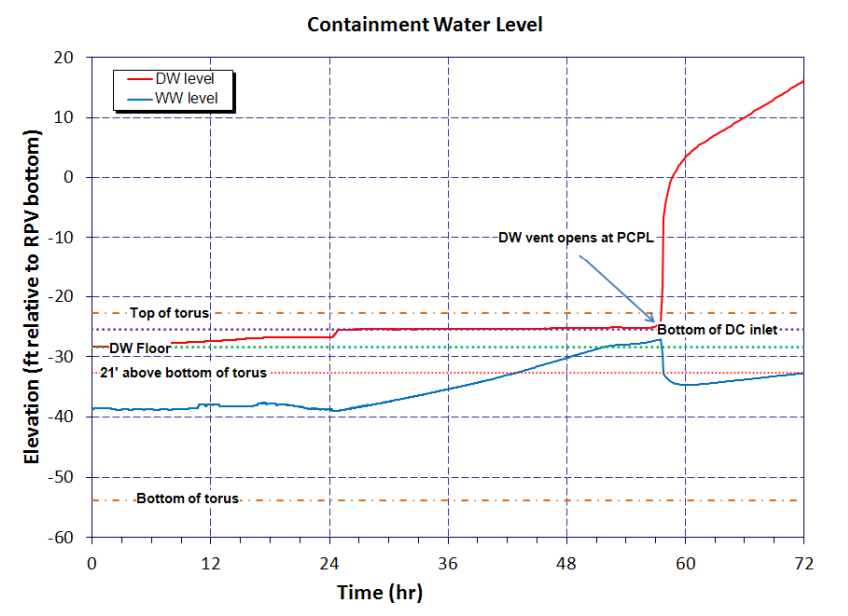


MELCOR Results (WW Level)

Case 1
(no injection)

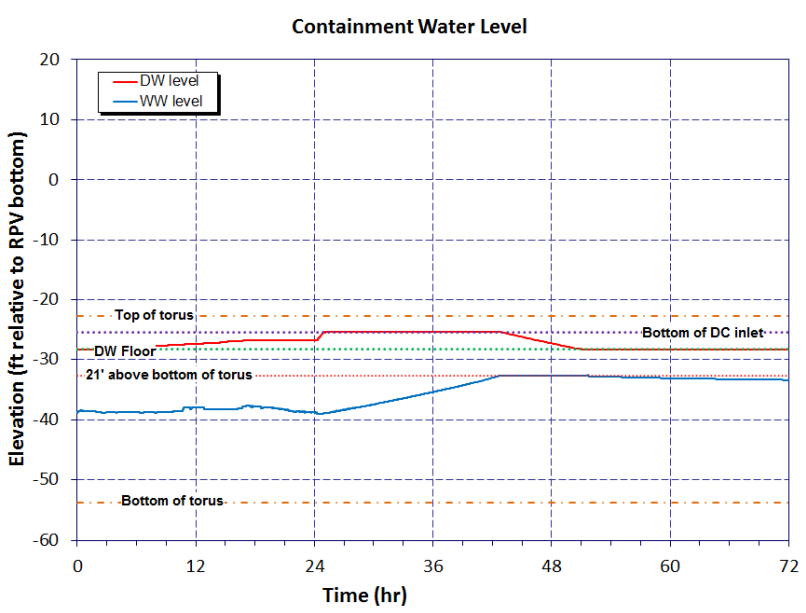


Case 10
(RPV injection)
(no WW level control)

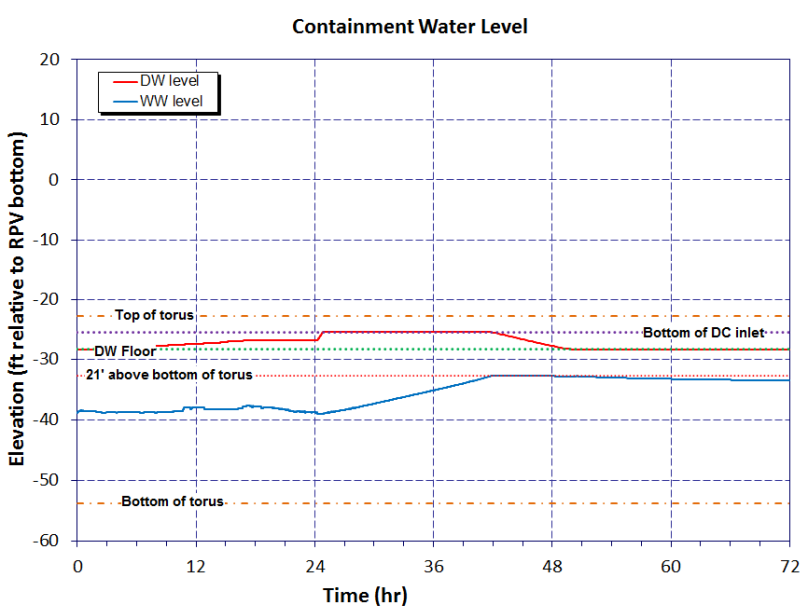


MELCOR Results (WW Level)

Case 7
(RPV injection)

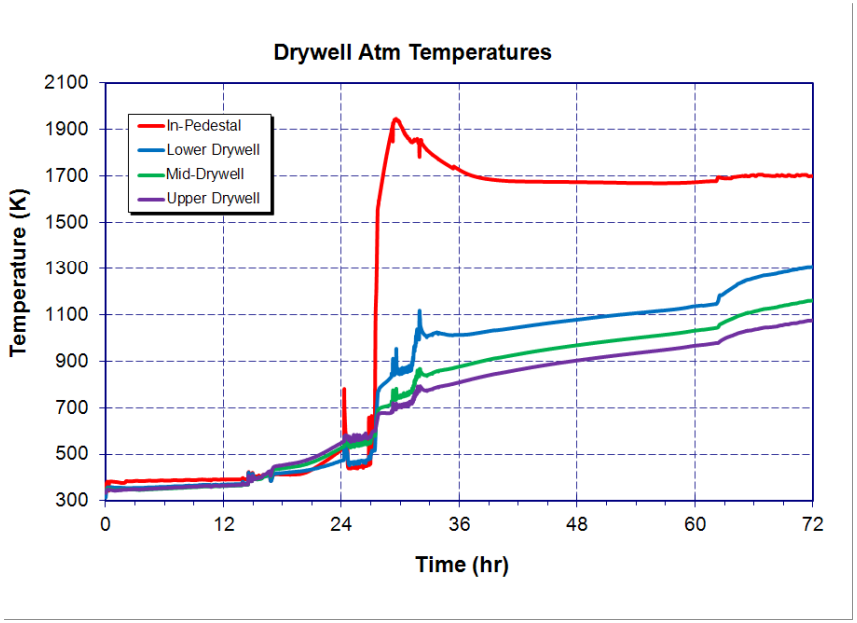


Case 21
(DW spray)

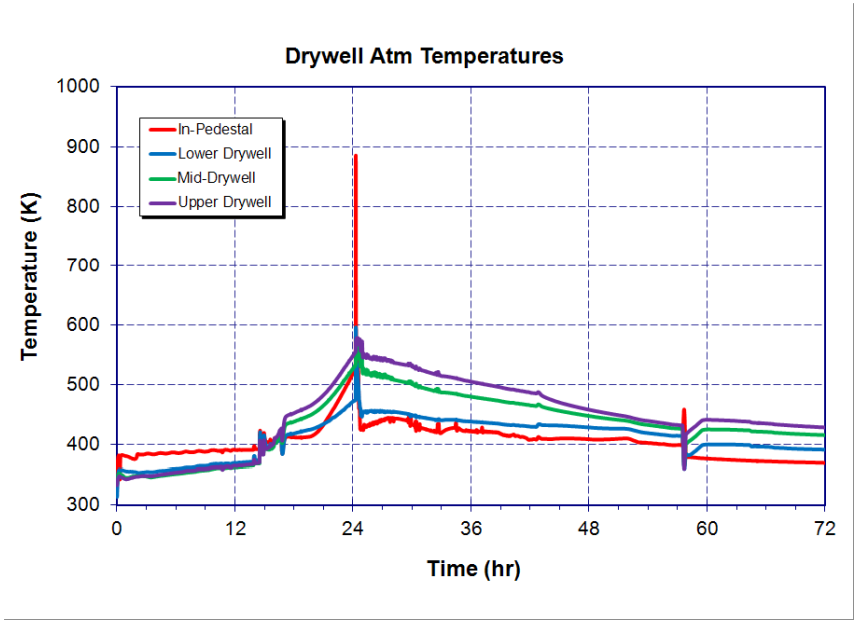


MELCOR Results (DW Temperature)

Case 1
(no injection)

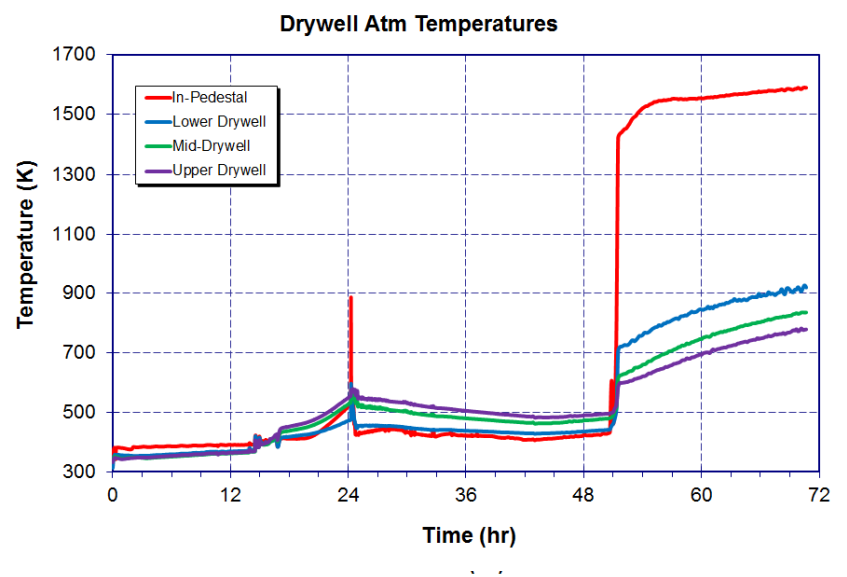


Case 10
(RPV injection)
(no WW level control)

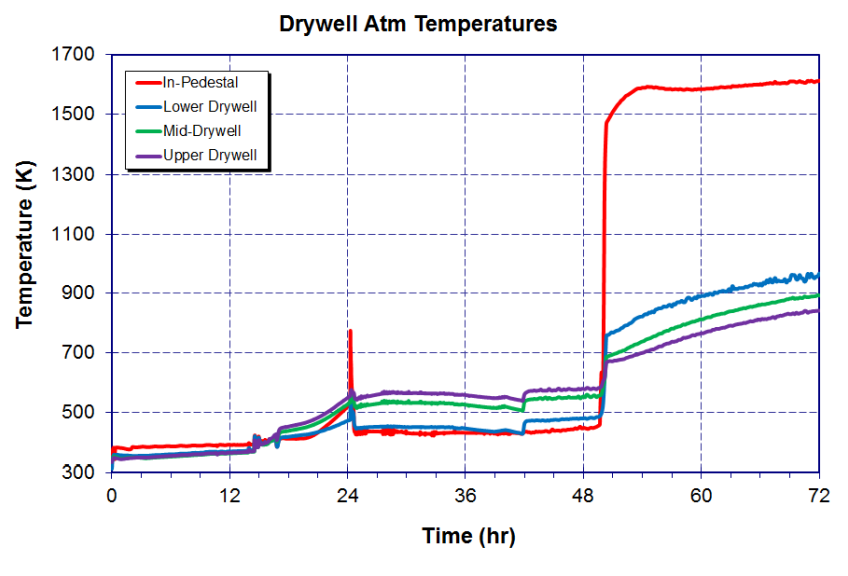


MELCOR Results (DW Temperature)

Case 7
(RPV injection)



Case 21
(DW spray)



Acronyms and Abbreviations

- ACRS – Advisory Committee on Reactor Safeguards
- APET – Accident Progression Event Tree
- BWR – Boiling Water Reactor
- BWROG – Boiling Water Reactor Owners Group
- CDET – Core Damage Event Tree
- CST – Containment Storage Tank
- DF – Decontamination Factor
- DW – Drywell
- EDO – Executive Director for Operations
- ELAP – Extended Loss of AC Power
- EPG – Emergency Procedure Guidelines
- EPRI – Electric Power Research Institute
- FLEX – Diverse and Flexible Coping Strategies
- MACCS – MELCOR Accident Consequence Code System
- MSL – Main Steam Line
- NEI – Nuclear Energy Institute

Acronyms and Abbreviations

- NRC – U.S. Nuclear Regulatory Commission
- NRR – Office of Nuclear Reactor Regulation
- PCPL – Primary Containment Pressure Limit
- PRA – Probabilistic Risk Assessment
- PSIG – Pound per Square Inch
- RCIC – Reactor Core Isolation Cooling
- RES – Office of Nuclear Regulatory Research
- RPV – Reactor Pressure Vessel
- SAG – Severe Accident Guidelines
- SAMG – Severe Accident Management Guidelines
- SP – Suppression Pool
- SRM – Staff Requirements Memorandum
- SRV – Safety Relief Valve
- TSC – Technical Support Center
- WW – Wetwell