Initial Assessment of EPRI Technical Report "Investigation of Strategies for Mitigating Radiological Releases in Severe Accidents"

Japan Lessons Learned Steering Committee
October 9, 2012

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Purpose

- Information briefing
  - Provide an overview of the EPRI report
  - Discuss preliminary observations
  - Assess fundamental differences between the EPRI and NRC staff approaches

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EPRI Study

- Purpose
  - Investigate strategies to reduce fission product releases and land contamination
- Scope
  - Mark I and II containments
- Station blackout sequences
  - 4 hour RCIC
- MAAP
- Metric – Cs release / integral decontamination factor

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Mark I "Strategies" Evaluated

- Base case
  - No venting or core debris cooling
- Containment venting
  - Reliable hardened vent
  - External torus spray with reliable hardened vent
- Core debris cooling
  - Containment flooding
  - Drywell sprays
- Containment venting and core debris cooling
  - Containment flooding with reliable hardened vent
  - Drywell spray with reliable hardened vent
  - Containment flooding with controlled reliable hardened vent
  - Spray and controlled reliable hardened vent
- Calculated decontamination factors from 8 to 3594

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Mark I Accident Progression

In-Vessel Phenomenon (Minor variations in timing for sequences)	Time (hr)
Reactor Trip	0.0
RCIC Lost due to Loss of dc Power	4.0
Core Uncovered	5.2
Onset of Core Damage	6.1
SRV Seize Open	6.1
Core Material to Lower Plenum	8.8
Reactor Vessel Breach	12.0

Containment Failure Modes	Time (hr)
Liner Melt-Through	12.2-12.3
Wetwell Venting	11.9-12.1
Drywell Venting	17.9-67.0
Drywell Leakage	12.0-63.7
Drywell Overpressurization	12.5

Options	Time (hr)
Initiate Torus External Spray	5.0
Initiate Drywell Flooding	5.0
Secure DW Flood due to hi DW level	52.1-52.2
Initiate Drywell Sprays	5.0
Secure DW Sprays due to hi DW level	49.7-58.3
Cycle Wetwell Vent	11.9-17.9
Close Wetwell Vent due to hi SP level	16.8-17.9
Cycle Drywell Vent	17.9-72.0

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Mark II "Strategies" Evaluated

- Considered same cases as those for Mark I except external torus spray
- Bifurcation - Results significantly influenced by failure of drywell drain pipe running through wetwell airspace resulting in bypass of suppression capability
- Calculated decontamination factors from 6 to 1000

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Sensitivity Analysis

- Core damage timing
- Reactor vessel pressure
- Early containment venting for hydrogen control
- Early containment venting for pressure control
- Spray water droplet diameter
- Spray aerosol removal efficiency
- Spray flow rate
- Core debris flow to suppression pool
- In-vessel recovery
- Reliable hardened vent sizing

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Staff Views on EPRI Insights

- Staff agrees
  - No single strategy is effective
  - Active core debris cooling is required
  - Existing SAMGs provide substantial benefit
  - Venting prevents uncontrolled release and manages hydrogen
- Staff concerns
  - Spraying the containment atmosphere is beneficial
    - Effectiveness at low flow rates, consideration of geometry?
  - Control of the vent provides benefit
    - Feasibility and reliability of operator actions and WW/DW switchover?
  - Low-efficiency filters can further reduce radioactive releases
    - Is low-efficiency sufficient in light of uncertainty?

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Observations - General

- Analytical code calculations are not "strategies"
  - Strategies could potentially be developed from the analytical insights
- States that a "highly conservative set of assumptions" was used
  - Not necessarily obvious (e.g., timing, spray flow rates, decontamination due to suppression pool temperature and spray coverage, operator actions)
- Differences in problem statement much more significant than differences in analytical models

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Observations – Controlled Venting

- Automatic vs. manual
  - Automatic system response time 1 minute
  - Manual response time 5 minutes
    - Not sufficient to achieve DF desired
- Instrumentation
  - Containment pressure instrumentation
  - Containment level instrumentation (swapover to DW venting)
- Locations for controlled venting
  - Wetwell first
  - Swapover to drywell

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Observations – Controlled Venting

- Sept 27 Steering Committee statement
  - Manual venting twice in 1st 24 hours and once in next 24 hours
- Pressure plots from EPRI report 1026539

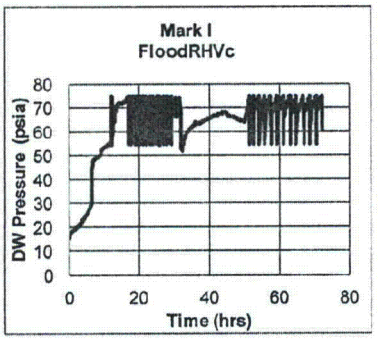

Figure B-43
Mark I, FloodRHVc, drywell pressure

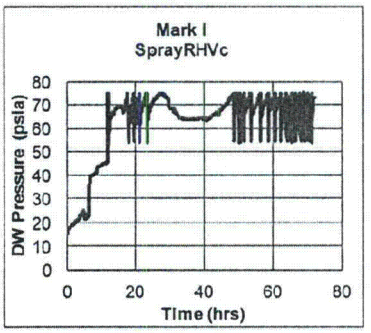

Figure B-49
Mark I, SprayRHVc, drywell pressure

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Observations

- Discounts the state of art for filters
  - States that substantial research and testing is likely necessary
- Concludes that plant-specific analyses would be necessary to optimize implementation

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Most Important Slide

"Two Acceptable Approaches – Fundamentally Different Results"

Industry

- Purpose - Minimize land contamination due to potential releases
- Belief - High confidence in Mark I & II containments, plant systems, and analytical codes
- Maximize use of existing systems
- More active management of containment and other systems following a severe accident

NRC Staff

- Purpose - Evaluate Mark I and II containment vulnerabilities to improve defense-in-depth
- Belief – Greater level of uncertainty in Mark I and II containments, plant systems, and analytical codes
- Provide additional tools for response
- Minimize need for operator actions through incorporation of some "passive" aspects

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Result of Differences in Approaches Decontamination Factors

Industry

- Evaluate integrated ability of plant to limit radionuclide release
- Inverse of entire radionuclide release fraction to environment
  - DF=(1/(1-.5-.32-.08-.07-.0288))=893
- Accounts for release, transport, deposition, and hold up
  - Reactor core and vessel
  - Reactor coolant system
  - Drywell and wetwell
  - Suppression Pool
  - Reactor Building
- Consistent with risk-informed regulation

NRC Staff

- Evaluate design to improve containment defense-in-depth
- Inverse of radionuclide release fraction exiting filter
  - DF=(1/(1-.99888))=893
- Accounts for filtering mechanisms only
- Consistent with addressing weaknesses in design
- Consistent with approach in other countries (assumes severe accident with release will occur and need to mitigate it)

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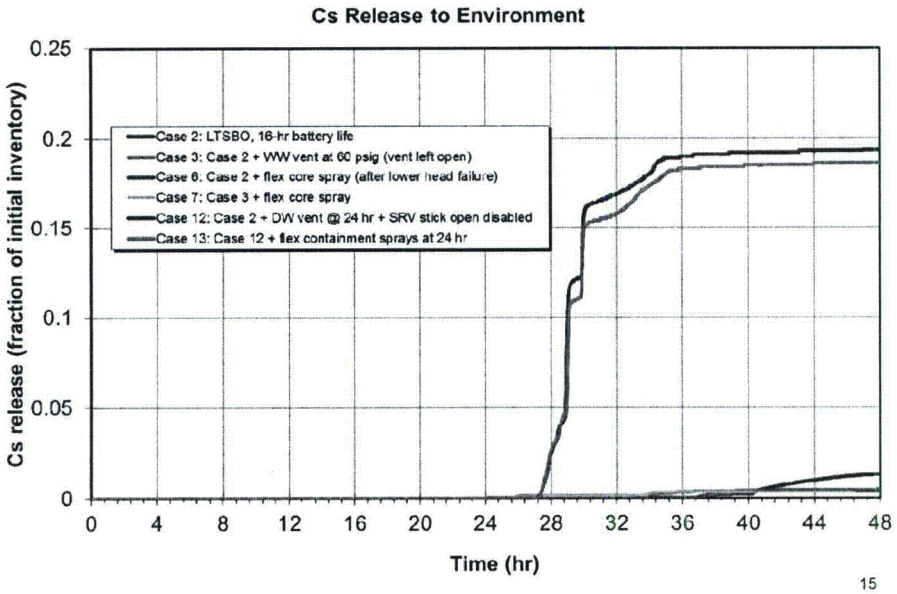
Differences in Releases (DW vs. WW release)



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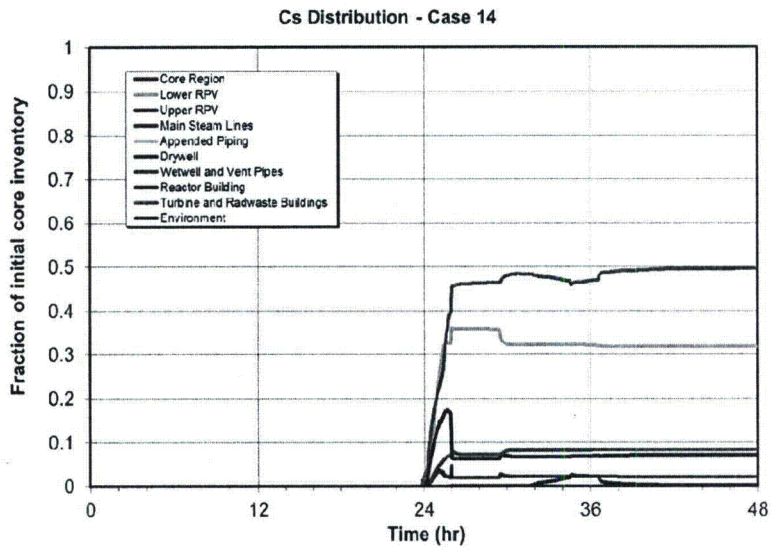
Integrated Fission Product Holdup



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Result of Differences in Approaches Regulatory Analysis

Industry

- Focus will be on the quantitative results to reduce land contamination

Staff

- Focus will be on the qualitative arguments for defense-in-depth

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NEI 10/5/12 Letter

- Plan for moving the issue forward
- Consistent with past views
  - Various filtration strategies should be used
  - Restates EPRI report conclusions
  - Discounts state of the art in filter technologies
  - Endorses a performance-based approach
- Plant specific analysis, modification, and implementation
- Significant time and effort
  - 24+ months for evaluation approach
  - Subsequent time and effort for analysis, engineering, installation, testing, etc.

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NEI 10/5/12 Letter

- Feedback on NRC 9/21/12 letter
  - Operator reliability during a severe accident
  - Containment vent control
  - Hydrogen control
- Issue should be more integrated into NTTF Recommendation 1, Risk-Management Task Force report, and Economic Consequences post Commission Paper efforts
- May require public meeting to further discuss
- Will be reflected in Commission paper
- Should a performance-based approach be extended to all designs
  - No longer focused on addressing perceived/real "weaknesses" in Mark I and II containment designs

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Conclusions

- One's views of the Mark I and II containment design and response to severe accidents fundamentally influences the approach and assessment
  - NTTF Recommendation is focused on the containment's design
- Progress with industry will be limited unless alignment on the issue is achieved
  - Containment design: More limited set of potential fixes
  - Land contamination: Broader set of potential fixes

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