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Investigation of Strategies for Mitigating Radiological Releases in Severe Accidents

BWR Mark I and Mark II Studies

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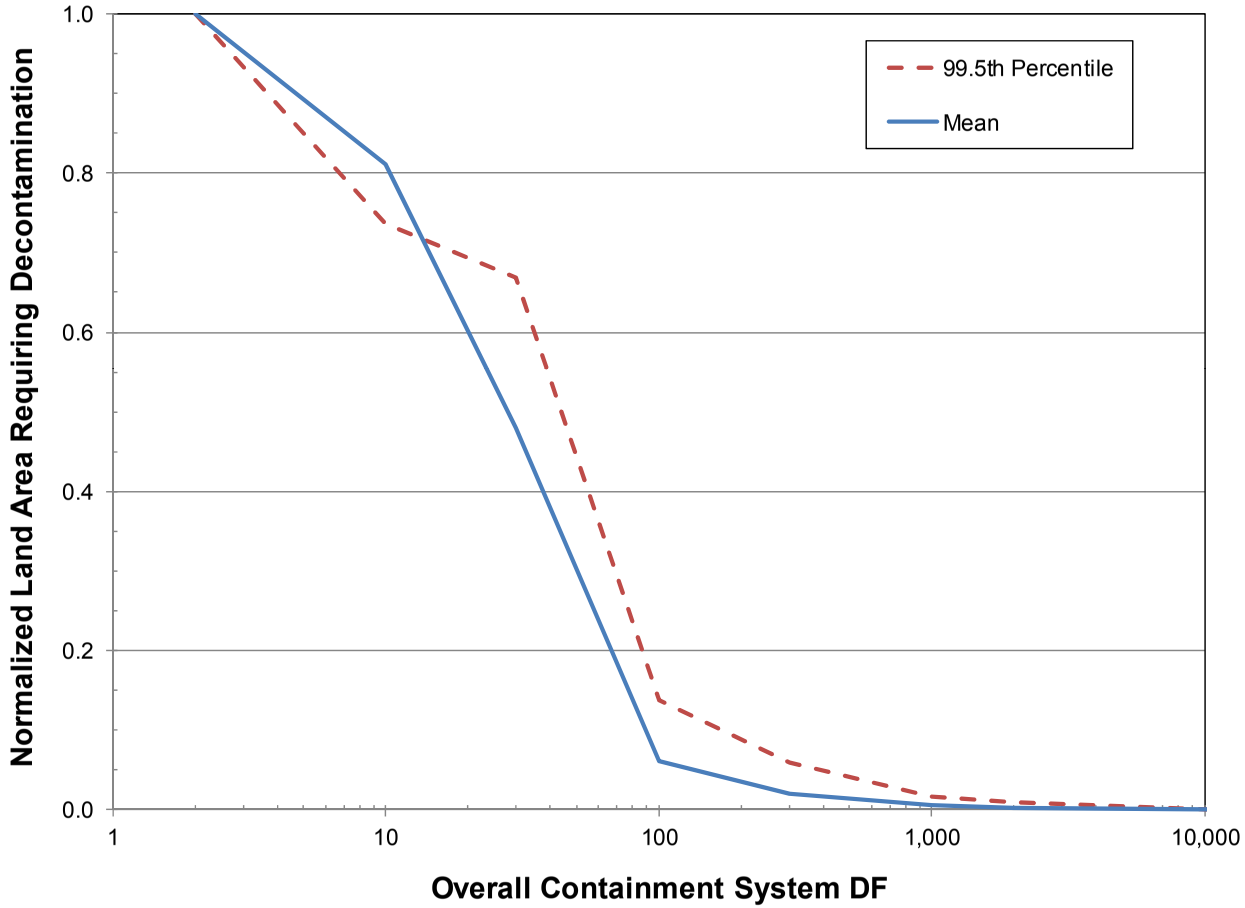
Topics

- EPRI's use of MAAP and MAACS2 to evaluate strategies to reduce radioactive release following a severe accident
  - Introduction
  - Selection of representative scenarios and viable strategies
  - MAAP models, assumptions, and output
  - Sensitivity analyses
  - Insights and conclusions

Introduction

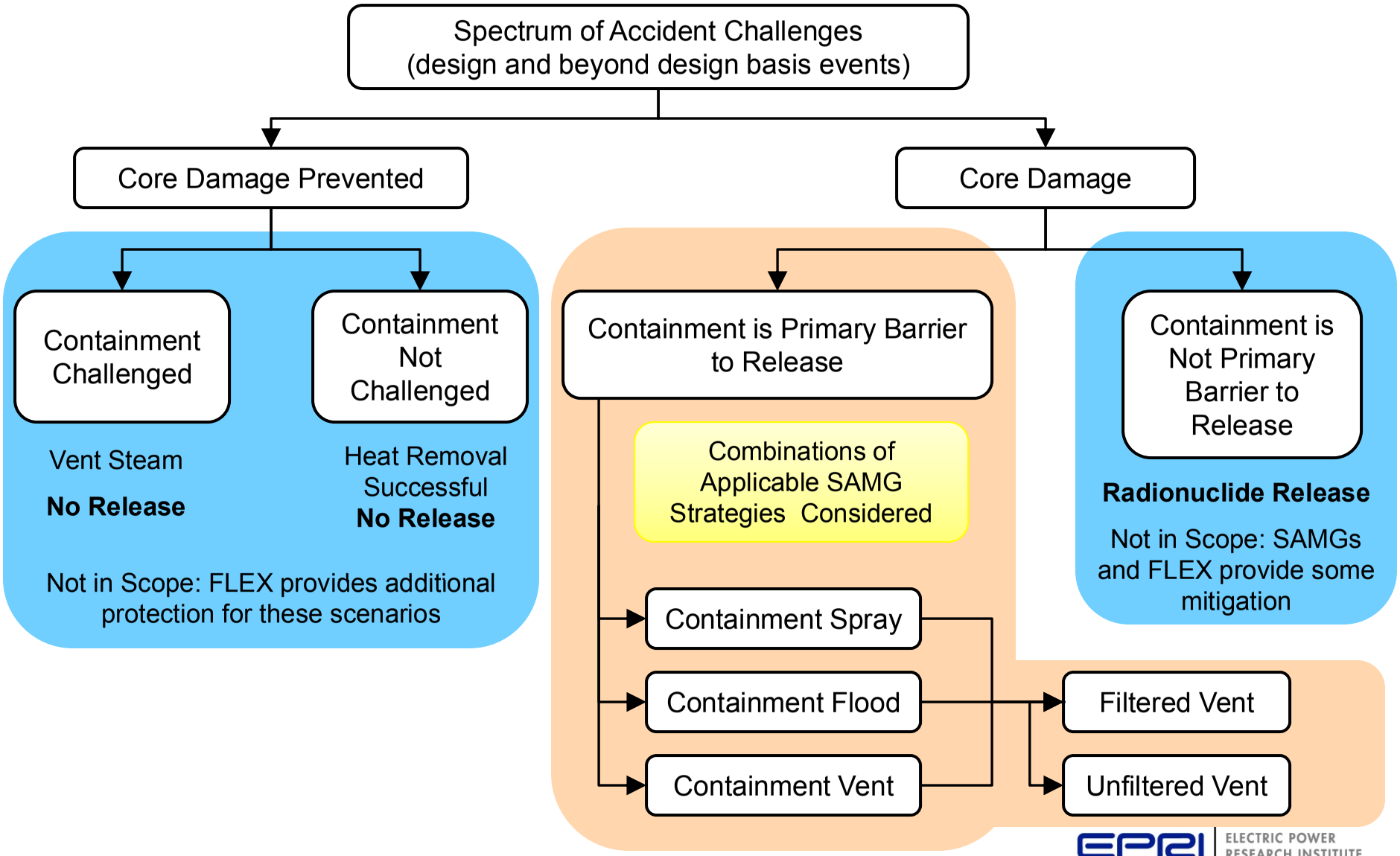
- Best way to avoid radiological release is to prevent core damage
- Containment function is to retain fission products and the most effective strategies should maximize the retention within containment
- The goal of the EPRI work is to assess strategies for mitigating releases to the environment in a severe accident

Land Contamination Figure of Merit



Diminishing Benefit as Decontamination Factor (DF) Approaches 1000

Containment Enhancement Scenarios Evaluated



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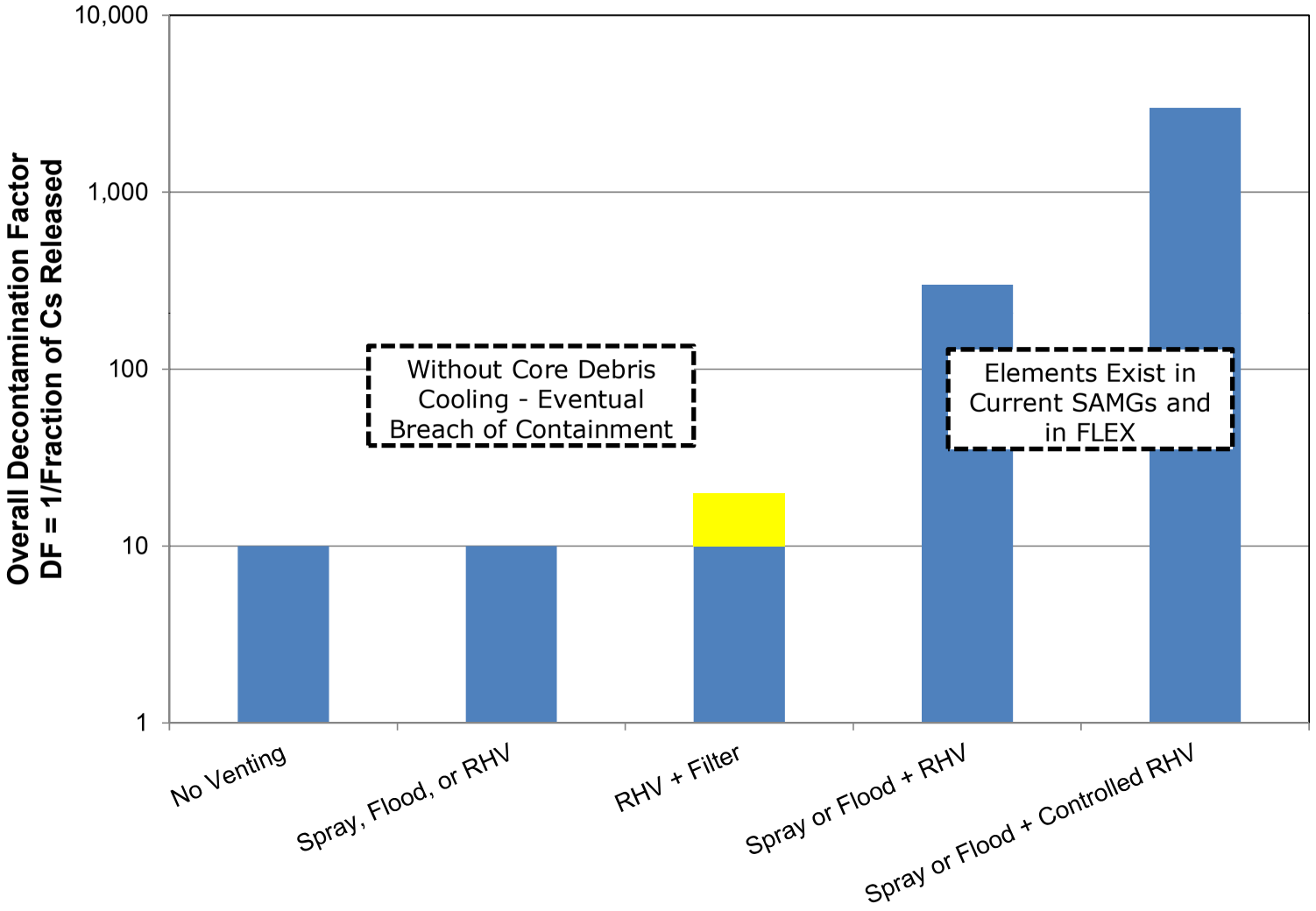
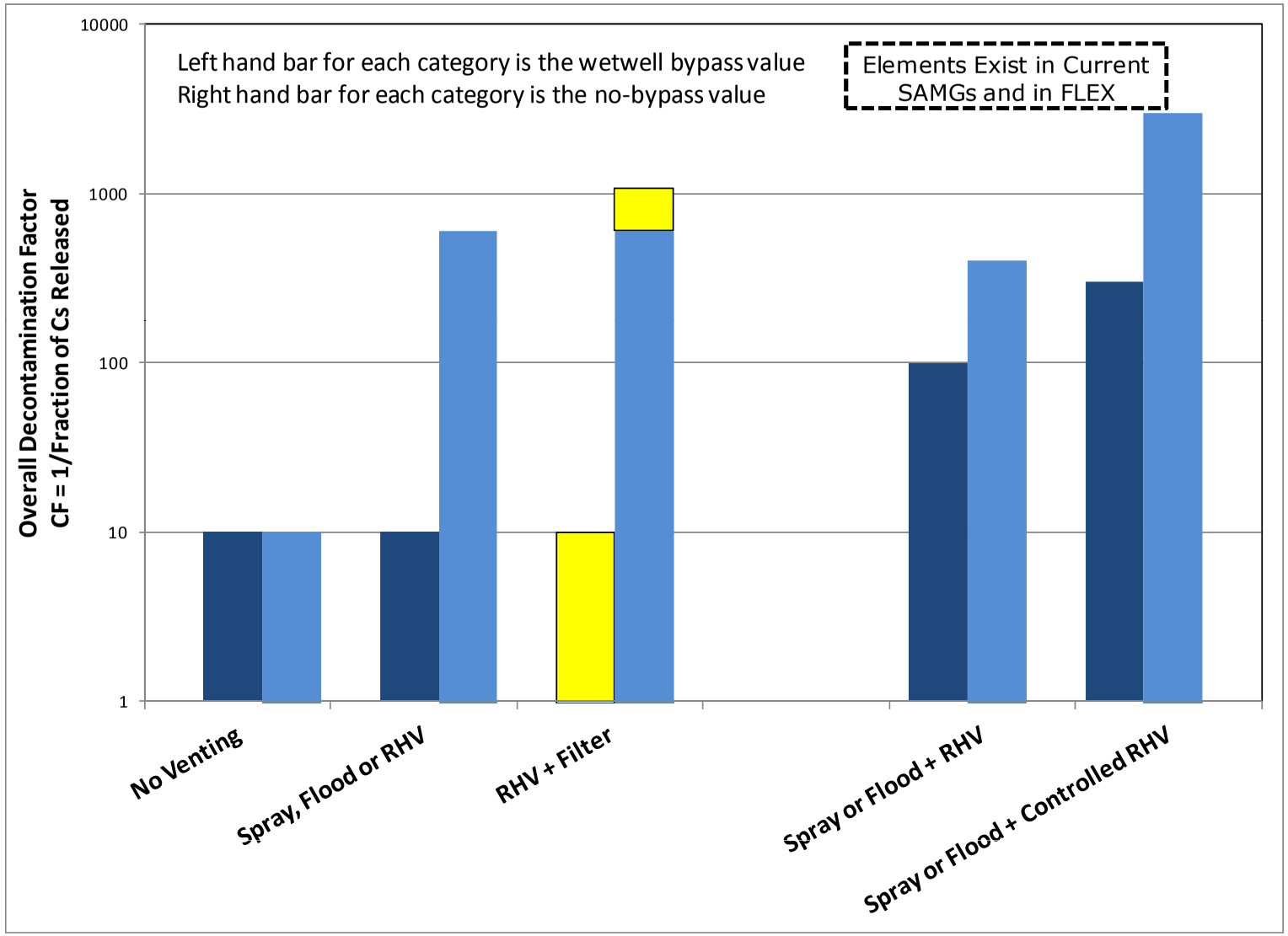
Objective Analysis of Mitigation Options

- Focus on strategies that can achieve a high DF
- Understand release drivers
- Comprehensive sensitivity studies
  - Deal with uncertainty
  - Identify plant specific attributes
  - Identify phenomena that can affect results
  - Provides robust conclusions

Representative Results for BWR Mark I Strategies

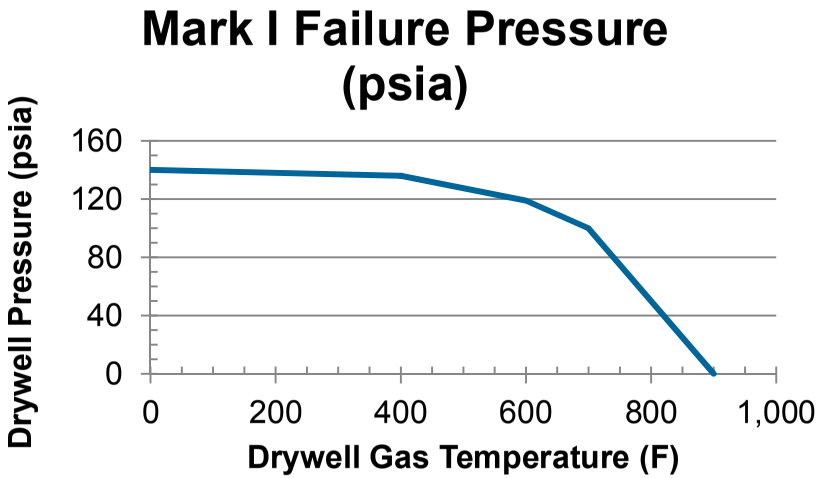


Representative Results for BWR Mark II Strategies



Mark I Containment – Baseline Assumptions

- Station Blackout (SBO) with Reactor Core Isolation Cooling (RCIC) for 4 hours
- 36 GPM seal leakage at t=0
- Single Safety Relief Valve (SRV) seizes open at onset of core damage
- Vessel breach due to melting of Control Rod Drive (CRD) penetration weld
- Drywell shell failure assumed to occur 15 minutes after vessel breach if no injection or spray
- Wetwell vent closed if pool level exceeds 21 feet
- Vent controlled between 60-40 psig
- Secure flood/spray if drywell water level exceeds 59 feet
- Drywell failure area = 2 ft^2
- Mark I failure criteria:



Sensitivity Analyses

- Helps to completely understand the nature of the results
- Ensure robust insights and recommendations
- Variability of input
- Key areas of uncertainty

- In-vessel recovery
- Early Venting
  - Open at 40 psia and close at 18 psia
- RPV Pressure
- Drywell spray droplet diameter
  - Nominal value = 0.012 ft
  - Sensitivity value = 0.12 ft
  - Sensitivity value = 0.12 ft plus early wetwell venting
  - Performed for Spray and Controlled RHV case
- Drywell spray aerosol removal efficiency
  - Nominal value = 0.02
  - Sensitivity value = 0.002 and 0.0002
  - Performed for Spray and Controlled RHV case
- RCIC operation timing
  - 0,4,8, and 12 hours
  - Performed on Spray and RHV case
- Spray/Injection flow rate
  - 100, 500 gpm
  - Flood and spray

Insights

- Existing SAMG strategies provide substantial benefit
  - Active core debris cooling is required
  - Spraying the containment atmosphere is beneficial, but not required
  - Venting prevents uncontrolled release and manages hydrogen
- Additional insights
  - No single strategy effective
  - Control of the vent can provide significant benefit
  - A low DF filter can further reduce the radionuclide release
  - Protection of sump drain lines in Mark II containment beneficial

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