U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

Filtering Strategies for BWR Mark I and Mark II Containments Rulemaking

June 13, 2013

Enclosure 2

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

Acronyms

- AC – Alternating Current
- ACRS – Advisory Committee on Reactor Safeguards
- ATWS – Anticipated Transient Without Scram
- AOP – Abnormal Operating Procedures
- BWR – Boiling Water Reactor
- CD – Core Damage
- CFR – Code of Federal Regulations
- DC – Direct Current
- DF – Decontamination Factor
- EDMG – Extreme Damage Mitigating Guidelines
- ELAP – Extended Loss of AC Power
- EOP – Emergency Operating Procedures
- LCF – Latent Cancer Fatalities
- LMT – Liner Melt-Through

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

Acronyms

- MACCS – MELCOR Accident Consequence Code System
- MSL – Main Steam Line
- NTE – Not To Exceed
- PRA – Probabilistic Risk Assessment
- RCIC – Reactor Core Isolation Cooling
- RCS – Reactor Coolant System
- RPV – Reactor Pressure Vessel
- SAMG – Severe Accident Management Guidelines
- SOARCA – State-of-the-Art Reactor Consequence Analyses
- SRM – Staff Requirements Memorandum
- SRV – Safety Relief Valve
- STSBO – Short-term Station Blackout
- VB – Vessel Breach

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

Agenda

- Process and schedule
- Scope
- Performance based requirements
- Accident scenarios
- Mitigation actions
- Alternatives
- Uncertainties
- Testing to reduce uncertainties
- Next Steps

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

Process and Schedule

- Rulemaking Working Group formed
- SRM-SECY-12-0157 directed:
  - Technical basis due March 19, 2014
  - Proposed rule due March 19, 2015
  - Final rule due March 19, 2017
- Engage Advisory Committee on Reactor Safeguards and stakeholders
- Provide policy issues to Commission

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

Detailed Schedule (Technical Basis)

Draft Technical Basis
(ACRS Briefing)

Public Comment Period

Final Technical Basis
(ACRS Briefing)

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

NRC Process for Draft Technical Basis

Feedback and resolution on topics discussed at this meeting

Develop Event Tree Probabilities

Perform Accident Sequences and Accident Progression Analysis (MELCOR)

Perform Offsite Consequences Analysis (MACCS)

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

Scope

- Containments
  - BWR Mark I and Mark II Containments
- Performance based regulation
  - NUREG 1860

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

Performance Based Requirements

- 3 Tiers for Performance Based Requirements
  - Performance Goal
  - Performance Objective
  - Performance Measure

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

Performance Goal

- Prevent the release of significant amounts of radioactive material following the dominant severe accident sequences through filtering strategies with dry well filtration and severe accident management
  - Based on SRM-SECY-12-0157

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

Performance Objectives

- Reduce the conditional failure probability of Mark I and Mark II containments:
  - For containment failure from liner melt-through; and
  - For severe accident over-pressure/over-temperature conditions
- Provide adequate decontamination of controlled (venting) and uncontrolled (diffuse) fission product releases
- Remove heat from core debris in the reactor vessel and in the primary containment
- Vent hydrogen from primary containment and away from onsite buildings and structures

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

Performance Measures

NRC	Rationale	Industry	Rationale
Integrated radionuclide release over xx hours NTE yy% of core inventory	Top level performance measure - Relatable to person-rem metric and offsite cost metric used in regulatory analysis - Relatable to health risk (prompt fatalities, LCF)		
Decontamination factor (DF) of 10^N or more	Second level performance measure - Relatable to integrated radionuclide release		
Adequate and reliable water injection into RPV and/or containment	Possible performance goal - Maintain RPV integrity - Prevent vessel failure - Minimize radionuclide release from RPV - Prevent dry well liner melt-through - Control dry well temperature	Adequate and reliable water injection into RPV and/or containment	Possible performance goal - Relatable to RPV integrity - Relatable to containment integrity - Relatable to controlled dry well temperature - In-containment filtration of radionuclides
Controlled venting	Possible performance goal - Prevent containment failure and radionuclide releases - Prevent hydrogen releases to reactor building	Controlled venting	Possible performance goal - Relatable to containment integrity - Relatable to controlled dry well temperature - Suppression pool filtration
		Capability of external filter	Possible performance goal - Further reduce radionuclide releases
		Operator training	Possible performance goal - Reliable utilization and operation of EOPs, SAMGs, and FLEX

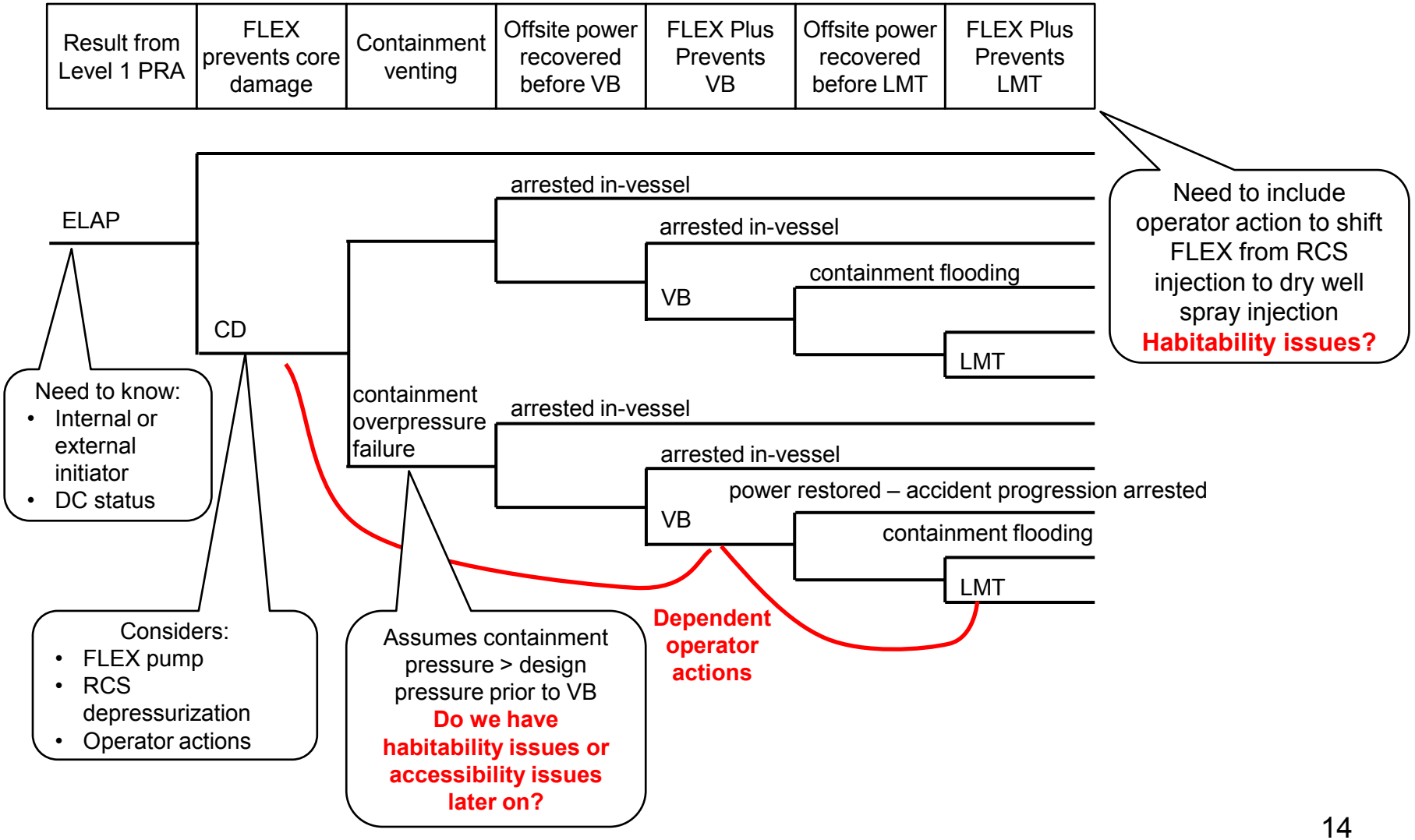
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Accident Scenarios

- Focus on risk-significant sequences
  - Informed by Fukushima
  - Built on SOARCA and earlier PRA studies
  - Commission Guidance
- Base-case: Extended Loss of AC Power (ELAP)
  - Include SRV failures, induced MSL creep rupture, vessel breach, seal failures, etc.
- Additional scenarios of low probability & high consequence events
  - Loss of containment heat removal, etc.
  - ATWS will not be included

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

Example Event Tree



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

Mitigation Actions

- Mitigation actions:
  - RCIC
  - SAMG/EOP/EDMG/AOP
  - RPV depressurization by operator (some cases)
  - Core and dry well spray (10 CFR 50.54(hh) and FLEX)
  - Containment venting
- Determinations needed for:
  - Timing of RCIC
  - Size and timing of dry well spray
  - Timing of venting
- Sensitivities required

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

Alternatives

- Question: How to handle containment flooding in Base Case vs. Alternatives?
  - What is assumed for base case vs. alternatives?
  - Should some enhanced capability of containment flood be handled as a stand-alone alternative?
  - What would the enhanced capability be? What if just adding a filter? What if employing water management?

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

Alternative 1 – Base Case

- Mark I – ELAP + severe accident capable wet well vent + severe accident dry well vent + some containment flood?
- Mark II – ELAP + severe accident capable wet well vent + severe accident dry well vent + some containment flood?
- Sensitivity: plant-specific probability of wet well bypass and cost to fix

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

Alternative 2

- Add engineered filter (24 hours of passive operation) to dry well and/or wet well vent line + some enhanced containment flood?
- Costs: construction and installation of equipment, training, testing, and guidance document development
  - Costs of different filters, dry well only option
  - Available industry cost estimates requested

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

Alternative 3

- Plant-specific filtering strategies
  - Water management for decontamination and venting
    - Full enhanced containment flood included by definition of water management?
- Costs: PRA, testing, training, construction and installation of equipment, development of guidance documents
  - Available industry cost estimates requested

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

Uncertainties

- Human Factors/Performance
- Level 2, Level 3 PRA
  - NUREG/CR-7155 (Draft)
- Suppression pool/core debris pool DF
- Dry well spray debris coverage/cooling and DF
- Other decontamination processes
- Instruments
- Engineered filter performance
- Upper dry well temperature rise and the impact on penetration leakage and head flange leakage

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

Testing to Reduce Uncertainties

- Dry well spray DF performance in actual containment – integrated testing
- Engineered filter performance
  - Determine applicability/coverage of vendor test data
  - Identify any additional testing needed

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

Info needed from licensees

- Purpose: Ensure staff has information critical to providing the Commission with a high quality technical basis for filtering strategies rulemaking as directed in SRM-SECY-12-0157
- Consequences of not getting the information: Staff will not be able to (1) give credit for spray and pool decontamination factors in filtering strategies, or (2) determine acceptability of any generic models proposed by industry.
- Scope: Mark I and Mark II BWRs (31 plants, 19 sites)
- Level of detail – suitable for MELCOR/MAAP modeling, include drawings when possible

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

Info needed from licensees

- Dry well spray header configuration and nozzle data – e.g., locations, size, nozzle design, etc.
- Wet well spray header configuration and nozzle data
- Mark I suppression pool wet well (suppression pool) configuration – e.g., key penetration elevations, volume, etc.
- Mark II wet well (suppression pool) configuration - e.g., key penetration elevations, volume, etc.
- Mark I dry well floor configuration, including pedestal area
- Mark II dry well (diaphragm) floor configuration, including pedestal area (drawings recv'd and under review)
- Primary system relief valve data, including any relief directly to the dry well
- Dry well head seal configuration and design data
- Configuration of dry well spray interferences (equipment between the spray header and the dry well floor that affects fall height, droplet shape)
- RCIC plants – turbine/pump performance specifications

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

Next Steps/Takeaways

- Begin developing Draft Technical Basis
- Next public meeting(s)
- Expected deliverables and due dates