Dose Analysis for Design Basis Accidents

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Outline

- History
- Regulatory requirements
- Purpose of analysis
- Dose analysis basics
- Tools
- Products
- Summary

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History

- Siting critical issue
  - Safety & Cost
- Principle hazard – Public Exposure
  - Siting key element in protecting public health
- Earliest reactors used containments
- AEC proposed siting on population densities – judged too rigid
- Final compromise - dose calculations

4. Site of proposed Ravenswood nuclear plant in New York City. The Empire State Building is at the lower left; the United Nations is in the center along the East River. (AEC Docket 50-204)

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Ravenswood

- 1962
- Availability / reliability of fuel, transmission costs, concerns over air pollution
- East Queens River
- Daytime pop. within 5 miles - 5 Million
- Proposed PWR 1000 MWe – Largest in world
- Could not meet AEC site guidelines
- Con Edison canceled plant.

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Regulatory Requirements

- 10 CFR Part 100 – “Reactor Site Criteria”
- 10 CFR 50.67, “Accident Source Term”
- 10 CFR 50.34, “Contents of applications; technical information”
- 10 CFR 50, Appendix A, GDC 19, “Control Room”

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Plain Language

- Licensee required to calculate offsite and control room doses following a maximum credible accident.
- Licensees must demonstrate dose criteria are met by the plant design.
- Does not establish acceptable doses, but provides a test for low probability / high consequence events.

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Purpose of Analysis

- Site suitability (establishing plant boundaries)
- Control room habitability
- Test safety systems (containment leak rates, filtration systems, sprays etc.)
- Used for new plant reviews & amendments for existing plants (modifications to plant design or technical specification)

Other analysis

- Equipment qualification (Radiation)
- Post-accident vital area access

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Dose Analysis Basics

- Design Basis Accident
- Assumptions / Requirements
- Source
- Pathway - Transport/Removal
- Receptors - Dose Location
- Criteria

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Design Basis Accident

- Surrogate – enables evaluation of responses of engineered safety features.
- Intentionally conservative to address uncertainties in accident progression, fission product transport and atmospheric dispersion.
- LOCA, SGTR, MSLB, Locked Rotor, CRDA, Rod Ejection, Letdown line Break, FHA….
- Acceptable methodology – RG 1.183 & 1.195

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Assumptions & Requirements

- One initiating event (LOCA, MSLB)
- Limiting single failure (typically loss of ESF train by failure of a DG)
- LOOP
- Credit only for QA Cat. 1 components
- Credit only seismically qualified components
- Assumed to fail in worst configuration

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Source Term - Containment

Maximum credible accident

- Assumed significant core-melt accident releases to the containment… “not to be exceeded” by any credible accident
- TID-14844 - 1962
  - Instantaneous, primarily elemental iodine
- NUREG-1465 - 1995
  - Delayed release, primarily aerosol

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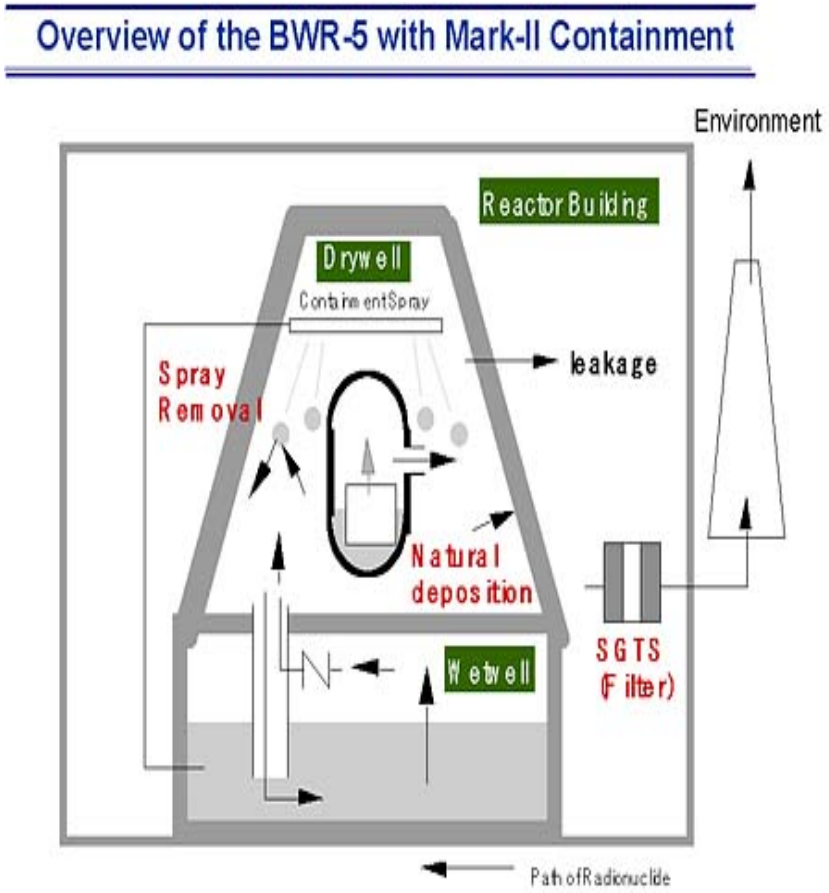
Pathways – BWR Examples

- From Source to Environment
  - Drywell Leakage
  - Rx Building Leakage
  - HVAC – SGTS
  - ESF Leakage
  - Bypass Leakage
    - MSIV



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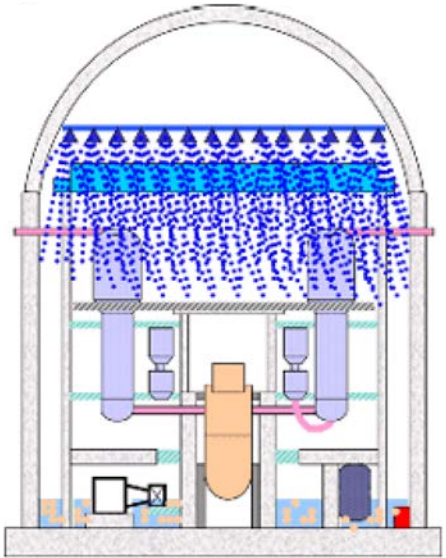
Pathway - Removal by ESF Systems

- Primary Containment / Secondary Containment
- Containment Sprays
- Reactor Containment Fan Coolers
- Standby Gas Treatment Systems
- Control Room Emergency Filtration System
- Containment Purge System
- Standby Leakage Control System
- Isolation Valves
- Suppression Pool
- Ice Condensers



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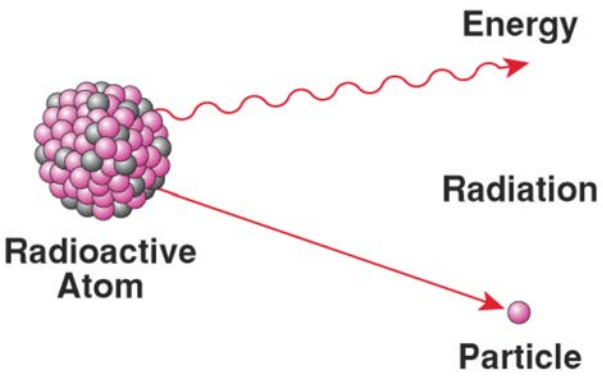
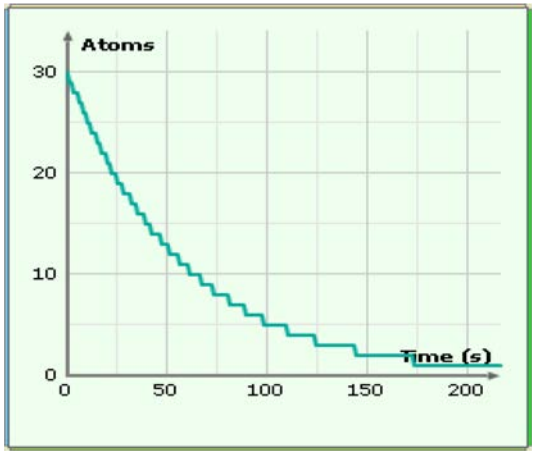
Pathway - Removal by Natural Processes

- Gravitational Settling
- Atmospheric Dispersion
- Decay





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Pathways – Environment to CR

- Control Room Dose
  - Intake of radioactive plume (from outside)
  - Infiltration of radioactivity from adjacent rooms
  - Shine from external plume
  - Shine from reactor containment
  - Shine from buildup on components (filters etc.)

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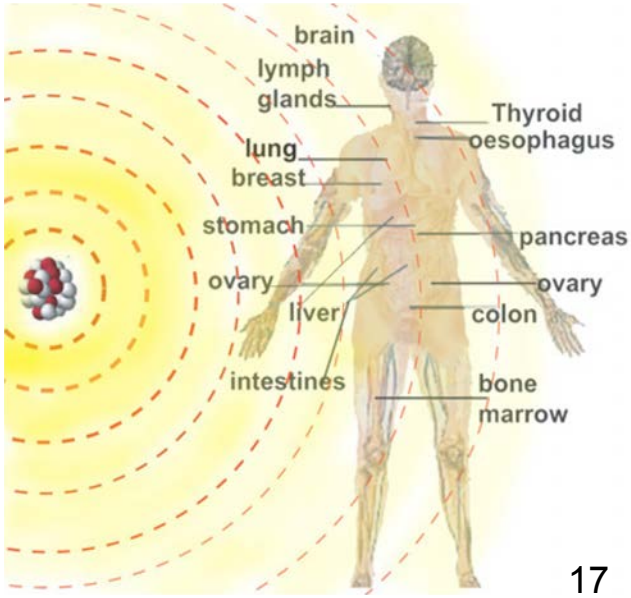
Receptor- Dose Locations (LOCA Criteria)

- Person at Site Boundary – (25 Rem TEDE)
- Person at Low Population Zone – (25 Rem TEDE)
- Control Room Operator – 5 Rem TEDE

TEDE – Total Effective Dose Equivalent (See 10 CFR 50.2)



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Tools

- ORIGEN (Core Inventory)
- ARCON96, PAVAN (Meteorology – Atmospheric Dispersion, RG 1.194)
- RADTRAD – Dose Calculation
- QAD / Microshield / MCNP - Shielding
- SCALE

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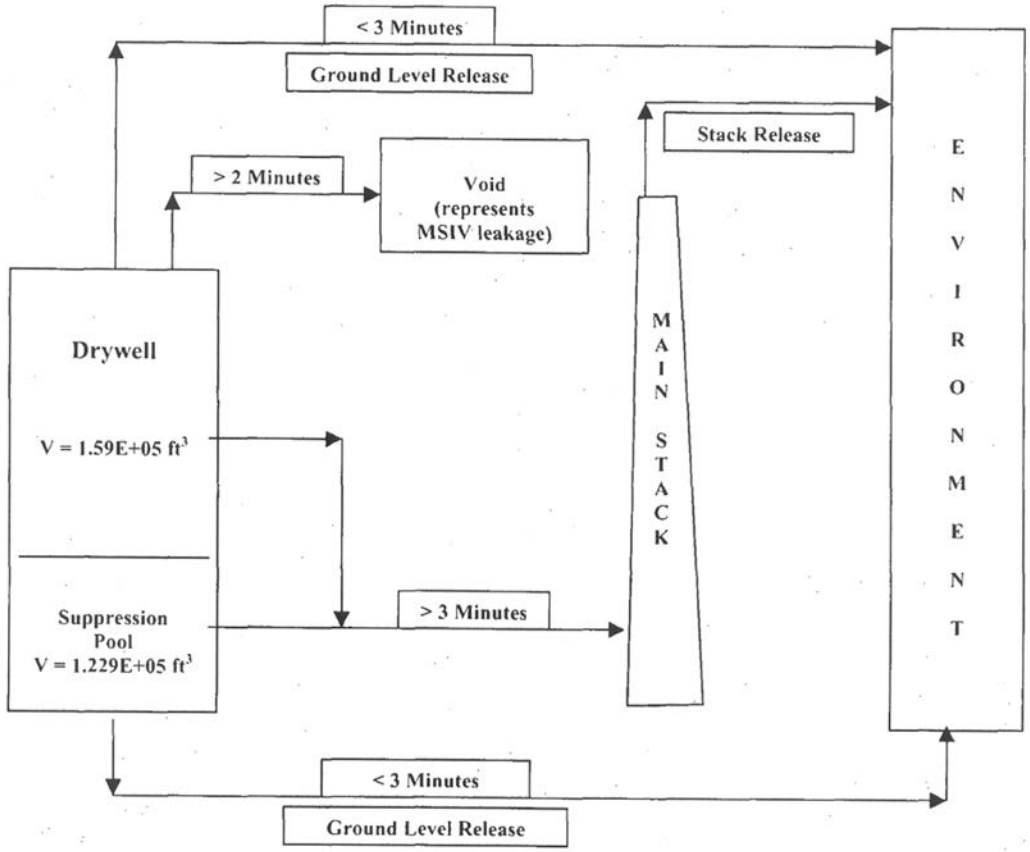
RADTRAD Model – BWR



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Products

- Confirmatory Analysis
- Safety Evaluation
- Enforcement Discretion

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Summary

Design basis dose analyses:

- Are used to determine what measures and barriers are necessary to protect operators and the public if we are wrong about the plants response to events.
- Use a stylized, simplified and conservative approach documented in RG 1.183 and RG 1.195 (maximum credible source term, transport, deposition).
- Are required by regulation for siting and ongoing assessments of safety systems.

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References

1. NUREG-1465, “Accident Source Terms for Light-Water Nuclear Power Plants,” ADAMS Accession No. ML041040063.
2. RG 1.183, “Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors,” ADAMS Accession No. ML003716792.
3. RG 1.194, “Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants,” ADAMS Accession No. ML031530505.
4. RG 1.195, “Methods and Assumptions for Evaluating Radiological Consequences of Design Basis Accidents at Light-Water Nuclear Power Reactors,” ADAMS Accession No. ML031490640.
5. TID-14844, “Calculation of Distance Factors for Power and Test Reactor Sites,” ADAMS Accession No. ML083380438.

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Acronyms

- AEC – Atomic Energy Commission
- BWR – boiling water reactor
- CFR – *Code of Federal Regulations*
- CR – control room
- CRDA – control rod drop accident
- DG – diesel generator
- ESF – engineered safety feature
- FHA – fuel handling accident
- GDC – General Design Criterion

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Acronyms

- HVAC – heating ventilation and air conditioning
- LOCA – loss of coolant accident
- MSIV – main steam line isolation valve
- MSLB – main steam line break accident
- PWR – pressurized water reactor
- QA – quality assurance
- RG – regulatory guide
- Rx - reactor
- SGTR – steam generator tube rupture accident
- TEDE – total effective dose equivalent

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Backup Slides

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BWR Source Term

	NUREG 1465		TID 14844
	Gap	Early In-vessel	
Duration (hours)	.5	1.3	Instant.
Noble Gases (%)	5	95	100
Halogens (%)	5	25	50
	Elemental I2– 4.85 Aerosol (CsI) – 95 Organic 0.15		Elem. – 91 Aerosol –5 Organic 4