SEVERE NUCLEAR ACCIDENTS: CAUSES AND CONSEQUENCES

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SEVERE NUCLEAR ACCIDENTS: UNLIKELY OCCURRENCES?

- Previous Estimates: Once in 20,000 Reactor Years or Less
- Three Major Nuclear Reactor Accidents
  - Three Mile Island, 3/28/1979
  - Chernobyl, 4/26/1996
  - Fukushima, 3/11/2011
- Observed Frequency: Approximately Once in 2,000 Reactor Years?

PREVENTING SEVERE NUCLEAR ACCIDENTS

- Application of Fundamental Safety Principles of Redundancy, Diversity, and Physical Separation
- Attention to Design, Manufacture, Installation, Operation, and Maintenance of Critical Equipment
- Constant Federal Oversight
- Continuing Licensee Vigilance

PREVENTING SEVERE NUCLEAR ACCIDENTS (Continued)

- Industry Groups Participation (e.g., INPO, EPRI, and NEI)
- International Cooperation (e.g., IAEA, WANO)
- State Agencies Involvement (e.g., Diablo Canyon Independent Safety Committee)
- Operational Experience Analyses and Feedback

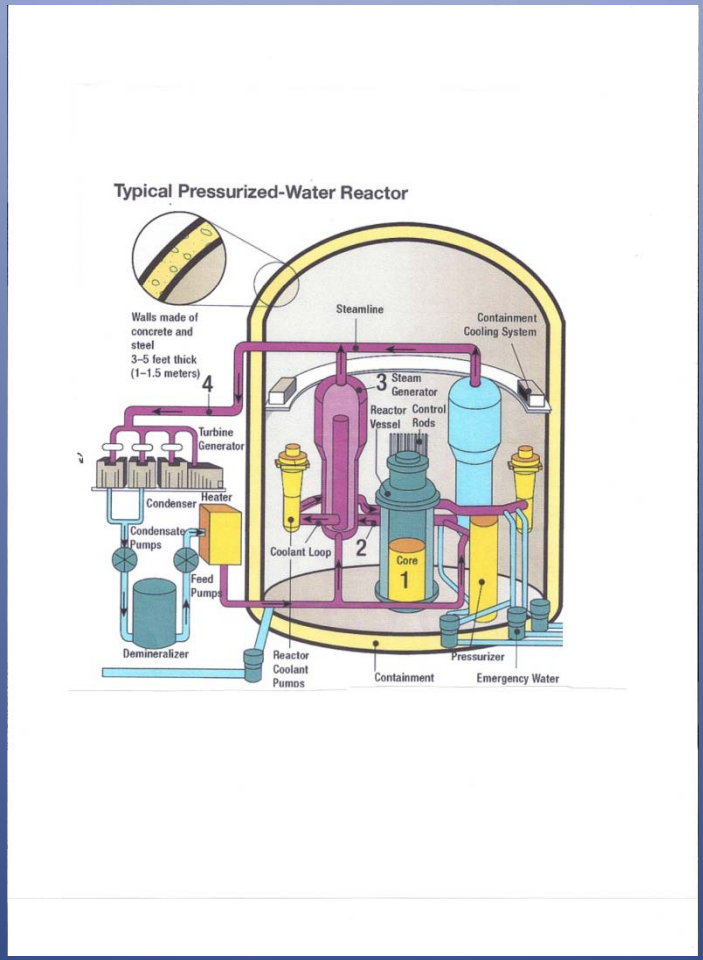
SEVERE ACCIDENTS: CAUSES & COMPOUNDING FACTORS

- Complex and Unforgiving Technology
- Intricate System Interactions
- Numerous Human-Machine Interfaces
- Safety Systems on Standby with Large Instantaneous Demands
- Equipment Unavailability & Failures
- Human Errors in Operation, Repair & Tests
- Beyond Design Basis External Events

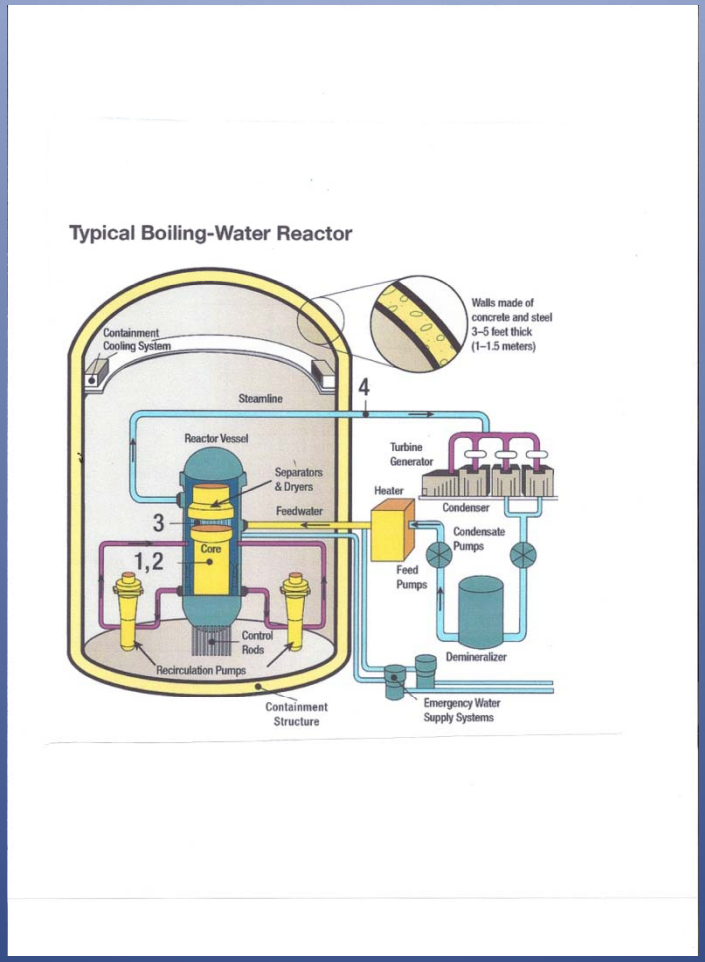
SEVERE ACCIDENTS: CAUSES & COMPOUNDING FACTORS (Continued)

- Numerous Potential Accident Initiators, from
  - Equipment Failures
  - Human Errors
  - External Events
- Many Vulnerabilities
- Myriad Unpredictable Potential Sequences
- Unknown or unknowable Developments

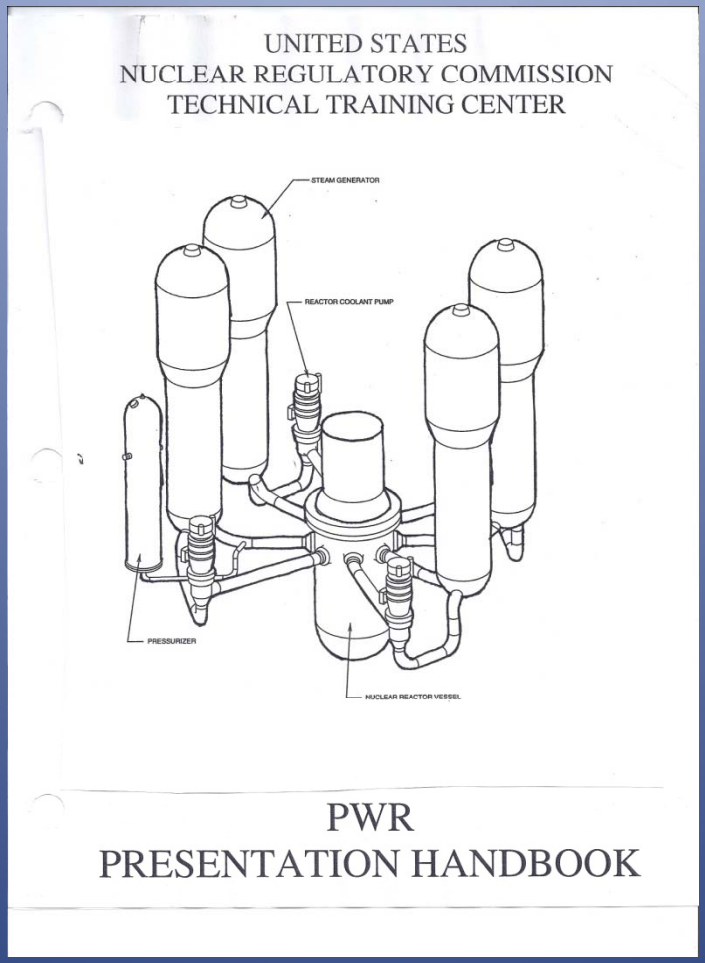
A TYPICAL 2-LOOP PWR



A TYPICAL BWR



A TYPICAL PWR 4-LOOP CONFIGURATION



SEVERE NUCLEAR ACCIDENTS: MAJOR CONSEQUENCES

- Potential Human Fatalities and Latent Health Hazards
- Immense Environmental Impact From Radioactive Materials Release and Dispersion
- Colossal Financial Penalties
- Long-Term Post-Accident Management For Years or Decades

RADIATION HAZARDS

- Large Inventory of Radioactive Materials in Reactor Core and Spent Fuel Pool
- Lethal Doses
- Inhalation, Ingestion, and Shine Pathways
- Some very long half-life Isotopes
- Some Isotopes Mimic Calcium and Potassium, Leading to Wide Distribution in Bone & Tissues

LETHAL DOSES

- LD50 (Lethal Dose to 50% of Population) is Approximately 500 rems
- Contact Dose of a Fresh Spent Fuel Bundle is About 1,000,000 to 10,000,000 rems per Second
- Greek Mythological Figure Medusa

DECAY HEAT REMOVAL

- Long-term Decay Heat Less Than 0.1% of Reactor Thermal Power
- 3 MWth Approximately Equivalent to The Heat from 1,000 Kitchen Ovens
- Sealed, Relatively-Limited Space, and Hazardous Environment
- Mixtures of Steam, Radioactive materials, and Combustible Gases?

POST-ACCIDENT MANAGEMENT REALITIES

- Two Conflicting Technical Demands
  - Removing Decay Heat
  - Containing Radiation
- Duration Lasting for Years or Decades
- Relocation of Population
- Denial of Land Use
- Funding Sources

SEVERE ACCIDENTS: POLICY CONSIDERATIONS

- Compliance Alone with Federal Regulations Sufficient?
- Do Federal Design Basis Accidents Cover All the Important Accidents?
- Completeness of Technical Analyses?
- Realistic Assumptions?

ADEQUACY OF FEDERAL RULES

- Example #1: 2011 Earth Quake Impacting North Anna
- Forces Experienced Were Higher Than Design Basis Seismic Event
- Proponents: Little Equipment Damage; Demonstration of Large Safety Margin
- Opponents: Design Basis Too Low

ADEQUACY OF FEDERAL RULES (Continued)

- Example #2: Pressurized Thermal shock (PTS) Rule
- NRC Old PTS Rule
  - 7 Plants not Eligible for License Extension
- NRC New PTS Rule
  - Developed from Decades of Research
  - All Plants are eligible for License Extension
- Proponents: Elimination of Unnecessary Regulatory Burden; Realistic Limits for Neutron Damage
- Opponents: Reduction of Safety Margin; Politically Motivated Rulemaking

ADEQUACY OF FEDERAL RULES (Continued)

- Example #3: Tsuruga Reactor Unit 2, Japan
- Recently Revealed: Reactor Sitting on Active Seismic Fault
- Proponents: Seismic Event Unlikely; Remedy Can be Developed
- Opponents: Risks Overlooked for Decades

CONCLUDING OBSERVATIONS

- Accident Prevention
  - Prevention of Recurrence
  - Prevention of New Accidents
- Adequacy of Federal Rules
- Post-Accident Management Involves
  - National-Scale Efforts
  - Long-Term Duration Measured in Decades
  - Multi-disciplinary Expertise
  - Immense Financial Commitment