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

How Regulators Make a Difference in New Reactor Safety

Mohamed Shams, Ph.D.
Division of Engineering
Office of New Reactors
May 20, 2010

Document Date: 5/20/2010

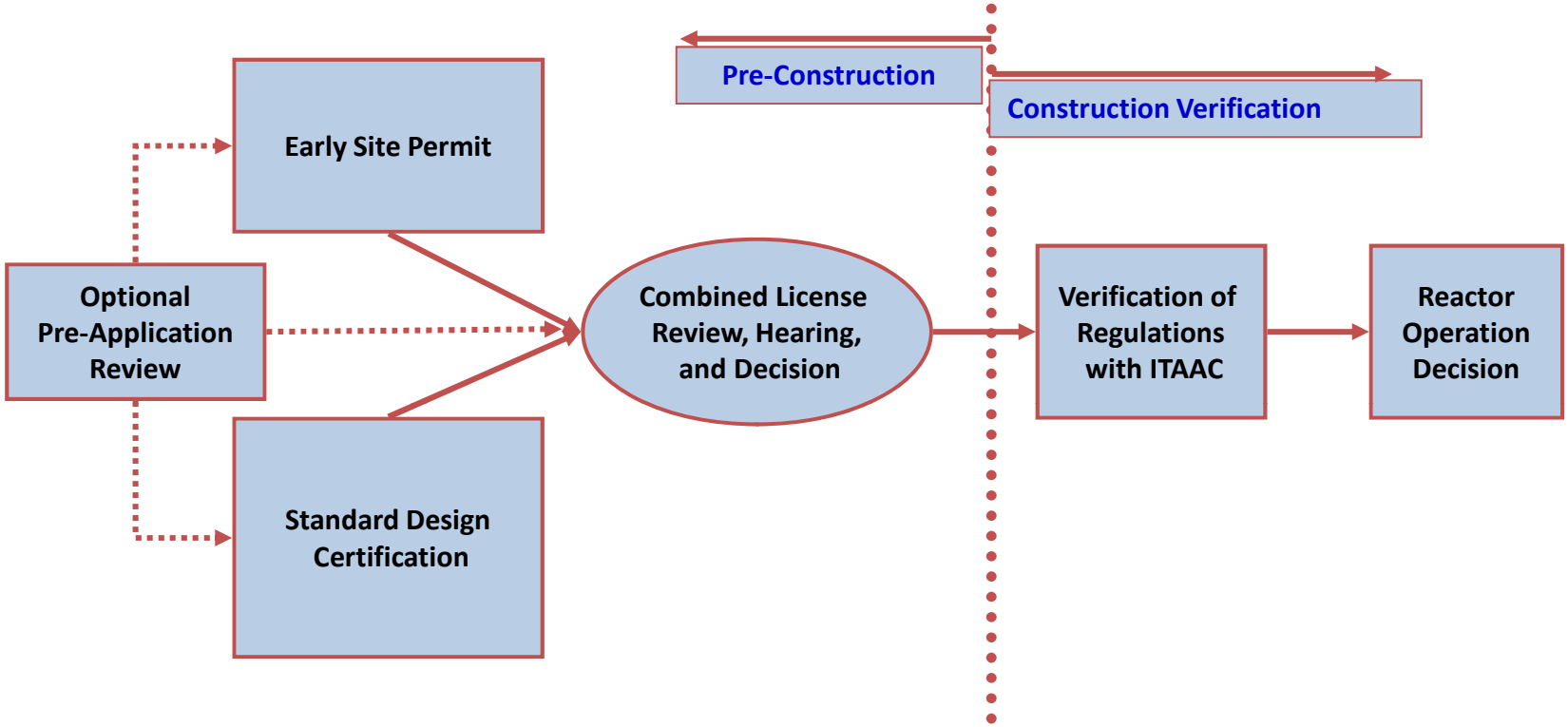
Discussion Topics

- NRC Regulatory Framework
- Part 52 Licensing
- New Reactor Reviews
- Review Process
- Regulatory Review Impact Examples

U.S. Regulatory Framework

- Applicants submit applications for design certification and new reactor licensing
- NRC staff reviews the applications for consistency with regulations and issue safety and environmental evaluations
- Advisory Committee on Reactor Safeguards (ACRS) performs an independent review of the applications
- Public participates in the process throughout the review, hearing, and rulemaking activities
- The Commission makes decisions on certification and licensing

Part 52 Licensing



Licensing decisions finalized before major construction begins
Inspections w/ITAAC to verify construction
Limited work may be authorized before COL issuance

New Reactor Reviews

- Current Applications
  - 17 Combined License (COL) Applications
  - 3 Design Certification (DC) Applications
  - 2 Amended DC Applications
- Issued
  - 4 DCs
  - 4 ESPs

Review Process

Level of Detail

- § 52.47 Contents of applications; technical information.

  "The application must contain a level of design information sufficient to enable the Commission to judge the applicant's proposed means of assuring that construction conforms to the design and to reach a **final conclusion on all safety questions** associated with the design before the certification is granted."

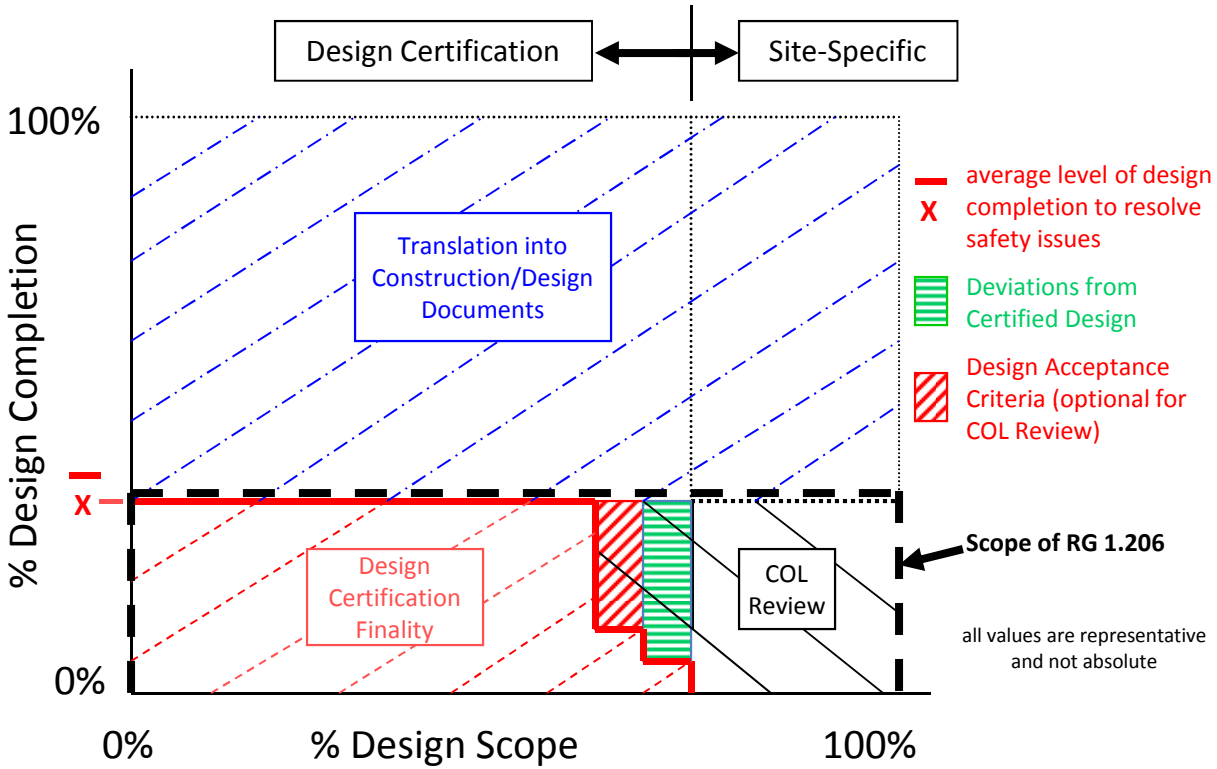
Contents of Design Certification Applications

- What is reviewed
  - Final design information
  - Postulated site parameters
  - Interface requirements
  - Proposed resolutions for unresolved safety issues
  - Design features to mitigate/ prevent severe accident
  - Inspections, tests, analyses, and acceptance criteria

Contents of Design Certification Applications

- What is NOT reviewed
  - Site safety
  - Environmental impact
  - Operational programs
  - Site-specific design features
  - Select design areas (DAC)

Scope of Review



Combined License Application Referencing a Certified Design

Enhance Safety

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

ESBWR Containment Structural Design

Issue	Outcome
• Impact of design basis accident temperature on the Reactor Building design	• Reactor Building design changes • Increased top slab concrete strength by ~15% • Increased floor and wall concrete thickness by ~50% • Reinforcement re-configuration

Enhance Safety

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

ESBWR Fuel Storage Rack Design

Issue	Outcome
• Combination of design basis accident temperature with other loads • Effect of rack elongation on integrity of pool liner	• Increased spent fuel pool size • Ensure adequate space between fuel racks and pool liner • Liner integrity is protected during accident

Enhance Safety

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

AP1000 Shield Building Structural Design

Issue	Outcome
• Composite wall design methodology • Ensure integrity and ductility of design	• Building reanalysis and redesign • Additional transverse reinforcement • Thicker modular steel plates • Validation tests for seismic loading

Enhance Safety

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

AP1000 Radioactive Gaseous Effluent Sampling System

Issue	Outcome
• Assure representative sample during normal and accident conditions • Essential to assess impact of releases on public health and safety and the environment	• System redesigned to higher performance criteria • Enhanced characterization of radioactive gaseous effluent releases • Improved incident response

Enhance Safety

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

ESBWR Reactor Internals Classification

Issue	Outcome
• Classification of reactor internals as non-prototype based on the ABWR design • Limited pre-operation stress and vibration measurements	• Re-classification as prototype • Ensures adequate pre-operation testing and vibration measurements • Enhanced ability to identify adverse-flow vibration

Enhance Safety

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

ESBWR Digital I&C – Reactor Trip and Isolation Function Platform

Issue	Outcome
• Diversity of design to ensure adequate communications independence between divisions • Loss of communications or communication upsets must not inhibit redundant divisions to perform their function	• Platform redesign with diverse communication methods within division and between redundant divisions • Enhanced protection against single-failure

Enhance Safety

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

U.S. EPR Reactor Vessel Welding

Issue	Outcome
• Weld cracking associated with dissimilar metal welding between the reactor vessel cladding (stainless steel/Inconel) and the core support structure (radial key)	• Clearly defined materials and processes for welding the core support to the vessel cladding • Avoid improper sequence of dissimilar metal welding • Incorporate lessons learned from Seabrook NPP

Enhance Safety

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

U.S. EPR Liquid Waste Management System

Issue	Outcome
• Design considerations for resin fines filters in the demineralizer subsystem of the Liquid Waste Management Systems • Concerns with high radioactivity resin fines discharged to the environment	• System is revised to add resin traps • Improved monitoring and characterization of radioactive liquid effluent releases • Improved incident response

Enhance Safety

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

U.S. EPR Emergency Feedwater Volume

Issue	Outcome
• Calculation of minimum volume of emergency feedwater necessary to remove heat over the entire range of reactor operations • Basis for lower volume as compared to other similar reactors	• Revised calculations to include more limiting cases • Increased minimum inventory by 65,000 gallons

Enhance Safety

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

ESBWR Design of Systems Important to Safety

Issue	Outcome
• Electrical and mechanical systems required to maintain safe shutdown are classified as non-safety systems. • Non-safety systems important to safety must receive special regulatory treatment and design criteria to ensure reliability and availability .	• Redesign various systems and components • Added new ancillary diesel generators • Enhanced seismic design criteria for certain equipment • Special treatment applied to risk-significant SSCs to ensure reliability

Enhance Safety

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

Bellefonte Hydrology Review

Issue	Outcome
• Concerns regarding model used to establish the Probable Maximum Flood (PMF) for the site • Quality Assurance (QA) inspection identified areas for improvement	• Improvement plan to meet QA requirements • PMF increased for four nearby dams • Temporary erosion protection measures installed • Permanent modifications are under development

Innovative Designs

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

Passive Reactors Extended-Duty Batteries

- Only safety-related power source in plant
- Battery duty cycle extended to 72 hours
- Appropriate qualification procedures needed to address possible new failure modes
- Worked with industry and IEEE standard to establish guidance for a generic qualification plan

U.S. APWR Gas Turbine Generators

- Proposed as safety-related on-site power source
- First-of-a-kind application with no operating experience
- Guidance for qualification not available
- Proposed qualification through type testing to demonstrate reliability
- Engaged applicant to resolve technical aspects of testing plan

Regulatory Differences

EPR Process Information and Control System

- System is classified as non-safety related in U.S. design and important to safety in European designs
- PICS is primary human-machine interface
- Safety-related human-machine interface provides limited functions
- Loss of PICS may impact operator flexibility during abnormal and emergency scenarios
- Engaged applicant to classify as important to safety in U.S. design in order to meet appropriate design standards and criteria

Regulatory Collaboration

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

International Collaboration

MDEP EPR Working Group

- Single failure criteria for protection system
- Steam generator isolation actions

MDEP Digital I&C Working Group

- Embedded software-based devices in plant components

MDEP AP1000 Working Group

- Technical guidelines for Squib Valves
- Shield building structural design

Component Quality and Integrity

- Fabrication defects in imported components
- Regulators exchanged insights on code requirements and course of action

Applicant Strategies

EPR and APWR Following ASME Code

- Original designs developed to native code requirements
- U.S. regulations require use of ASME Boiler and Pressure Vessel Code but allow alternatives
- Applicants elected to meet ASME Code requirements
- Different Code requirements may lead to differences in aspects of licensed designs

Applicant Strategies

Use of Alternative Vendor

- South Texas Project COL application uses Toshiba to supply the ABWR design
- Original vendor for the ABWR certified design is General Electric–Hitachi
- Challenges with required proprietary information
- Applicant reconstituted information and proposed changes requiring additional reviews
  - RCIC system turbine design
  - Containment analysis
  - Re-classification of reactor internals

Applicant Strategies

Low-Level Radioactive Waste Disposal

- AP1000 applicants did not address lack of disposal sites for low-level radioactive waste
- Several proposed reactor sites are in areas with no permanent disposal options for Class B and C waste
- Contentions have been submitted into the hearing process

Regulatory Perspectives

- Regulatory reviews improve the safety of proposed new reactor designs
- International regulators collaborate to resolve key technical issues and enhance safety
- Differences in international regulatory requirements may impact standardization
- Applicant strategies impact the licensing process

Glossary

ESBWR	Economic Simplified Boiling Water Reactor
AP1000	Advanced Passive 1000
APWR	Advanced Pressurized Water Reactor
EPR	Evolutionary Power Reactor
ABWR	Advanced Boiling Water Reactor
IEEE	Institute of Electrical and Electronics Engineers
SSC	Structures, Systems and Components
QA	Quality Assurance
PMF	Probable Maximum Flood
PICS	Process Information and Control System
ASME	American Society of Mechanical Engineers
COL	Combined License
DC	Design Certification
RCIC	Reactor Core Isolation Cooling
MDEP	Multinational Design Evaluation Program
ACRS	Advisory Committee on Reactor Safeguards
ITAAC	Inspections, tests, analyses, and acceptance criteria
ESP	Early Site Permit