AP1000 COL Fuel Technical Report

Pre-submittal Meeting with NRC

September 12, 2006

Westinghouse Electric Company
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Meeting Agenda

- Introductions (R. Sisk)
- AP1000 Pre-application COL Licensing Approach (D. Lindgren)
- Approach to Initial Core Load (R. Sisk)
- Review AP1000 DCD COL Information Items (R. Sisk)
- AP1000 COL Fuel Technical Report (R. Sisk)
- AP1000 Core Reference Report (R. Sisk)
- Review AP1000 Core Design and Operations (W. Miller)
- Review AP1000 Fuel & Core Components (R. Knott)
- Open Discussion (All)
- Wrap-up (R. Sisk)

Introductions

Nuclear Fuel

Nuclear Power Plants

New Reactor Fuel Engineering

Fuel Licensing

Core Engineering
Monroeville

Product Engineering
Columbia

Core Design & Operations

Fuel and Core Component Design

AP1000 Pre-Application Licensing Approach

Don Lindgren
AP1000 Licensing

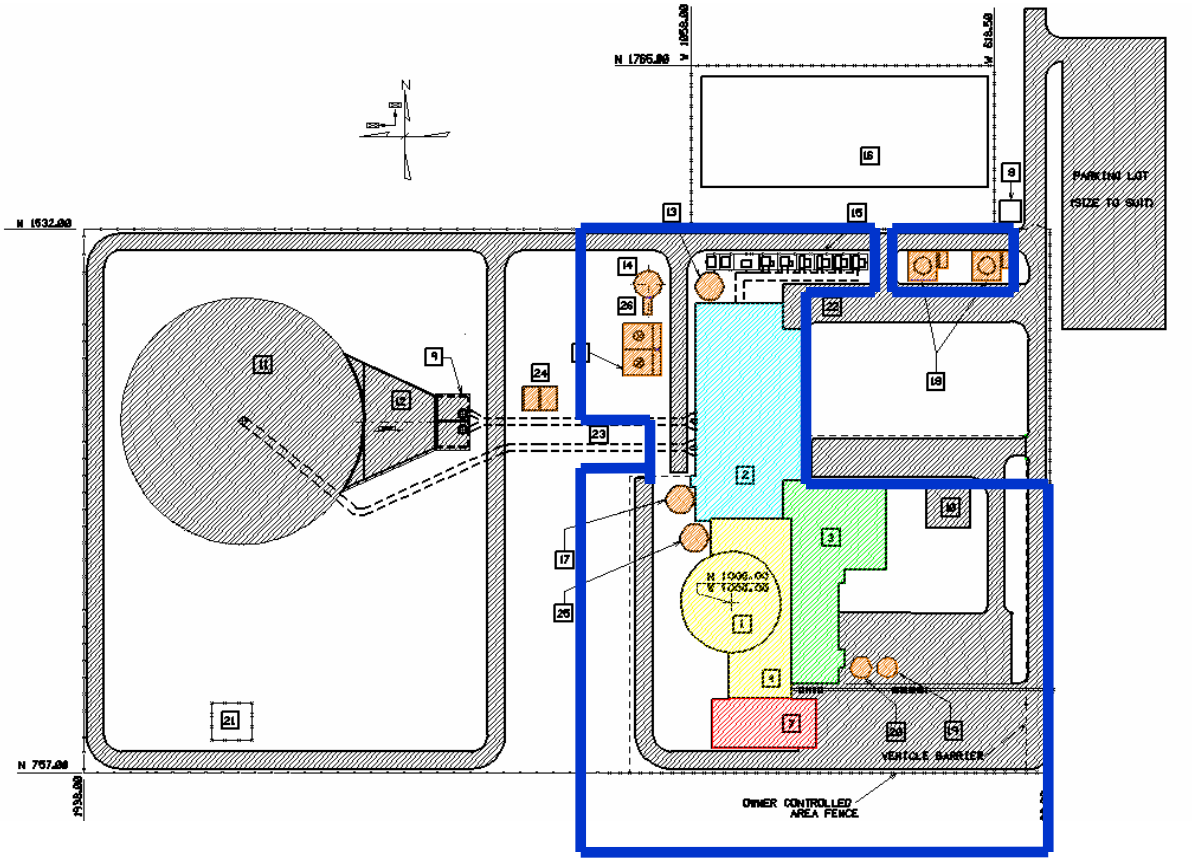
AP1000 Pre-Application Licensing Approach

- Pre-Application activities build on AP1000 Design Certification
- Design Certification was approved December 30, 2005
- Pre-Application activities are active now
- COL Applications are expected in Fall of 2007

What's In the Certified Scope? (DCD FiG. 1.2-2)

- The AP1000 Design Certification includes more scope than the traditional NSSS

- Only areas not included in the standard design scope and certification scope are the site specific aspects (e.g. circulating water and switchyard design)



AP1000 Design Approach is Centered on Standardization

- Standardization Built into AP1000 Design Process
  - Simplifies initial procurement and later maintenance / spare parts
- Types of components are standardized within certified scope and the AP1000 fleet.

Licensing Approach and Activities

- Pre-Application Review via Technical Report submittal
  - COL Information Item Closures
  - Limited design changes
- DAC Completion (none for Fuel)
- ITAAC Scheduling
- As-Built Verification and Inspections

No Tier 1 Changes to Fuel
Tier 2 Changes Addressed in Fuel Technical Report

Pre-Application Review

- Westinghouse is preparing technical reports
  - Address COL information items
  - Address other design completion activities

- Pre-application activities are in support of standardization of AP1000 COL applications.

- Pre-application activities support the NRC Design Centered Review Approach.

Pre-Application Review

- The technical reports document COL information item closure activities
- A limited number of design changes are documented in technical reports
- NuStart review and oversight of technical report preparation and other pre-application activities promote standardization of AP1000 COL applications.

Pre-Application Review

- Submittal of technical reports by Westinghouse to provide standardized AP1000 Design information
- NRC Staff Review (Interaction as necessary)
- NRC SER Preparation
- Applicable to all COL Applications via reference to technical reports and corresponding SERs

Potential Part 52 Revision

- Revision of AP1000 Design Certification Rule
  - Part 52 does not currently provide for significant revision
  - Substantial industry comments on NOPR for revising Part 52 to permit revision
  - Indications are that revised rule will include mechanism for revision
    - October 2006 to the Commission
    - Anticipated publishing date end of 2006
- If revised Part 52 allows, Westinghouse plans to submit a revised DCD in May 2007.

COL Information Items Closures

- NRC Review and approval of technical reports documenting COL information items closure activities will:
  - Provide one standard approach by COL applicants
  - Require one review by NRC
  - Remove the review of these items from the critical path in application review.
- Reports for approximately half of scheduled COL information items have been submitted for NRC review.
- Three of four COL items addressing the fuel design will be closed by the upcoming technical report.
- The fourth COL item is an as-built information item

As-Built COL Information Item Verification

- COL information items that include as-built requirements or other timing issues must be deferred until after COL application.
- These items are identified in a technical report justifying the deferral or deletion of the item.
- Most of these items have explicit or implicit requirements or criteria that require as-built information.
- Appropriate NRC control, inspection, or verification for deferred items covered under Inspection Branch instruction documentation.

Fuel ITAAC

- One fuel ITAAC included in Tier 1 Reactor System (2.1.3) section.

- Key design parameters are established by reactor internals requirements.

Fuel Technical Report

- Fuel related COL items are addressed by Westinghouse for all AP1000 applicants.
  - Standardization
  - Standardization
  - Standardization
- Technical Report Standard
- Licensing Standard
- ITAAC Closure Standard

One Design – One Review – One Position

Fuels Licensing Approach to Initial Core Load

Rob Sisk, Manager
Fuel Engineering Licensing
Westinghouse Electric Company, LLC

Approach to Initial Core Load

The AP1000 fuel, core components and core design are being developed in three distinct stages:

1. Reference Design ⇨ defined by the DCD
2. Licensed Design ⇨ defined by the DCD + Technical Report ⇨ COL
3. Final Design ⇨ defined by the COL + Core Reference Report ⇨ Initial Plant Start-up

A 3 step process allows the use of the best fuel product, core components and core design at the time of initial plant start-up consistent with the ongoing advancements we are seeing today.

Approach to Initial Core Load (continued)

- Reference Design ⇨ defined by the DCD
  - Purpose to provide a reference design on which to base plant certification completed (circa 1990s)
  - Establishes the AP1000 plant requirements
- Licensed Design ⇨ defined by the DCD + Technical Report ⇨ COL
  - Provides the licensed design in support of the COL application
  - Establishes a process for making changes and enhancements to the Fuel, Core Components and Core Design prior to initial start-up and for subsequent reloads
  - Bases for supplemental rulemaking?
  - COL's submitted fall 2007 ⇨ Initial plant operations ~2014

Approach to Initial Core Load (continued)

- Final Design ⇨ defined by a Core Reference Report
  - Submitted after the initial COL is issued but prior to initial fuel load with sufficient time for NRC review and approval .
  - A core reference report submitted to the NRC for review and approval (consistent with the requirements to address Tier 2* items)
    - Addresses enhancements to fuel assembly and core components design
    - Addresses initial fuel loading pattern, control rod patterns and associated core physics parameters
  - Standardized Core Reference Report for the AP1000 fleet would be incorporated into the New Plant License following the standard license amendment process (10 CFR50.92)
  - Provides for NRC review & approval of initial core

A COL License can be amended using 10 CFR 50.92 to implement changes to the initial fuel, core component and core design.

Approach to Initial Core Load

- Basic Ground Rules for the Initial Core
  - Basic changes must be NRC Reviewed and Approved
  - "DCD Design Criteria" is defined as the Principal Design Requirements
    - Section 4.1.1 defines the Principal Design Requirements
    - Conclusions of the Chapter 15 Safety Analyses remain valid
  - Actual fuel and core component designs, loading pattern, control rod patterns and core physics changes from the reference design in the DCD **will be submitted to the NRC for review and approval (Core Reference Report) prior to initial fuel load** .
    - Subsequent cycles /reloads will follow the guidelines established by WCAP-9272-A "Reload Methodology" and WCAP-12488-P-A "Fuel Acceptance Criteria"

Controls Rods (RCCAs) are Different from Gray Rods (GRCA)

- Black Rods (RCCAs) have different design purposes from Gray Rods (GRCAs)

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Review of AP1000 DCD COL Information Items

1. Combined License applicants referencing the AP1000 certified design will address changes to the reference design of the fuel, burnable absorber rods, rod cluster control assemblies, or initial core design from that presented in the DCD. (4.2-1, 4.3-1, 4.4-1)

2. Following selection of the actual plant operating instrumentation and calculation of the instrumentation uncertainties of the operating plant parameters as discussed in subsection 7.1.6, Combined License applicants will calculate the design limit DNBR values using the RTDP with these instrumentation uncertainties and confirm that either the design limit DNBR values as described in Section 4.4, "Thermal and Hydraulic Design," remain valid, or that the safety analysis minimum DNBR bounds the new design limit DNBR values plus DNBR penalties, such as rod bow penalty. (4.4-2)

The AP1000 COL Fuel Technical Report

Report Objectives:

- The fuel technical report once reviewed and approved by the NRC will close out the 3 of 4 COL Information Items
- The report will:
  - establish or clarify the requirements for the initial core as currently described in the AP1000 DCD to address COL requirements
  - define a process to implement changes to core, core components and fuel design
- Reflects current values provided are for a “typical” or “reference” first core design
- Westinghouse uses NRC approved methods and codes to satisfy the DCD fuel design criteria.
- This report may either be incorporated into the Certified AP1000 Design as a revision to the DCD or referenced in the COL applications depending on the results of the Part 52 rulemaking

The AP1000 COL Fuel Technical Report

Report Outline:

1 Introduction
- 1.1 Background
- 1.2 Summary

2 Review of AP1000 Fuel Products and Core Management
- 2.1 Comparison to DCD design

3 Initial Core and Reload Change Control Process

The AP1000 COL Fuel Technical Report

Report Outline (continued):

4 Response to COL Information Items
- 4.1 Summary Description - 4.1.2
- 4.2 Fuel System Design - 4.2.5
- 4.3 Nuclear Design - 4.3.4
- 4.4 Thermal and Hydraulic Design - 4.4.7
- 4.5 Reactor Materials
  - Addressed in separate Technical Report
- 4.6 Functional Design of Reactivity Control System
  - CRDM changes will be addressed under DCD Ch. 3.9.

5 Conclusion

6 References

The AP1000 COL Fuel Technical Report

Report Outline (continued):

Attachments

A.1 DCD Markups

A.1.1 DCD 4.1
A.1.2 DCD 4.2
A.1.3 DCD 4.3
A.1.4 DCD 4.4

Approach to Initial Core Load

The AP1000 fuel, core components and core design are being developed in three distinct stages:

1. Reference Design ⇨ defined by the DCD
2. Licensed Design ⇨ defined by the DCD + Technical Report ⇨ COL
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A 3 step process allows the use of the best fuel product, core components and core design at the time of initial plant start-up consistent with the ongoing advancements we are seeing today.

The AP1000 Core Reference Report

AP1000 Core Reference Report

- The AP1000 Core Reference Report once reviewed and approved by the NRC would address any final changes to the fuel assembly design, methods and requirements prior to initial core load.

- The report presents the COL holder's actual initial core (cycle 1) fuel loading pattern, control rod patterns (both RCCAs and GRCA) and associated core physics parameters at the time of initial start-up .

Core Reference Report

Examples of Fuel and Core Design evolutions that will be addressed in the Core Reference Report:

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Core Reference Report will be submitted to the NRC for review and approval and there will be **NO** change to the Chapter 15 conclusions.

The AP1000 Fuel Reports

Schedule

- Fuel Technical Report to be issued to the NRC for review and approval October 2006
  - Requesting NRC approval by summer of 2007
  - Supports COL applications
- Core Reference Report to be submitted to the NRC consistent with construction to maximize opportunity to incorporate fuel and core design evolutions.
  - Allow sufficient time for NRC review
  - Follow Topical/LAR Process

Summary

- AP1000 Fuel Technical Report
  - Addresses COL Information Items
  - Establish a process for implementing evolutionary changes
  - Reviewed and approved by the NRC
  - Referenced by COL applicants

- AP1000 Core Reference Report
  - Reviewed and approved by the NRC via LAR process
  - Addresses final changes to the methods, core, fuel and core components design prior to initial core load

Operation & Core Monitoring

R. Wade Miller, Manager
New Reactor Core Engineering
Westinghouse Electric Company, LLC

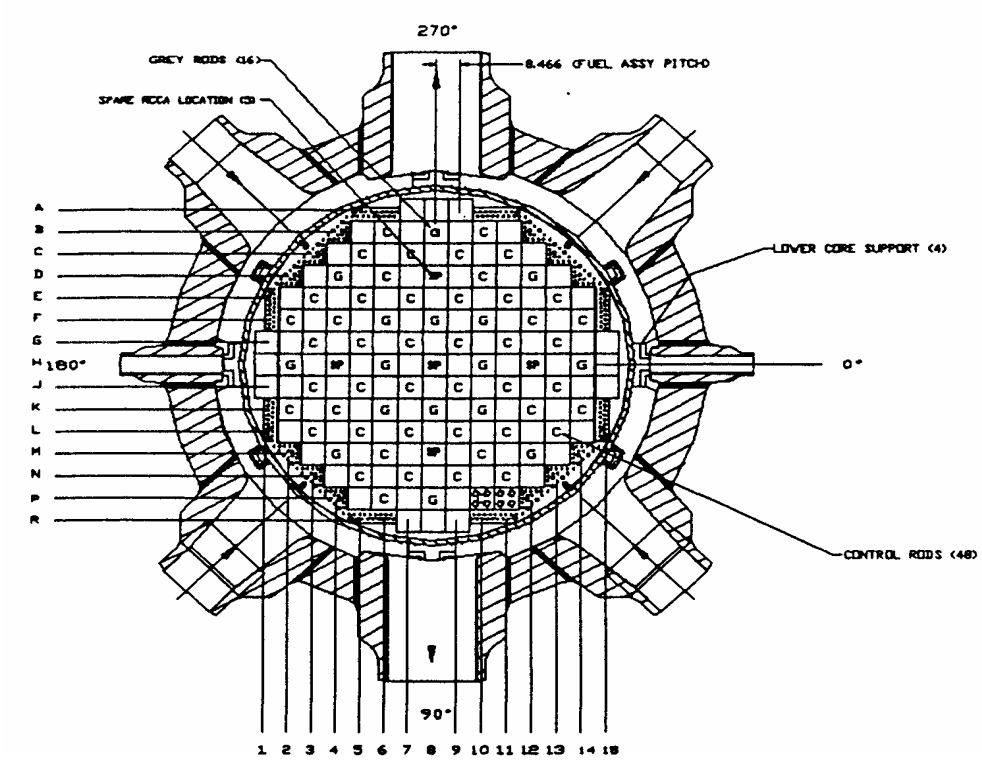
Agenda

- Operation & Core Monitoring
  - MSHIM operation
  - Core Monitoring with BEACON™
  - Changes to DCD to support efficient Core Operation

BEACON is a trademark of Westinghouse Electric Company LLC

AP1000 Core Operation and Monitoring Features

- MSHIM control system
  - GRCA for load change and temperature control
  - Axial Offset Control with AO Bank
  - Boron changes limited to fuel depletion, startup & shutdown
- Rapid Power Reduction System
  - Allows full load rejection capability [ ]a,c
- Top-mounted fixed incore instrumentation
  - Fixed position, online readout
  - No penetrations in bottom of vessel
- BEACON core monitoring system
  - Thermal margin monitoring
  - Core reactivity (SDM) monitoring



AP1000 MSHIM Operation

- AP1000 uses MSHIM control strategy for reactivity changes associated with power level, power distribution and temperature control.
- MSHIM operation allows significant simplification in CVCS by eliminating previous requirements for boron change associated with power change.
- Operational boron change requirements with MSHIM are limited to startup, shutdown and fuel depletion.
- MSHIM control strategy fully automated in AP1000 power control system at power levels [ ]^{a,c}

MSHIM Control Rod Functions

- MSHIM uses three separate sets of control rods for three unique reactivity control requirements.
  - SD Banks for rapid shutdown
  - AO Bank for axial power distribution control
  - M Banks for reactivity control associated with temperature, power level, and transient xenon changes.

AP1000 Control And Shutdown Bank Locations

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MSHIM Control Rod Functions

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  - SD Banks for rapid shutdown
  - AO Bank for axial power distribution control

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AP1000 First Cycle
Daily Load Follow 100% to 50% Power at BOL

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AP1000 BEACON™

- AP1000 uses NRC approved BEACON Core Monitoring System to provide:

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DCD Changes for AP1000 Core Design

- Minor clarifications will be made in the Fuel Technical Report to address inconsistencies in some areas, e.g.:
  - Distinction between RCCAs and GRCAs
  - Pyrex vs. Wet Annular Burnable Absorbers
- GRCA design will be updated

GRCA Design Enhancement

- Reactivity worth of Gray Rods optimized for load change with no change in boron concentration
- GRCA design used in the DCD meets these reactivity requirements, however:
  - A more distributed absorber material within the GRCA:
    - reduces inter-assembly peaking
    - improves thermal margins
- Reactivity worth of GRCAs is maintained

An enhanced GRCA design will be included in the Fuel Technical Report.

GRCA Design Evolution

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Summary

- AP1000 MSHIM and Core Monitoring design features (described in DCD) support:
  - No change in boron concentration required for routine power maneuvers
  - No lower vessel penetrations
  - BEACON using fixed incore detectors
  - Rapid Power Reduction System

- Minor clarifications / enhancements needed to DCD

AP1000 Fuel Assembly and Core Component Design

Ron Knott, Manager

New Reactor Product Engineering

Westinghouse Electric Company, LLC

Overview of Fuel Assembly and Core Components

- Fuel Assembly
  - Base design is W Robust Fuel Assembly (RFA)
  - 14 foot active fuel length (South Texas, EDF, and Doel 4 use the 14', RFA design)
  - Features adapted to AP1000 requirements
- Core Components
  - Core components are based on standard designs
  - GRCAs have been adapted from RCCAs to enable utilization of MSHIM control strategy
  - Core components and top nozzle have been adapted to allow top mounted in-core instrumentation

AP1000 Fuel Design Based on RFA

- AP1000 basic fuel assembly design is derived from the W 17X17 Robust Fuel Assembly (RFA) XL design
- Westinghouse has significant experience with the RFA design

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- Detailed AP1000 fuel dimensions defined to meet specific AP1000 design requirements

AP1000 Fuel Features versus 17x17XL

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Red text indicates AP1000 specific features

Changes in Design Control Document (DCD)

- Minor clarifications will be made in the Fuel Technical Report to address inconsistencies in the fuel design description, e.g.:
  - ICTN vs. WIN top nozzle (nomenclature)
  - Inconsistent description of protective bottom grid
  - Inconsistent description of tube-in-tube thimble design
  - Discussion of oxide coated cladding used in current designs for added debris protection

AP1000 Core Components

- Rod Cluster Control Assembly (RCCA)
  - Standard design, basic component for shutdown
- Gray Rod Control Assembly (GRCA)
  - Adapted from RCCA design to enable MSHIM operating strategy
  - Not included in shutdown reactivity
- Secondary Source Assembly (Spider mounted)
  - Standard design, used for reactor startup
- Primary Source Assembly
  - Standard design, used for reactor startup
- Discrete Burnable Absorber Assembly
  - Standard design, used for power distribution and reactivity control
- Thimble plug
  - Based on standard design adapted for top mounted instrumentation

Impacts on Design Control Document (DCD)

- Update Needed for GRCA design

- Minor clarifications needed due to inconsistencies, for example
  - Inconsistent discussion of the application of WABA and Pyrex burnable absorbers
  - Inconsistent discussion of base plate vs. spider mounted secondary source assemblies

Wrap-up

Conclusions

- AP1000 Fuel Technical Report
  - Addresses COL Information Items
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- AP1000 Core Reference Report
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  - Addresses final changes to the methods, core, fuel and core components design prior to initial core load