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Westinghouse Presentation on Westinghouse Fuel Criteria Evaluation Process (Slide Presentation of April 18, 2002)

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Westinghouse Fuel Criteria Evaluation Process (FCEP) - WCAP-12488-A & WCAP-12488-A, Addendum 1-A, Revision 1

NRC/Westinghouse Meeting
White Flint Offices, Rockville, MD
April 18, 2002

Agenda

- Overview of Westinghouse FCEP — Slagle
- Application of FCEP to "CE" fuel designs — Molnar
- DNB Correlation Applicability using the FCEP — Slagle
- Application of FCEP to 17x17 and 15x15 RFA fuel — Reid

Overview of Westinghouse FCEP

W. H. Slagle, Sr. Engineer
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Overview of Westinghouse FCEP

- FCEP allows for 10 CFR 50.59 conclusions to be reached by demonstrating that the criteria defined in WCAP-12488-A and Addendum 1 are used for the evaluation of the fuel mechanical change(s) and are shown to be met

- When applied to specific design changes, FCEP will also show compliance with the SAR acceptance limits since the design criteria specified in FCEP are the acceptance limits denoted in the SAR

Overview of Westinghouse FCEP

- Section 4.2 of the SRP indicates that the NRC reviews the vendor-established specified acceptable fuel design limits to provide assurance that:
  - the fuel system is not damaged as a result of normal operation and anticipated operational occurrences,
  - fuel system damage is never so severe as to prevent control rod insertion when it is required,
  - the number of fuel rod failures is not under-estimated for postulated accidents, and
  - coolability is always maintained

Overview of Westinghouse FCEP

- These design bases, or Specified Acceptable Fuel Design Limits (SAFDLs), and their respective evaluations comply with the "Acceptance Criteria" of SRP 4.2, "Fuel System Design," and as such provide assurance that the fuel system is mechanically designed to perform safely, consistent with General Design Criteria 10

Overview of Westinghouse FCEP

- FCEP consists of the following sections:
  - 1.0 Introduction
  - 2.0 Background
  - 3.0 Fuel Criteria Evaluation Process Description/Evaluation
  - 4.0 Fuel Design Bases and Limits
  - 5.0 Lead Test Assemblies Application
  - 6.0 Evaluation of Methodology Changes
  - 7.0 Fuel Performance and Material Properties Models
- The presentations today will briefly discuss Sections 4.0 and 7.0 with the primary focus on Section 6.0

Overview of Westinghouse FCEP

- Section 4 of WCAP-12488-A discusses "Fuel Design Bases and Limits"
- The Fuel Design Bases and Limits are further categorized into three subsection, consistent with the SRP: 1) Fuel System Damage and Fuel Rod Failure Criteria, 2) Fuel Coolability Criteria, and 3) Nuclear Design Criteria
- These subsections define all the design criteria that would need to be addressed to demonstrate that FCEP is applicable (less grid modification and correlation applicability which has its own section)

Overview of Westinghouse FCEP

Fuel System Damage and Fuel Rod Failure Criteria:

- DNB
- Clad Stress
- Clad Strain
- Clad Fatigue
- Clad Oxidation
- Clad Flattening
- Rod Internal Pressure
- Fuel Rod Axial Growth
- Fuel Clad Fretting Wear
- Fuel Pellet Overheating
- Fuel Rod Clad Rupture (Burst)
- LOCA Fuel Clad Temperature
- Zircaloy Clad Hydrogen Pickup
- Thermo-hydrodynamic Stability
- Fuel Assembly Holddown Force
- Non-LOCA Fuel Clad Temperature
- Fuel Structural Hydrogen Content replaced by Structural Component Stress (Addendum 1)

Overview of Westinghouse FCEP

Fuel Coolability Criteria:

- Clad Ballooning and Flow Blockage
- Violent Expulsion of Fuel (Rod Ejection)
- Fuel Assembly Structural Response to Seismic/LOCA Loads
- Clad Embrittlement During Locked Rotor/Shaft Break Accident

Nuclear Design Criteria:

- Stability
- Shutdown Margin
- Power Distribution
- Fuel Storage Subcriticality
- Reactivity Feedback Coefficients
- Maximum Controlled Reactivity Insertion Rate

Overview of Westinghouse FCEP

- As noted previously, Section 4 of WCAP-12488-A discusses "Fuel Design Bases and Limits" (less grid modification and correlation applicability which has its own section)
- Section 6.0 of WCAP-12488-A discusses "Evaluation of Methodology Changes", specifically addresses DNB Correlation Applicability
- This section will be addressed in more detail in the next presentation

Overview of Westinghouse FCEP

- The last major section of FCEP is Section 7.0, "Fuel Performance and Material Properties Models"
- This section of FCEP allows for fuel performance and materials properties model revisions to the extent that [

  ] [a, c] and accepted by the NRC
- Note that with PAD 4.0, model changes were made and for [

  ] [a, c] that allowed under FCEP

Overview of Westinghouse FCEP

- To understand the level of engineering effort involved in FCEP, the following information is provided:

a, c

[ ]

- The only difference in the level of effort involved in FCEP versus a traditional submittal is the actual topical report vice an FCEP Notification Letter

Application of FCEP to "CE" Fuel Designs

C. M. Molnar, Sr. Consulting Licensing Engineer
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Application of FCEP to "CE" Fuel Designs

Purpose:

- Continue integration of Westinghouse and CE Nuclear Power product lines by bringing CE fuel designs under the umbrella of the Westinghouse Fuel Criteria Evaluation Process (FCEP), WCAP-12488-P-A, which has already been reviewed and accepted by the Nuclear Regulatory Commission

- Obtain NRC feedback on such an integration activity with respect to degree of Regulatory review required and areas of particular interest that should be considered

Application of FCEP to "CE" Fuel Designs

Implementation

- Restructure existing WCAP-12488-P-A
  - 1.0 Introduction
  - 2.0 Background
  - 3.0 Fuel Criteria Evaluation Process Description/Evaluation
  - 4.0 Fuel Design Bases and Limits
  - 5.0 Lead Test Assemblies Application
  - 6.0 Evaluation of Methodology Changes
  - 7.0 Fuel Performance and Material Properties Models
- Section 4 will be restructured
  - *No* Westinghouse fuel design information will be altered
  - CE fuel design information will be added
  - Fuel design information presentation will be restructured (i.e., parallel column format)
- A new Section 8 will be added
  - This section will incorporate the equivalent of Section 7 but for CE Fuel Performance and Material Properties Models

Application of FCEP to "CE" Fuel Designs

- Existing Section 4 Presentation Format

Design Category - The NRC groups acceptance criteria for design limits into three categories in the Standard Review Plan. (See Section 3.2)

Design Parameter - The specific parameter that will be evaluated.

Design Basis - The reason that the design parameter needs to be considered in the safety evaluations.

Acceptance Limit - The acceptance limit is the value prescribed/approved/accepted by the NRC. For certain evaluations, Westinghouse uses limits that are more restrictive than NRC approved acceptance limits; these are described as appropriate.

Design Evaluation - This is a brief description of the methods used to evaluate the design or acceptance limits. Often, the evaluation methods are described more fully in Westinghouse topical reports that have been approved by the NRC. These methods are referenced in this section.

References(s) - A list of topical reports that are applicable to the design evaluation.

Application of FCEP to "CE" Fuel Designs

- Restructured Presentation Format Candidate

Fuel Design Bases and Limits

Design Parameter

Design Category

- Fuel System Damage and Fuel Rod Failure Criteria (typically applicable to Conditions I, II and III)
- Fuel Coolability Criteria (typically applicable to Condition IV)
- Nuclear Design Criteria (typically applicable to Condition I)

Design Basis

W FUEL DESIGNS	CE FUEL DESIGNS
-	-

OPERATING FREQUENCY CONDITION APPLICABILITY

FREQUENCY	W FUEL DESIGNS	CE FUEL DESIGNS
- Condition I – Normal Operation		
- Condition II – Moderate Frequency Events		
- Condition III – Infrequent Events		
- Condition IV – Limiting Faults		

Acceptance Limit

W FUEL DESIGNS	CE FUEL DESIGNS
-	-

Design Evaluation

W FUEL DESIGNS	CE FUEL DESIGNS
-	-

References(s)

W FUEL DESIGNS	CE FUEL DESIGNS
-	-

Application of FCEP to "CE" Fuel Designs

Licensing Approach:

- Westinghouse believes that the Regulatory Review can focus on the proper integration of CE fuel information into the established FCEP

- Westinghouse will not, at this time, introduce any new CE fuel Design Bases and Limits or Fuel Performance and Material Properties Models
  - Only CE fuel information already reviewed and approved by the NRC will be incorporated
  - This approach precludes the need for technical review of design bases, limits material properties, etc.
  - Should minimize the amount of review time required

Application of FCEP to "CE" Fuel Designs

Schedule:

- No firm submittal schedule has been established at this time
- Westinghouse has only recently begun investigation of this initiative
- Presently trying to establish the level of effort needed to incorporate the relevant CE fuel design information
- Determine when the established level of effort can be fit into customer driven fuel activities (i.e., reload design and analysis)
- Establish the level of effort the NRC believes would be needed to conduct their acceptance review and issue a Safety Evaluation Report

DNB Correlation Applicability using FCEP

W. H. Slagle, Sr. Engineer
Nuclear Fuel Division

DNB Correlation Applicability using FCEP

Westinghouse FCEP Section 6.0 specifies the guidelines relevant to determining Correlation Applicability for either grid design modifications or a new grid design:

"An existing DNB correlation will be valid and will meet the above design basis* without reservation provided the new fuel assembly geometry is [ ] a, c." (of the licensed database for the DNB correlation of interest).

"If the new geometry is [ ] a, c of the test data, Westinghouse will evaluate the geometry [ ] a, c."

* DNB design basis is that the probability of the limiting fuel rod not being in DNB be greater than 95 percent at a 95 percent confidence level.

DNB Correlation Applicability using FCEP

(Cont.):

"If additional test data are used, [ ]a,c. The new data will then be [ ]a,c.

"If the new data [ ]a,c it may be treated explicitly as a [ ]a,c may be developed. If this step is necessary, it would involve NRC review."

Thus, there are three approaches that can be used: [ ]a,c. If none of these approaches yield acceptable results, then a submittal to the NRC is required.

DNB Correlation Applicability using FCEP

As specified in the TER of FCEP:

> "An existing NRC approved DNB correlation is considered to be valid by Westinghouse for application to a new design when the new fuel assembly geometry is similar to or bracketed by the fuel assembly geometric parameters and correlation parameters of the critical heat flux (CHF) test data used to develop the approved DNB correlation."

DNB Correlation Applicability using FCEP

The relevant geometric parameters are:

a, b, c

DNB Correlation Applicability using FCEP

The relevant correlation parameters are:

a, b, c

DNB Correlation Applicability using FCEP

Example:

a, b, c

DNB Correlation Applicability using FCEP

The FCEP approach (WCAP-12488-A & WCAP-12488-A, Addendum 1-A, Revision 1) has been approved by the NRC. As stipulated in the SER/TER, Westinghouse must:

- Inform the NRC of each first time application of the FCEP process for each design change (this is handled through letters to the NRC of FCEP Notification for each change - see list), and
- Maintain auditable records for each application of the FCEP process.

DNB Correlation Applicability using FCEP

NTD-NRC-94-4275	8/29/94	Westinghouse's Interpretation of Staff's Position on Extended Burnup
NSD-NRC-96-4694	4/22/96	Transmittal of Presentation Material from NRC/Westinghouse Fuel Design Change Meeting on April 15, 1996
NSD-NRC-97-5189	6/24/97	Transmittal of Response to NRC Request for Information on Wolf Creek Fuel Design Modifications
NPL 97-0538 CAW-97-1166	9/9/97	Slide Presentation "14x14, 0.422" OD VANTAGE + (422V+) Fuel Design, Application for Point Beach Units 1 & 2"

DNB Correlation Applicability using FCEP

NSD-NRC-98-5618	3/25/98	Notification of FCEP Application for WRB-1 and WRB-2 Applicability to the 17x17 Modified LPD Grid Design for Robust Fuel Assembly Application
NSD-NRC-98-5722	6/23/98	Fuel Criteria Evaluation Process Notification for the Revised Guide Thimble Dashpot Design for the 17x17 XL Robust Fuel Assembly Design
NSD-NRC-98-5796	10/13/98	Fuel Criteria Evaluation Process Notification for the 17x17 Robust Fuel Assembly with IFM Grid Design
NSD-NRC-99-5828	03/29/99	Notification of FCEP Application for DNB Testing for Revalidation of WRB-1 Applicability to the 15x15 VANTAGE + Fuel Design

DNB Correlation Applicability using FCEP

NSBU-NRC-00-5960	01/24/00	Fuel Criteria Evaluation Process Notification for Axial Blanket Modification
LTR-NRC-01-44	12/19/01	Fuel Criterion Evaluation Process (FCEP) Notification of the RFA-2 Design
LTR-NRC-02-2	01/15/02	Fuel Criterion Evaluation Process (FCEP) Notification of the Quick Release Top Nozzle (QRTN) Design, (Proprietary)

Application of FCEP to 17x17 and 15x15 RFA Fuel

D. G. Reid, Sr. Engineer
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Application of FCEP to 17x17 and 15x15 RFA Fuel

- As noted on the previous slides, the evolution of the 17x17 RFA fuel assembly started with the development of the Modified V5H (MV5H) mid-grid and Modified IFM (MIFM) grid (refer to NSD-NRC-96-4694)

- This design change: [ ]a, c
  that had been seen at Salem and Beaver Valley and [ ]a, c

- The FCEP notification documented that [ ]a, c, the WRB-2 correlation was applicable

Application of FCEP to 17x17 and 15x15 RFA Fuel

- Around the same time period, the Incomplete Rod Insertion (IRI) issue surfaced
- The resolution for IRI was: [ ]a, c
- The combination of ZIRLO™ skeleton, thicker walled GTs and MV5H/MIFM grids was named Robust Fuel Assembly (RFA) (refer to NSD-NRC-97-5189)
- This FCEP notification showed that the WRB-2 correlation remained applicable for the combination of MV5H/MIFM grids with the thicker walled GTs

Application of FCEP to 17x17 and 15x15 RFA Fuel

- The original development of RFA covered only 12 foot cores that used V5H fuel with IFMs. To address 14 foot (XL) designs, a slight modification was required to the GT dashpot design. This modification eliminated the double dashpot configuration and introduced a tube-in-a-tube dashpot configuration (refer to NSD-NRC-98-5722)

- In addition, the original FCEP notification for MV5H/MIFM showed that WRB-2 was an applicable correlation. For the XL design, it was necessary to show that the WRB-1 correlation was applicable for designs that did <u>not</u> incorporate the MIFM grid (refer to NSD-NRC-98-5618)

- This FCEP notification documented that WRB-1 and/or WRB-2 were applicable correlations for both 12 foot and 14 foot cores with RFA fuel that did <u>not</u> incorporate the MIFM grid

Application of FCEP to 17x17 and 15x15 RFA Fuel

- The first FCEP notification for RFA fuel was specific to Wolf Creek LUA application
- Since this FCEP notification was specific to Wolf Creek, a follow-on FCEP notification that documented WRB-2 correlation applicability to RFA fuel with IFMs (MIFMs) for all 12 foot V5H plants was sent to the NRC staff (refer to NSD-NRC-98-5796)
- The latest evolution of RFA fuel is called RFA-2. The principal difference between RFA and RFA-2 is a minor modification to the [ ][a,c]. The change results in more surface area supporting the fuel rod which substantially reduces the fuel rod vibration that was seen on the V5H fuel (refer to LTR-NRC-01-44)

Application of FCEP to 17x17 and 15x15 RFA Fuel

- In the 1970's, Westinghouse performed a large number of CHF tests on rod bundles prototypical of the 15x15 (0.422 in OD rod) and 17x17 (0.374 in OD rod) Inconel "R-grid" mixing vane grid types. The WRB-1 CHF correlation was developed based on the results from these tests

- Westinghouse continued to develop new fuel products, including the Optimized Fuel Assembly (OFA) designs, which were "scaled" or extrapolated from the R-grid designs

- The 14x14 and 17x17 OFA designs were DNB tested and the results showed that WRB-1 accurately predicted CHF for OFA fuel designs

Application of FCEP to 17x17 and 15x15 RFA Fuel

- Based on the scaling method and the similarity of the 15x15 OFA design with the R-grid geometry, the WRB-1 correlation was extended to cover 15x15 OFA fuel without DNB tests

- Similarly, when the 15x15 V5H product was first developed, it was again compared with the R-grid geometry and it was determined that the WRB-1 correlation could also be extended to cover the design again without DNB tests

- In the process of getting a license amendment submittal approved for a licensee, the NRC staff insisted that Westinghouse perform DNB water tests on the 15x15 VANTAGE + fuel product (geometrically equivalent to the 15x15 V5H design with IFMs)

Application of FCEP to 17x17 and 15x15 RFA Fuel

- As a result, Westinghouse proceeded to perform a DNB test on the 15x15 VANTAGE + product with IFMs to confirm that the WRB-1 correlation would be applicable to this design (refer to the table below)

- In looking at the 15x15 VANTAGE + fuel product from an analytical approach through FCEP, it was noted that the design had [ ]a, c

  (refer to the table on the following slide)

[ ]a, c

Application of FCEP to 17x17 and 15x15 RFA Fuel

- Based on the DNB test performed for the 15x15 VANTAGE + fuel product with IFMs, Westinghouse submitted an FCEP Notification to the NRC to document the fact that the WRB-1 correlation was applicable to the design (refer to NSD-NRC-99-5828)

- Based on these results and in reviewing the table on the following slide, it can be seen that the 15x15 RFA-2 design meets the geometric conditions

- Thus, WRB-1 is applicable to the 15x15 RFA-2 design

Application of FCEP to 17x17 and 15x15 RFA Fuel

a, b, c

Application of FCEP to 17x17 and 15x15 RFA Fuel

- Based on the information learned by Westinghouse in developing the 17x17 MV5H mid-grid, the [

  ]a, b, c

- [

  ]a, c

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