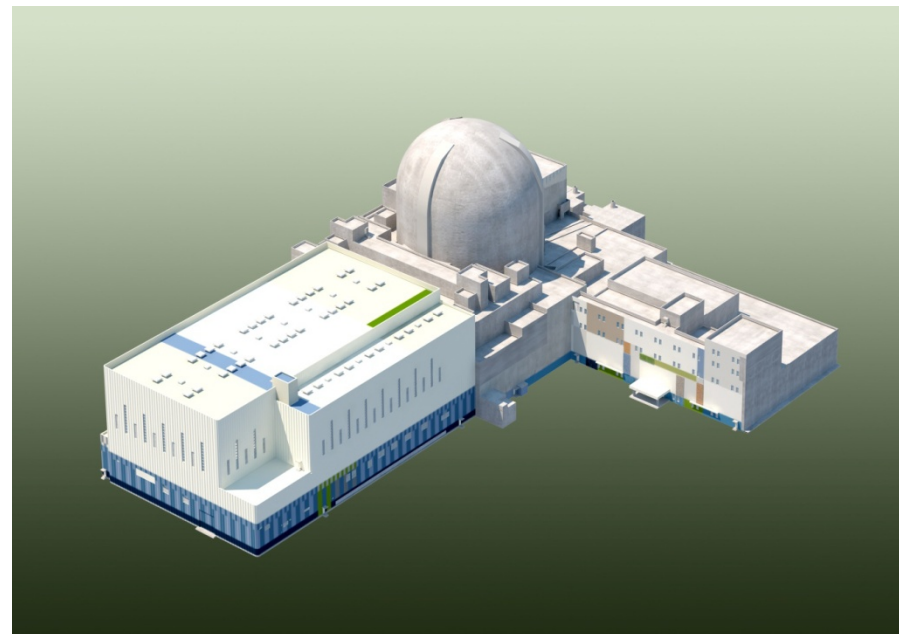


NON-PROPRIETARY

Cross-section Library



KEPCO/KHNP

April 28, 2015

Public Meeting

Contents

- **Introduction**

- ❖ **APR1400**
- ❖ **DIT/ROCS**
- ❖ **Cross-section Library for DIT Code**
- ❖ **Current Plan for New Cross-section Library**

- **CE Methodology**

- ❖ **Physics Bias/Uncertainty**

- **Design Experience & Accuracy**

- **Conclusions**

Introduction

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Introduction

- APR1400

- ✓ Comparison with OPR1000

Parameters	APR1400	OPR1000
Electric Power, MWe	1,400	1,000
Thermal Power, MWth	4,000	2,815
Fuel Assembly Type	PLUS7	PLUS7
No of Loops	2	2
Primary System pressure, psia	2,250	2,250
Fuel Assembly Array	241	177
Linear Heat Rate, kW/ft	5.60	5.39
Design Life, yrs	60	40
Refueling Intervals, Month	18	12, 15, 18
Maximum Fuel Rod Burnup, MWD/MTU	60,000	60,000

Introduction

- **DIT/ROCS**

- ✓ **Topical Report: C-E. INC. , “The ROCS And DIT Computer Codes For Nuclear Design,” April 1983, CENPD-266-P-A**

- ✓ **DIT: for the generation of few-group neutron cross sections**

- ✓ **ROCS: for two-and three-dimensional neutronics analysis**

- ✓ **DIT/ROCS Cross Section**

- **DIT – ENDF/B-IV Library(41 or 85 gr from NJOY)**

- **ROCS – few group HARMONY Type Cross-section Tableset(from DIT/CESAW/VERDCT Code Package)**

- **From YGN-3 to SHN-2(earlier 1990’s ~ later 2010’s)**

- **Sufficient Accuracy for Design Purpose – from Periodic Update of Bias/Uncertainty (Rev.0 ~11)**

Introduction

- **Cross-section Library for DIT Code**

- ✓ **Cross Section Library is linked to DIT/ROCS Code System**
 - **The effects of biases and uncertainty associated with ENDF/B-IV cross section library are incorporated into the ROCS biases and uncertainties and are not treated separately for DIT/ROCS code system.**
- ✓ **Usage of ENDF/B-IV cross section library can be compensated the defect by Bias/Uncertainty update and cross-section adjustments**

Introduction

- **Current Plan for New Cross-section Library**

- ✓ **Current Bias/Uncertainty Manual(Rev.11) contains ENDF/B-VI(for only “Calvert Cliffs”) as well as ENDF/B-IV(for All CE type plant)**
- ✓ **In general, complete version of ENDF/B-VI cross-sections should require some additional benchmarking prior to design use.**
- ✓ **KEPCO_{NE} do not have ENDF/B-VI library provided from WEC for design purpose or rights to update Cross-section Library for itself(from “LA Contract Agreement” with WEC)**
 - ➔ **currently can not provide the proper evaluation of the subsequent impacts from Library Update on the transient and accident analysis**



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CE Methodology

CE Methodology

- **Physics Bias/Uncertainty**

- ✓ **For Plants Using the CE Safety Analysis Methodology**
- ✓ **This methodology utilizes the standard three-dimensional ROCS models, using design grade universal cross section table sets generated by DIT using the ENDF/B-IV data files**
- ✓ **Bias/Uncertainty is generated from many data of “Measured – Calculated” of various operating plant by statistically complicated treatment**
- ✓ **The effectiveness of current bias and uncertainty is confirmed by every reload cycle LPPT & PAT measurement**

Design Experience & Accuracy (of ENDF/B-IV)

Design Experience & Accuracy

- **Measurement Item for Physics Parameter Validation**
 - ✓ **Core Keff : HZP CBC, HFP CBC Behavior**
 - ✓ **MTC : HZP & HFP ITC**
 - ✓ **Control Rod Worth : Individual Rod Worth & Total Rod Worth**
 - ✓ **Doppler Coefficient : Doppler Power Coefficient at 20, 50, 80, 95% & Difference between HZP CBC and HFP CBC**
- **Physics Uncertainty is used as Test Criteria for LPPT & PAT**
 - ✓ **Core Keff : 50 ppm (1,000 pcm for Safety Analysis)**
 - ✓ **MTC : 2.808 pcm/deg F**
 - ✓ **Control Rod Worth : -6.52%**
 - ✓ **Doppler Coefficient : 14 %**

Design Experience & Accuracy

- **OPR1000 Plant Design**

- ✓ **Over total 71 Cycles of 12 plants, We have a good result from a plenty of design experience**

PLANT	# of Total CYCLE (Designed by DIT/ROCS)
YGN3	13
YGN4	12
YGN5	7
YGN6	6
UCN3	10
UCN4	9
UCN5	5
UCN6	5
SKN1	1
SKN2	1
SWN1	1
SWN2	1
Total	71

- Low Power Physics Test & Power Ascension Test
- Safety Analysis (PSAR & FSAR Stage)
- Comparison for Accuracy : See next pages

ROCS LPPT Results (CBC of YGN-3 Cy 10 ~ 12)

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ROCS LPPT Results (ITC of YGN-3 Cy 10 ~ 12)

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ROCS LPPT Results (Bank Worth of YGN-3 Cy 10)

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ROCS LPPT Results (Bank Worth of YGN-3 Cy 11)

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ROCS LPPT Results (Bank Worth of YGN-3 Cy 12)

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ROCS LPPT Results (UCN-4 Cycle 1)

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Design Experience & Accuracy

- **APR1400 Plant Design**
 - ✓ **Identical Lattice Configuration with OPR1000 Fuel Assembly**
 - ✓ **Similar to Fuel Management of OPR1000 Core**
 - ✓ **Same Core Size with PVNGS Unit 1 & 2 (ENDF/B-IV for Cy 1)**

Design Experience & Accuracy

- **DIT/ROCS Topical Report**

- ✓ **DIT Code: Verification Against 6 Critical Experiments**

- ✓ **ROCS Code: benchmark comparison with various Plant Data**

- Normal Operation(Reactivity, Assembly Power Distribution, Inverse Boron Worth, ITC, Control Rod Bank Worth, Power Coefficient)

- Upset Condition(Dropped, Ejected and Net Rod Worths & Dropped, Ejected Rod Power Distribution)

- ➔ **Parameters calculated with design method and data shows good agreement with experiment**

- ➔ **Tolerance limits are in all cases smaller than the conservatism applied by C-E to input for safety analyses**

Conclusions

Conclusions

- **Basis for using ENDF/B-IV instead of more recent B-VI or B-VII.**
 - ✓ **The DIT/ROCS Topical Report documents in terms of biases and uncertainties, the accuracy associated with the methodology. This “level of accuracy” is the primary basis by which the NRC approved use of the Westinghouse nuclear design methodology for CE plants for licensing applications. The SER issued by the NRC approved use of the methodology and its level of accuracy. It was presumed that the level of accuracy will be maintained for future applications.**
 - ✓ **Thus bias and uncertainty factors associated with ENDF/B-IV data library have been updated periodically in order to maintain the level of accuracy when sufficient evidence accumulates that these factors need to be revised, based on the measurement data of operating plants.**

Conclusions

- **Basis for using ENDF/B-IV instead of more recent B-VI or B-VII.(Cont.)**
 - ✓ **The bias and uncertainty factors of ENDF/B-VI or VII will be different from those of ENDF/B-IV and requires huge effort or time for statistical analysis of the measurement data for several plants.**
 - ✓ **The current ENDF/B-IV data library and its associated biases and uncertainties have been verified to be acceptable for numerous operating experiences of CE-type plants and OPR1000 plants.**

Thank you for your attention.