NRR-PMDAPEm Resource

From: Miller, Ed
Sent: Wednesday, May 13, 2015 3:21 PM
To: Hardgrove, Matthew; Jenkins, Joel; Jackson, Christopher; Pascarelli, Robert; Poehler, Jeffrey
Subject: Duke/Westinghouse Presentation Slides for 5/19/15 Public Meeting on RAPTOR
Attachments: Duke Final slides for NRC RAPTOR presentation dated 5-12-15 rev 0.pdf; Catawba Unit 1 MUR RAI Whitepaper Slides_prop3_NRC.PDF

All,
Attached are the slides for the May 19 public meeting with Duke on their MUR fluence methodology. Please let me know if you have any questions. Thanks.

Ed Miller

Hearing Identifier: NRR_PMDA
Email Number: 2066

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Subject: Duke/Westinghouse Presentation Slides for 5/19/15 Public Meeting on RAPTOR
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Catawba Unit 1 MUR RAI Whitepaper Slides_prop3_NRC.PDF	634311	

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Catawba
Nuclear Station

Justification for the use of RAPTOR-M3G for the Catawba Unit 1 Measurement Uncertainty Recapture Power Uprate (MUR) Fluence Evaluations

Cecil Fletcher, Catawba Nuclear Station
Manager of Regulatory Affairs

May 19, 2015

- Joint NRC / Duke: Welcome / Introduction / Safety

  Per the NRC agenda

  – Inquire about nearest exits

  – Inquire about protocol for Alarms

Purpose of the meeting

- Duke requested this meeting to present its written response to RAI SRXB-RAI 8.

- *(RAI SRXB-RAI 8) The RAPTOR-M3G code used to calculate fluence for MUR conditions does not appear to be approved by the NRC for use in this scenario. The NRC staff requests that the licensee provide justification for the use of RAPTOR-M3G for fluence calculations for MUR conditions, or provide an alternative fluence calculation using an NRC approved method.*

- This meeting coupled with additional technical information submitted to the NRC provides the justification for the use of RAPTOR-M3G for the Catawba Unit 1 MUR Power Uprate Fluence evaluations.

Project Overview

- During the course of the project, design and operational margin evaluations have been completed on all Catawba Unit 1 and Shared Structure, Systems and Components (SSCs). These evaluations demonstrate that Catawba Unit 1 and Shared SSCs have sufficient margin to accommodate the MUR Power Uprate.

- Cameron Measurement Systems, Caldon Ultrasonics LEFM CheckPlus Flow Measurement system was installed in Catawba unit 1 in May 2013.

- LAR Submittal Background:

- Initial submittal made on June 23, 2014 consistent with Regulatory Issue Summary (RIS) 2002-03 format.
- Supplemented on August 26, 2014 to confirm completion of commitment related to evaluation of components for acceptability for post-MUR equipment qualification (EQ) conditions.
- First request for additional information (RAI) response letter submitted on December 15, 2014 (responded to questions from SRXB, SCVB, AFPB, EMCB, and ESGB branches and included WCAP-16083-NP and WCAP-17669-NP).
- Second RAI response letter submitted on January 22, 2015 (responded to questions from EVIB and EEEB branches).
- Third RAI response letter submitted on April 23, 2015 (responded to questions from SRXB, ESGB, and EEEB branches and included WCAP-17993-NP).

- 2012 Decision to Use Raptor
  - Both DORT/SYNTHESIS and RAPTOR-M3G had been performed. Comparison showed:
    - The two methods calculated essentially identical (<2%) fluence values for the original beltline region.
    - Being better able to track and account for high energy neutrons, RAPTOR fluence values in the extended beltline region were more realistic.
  - RAPTOR was validated within Westinghouse using by past surveillance capsule dosimetry data per Reg. Guide 1.190.
  - RAPTOR was previously used for South Texas Capsule fluence. NRC stated:
    - "Should future evaluations employ fluence methods that have not been NRC reviewed and approved, adequate justification regarding the application and qualification of those methods should be provided. RG 1.190 provides guidance for acceptable fluence methods."

- Catawba Reactor Vessel Material
  - During recent license amendment submittals the NRC Staff has requested all RV ferritic material be included when addressing fracture toughness requirement for RV integrity. RIS 2014-11 defines these requirements.
  - As a result of considering all ferritic material for the MUR submittal, the lead material for P-T limits is located in the Catawba Unit 1 extended beltline region. Factors that contributed to the shift in location are:
    - The original beltline materials have good toughness properties based on actual material data.
    - Not all material properties are available for the extended beltline material resulting in uncertainty which requires additional margin.
  - The current Catawba Unit 1 P-T limits are for 34 EFPY. Using RAPTOR to calculate fluence including the extended beltline for MUR, the current P-T limits would be good for 30.7 EFPY. (Currently 25.1 EFPY)
  - With inclusion of margin associated with extended beltline material/nozzles and possibly BTP 5-3, the improved accuracy obtained by using RAPTOR is important in maintaining adequate but reasonable operational limits.

Catawba Unit 1 MUR SRXB-RAI 8 Response

Jianwei Chen
Principal Engineer, Ph. D
Greg A. Fischer
Principal Engineer, P.E.

Westinghouse

Background

- The neutron fluence exposure at reactor pressure vessel (RPV) is an important input to the reactor vessel integrity (RVI) assessment, which is a critical evaluation for power uprate and plant life extension
- Traditionally, the neutron fluence has been evaluated using discrete ordinates radiation transport codes:
  - TWOTRAN (1968) – Can only solve 1-D and 2-D problems
  - DOT (1970) – Can only solve 1-D and 2-D problems
  - DORT (1980's) – Can only solve 1-D and 2-D problems
  - TORT – Can solve 3-D problems, but not for full-size commercial reactor vessels per Regulatory Guide 1.190 pedigree due to computer resource limitations

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Background

- RAPTOR-M3G was developed to overcome TORT's limitations

Feature	TORT	RAPTOR-M3G
Solves the linear Boltzmann radiation transport equation in 3D	√	√
Applies the method of discrete ordinates (the S_N method) to treat directional variables	√	√
Applies weighted finite-difference methods to treat spatial variables	√	√
Applies a multigroup formulation to treat energy dependence	√	√
DOORS Package (DORT/TORT) input format	√	√
Execute on a one-workstation platform	√	√
Executes simultaneously in-parallel on a network of workstations		√
Execute with theta-weighted (TW) spatial differencing scheme	√	√
Execute with directional theta-weighted (DTW) spatial differencing scheme		√

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Background

- Westinghouse has performed the neutron fluence evaluation in support of the Catawba Unit 1 MUR using RAPTOR-M3G in WCAP-17669-NP, Revision 0
- NRC issued SRXB-RAI 8:
  - The RAPTOR-M3G code used to calculate fluence for MUR conditions does not appear to be approved by the NRC for use in this scenario. The NRC staff requests that the licensee provide justification for the use of RAPTOR-M3G for fluence calculations for MUR conditions, or provide an alternative fluence calculation using an NRC approved method.

Westinghouse

Westinghouse RAI Response

- Westinghouse/Duke are providing justification to the NRC that the use of RAPTOR-M3G for fluence calculations for MUR conditions is acceptable.
- Additional Catawba Unit 1 specific benchmark calculations have been done between TORT and RAPTOR-M3G
  - For limiting RPV materials
  - For representative fuel cycles
- Due to computer limitations with TORT, three reduced size models were used:
  - Upper Reactor Environment (URE) model (Weld 06)
  - Midplane Reactor Environment (MRE) model (Weld 05)
  - Lower Reactor Environment (LRE) model (Weld 04)

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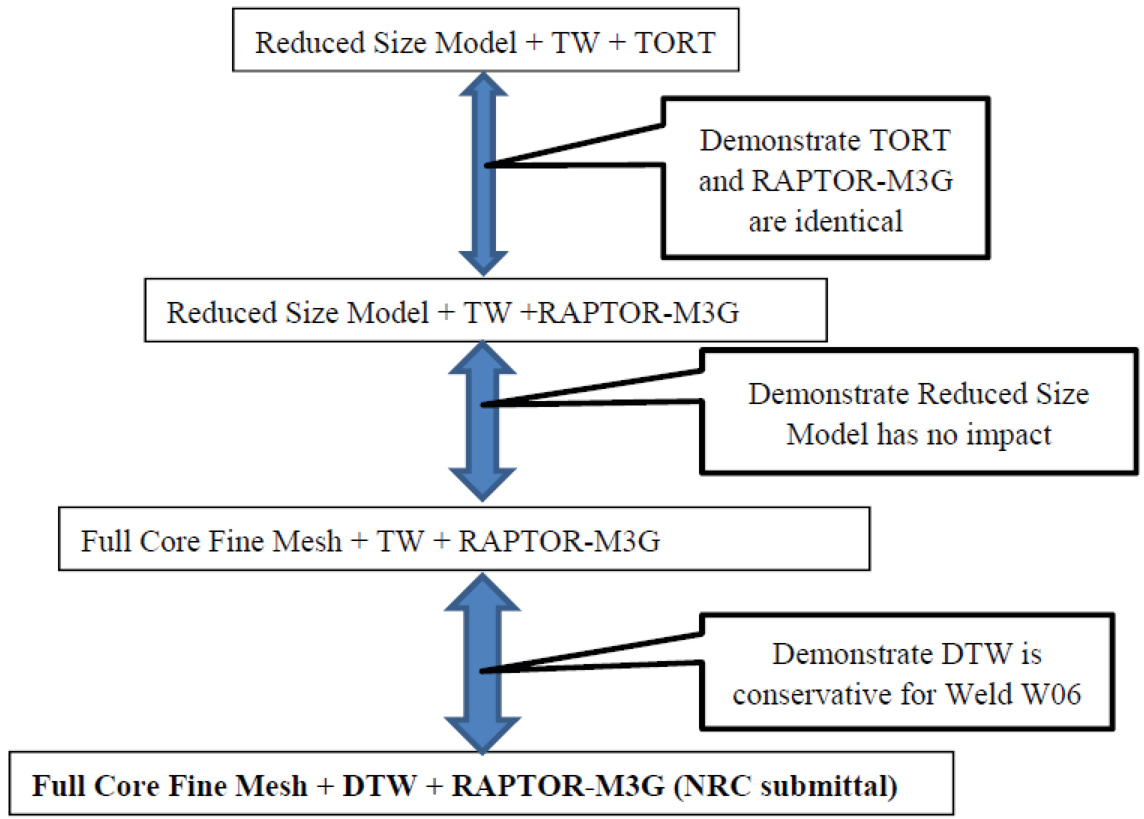
Westinghouse RAI Response Strategy



4 sets of results for detailed comparison of TORT and RAPTOR-M3G runs

Westinghouse

Questions?

Westinghouse RAI Response Calculations

- RPV Materials Evaluated in Benchmark Calculations
  - Upper Shell to Intermediate Shell Circumferential Weld W06
  - Intermediate Shell to Lower Shell Circumferential Weld W05
  - Lower Shell to Bottom Head Ring Circumferential Weld W04
- Power Distributions used in Benchmark Calculations
  - Cycle 3, representative of Out-In (High Leakage) core design strategies
  - Cycle 21, representative of Low-Leakage core design strategies
  - A time-weighted average of power distributions through 54 EFPY, to provide fluence projection at 54 EFPY based on one cycle calculation

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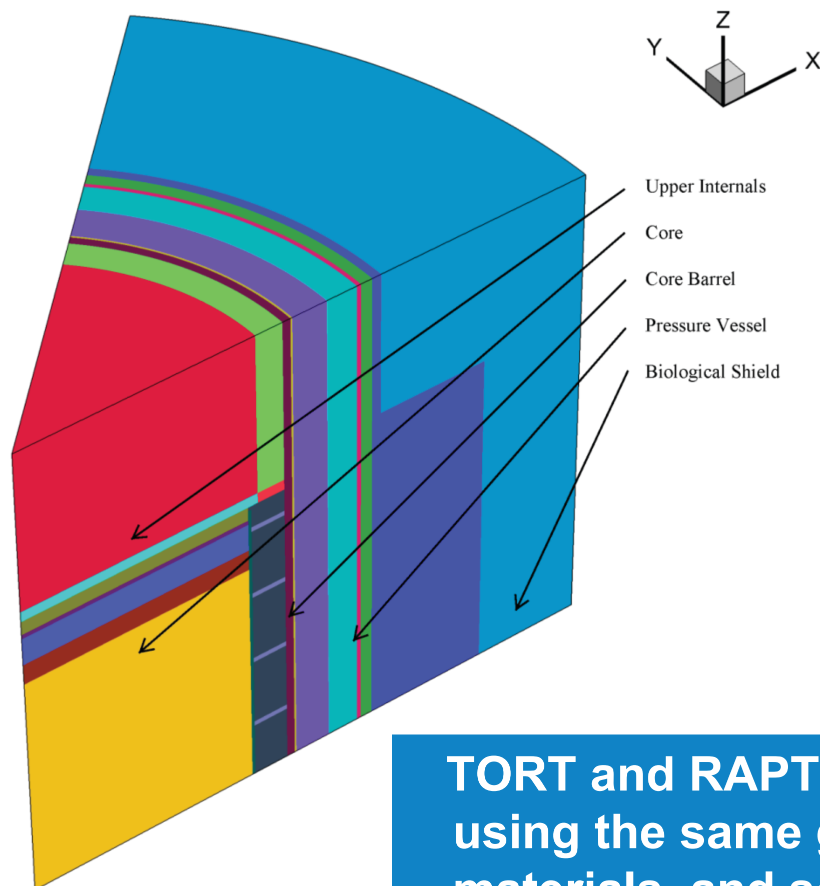
Westinghouse RAI Response Calculations

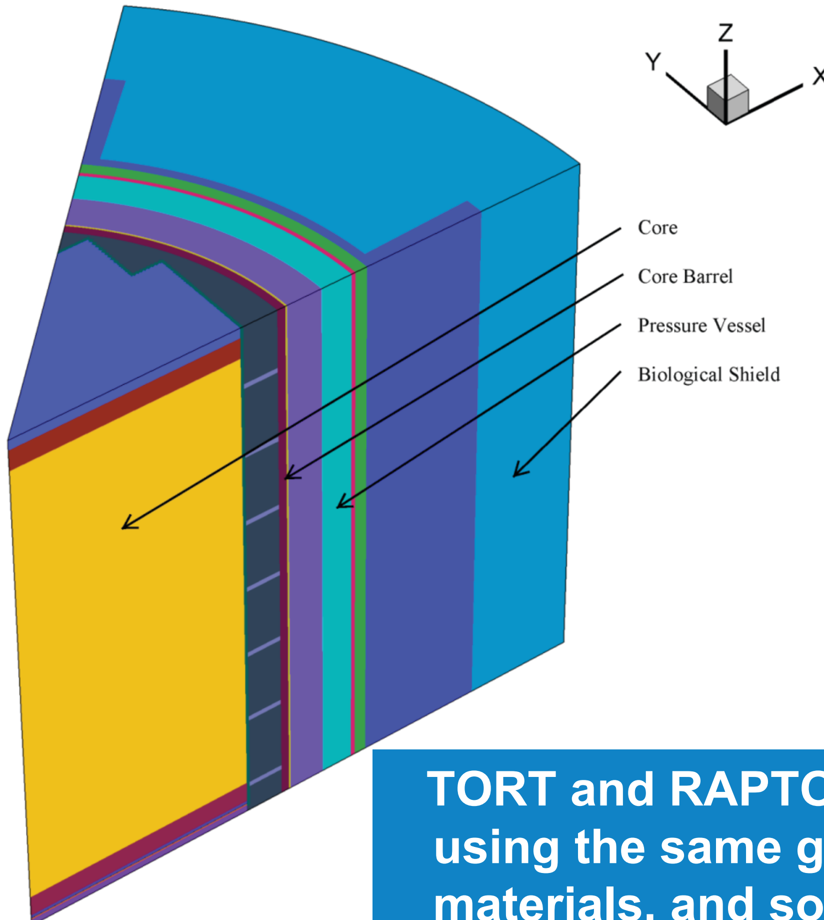
- URE model – 209 radial, 195 azimuthal, and 89 axial mesh intervals



TORT and RAPTOR-M3G runs are using the same geometry model, materials, and source distributions

Westinghouse RAI Response Calculations

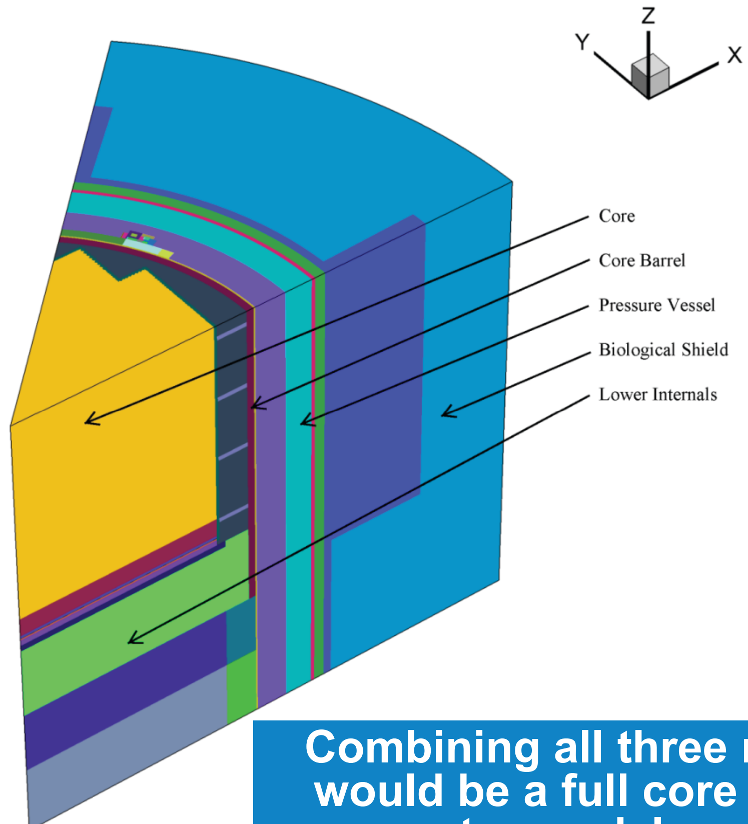
- MRE model – 209 radial, 195 azimuthal, and 85 axial mesh intervals



TORT and RAPTOR-M3G runs are using the same geometry model, materials, and source distributions

Westinghouse RAI Response Calculations

- LRE model – 209 radial, 195 azimuthal, and 91 axial mesh intervals



Combining all three reduced size models would be a full core model similar to geometry model used in WCAP-17669-NP, but still not as refined.

Westinghouse RAI Response Calculations

- Boundary Conditions and Extent of Applicability for the Reduced Size Models

Parameter	Reduced-Size Model		
	URE	MRE	LRE
Bottom of Model*	0.0 cm	-191.206 cm	-363.296 cm
Bottom Boundary Condition	Reflective	Void	Void
Top of Model*	343.46 cm	190.289 cm	0.0 cm
Top Boundary Condition	Void	Void	Reflective
Bottom Extent of Model Applicability*	75.0 cm	-75.0 cm	-330.0 cm
Top Extent of Model Applicability*	300.0 cm	75.0 cm	-75.0 cm
Materials Analyzed in Model	Weld W06	Weld W05	Weld W04

* Dimensions are given relative to the active core midplane

URE – Weld 06
MRE – Weld 05
LRE – Weld 04

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Westinghouse RAI Response Calculation Results

- Calculated Neutron Fluence Rates for Catawba Unit 1 Cycle 3

Model	**Calculated Neutron (E>1.0 MeV) Fluence Rate (Flux) [n/cm^2-s]**		
	Weld W06	**Weld W05**	**Weld W04**
Reduced-Size Models (TORT) with TW	1.06E+09	2.36E+10	1.91E+09
Reduced-Size Models (RAPTOR-M3G) with TW	1.06E+09	2.36E+10	1.90E+09
RAPTOR-M3G Model in WCAP-17669-NP, Rev. 0 with TW	1.06E+09	2.36E+10	1.90E+09
RAPTOR-M3G Model in WCAP-17669-NP, Rev. 0	1.14E+09	2.33E+10	1.98E+09

TORT and RAPTOR-M3G with TW methods give identical results (<1%).

RAPTOR-M3G with DTW method yields more conservative results for limiting weld W06

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Westinghouse RAI Response Calculation Results

- Calculated Neutron Fluence Rates for Catawba Unit 1 Cycle 21

Model	Calculated Neutron (E>1.0 MeV) Fluence Rate (Flux) [n/cm^2-s]		
	Weld W06	**Weld W05**	**Weld W04**
Reduced-Size Models (TORT) with TW	6.41E+08	1.54E+10	1.20E+09
Reduced-Size Models (RAPTOR-M3G) with TW	6.40E+08	1.54E+10	1.20E+09
RAPTOR-M3G Model in WCAP-17669-NP, Rev. 0 with TW	6.40E+08	1.54E+10	1.20E+09
RAPTOR-M3G Model in WCAP-17669-NP, Rev. 0	6.98E+08	1.54E+10	1.26E+09

TORT and RAPTOR-M3G with TW methods give identical results (<1%).

RAPTOR-M3G with DTW method yields more conservative results for limiting weld W06

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Westinghouse RAI Response Calculation Results

- Calculated Neutron Fluence after 54 EFPY at Catawba Unit 1 (Reduced-Size Models calculated using time-weighted average power distributions)

Model	Calculated Neutron (E>1.0 MeV) Fluence [n/cm^2]		
	Weld W06	**Weld W05**	**Weld W04**
Reduced-Size Models (TORT) with TW	1.05E+18	2.66E+19	1.83E+18
Reduced-Size Models (RAPTOR-M3G) with TW	1.05E+18	2.66E+19	1.83E+18
RAPTOR-M3G Model in WCAP-17669-NP, Rev. 0 with TW	1.05E+18 (1.07E+18)*	2.66E+19 (2.63E+19)*	1.83E+18 (1.86E+18)*
RAPTOR-M3G Model in WCAP-17669-NP, Rev. 0	1.16E+18	2.60E+19	1.95E+18

*The projected 54 EFPY fluence value in the parenthesis is calculated by accumulating cycle-specific fluence for cycles 1 through 22, and assuming Cycle 22 at MUR power for cycles beyond Cycle 22, the same approach used in WCAP-17669-NP, Rev. 0

TORT and RAPTOR-M3G with TW methods give identical results (<1%).

RAPTOR-M3G with DTW method yields more conservative results for limiting weld W06

Westinghouse RAI Response Calculation Conclusions

- TORT and RAPTOR-M3G produce nearly identical results, i.e., within 1%, when using the same geometrical model and calculation control parameters
- The results from RAPTOR-M3G and TORT agree better than the 13% uncertainty assigned to the calculational methodology and well within the 20% uncertainty deemed acceptable for RT_{PTS} and RT_{NDT} determination
- The fast neutron fluence reported to NRC for the limiting material at 54 EFPY (upper shell to intermediate shell circumferential weld W06) in WCAP-17669-NP, Rev. 0 is the bounding value
- Therefore, the fast neutron flux / fluence values submitted to NRC in WCAP-17669-NP, Rev. 0 are acceptable

Westinghouse RAI Response Calculation Conclusions

- The in-vessel surveillance capsule and ex-vessel neutron dosimetry data have been provided in WCAP-17669-NP, Rev. 0, Appendix C, the measurement-to-calculation comparisons show:
  - The in-vessel dosimeters meet the ±20% criteria for in-vessel surveillance capsules per Regulatory Guide 1.190
  - The ex-vessel dosimeters meet the ± 30% criteria for the cavity capsules per Regulatory Guide 1.190.
- Further sensitivity study has shown:
  - Both the RAPTOR-M3G model used in WCAP-17669-NP, Rev. 0 and the reduced size models have achieved geometrical convergence, i.e., using much coarser mesh only changes the fluence results less than 2%.
  - Using different quadrature sets (e.g., S_{12} vs. S_8) only renders less than 3% difference in the calculated fluence values.

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Thank you !
&
Questions?

Westinghouse