



TN-B1 Project

Docket No. 71-9372

Larry Tupper
Manager Special Projects
16 December 2013

FUEL BUSINESS GROUP



Agenda



- ▶ **TN-B1 Project Overview**
- ▶ **TN-B1 Initial Submittal**
- ▶ **ATRIUM™ 11 Fuel Assembly**
- ▶ **ATRIUM™ 11 LTA Shipment**
- ▶ **TN-B1 Revision to incorporate ATRIUM™ 11**
- ▶ **Next Steps**



TN-B1 Project Overview

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AREVA NP TN-B1 Shipping Container Pre-Submittal Meeting



RAJ-II Container License



- ▶ **Current RAJ-II CoC (Rev 9 to USA/9309/B(U)F-96)**
 - ◆ Based upon revision 7 to the SAR. This revision of the SAR supports both current GNF and AREVA NP BWR designs.
 - ◆ Current CoC expires in November 2014
- ▶ **GNF Proposed revision to SAR**
 - ◆ GNF has submitted a revision 8 to the SAR.
 - ◆ GNF responded to NRC RAIs on 7/23/13
 - ◆ This revision would amend the SAR to cover GNF and Westinghouse BWR designs.
 - ◆ AREVA NP declined to participate in this version of the SAR due to commercial reasons.

ATRIUM™ 11

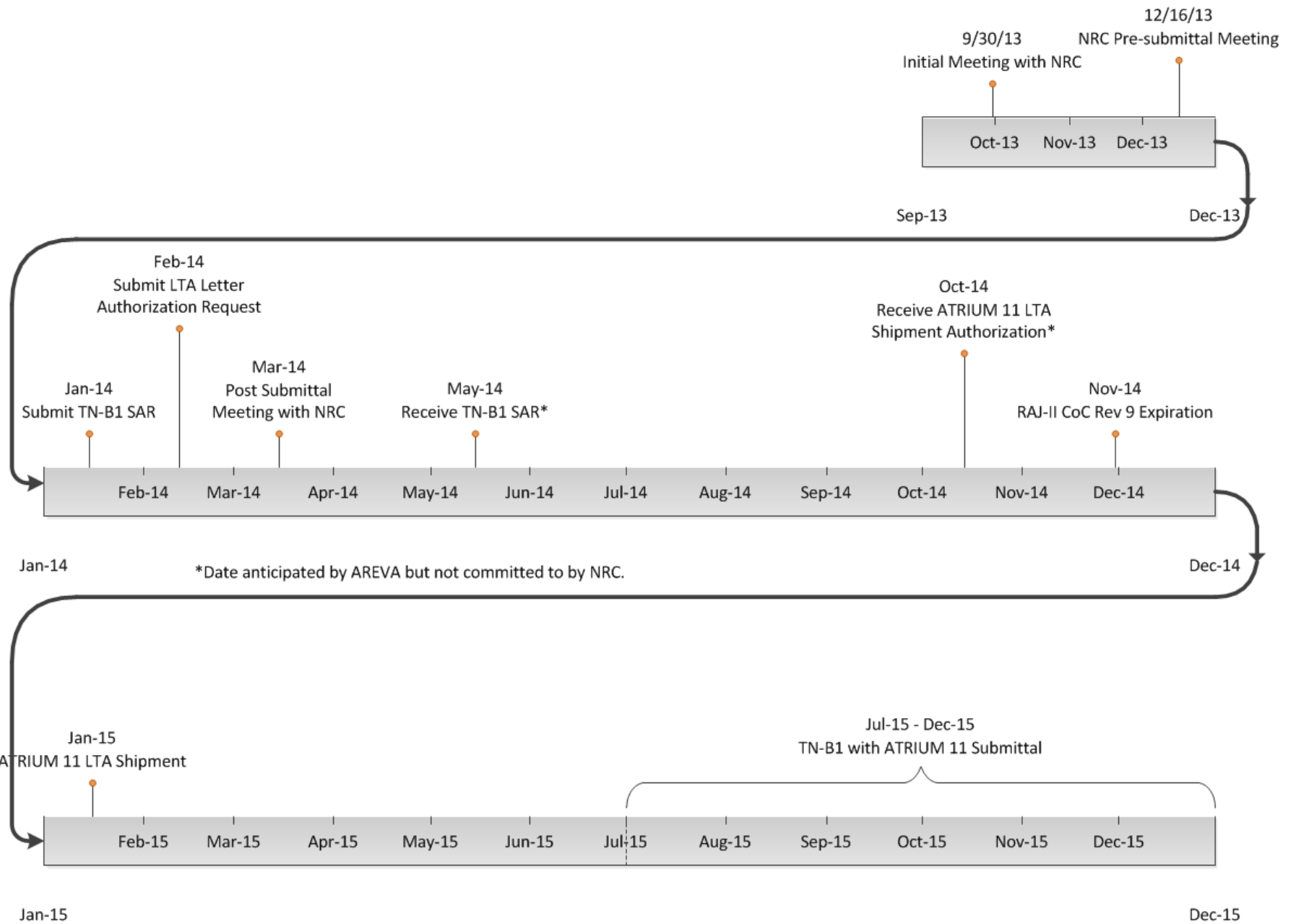


- ▶ **ATRIUM™ 11 is the next generation of AREVA's BWR fuel design.**
- ▶ **ATRIUM™ 11 Lead Test Assemblies (LTAs) will be shipped from Richland to the host utility plant in the December 2014 to January 2015 timeframe.**
- ▶ **Reloads of ATRIUM™ 11s are anticipated in approximately 2019.**
- ▶ **Current CoC for RAJ-II does not support the ATRIUM™ 11 design.**

TN-B1 Project



- ▶ **TN-B1 Project is designed to provide AREVA with a shipping container for both its existing BWR fuel designs and the ATRIUM™ 11.**
- ▶ **Project has 3 distinct phases**
 - ◆ **TN-B1 Initial Submittal**
 - ◆ **ATRIUM™ 11 LTA Letter Authorization Submittal**
 - ◆ **TN-B1 Revision to include ATRIUM™ 11**



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TN-B1 Initial Submittal

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TN-B1 Initial Submittal



- ▶ **TN-B1 container design is identical to that of the RAJ-II.**
- ▶ **TN-B1 submittal is based upon revision 7 to the SAR of the RAJ-II CoC (Rev 9 to USA/9309/B(U)F-96).**
- ▶ **The TN-B1 SAR submittal is an administrative change to revision 7 as follows:**
 - ◆ **RAJ-II has been changed to TN-B1 where appropriate.**
 - ◆ **AREVA is shown as the certificate holder instead of GNF-A.**
- ▶ **Since the design is identical to that of the RAJ-II, there are no changes to the structural evaluation, thermal evaluation, etc.**
- ▶ **There are no changes to package operations, acceptance test or maintenance programs.**

TN-B1 Initial Submittal



► The TN-B1 submittal will include:

- ◆ The SAR
- ◆ A document showing all of the differences between the SAR submittal and revision 7 to the SAR of the RAJ-II.

Comparison of TN-B1 R0 SAR with RAJ-II R7 SAR Identifying the Changes in the TN-B1 SAR

Section	Changes from RAJ-II R7 SAR
Title Page	GNF RAJ-II changed to AREVA TN-B1, Docket Number changed from 71-9309 to 71-9372, Revision 0 of the TN-B1 SAR, and Date changed from 05/04/2009 to 11/12/2013.
Throughout	Changed RAJ-II to TN-B1 where appropriate.
Section 1.1	New first paragraph, added to describe how the TN-B1 differs from the RAJ-II.
Section 1.2.3.4.6	Second sentence, drawing number changed from 0028B98 to 02-9162724.
Section 1.2.3.4.7	Last sentence, changed Table 6-2 to Section 7.1.2 to correct error. (Table 6-2 does not list quantities, only Section 7.1.2 does).
Section 1.4.1.1	Drawing list changed to list AREVA drawings 02-9162717 and 02-9162722 in place of GNF drawings 105E3744 and 105E3749.

Example



ATRIUM™ 11 Fuel Assembly

Corey Long
Group Leader
Mechanical Product Development Team
Richland Fuel Mechanics

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ATRIUM™ 11 – An advanced design for Boiling Water Reactors



Startup 05 Aug 2012

▶ ATRIUM™ 11 in-reactor service is now underway

- ◆ Annual inspections of first Lead Test Assemblies performed in 2013

▶ Extensive qualification assured readiness for in-reactor validation

- ◆ Proven materials
- ◆ Robust design practices
- ◆ FMEA* reviews
- ◆ Comprehensive testing

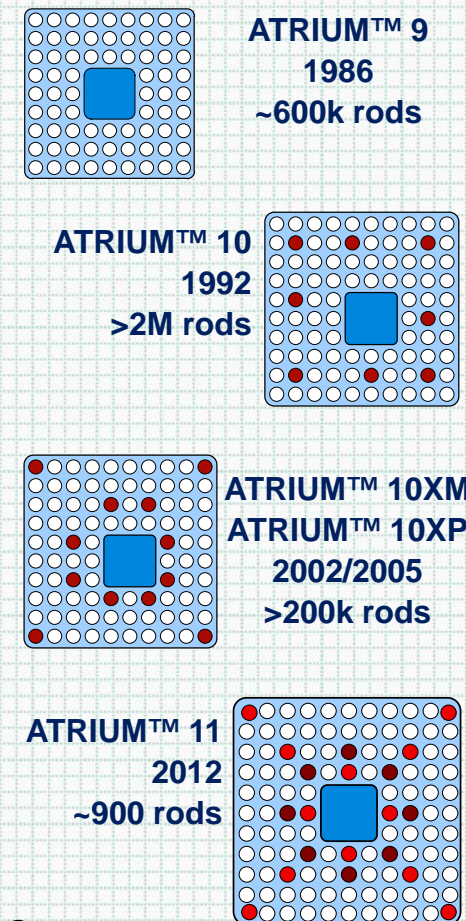
**Focus on
Reliability**



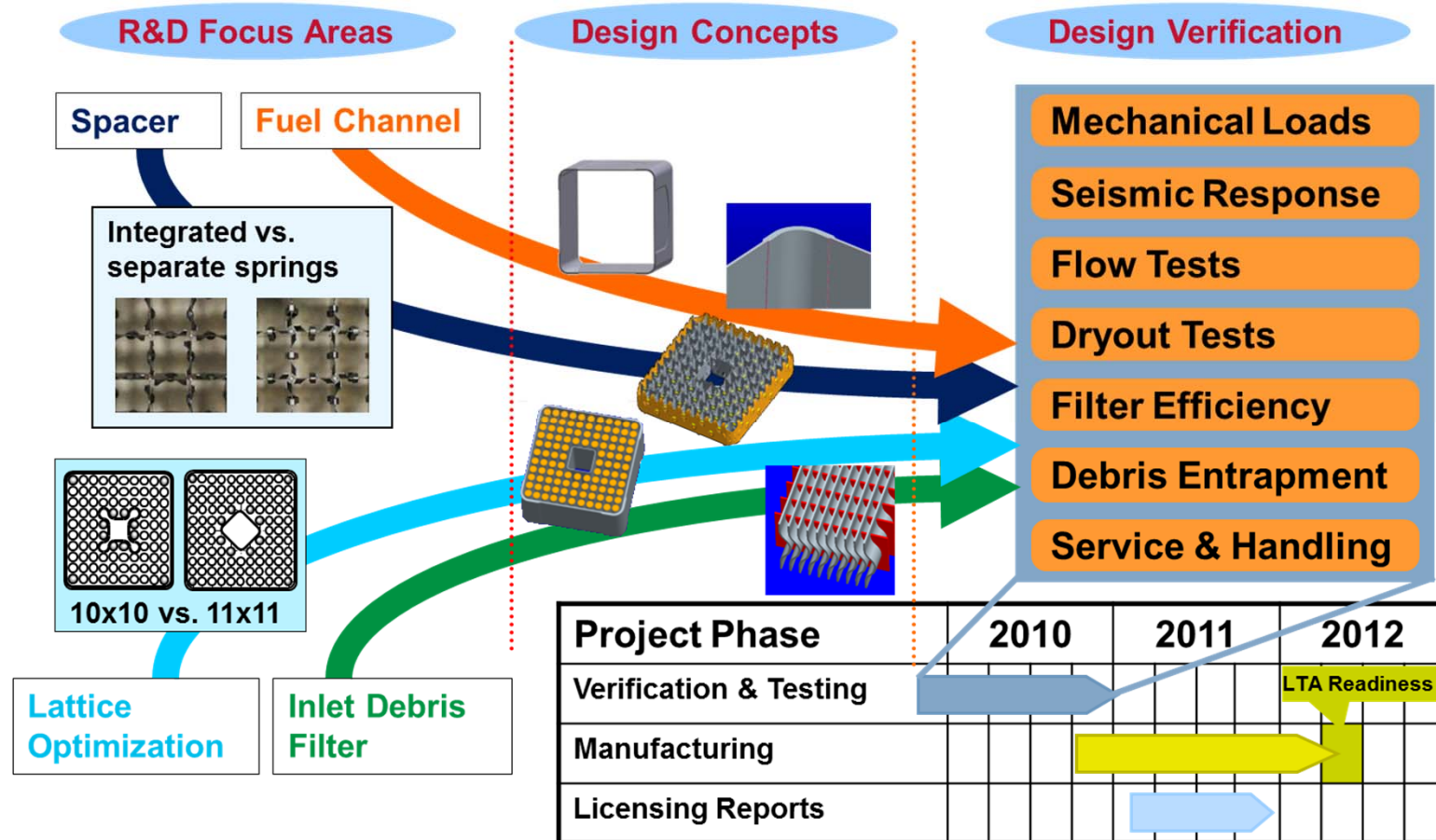
ATRIUM™ 11 builds on the successful experience of the ATRIUM™ product line

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* FMEA – Failure Modes and Effects Analysis



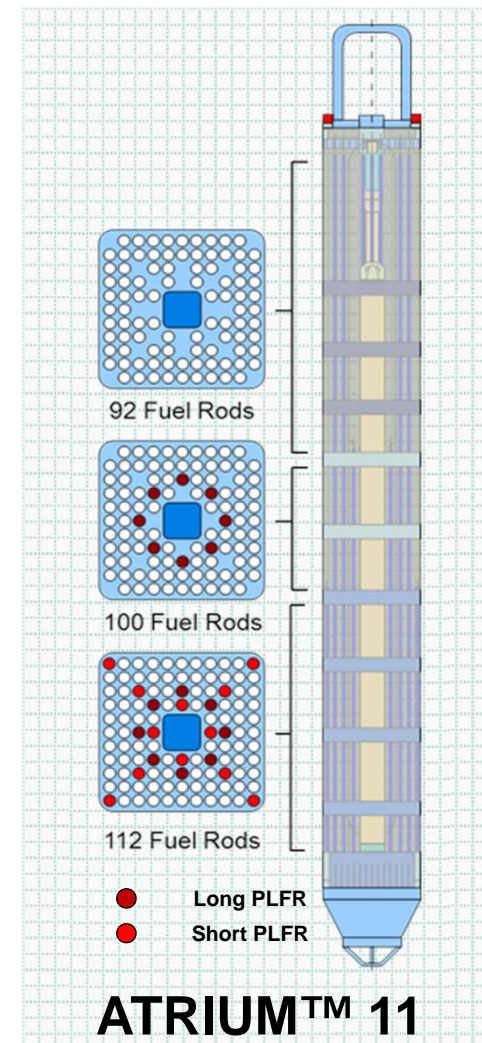
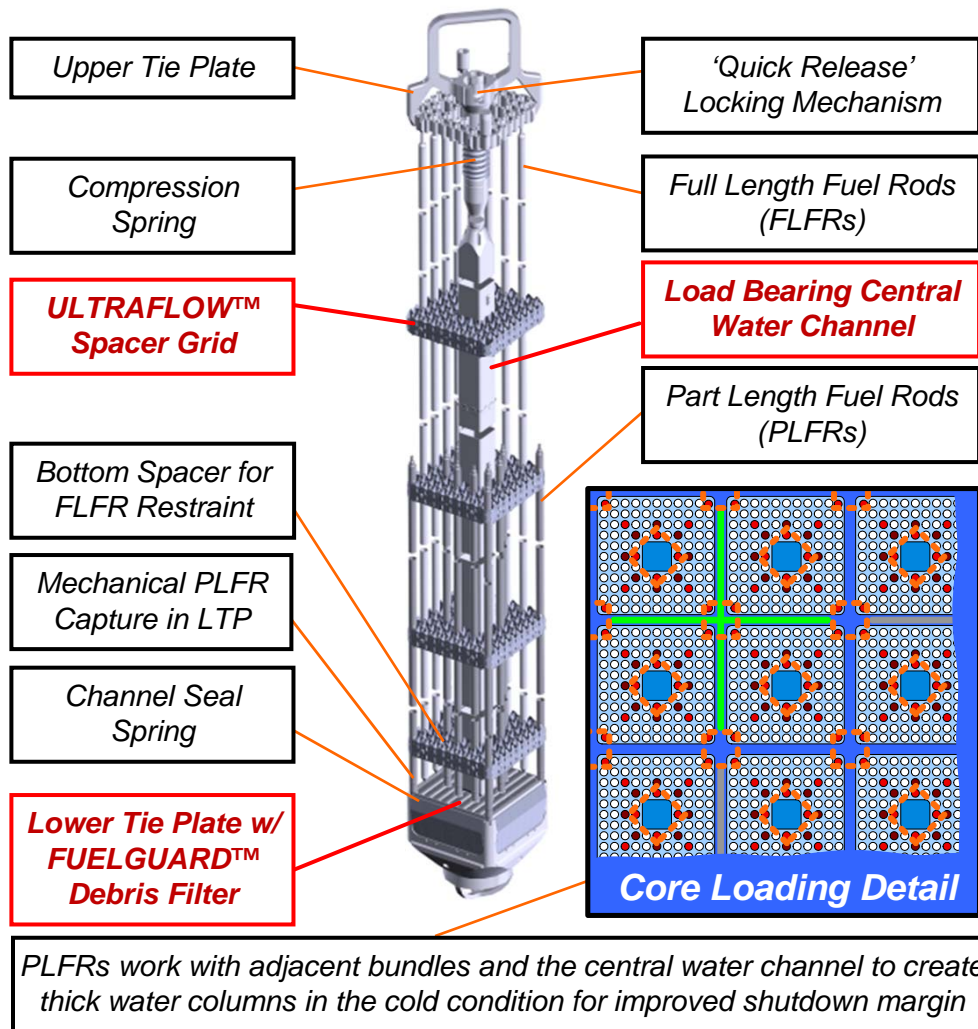
The Road to Readiness for In-service Qualification



» Extensive computer modelling of mechanical, neutronic, and thermal-hydraulic behaviour helped refine design

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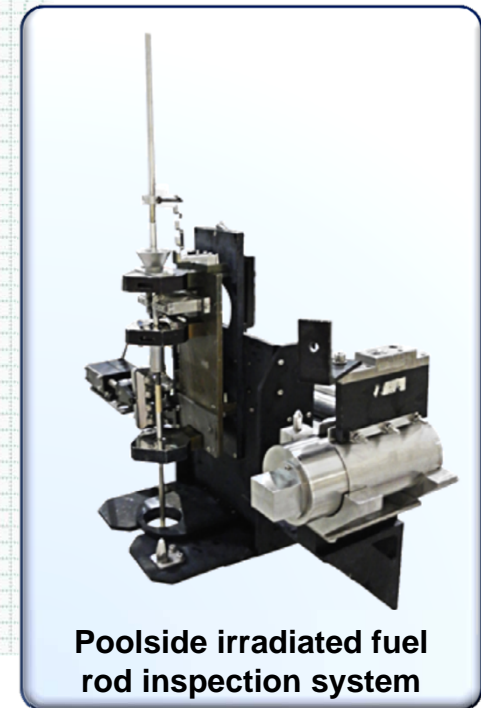
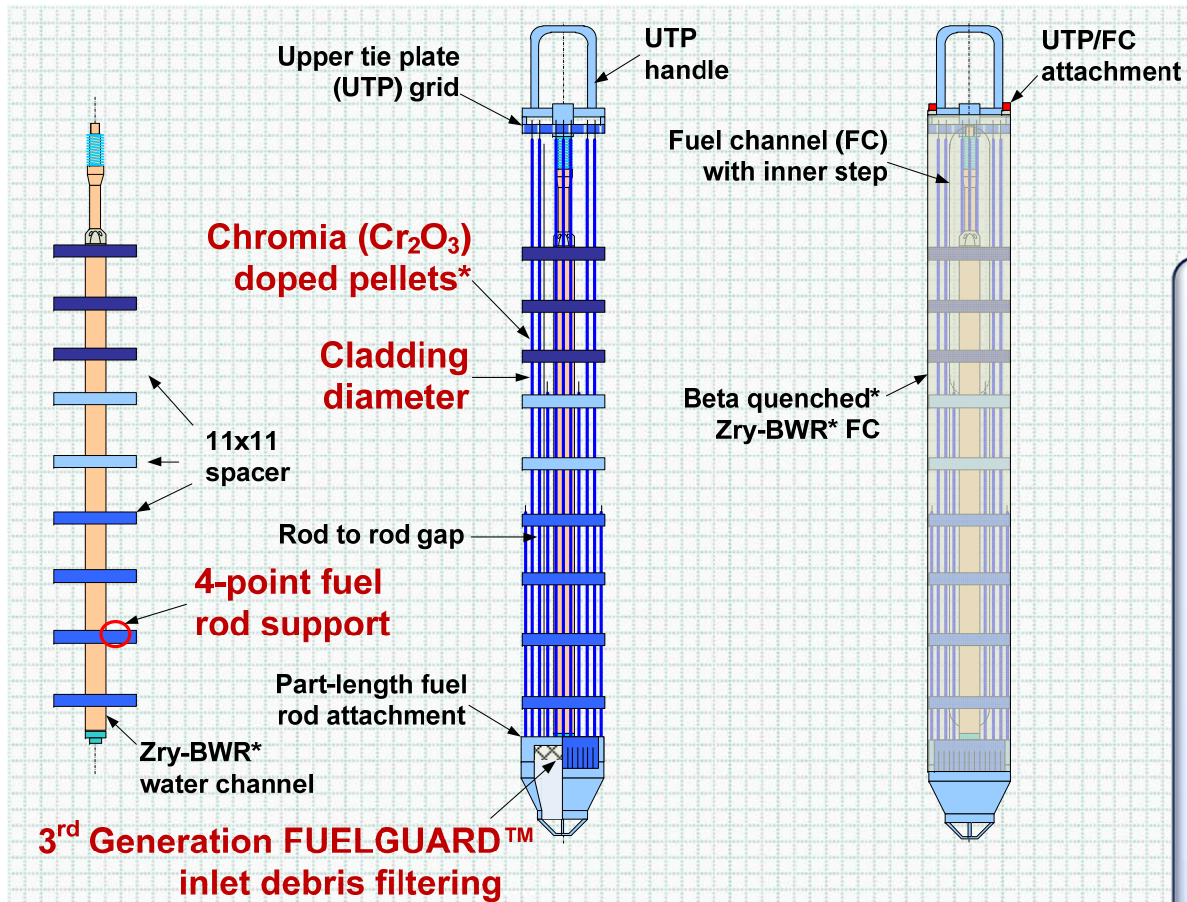
Common Features with Preceding ATRIUM™ Products



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Key New Features of the ATRIUM™ 11

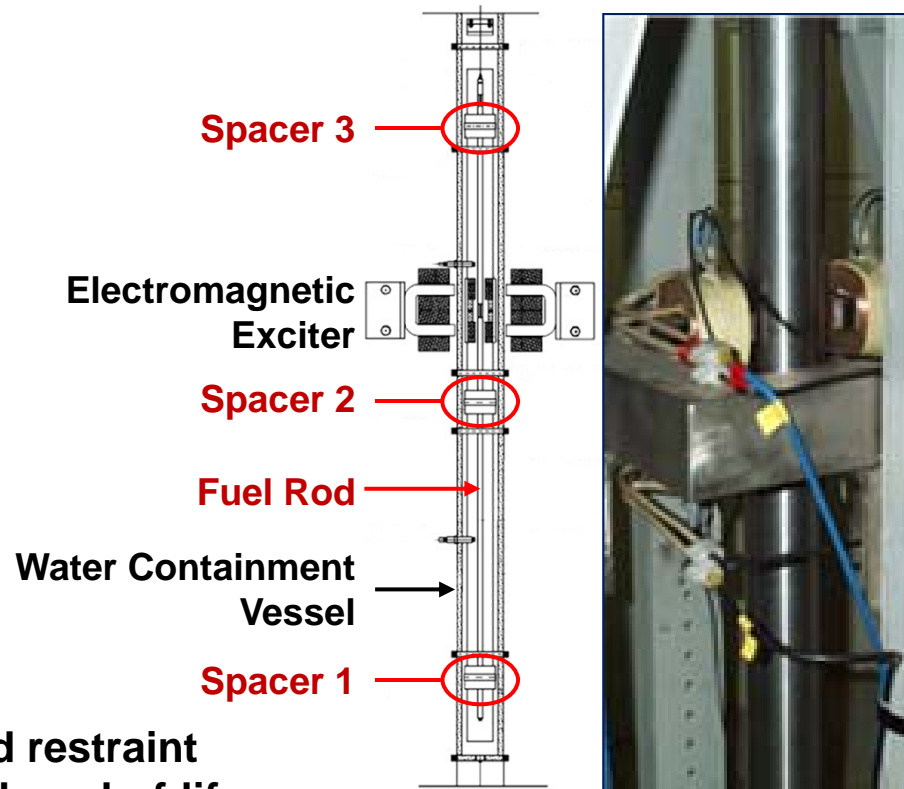
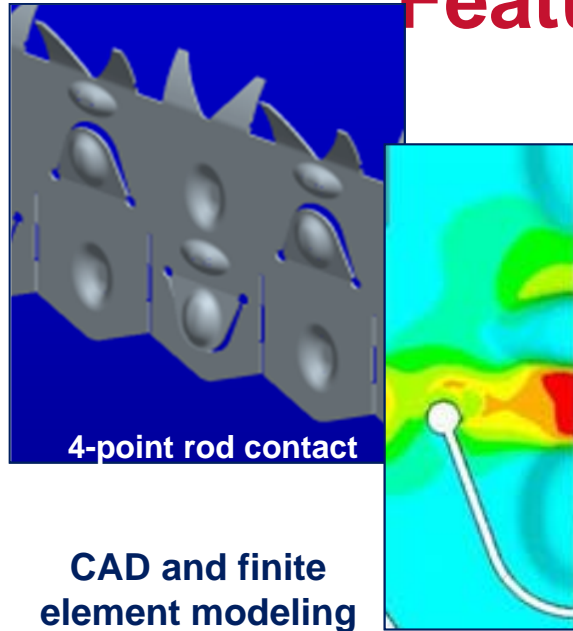


Extensive inspections will follow the in-service performance of new features

* Zry-BWR, FC beta quench, and $\text{UO}_2\text{-Cr}_2\text{O}_3$ qualification programs are proceeding independently

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Validating the Fuel Rod Support Features of the ATRIUM™ 11



► Key design objectives:

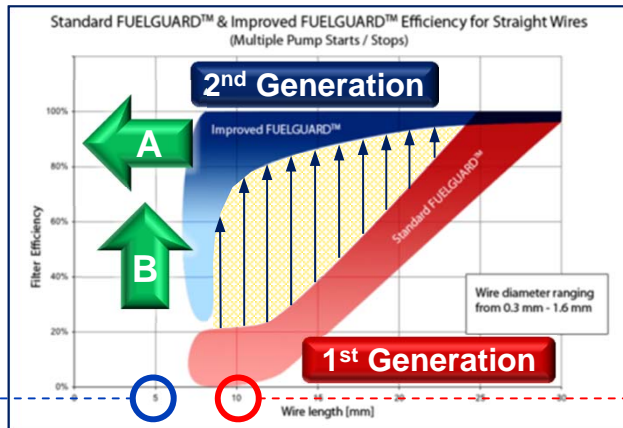
- ◆ Provide positive fuel rod restraint for shipping and through end-of-life
- ◆ Prevent flow-induced fretting
- ◆ Preclude stress corrosion cracking in the rod support features
- ◆ Preclude distortion of the spacer grid

Grid-to-rod fretting tests under lateral excitation

- Rods examined for wear after life-equivalent cycles

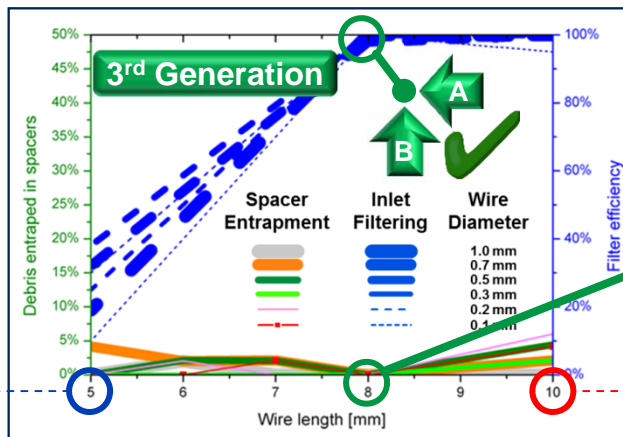
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Design and Validation for Wire Debris Resistance in the ATRIUM™ 11

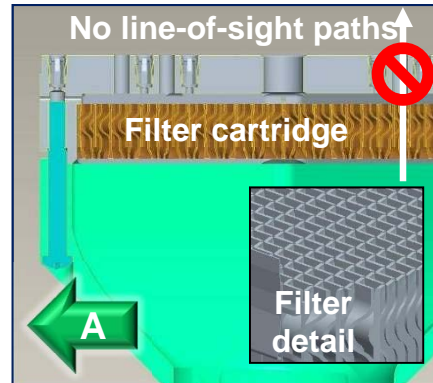


Improving Inlet Filtering:

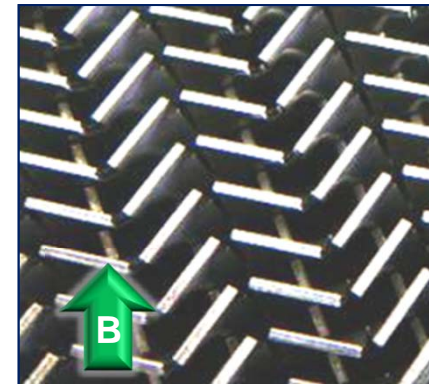
- A. Reducing wire size**
- B. Addressing flexible wires**



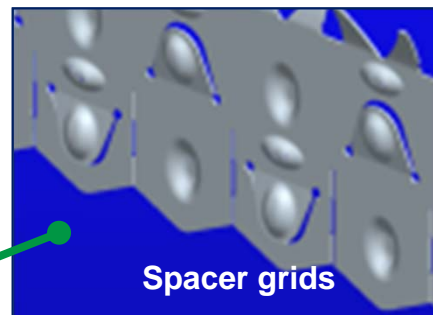
3rd Generation FUELGUARD™



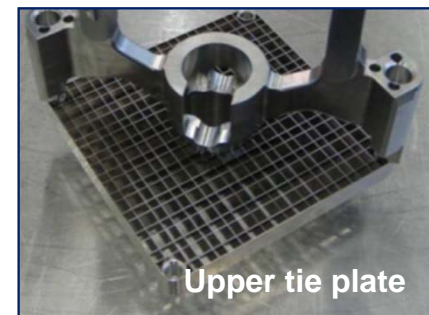
Cartridge design allows tighter inlet channels



“Twist” features at leading edge trap flexible wires



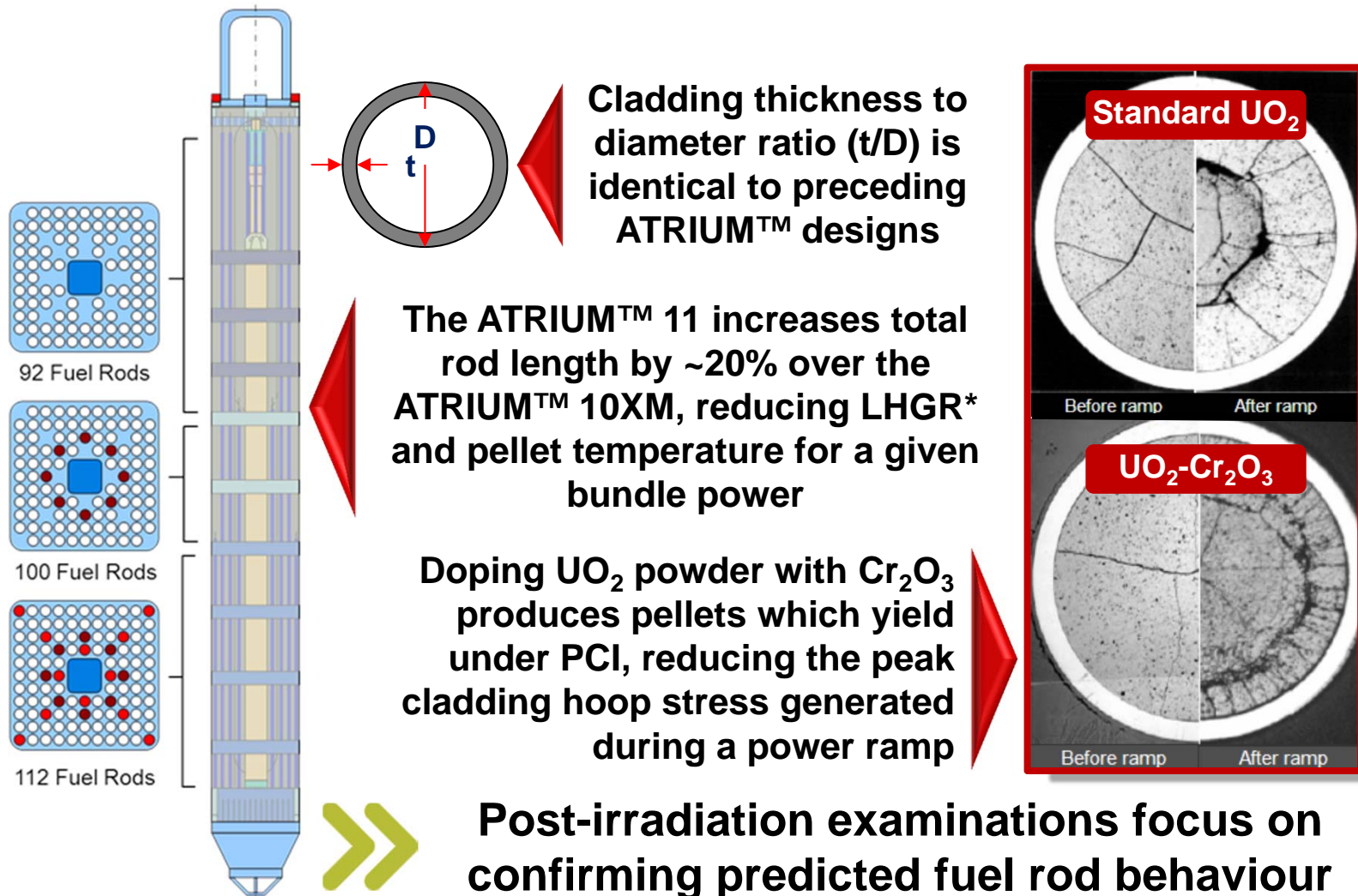
Zigzag leading edge, reduced number of contact points, and streamlined rod supports



Double strip upper tie grid adds protection to top of bundle

FUEL

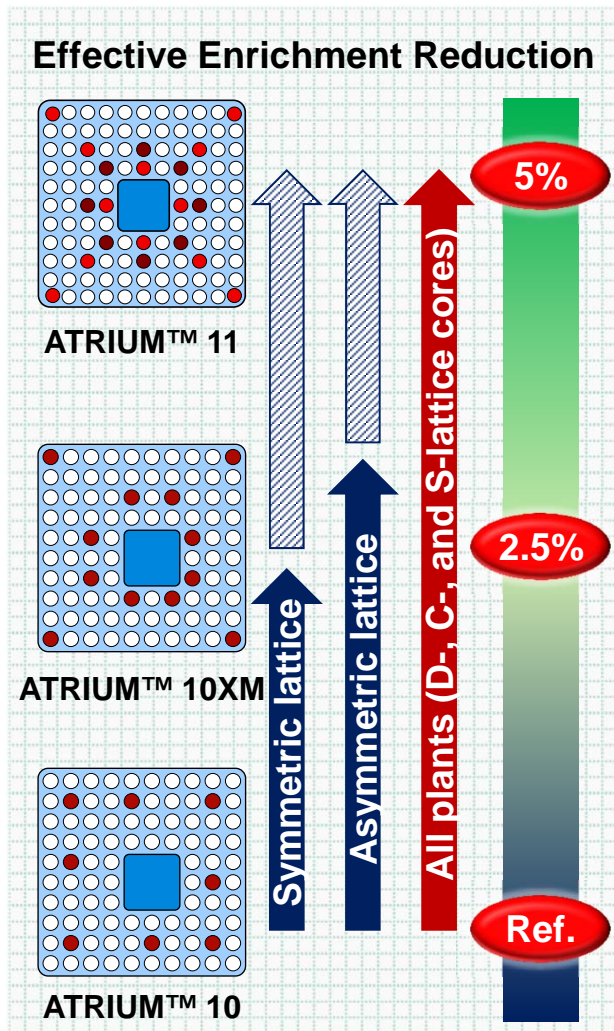
Design for Pellet-Clad Interaction Resistance in the ATRIUM™ 11



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* LHGR – Linear Heat Generation Rate

Realizing the Fuel Cycle Cost Benefits of the ATRIUM™ 11



- ▶ The ATRIUM™ 11 builds on the key gains realized by the ATRIUM™ 10XM

- ◆ Improved critical power capability
- ◆ Reduced reload batch size
- ◆ Reduced gadolinia demand

Plus

- ◆ Improved thermal-hydraulic stability
- ◆ Increased thermal-mechanical margin

- ▶ The ATRIUM™ 11 significantly improves the fuel-to-moderator distribution

- ◆ More optimal radial distribution
- ◆ More optimal axial distribution

- ▶ Operating margins assure optimal enrichment distribution is realized



Cycle studies confirm benefits for a wide range of plants

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AREVA is Pleased to Introduce the ATRIUM™ 11 to the World's BWR Fleet

*Engineered for enhanced reliability
and unrivalled fuel efficiency*



*Globally developed and rigorously
tested for world-wide applications*

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ATRIUM™ 11 LTA Shipment Letter Authorization

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ATRIUM™ 11 LTA Shipment



- ▶ Shipment will be 8 ATRIUM™ 11 Fuel Assemblies.
- ▶ Shipment will be in TN-B1 Shipping Containers
- ▶ In addition to the requirements of the proposed TN-B1 shipping container license, the following additional restrictions will be placed upon this shipment:
 - ◆ A single fuel assembly in each shipping container
 - ◆ The other side of the container will have either a fuel channel, cage assembly with tie plates or ballast having the equivalent peripheral envelope with no fissionable material
 - ◆ Maximum of 8 containers on a single truck.

TN-B1 Criticality Safety Analysis



- ▶ A Criticality analysis was performed using the additional restrictions previously listed.
- ▶ A criticality safety index (CSI) of 11.2 is justified, which allows up to 8 packages in an exclusive use shipment.
 - ◆ According to 10CFR71.59(c)(2), the total CSI should be <100 for all containers for exclusive use. For 8 containers, this is a CSI of $100/8 = 12.5$. The CSI is defined as $50/N$ where N is the lesser of 2x number of damaged containers or 5x the number of undamaged containers. To achieve this, the damaged condition was analyzed for 9 assemblies ($N=4.5$) and the undamaged condition was analyzed for 25 assemblies ($N=5$). This results in a CSI of $50/4.5 = 11.2$, and so meets the need of being <12.5 .

Nominal Conditions of Transport (NCT) Models



- ▶ **Nominal package dimensions**
- ▶ **No credit taken for gadolinium**
- ▶ **Polyethylene foam remains intact**
- ▶ **Pin pitch at nominal dimension**
- ▶ **Optimum water moderation**
- ▶ **Array configuration features 5x5 array**
- ▶ **NCT single package, $k = 0.6422$**
- ▶ **NCT array, $k = 0.7126$**

Hypothetical Accident Conditions (HAC) Models



- ▶ Damaged package dimensions
- ▶ No credit taken for gadolinium
- ▶ Polyethylene homogeneously mixes with fuel assembly lattice water
- ▶ Pin pitch expanded by 5%
- ▶ Optimum water moderation
- ▶ Array configuration features 3x3 array
- ▶ HAC single package, $k = 0.6899$
- ▶ HAC array, $k = 0.7180$

TN-B1 Criticality Safety Analysis Conclusion



- ▶ **Upper Subcritical Limit (USL) of 0.94254**
- ▶ **All results below the USL with large margins**
 - ◆ **NCT single package, $k = 0.6422$**
 - ◆ **NCT array, $k = 0.7126$**
 - ◆ **HAC single package, $k = 0.6899$**
 - ◆ **HAC array, $k = 0.7180$**

TN-B1 Structural Analysis



- ▶ **AREVA NP has subcontracted with Nuclear Safety Associates (NSA) to perform the Structural Analysis.**
- ▶ **The Structural Analysis will be conducted using the same assumptions as the criticality safety analysis.**
 - ◆ **A single fuel assembly in each shipping container**
 - ◆ **The other side of the container will have either a fuel channel, cage assembly with tie plates or ballast having the equivalent peripheral envelope with no fissionable material**
 - ◆ **Maximum of 8 containers on a single truck.**

TN-B1 Structural Analysis



- ▶ The evaluation of the TN-B1 package will be done using LS-DYNA finite element analysis software.
- ▶ Finite element model of the container and fuel assembly will be built using various types of elements (beam, shell and solid elements... etc.).
- ▶ The response of the fuel assembly and the container will be evaluated using finite element analysis method for various load cases.

TN-B1 Structural Analysis



- ▶ **The predicted response of the Atrium 11 fuel assembly will be compared against the available Atrium 10 fuel assembly response.**
- ▶ **The various load cases to be considered in the evaluation of container and fuel assembly are given in 10CFR71.71 (for NCT) and 10CFR71.73 (for HAC) loading conditions. It also includes thermal analysis and drop analysis. Drop analysis consisting of free drops (end drop and horizontal drop) and corner drop are also simulated using LS-DYNA Finite Element Analysis Software.**
- ▶ **The evaluation/design criteria is as per the requirement of Regulatory Guide 7.6 and the Load combination for the structural analysis is as per the Regulatory Guide 7.8**

TN-B1 Structural Analysis



- ▶ **The Structural Analysis and the Criticality Safety analysis will be compared to ensure that they are consistent with each other.**
- ▶ **Results are anticipated to be available late December 2013.**



TN-B1 Revision to incorporate ATRIUM™ 11

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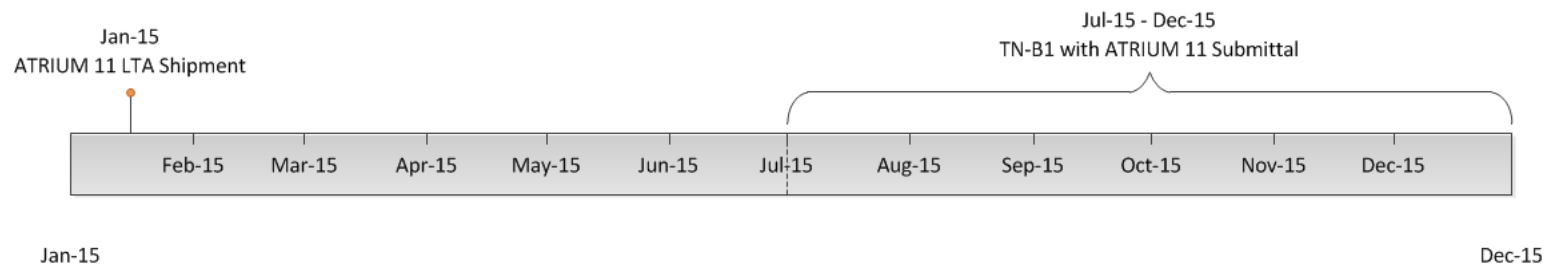
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TN-B1 Revision to incorporate ATRIUM™ 11



- ▶ Following the shipment of the ATRIUM™ 11 LTA's, AREVA anticipates beginning to prepare the revision to the TN-B1 license to incorporate the ATRIUM 11
- ▶ License will accommodate reload quantities of ATRIUM™ 11 and will not have the same restrictions as the LTA shipment.
- ▶ Submittal will be sometime during the second half of 2015 in anticipation of being able to deliver reload quantities of ATRIUM™ 11 in 2019.





Next Steps

Next Steps



► January 2014 - TN-B1 SAR Submittal

- ◆ No ATRIUM™ 11
- ◆ Will be an administrative change to revision 7 to the SAR of the RAJ-II CoC (Rev 9 to USA/9309/B(U)F-96).
- ◆ Will include a document showing all of the differences between the SAR submittal and revision 7 to the SAR of the RAJ-II.

► February 2014 – ATRIUM™ 11 LTA request for Letter Authorization submittal

- ◆ Will be based upon the TN-B1 SAR Submittal
- ◆ Criticality Safety Analysis – already complete
- ◆ Structural Analysis – in progress but will be complete prior to submittal.

► March 2014 – Proposed Meeting

- ◆ Post submittal meeting for TN-B1 application
- ◆ Pre submittal meeting for LTA Letter Authorization Request



Questions?

