BWR Channel Distortion

ISSUE STATEMENT

Seventeen of the 35 BWRs in the U.S. have reported control blade interference due to channel distortion in the last nine years. The affected fuel designs include Zircaloy-2 channels manufactured by all three U.S. fuel vendors: GNF, AREVA, and Westinghouse. Multiple mechanisms have been identified that can give rise to channel distortion (i.e., bow, bulge and twist of the channel) and alter the clearance that allows the control blade to move freely. Recent experience indicates that fuel vendor models can not sufficiently predict the channel distortion and therefore, the risk of additional plants experiencing interference to control blade movement remains. This is not only an operational issue but also can be a safety issue.

DRIVERS

There are a number of factors that drive the need for a carefully designed plan to resolve channel distortion, including:

Safety Implications: Control blades are the primary means of reactivity control and there are strict limits on how many of them can be inoperable. Analyses indicate that channel distortion — if not addressed — could prevent control blades from fully inserting during a low-pressure reactor trip.

Operational Impacts: Plants that have observed control blade interference (or low perceived margins) have implemented plans to periodically test control blade friction. This impacts capacity factors and increases the amount of work for the reactor operators.

Cost: Channel distortion can result in capacity factor reductions, as well as costs from additional fuel inspections, channel replacement, channel disposal, and less efficient core designs.

Anticipated Growth in Number of Impacted Plants: International experience with channel distortion is more limited because they operate on shorter cycles and do not control fresh fuel. However, these plants could experience control blade interference as they transition to longer cycles.

Verification of New Channel Designs: All fuel vendors are moving forward with new alloys as long-term solutions to reduce irradiation growth, corrosion and hydrogen pickup that need to be sufficiently tested and validated.

Lack of a Coordinated Approach: Prior to the development of this initiative, various proprietary data restrictions (particularly fuel vendor restrictions) prevented the stakeholders from collectively analyzing larger sets of data for developing improved channel distortion management models.

RESULTS IMPLEMENTATION

A Channel Distortion Industry Action Plan (CDIAP) has been developed to coordinate efforts among utilities, EPRI, fuel vendors, the Institute of Nuclear Power Operations, and the BWR Owners Group. The CDIAP outlines an integrated plan to effectively manage channel distortion in the near term and to ultimately eliminate the issue. Upon completion of this research, it is expected that:

- Utilities will have more-reliable tools (fuel vendor codes) to manage channel distortion for core design
- Fuel vendors will deploy advanced channel designs with demonstrated advantages

PROJECT PLAN

The CDIAP has multiple phases to address both near-term and long-term activities that encompass guidance, information gathering, surveillance, and detailed research. Integral to the project plan is to understand each mechanism of channel distortion at the scientific (or mechanistic) level. Specific project elements include:

- Update guidance to effectively manage channel distortion until more effective solutions are available
- Collect and analyze all available channel performance data (including operational performance data, poolside dimensional measurements, and hot cell examination data)
- Develop a mechanistic understanding of channel distortion and identify gaps in understanding
- Identify and conduct additional and more-detailed examinations that are needed to understand and quantify each distortion mechanism
- Develop improved distortion models
- Incorporate models into channel management tools (CMTs) and validate their performance via examination and surveillance
- Ensure proposed materials solutions are appropriately validated

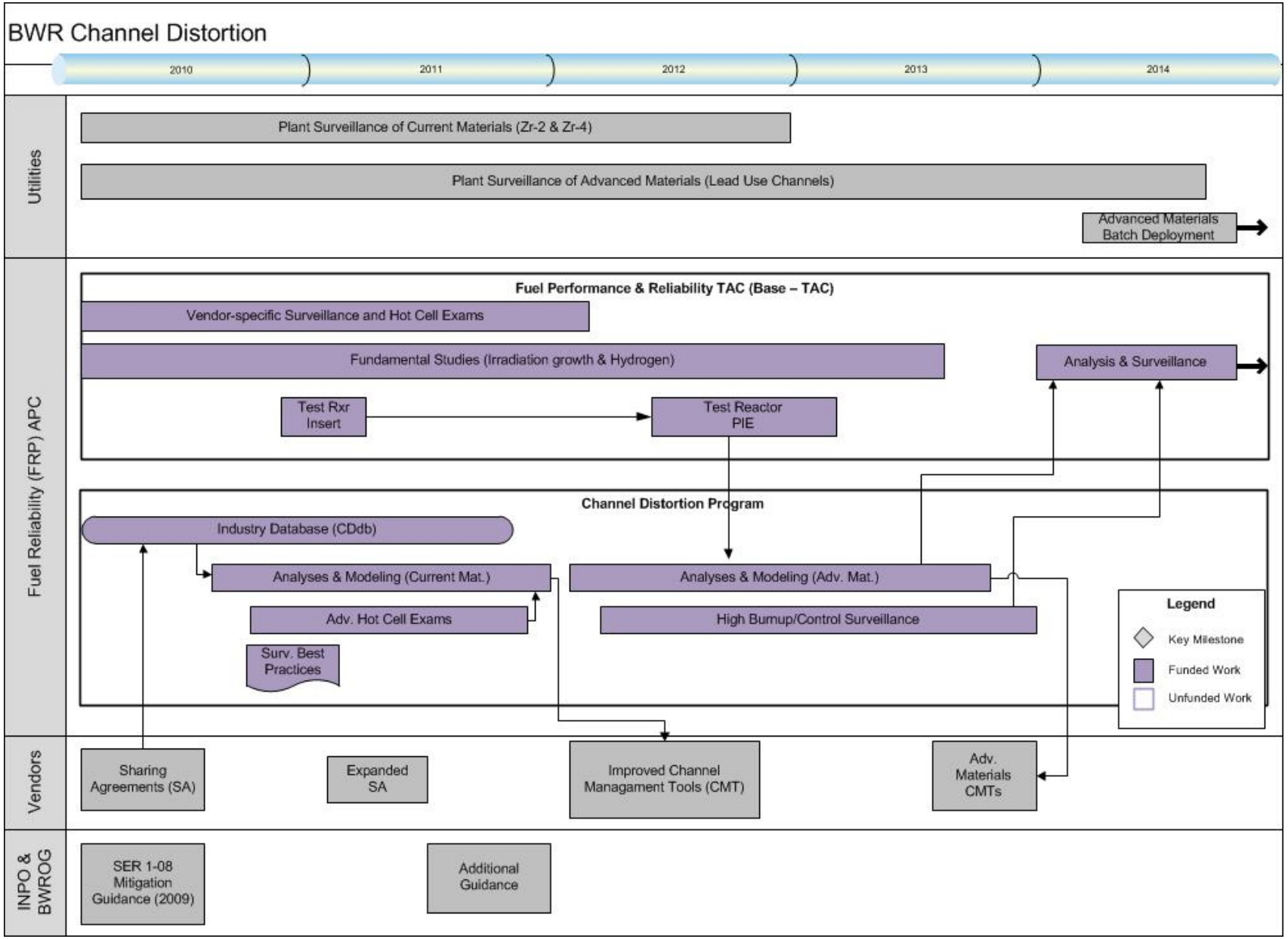
Fuel vendors will need to continue to cooperate and support the examination efforts aimed at current Zr-2 and Zr-4 materials and at advanced materials (i.e., lead channels). EPRI will drive the overall effort to integrate the activities of all stakeholders to ensure comprehensive and industry-wide solutions with no duplication of effort.

RISKS

The industry recognized the importance of this integrated approach to manage channel / control blade interference in 2010. Funding shortfalls in 2011 and beyond will delay solutions and challenge the integrated approach to understanding fundamental distortion mechanisms that are not considered vendor-specific. Maintaining vendor cooperation on existing materials work is essential to quickly resolving near-term issues. Legal sharing agreements already in place will need to be expanded to non-EPRI sponsored datasets so the experience basis for the mechanistic understanding is as broad as possible. Failure of the CDIAP implies that interference problems will likely persist sporadically throughout the fleet.
Risks associated with completion of this work include:

- Advanced materials solutions will not be as effective (i.e., new materials will not be less susceptible to irradiation growth, shadow corrosion and other distortion mechanisms) as early indications suggest.
- Improved fuel-vendor channel management tools will not be effective due to lack of plant data, improperly understood mechanisms, or evolving operational conditions outside the current experience base.

Efforts are ongoing to reduce and manage these risks (e.g., accelerated test reactor programs and modeling & analyses of data from different sources of materials other than channels) to enable successful completion of the work in this roadmap by balancing the need for data and analyses versus the costs associated with inspections, test reactor and hot cell campaigns.


BWR Channel Distortion
2010
2011
2012
2013
2014
Utilities
Plant Surveillance of Current Materials (Zr-2 & Zr-4)
Plant Surveillance of Advanced Materials (Lead Use Channels)
Advanced Materials Batch Deployment
Fuel Reliability (FRP) APC
Fuel Performance & Reliability TAC (Base – TAC)
Vendor-specific Surveillance and Hot Cell Exams
Fundamental Studies (Irradiation growth & Hydrogen)
Analysis & Surveillance
Test Rxr Insert
Test Reactor PIE
Channel Distortion Program
Industry Database (CDdb)
Analyses & Modeling (Current Mat.)
Analyses & Modeling (Adv. Mat.)
Adv. Hot Cell Exams
High Burnup/Control Surveillance
Surv. Best Practices
Legend
Key Milestone
Funded Work
Unfunded Work
Vendors
Sharing Agreements (SA)
Expanded SA
Improved Channel Managament Tools (CMT)
Adv. Materials CMTs
INPO & BWROG
SER 1-08 Mitigation Guidance (2009)
Additional Guidance