

# Discuss NDE Techniques

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**BFB FG NRC Meeting**  
July 12-13, 2017



# Topics

- Ultrasonic (UT) Modeling
- Revising Bolting Qualification Protocol
- UT Data Review
- Potential Mockup Fabrication

# Industry Focus Group Assessment of UT Techniques

- As designed, baffle-former-bolts were never intended to be UT examined
- Baffle-former-bolts with internal-hex head geometry are known to be the most challenging to UT inspect
  - Presence of locking devices, welds and internal hex head geometry challenge the UT
- Industry believes that the UT techniques are effective and are conservative
  - Initiatives being pursued and considered are for enhancements and improvements to increase our understanding of the conditions and resulting UT indications
- Inspection TAC is working to enhance UT techniques through rigorous procedure demonstrations
- Implementation plans of current UT techniques for the internal hex head BFB configurations
  - WEC plants with this configuration will complete UT exams by end of 2017 for Tier 1a plants and 2018 for remaining Tier 1b and Tier 2 plants
  - Replacement BFBs have external hex head with locking cup which is less challenging for UT exams

# BFB UT Issues Inspection TAC is Addressing

## ■ Objectives

- Address false calls during some of the field examinations
- Provide probability of detection (POD) for engineering analysis of vessel internals bolt examination results
- Review bolting UT protocol to determine if revision is required

Note: Three bolts with flaws at one unit were not identified in spring 2016. Subsequently, the vendor revised UT procedure to call bolts with similar UT indications “red” prior to additional implementation of the UT procedure

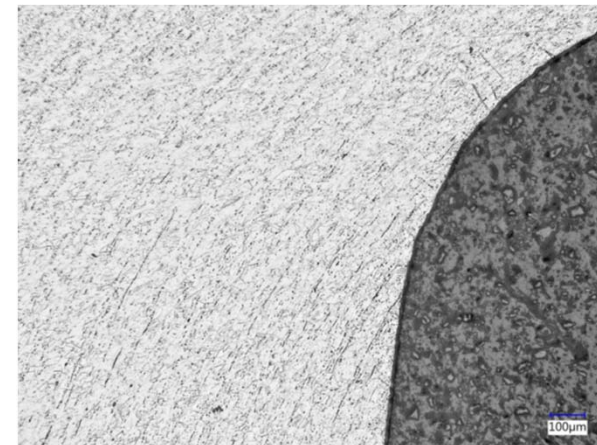
# Modeling of UT to Address Potential NDE Issues

- Modeling of BFB UT Technique during summer 2017
  - Investigating geometric effects and beam mode conversion at head-to-shank radius geometry
  - Potential modeling efforts
    - Investigating possibility of UT beam redirection due to flow lines in microstructure
    - Investigating impacts of variations in UT probe contact surfaces from bolt-to-bolt

Very visible flow lines – not a BFB



Flow lines in BFB



# UT Modeling (Cont'd)

- Geometric Effect on UT
  - BFB with washer
    - Internal hex geometry varies between bolts
    - Geometry affects both immersion and contact UT techniques; plant-to-plant variability considerations
  - BFB with locking bar
    - Small contact surface
    - Locking bar and welds interfere with probe
    - Internal Hex Head to shank geometry precludes use of 0 degree straight beam
    - Locking bar may partially block flaws located underneath

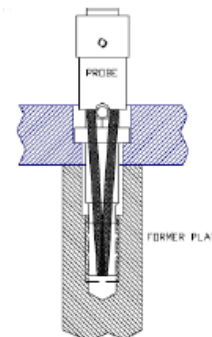


Figure 13 - UT probe design with pitch-catch mode

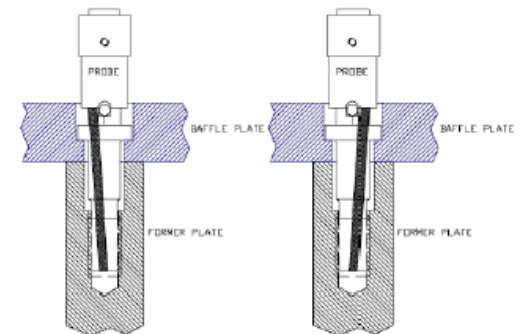


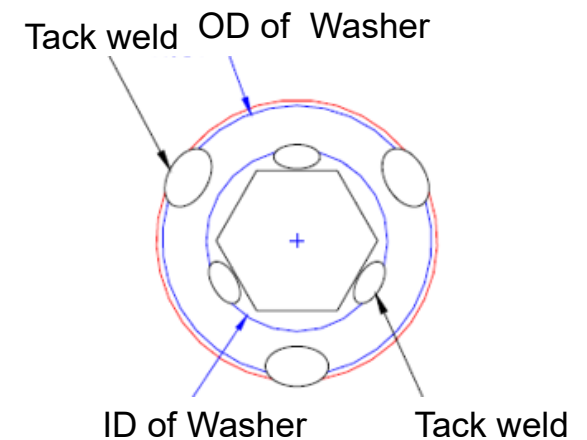
Figure 14 - UT probe design with impulse-echo mode

Ref: P Minogue, et al, Recent Experiences with Ultrasonic Inspection of Baffle Former Bolts, 8th International Conference on NDE in Relation to Structural Integrity for Nuclear and Pressurised Components 2010

# UT Modeling

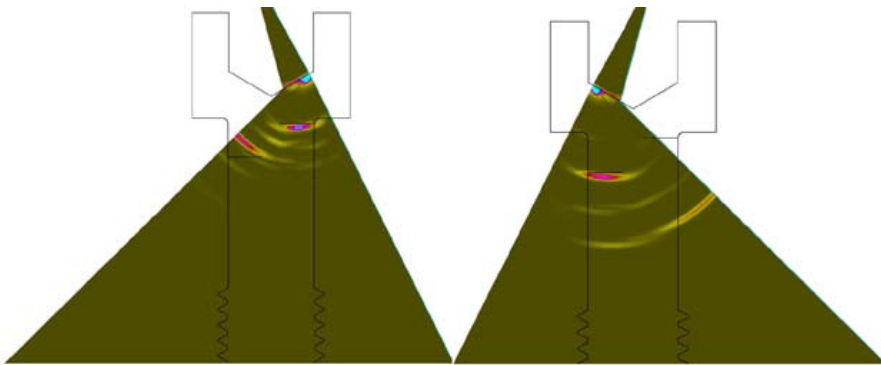
## ■ UT Modeling of BFBs

- Head–Shank Radius for Mode conversion
  - Longitudinal converting to shear wave
- Internal hex head with washer
  - Due 3<sup>rd</sup> Qtr 2017

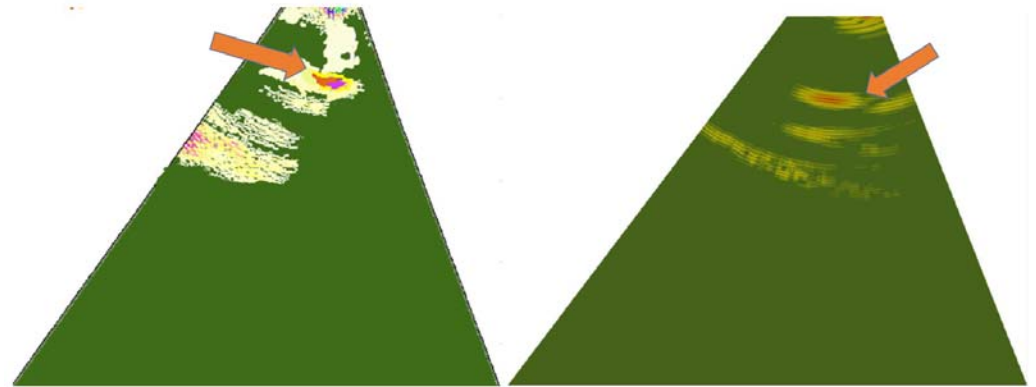


# General Approach

- Observe and compare flaw response results including mode converted signals from experiment and simulation.
- Document results in technical report.



Simulations in CIVA for two probe locations  
Flaws near radius region



**Experiment**

**Simulation**

Experimental results are similar to simulation



# Bolting UT Qualification Protocol Revision

- Enhancements to BFB UT exam protocol for 2018
  - Revising procedure qualification to require 100% detection
  - Enhance UT inspection personnel qualification for detecting flaws of various sizes and various orientations
- Revising protocol
  - Procedure qualification
    - Requires 30/30 correct detections on test bolts
      - Results in 92.6% POD at 90% confidence
    - Applicable to all internal bolting
    - Plan to begin implementation by spring 2018 outages
  - Personnel qualification
    - Detect at least 8/10 flaws
    - False calls: 10% or less
- Plan to issue protocol with MRP-228 interim guidance letter in July 2017

# UT Data Review

- Independent Data Review
  - Compare data from broken, loose and green bolts
  - Review data from bolts that have been examined
  - Objective is to understand the UT data and analysis to determine appropriate tasks to address potential issues
- Currently determining how much of the field inspection data can be reasonably reviewed in a short time
- All whole bolts at hot cell were UT re-examined
  - Used same procedure and UT search unit as in the field
  - Results were consistent with examinations performed in the field
- Schedule-Complete by end of 3<sup>rd</sup> quarter 2017

## UT Data Review

### Cause Analysis

- Cause analysis type effort needs to be applied in order to make sure the right enhancements will be made
- Some of the tasks to be considered:
  - Procedures
  - Transducers
  - Data analysis
  - BFB fabrication
  - BFB geometry
  - Coupling of the UT transducer to the bolt head

# Potential BFB Mockup Fabrication

Objective: Fabricate BFB mockups that represent conditions providing non-relevant UT indications

- Dependent on modeling and data review results
- Considerations of BFB NDE mockup program
  - First priority are hot headed 347 internal hex head bolts
  - Need to determine source of potential UT indications associated with the fabrication process
    - Head geometry
    - Head-to-shank Radius
    - Contact area
    - Flow lines in microstructure
  - NDE bar stock to ensure no flaws, make bolt mockups
  - Implant notches and cracks
  - UT then perhaps cross-section

Hot Heading Process



Heading press is engaged and punches down

## Summary Focus Group Assessment of UT Method

- Baffle-Former-Bolts with internal-hex head geometry are known to be the most challenging to UT inspect
  - Challenges associated with presence of locking devices, welds and internal hex head geometry challenge the UT
- Industry believes that the UT techniques are effective
  - Initiatives are being pursued and considered for enhancements and improvements to increase our understanding of the conditions and resulting UT indications
- New replacement bolts are designed to be UT inspectable



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