

# EPRI/NRC Joint Program on Welding Residual Stress Guidance

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Industry/NRC Materials Technical Update  
June 2015

# Background on MOU



- Concludes work performed under previous MOU
- Status of deliverables
  - Mockup measurements and round robin: complete
  - 3-D analyses and EWR: underway
  - WRS inputs for xLPR: complete
  - ASME Code practices for WRS: underway
- Expires December 2015
- No follow-on MOU currently planned

# Program History



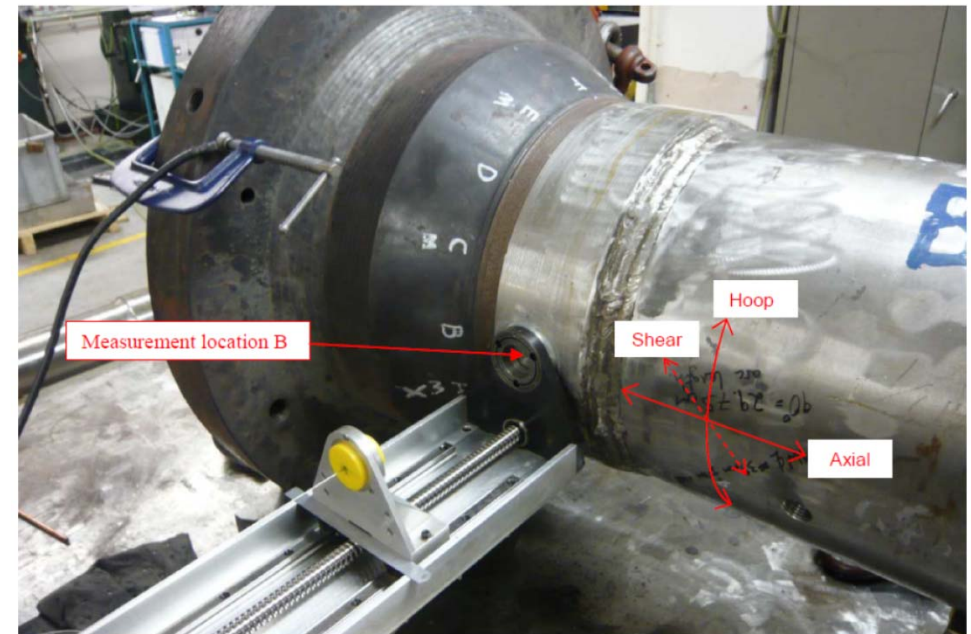
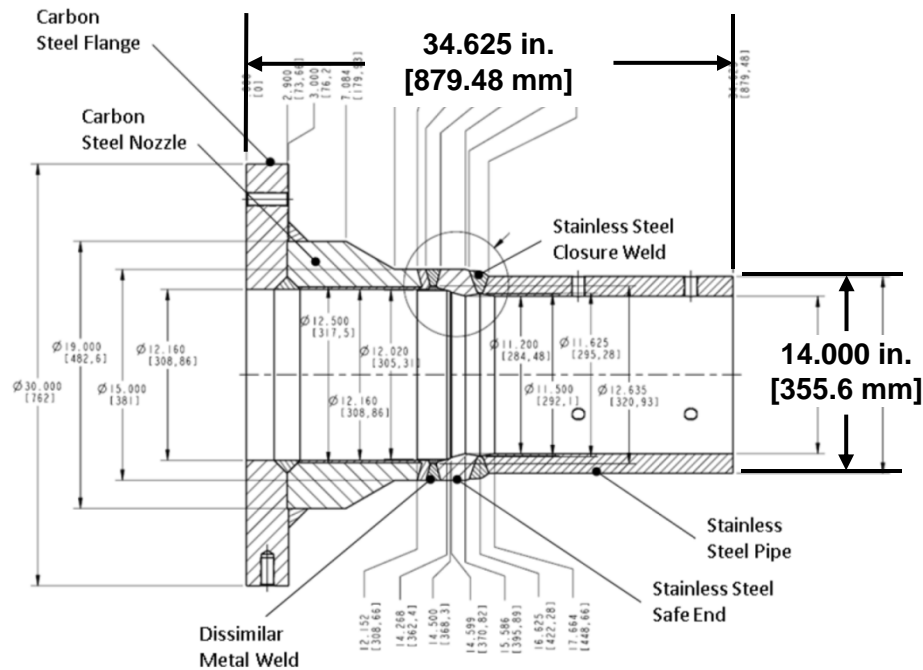
- 2008 to 2011 – Initial joint validation program effort
  - Measurement and modeling of small and full scale mockups as well as canceled plant components
  - Baseline study of variability between modelers and measurements
  - Documented in both NRC and EPRI documents
- 2012 to 2015 – New mockup and round robin study
  - Improve understanding of variability between modelers and measurement
  - Develop validation criteria
  - Incorporate WRS information into consensus standards

# Progress Since June 2014



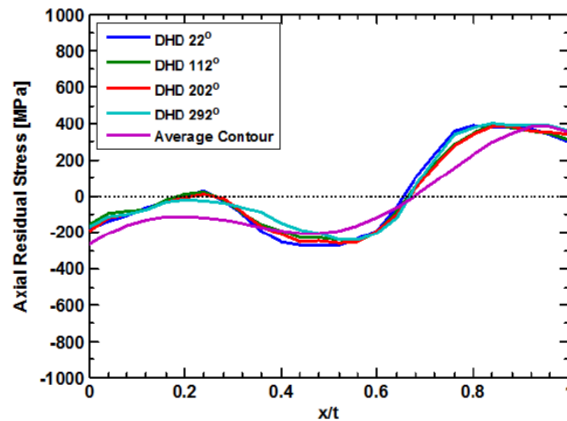
- Closed round robin in August 2014
- Round robin results made public
  - December 2014 NRC public meeting: ML14352A195
  - EPRI/NRC PVP paper: PVP2015-45636
- ASME Code Case development in Task Group Crack Growth Reference Curves
- EPRI-sponsored [UC Davis] research on uncertainty and validation criteria
- NRC-sponsored research [Sandia National Lab] on uncertainty and validation criteria

# WRS Round Robin Mockup

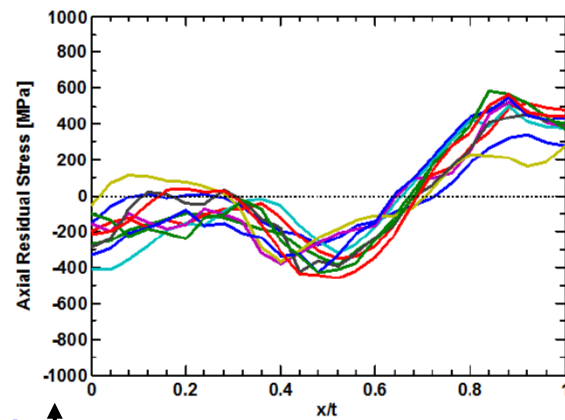


# WRS Round Robin Mockup

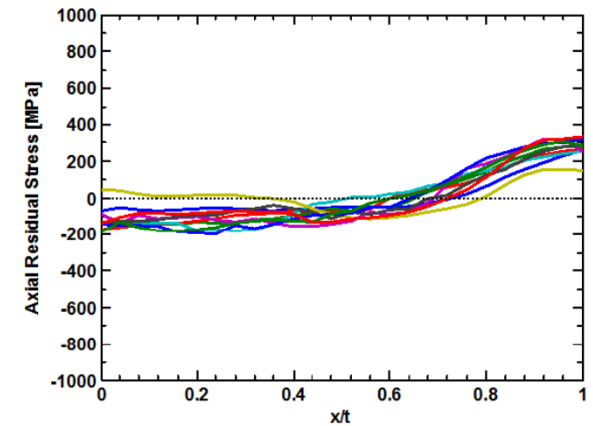
Measurement Data



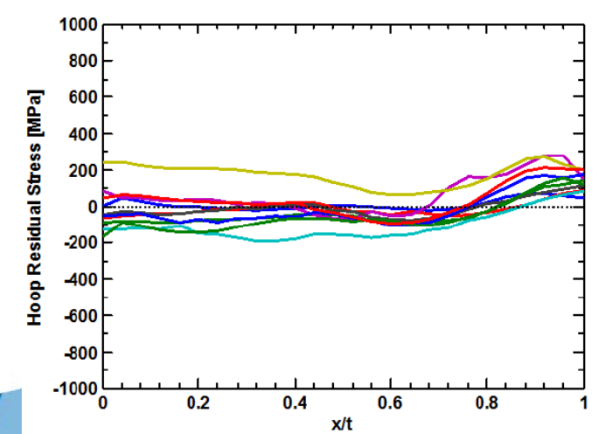
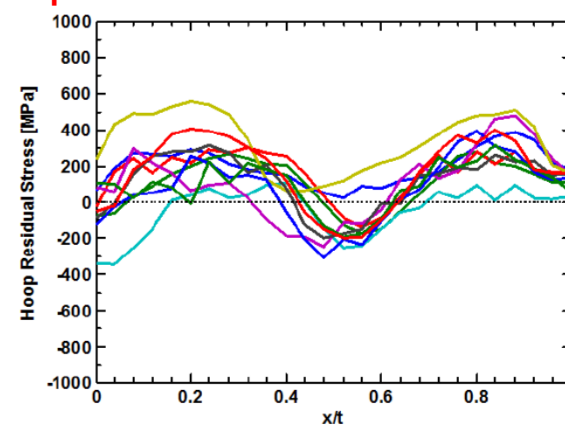
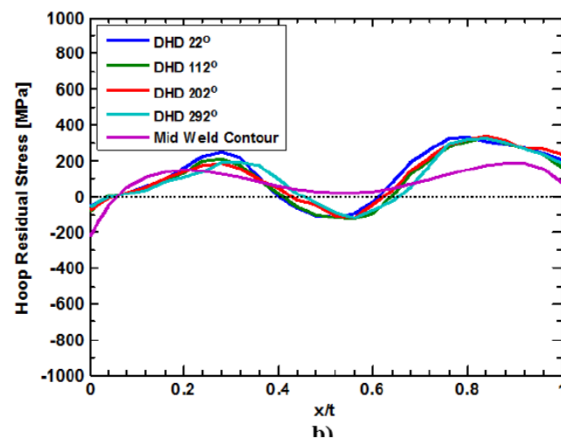
Modeling Data—Isotropic Hardening



Modeling Data—Kinematic Hardening



Axial ↑  
Hoop ↓



# ASME Section XI Code Case Development



- Section XI Code Case governing WRS for DM welds
- Draft language in development
- Analyses options include three level of analysis:
  - Assume at yield strength through-wall
  - Use bounding through-wall distributions developed for standard weld types
    - Proposed approach described in PVP2015 paper
  - Use standard practice and conduct own analysis
    - Acceptance criteria discussion informed by modeler variability from 2014 Round Robin submissions
    - Jan and April 2015 ASME Code Week Meetings on 2014 Round Robin results used to develop Code Case approach regarding model acceptance



# Excavate and Weld Repair



- EPRI shared EWR mockup information with NRC through the WRS MOU
- NRC developing finite element model
- Can be compared with measurements and other modeling efforts
- ASME Code Case currently under consideration



# Challenges Moving Forward



- Identification and disposition of outliers
- Quantifying measurement uncertainty
- Quantifying modeling uncertainty
- Use engineering judgement to determine acceptance criteria
  - Criteria types (K, root-mean-square prediction error, etc.)
  - Acceptable numbers
- Use engineering judgement to formulate hardening law guidance