Global Expertise • One Voice

PA-MSC-1283 & 1294
Alloy 600 Branch Connection Fracture Analysis and Contingency Weld Repair Design for Applicable Primary Loop Piping (B&W & Palisades Plants Only)

PWROG Materials Committee

Industry/NRC Exchange Meeting

June 2015

Dave Waskey (AREVA)

Background

PA-MSC-1283/1294

- NRC Regulatory Issue Summary (RIS)
  - Request ASME Code to Review ISI Requirements for A600 Branch Connections
- PWROG Initiated Two Projects
  - Original Configuration Fracture Analysis for B&W Plants
    - This work will be used by the TG-HSNAI as technical basis for establishing ISI requirements
  - Contingency Weld Repair Design for Palisades and B&W Plants

Fracture Analysis

PA-MSC-1283/1294

- Weld Residual Stress Analysis
  - Performed consistent with MRP-317
  - Analysis of the bounding branch connection configuration will be performed
    - 3-D quarter Symmetry Model of pipe run and branch connection
    - Fabrication history and heat input considered
    - 50% ID weld repair assumed
    - Hydro-test, operating pressure and temperatures shake-down simulated

Fracture Analysis

PA-MSC-1283/1294

- Explicit Flaw Models will be constructed for both circumferential and axial cracks
  - 3-D Quarter Symmetry model for WRS will be used
  - Initial flaw size at beginning of plant life assumed to be 0.025 and 0.1 inches
  - PWSCC crack growth rates for A82/182 per MRP-115
  - Service life time for cracks to grow ~75% through-wall (ASME Section XI limit) and ~90 to 95% will be determined

Fracture Analysis

PA-MSC-1283/1294

- Circumferential Flaw Analysis
  - Series of Crack-Tip Finite Element Models (~five) to evaluate circumferential cracks near center of weld will be constructed
  - Stress Intensity Factors (SIFs) for 360-degree circumferential cracks through the thickness of the nozzle near center of weld will be characterized
  - Radial stresses near the center of the weld – superimposed and applied to the crack tip models
- Axial Flaw Analysis
  - Series of Crack-Tip Finite Element Models (~five) to evaluate axial cracks postulated around the A82/182 weld and the A 600 nozzle region
  - An axially cut plane through the nozzle and along the length of the primary piping is expected to result in the highest stresses – due to higher than normal hoop stress
  - Following confirmation – axial flaws will be postulated along the axially cut plane

Fracture Analysis

PA-MSC-1283/1294

- Limit Load Analysis
  - To demonstrate Flaw Stability of circumferential and axial flaws, a limit load analysis will be performed
  - Limit Load Criteria will be based on ASME Section III, NB-3228.1
  - 3D Quarter Symmetry Model will be appropriately modified
  - Appropriate stresses due to external loads from piping and nozzle will be considered
  - Limiting circumferential and axial flaws will be modeled
  - The objective would be to show that the primary piping, primary piping to nozzle weld and the main nozzle body remain structurally stable per the rules of ASME Section III, NB-3228.1

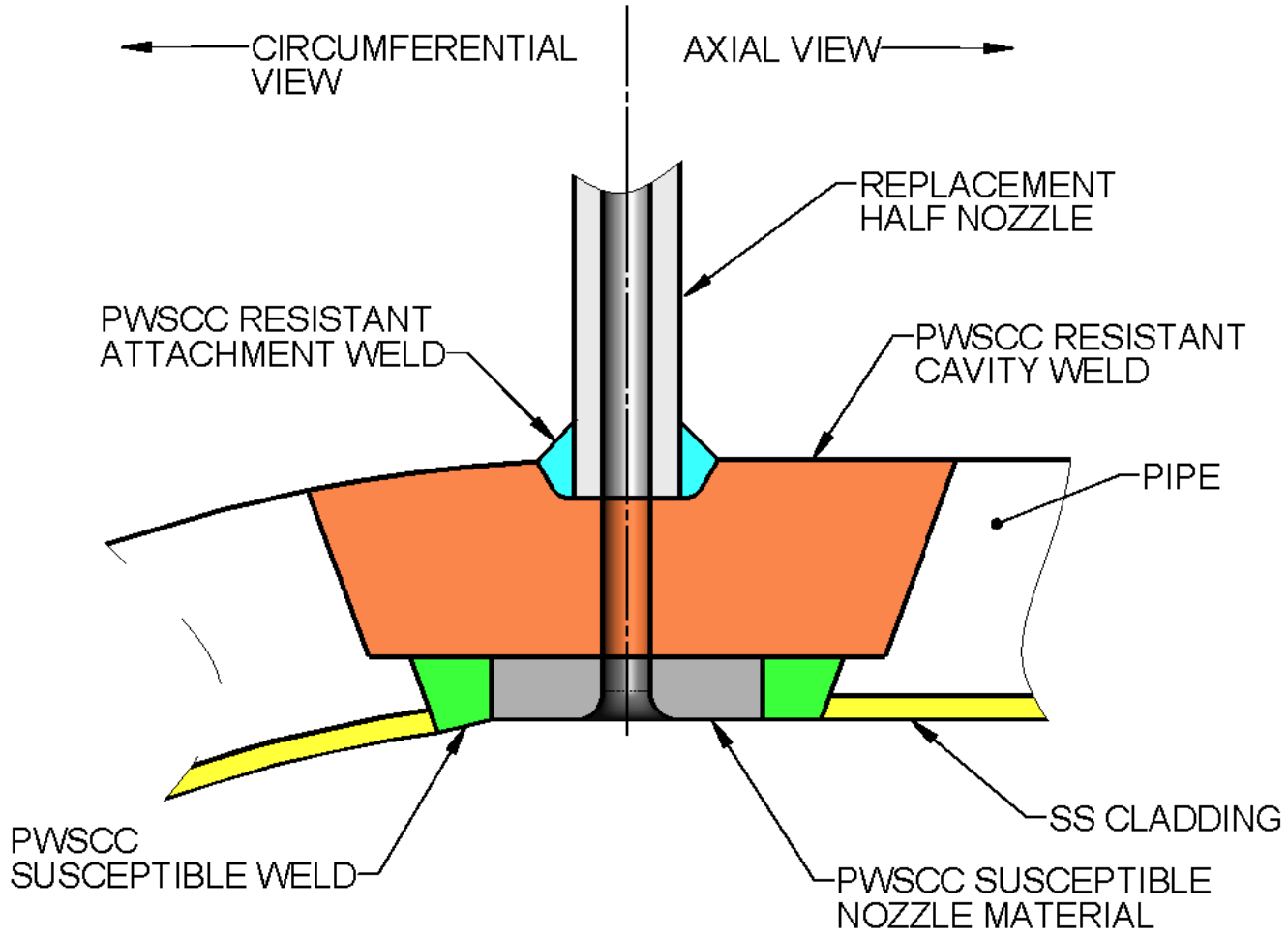
Contingency Repair

PA-MSC-1283/1294

- Work Scope
  - Establish weld repair design
  - Perform bounding analysis for all hot and cold leg connections
  - Repair implementation demonstration
- Plant applicability
  - AREVA - Oconee, TMI, Davis Besse and ANO-1
  - Westinghouse - Palisades

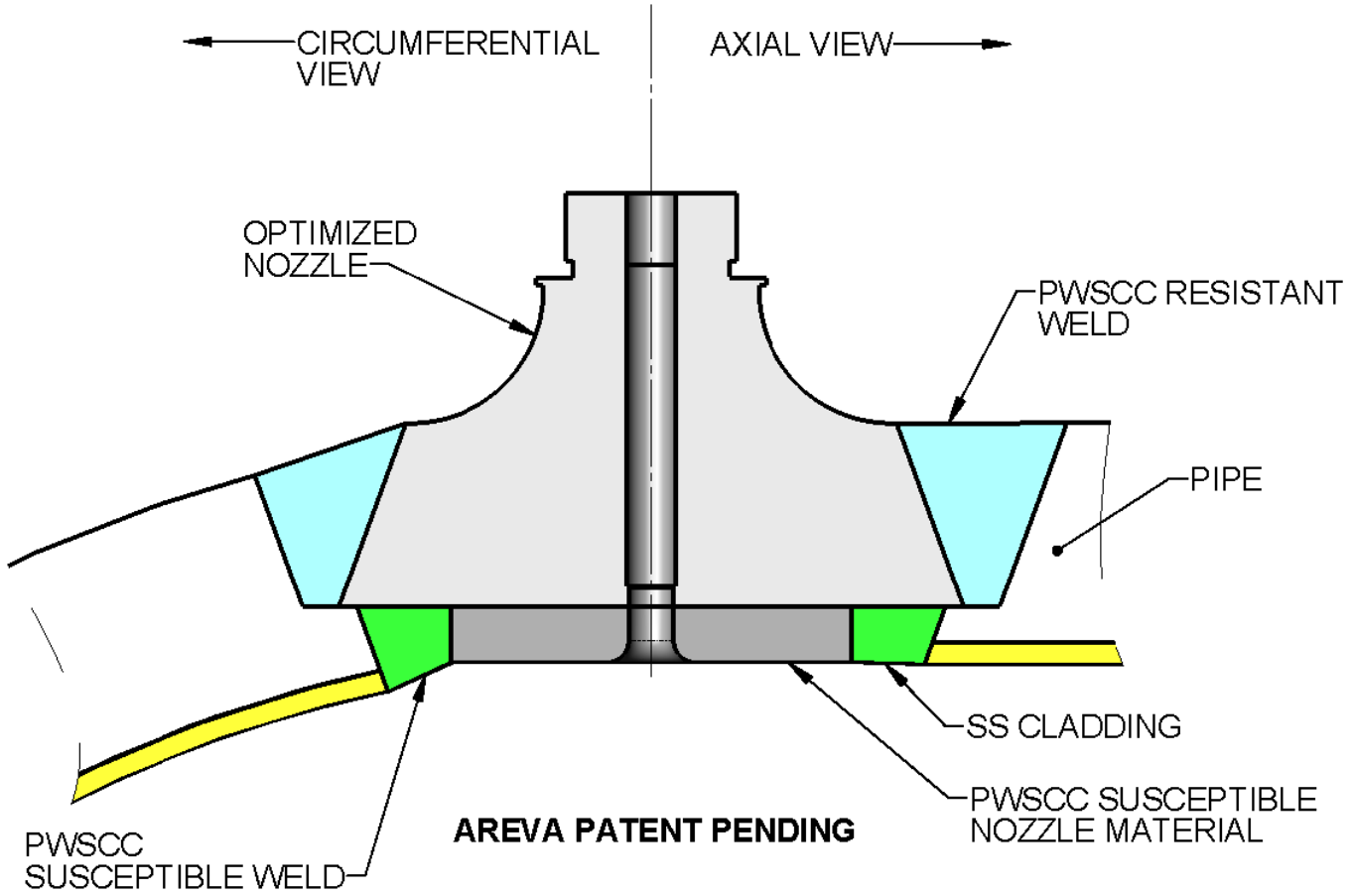
Proposed Alternate Design - EWR with J-groove ½ Nozzle

PA-MSC-1283/1294



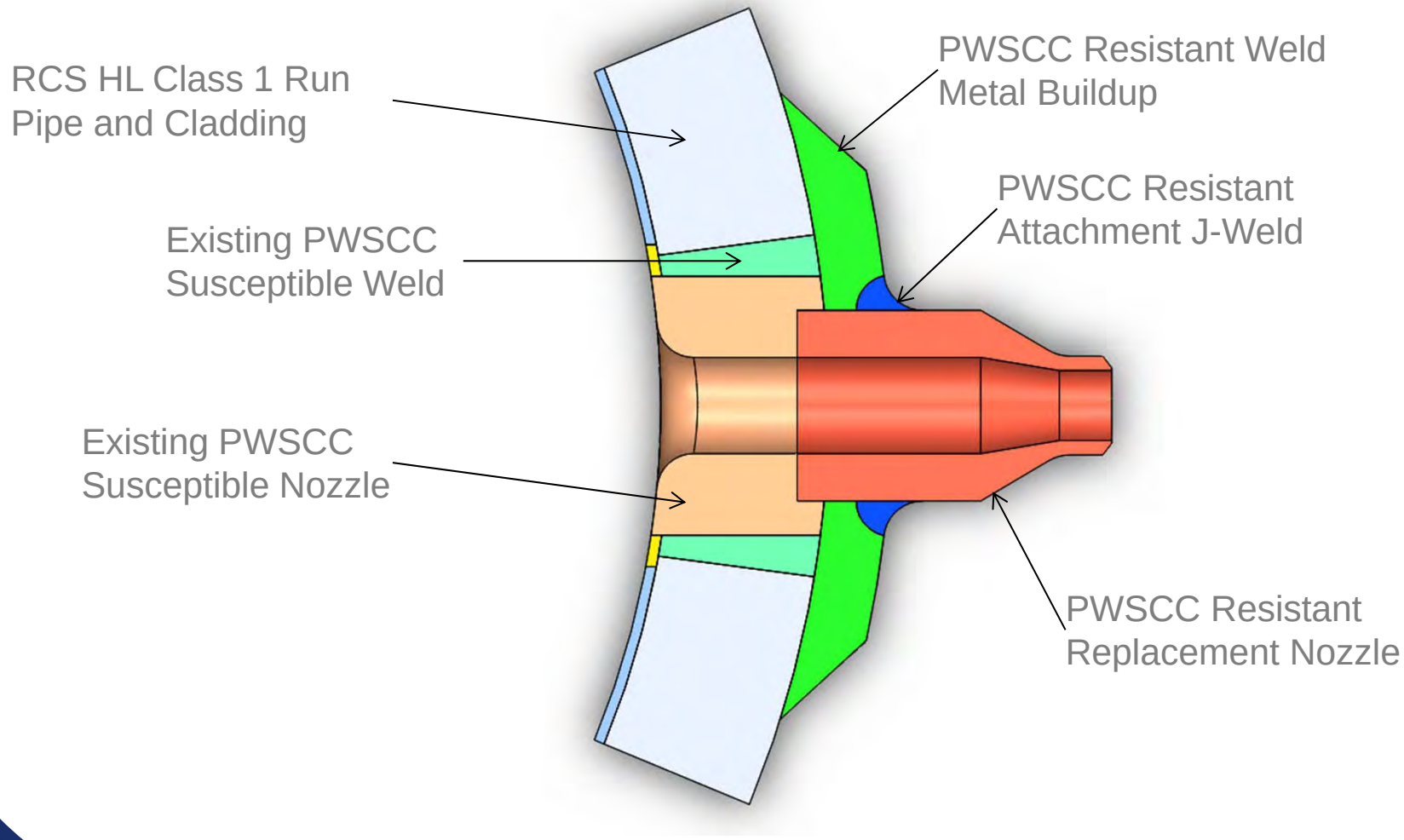
Proposed Alternate Design - EWR with Optimized Nozzle

PA-MSC-1283/1294



PWROG Chosen Repair Design

PA-MSC-1283/1294



Benefits

PA-MSC-1283/1294

- Provides off-the-shelf contingency repair design for all potential Alloy 600 Branch Connection mitigations
- Proof of principal repair method demonstration
  - Horizontal branch connection
  - Overhead branch connection
- Plants can choose any qualified repair vendor for implementation
- Structural Weld Metal Buildup with half nozzle design is a well proven repair approach with 100s applied on primary components in the industry.

Work Scope

PA-MSC-1283/1294

- Task 1 – Assessment of All Branch Connection Locations
- Task 2 – Engineering Design & Configuration
- Task 3/4 – Engineering Analysis (AREVA/Westinghouse)
  - ASME Section III Analysis
  - Weld Residual Stress Analysis
  - Section XI Crack Growth and Flaw Evaluation of Remnant Nozzle and Weld Analysis
- Task 5 – Process and Procedure Development
- Task 6 – Tooling and Mockup Preparation
- Task 7 – NDE Development – TBD
- Task 8 – Repair Method Demonstration
- Task 9 – ASME Code Interface
  - Develop Code Case N-853
  - Establish with TG-HSNAI NDE requirements, N-770-x, if required
  - Technical Basis Document to support Code Case
- Task 10 – Develop Generic Repair Design Relief Request

Global Expertise • One Voice

Hot Leg Water Level Nozzle Demonstration

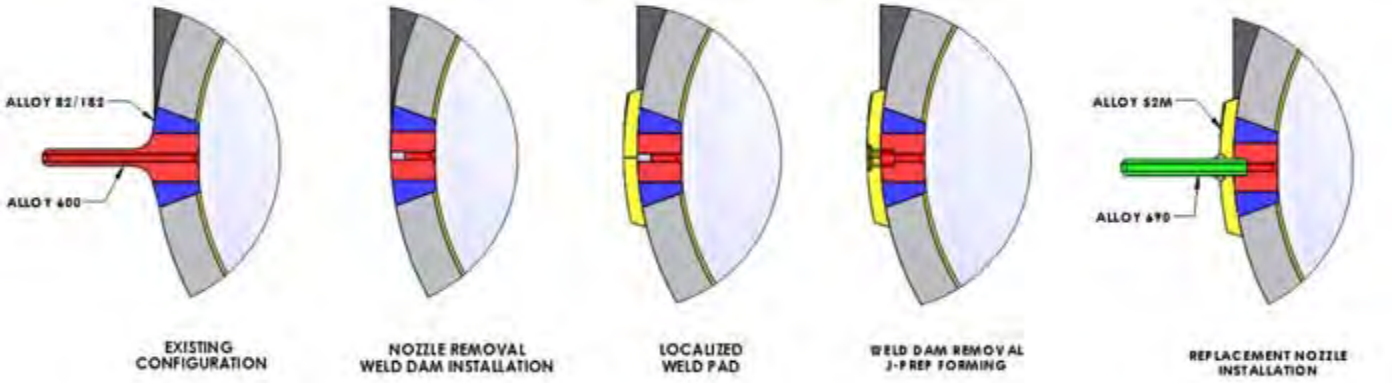
Typical Branch Connection at B&W Plant

PA-MSC-1283/1294

Repair Process Overview

PA-MSC-1283/1294

- Hot Leg Water Level Sensing Nozzle
  - Remove Existing Nozzle
  - Apply Structural Weld Metal Buildup
  - Perform a Half Nozzle Repair of the Nozzle

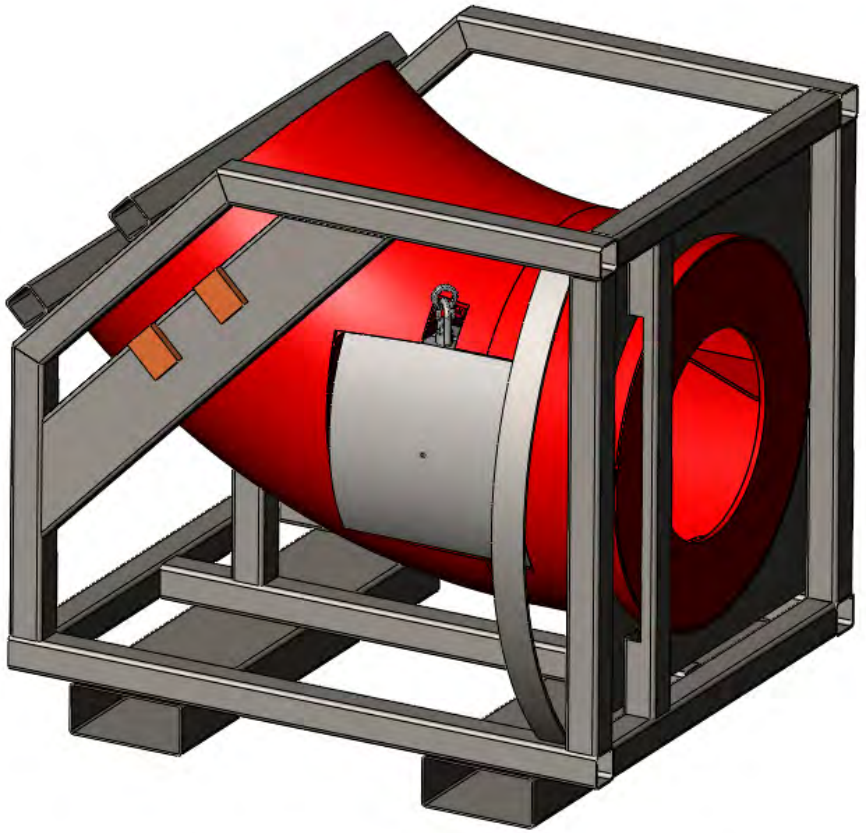


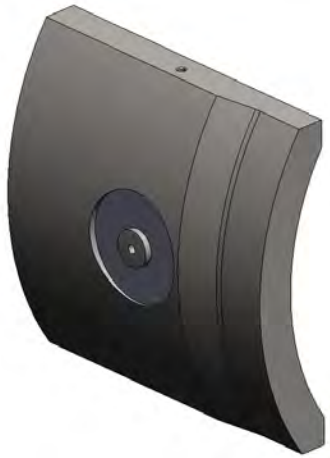
Note: Horizontal line shown in center of the local Pad is only graphical, weld pad is solid.

Mockup Configuration

PA-MSC-1283/1294

- Hot Leg Elbow
  - Coupon
    - Removable Insert
    - Carbon Steel (SA-516, Grade 70 or Similar)
  - Simulated O.D. Transition
    - 42” O.D. vs. 44” O.D.
  - Fixtured for Field Representation

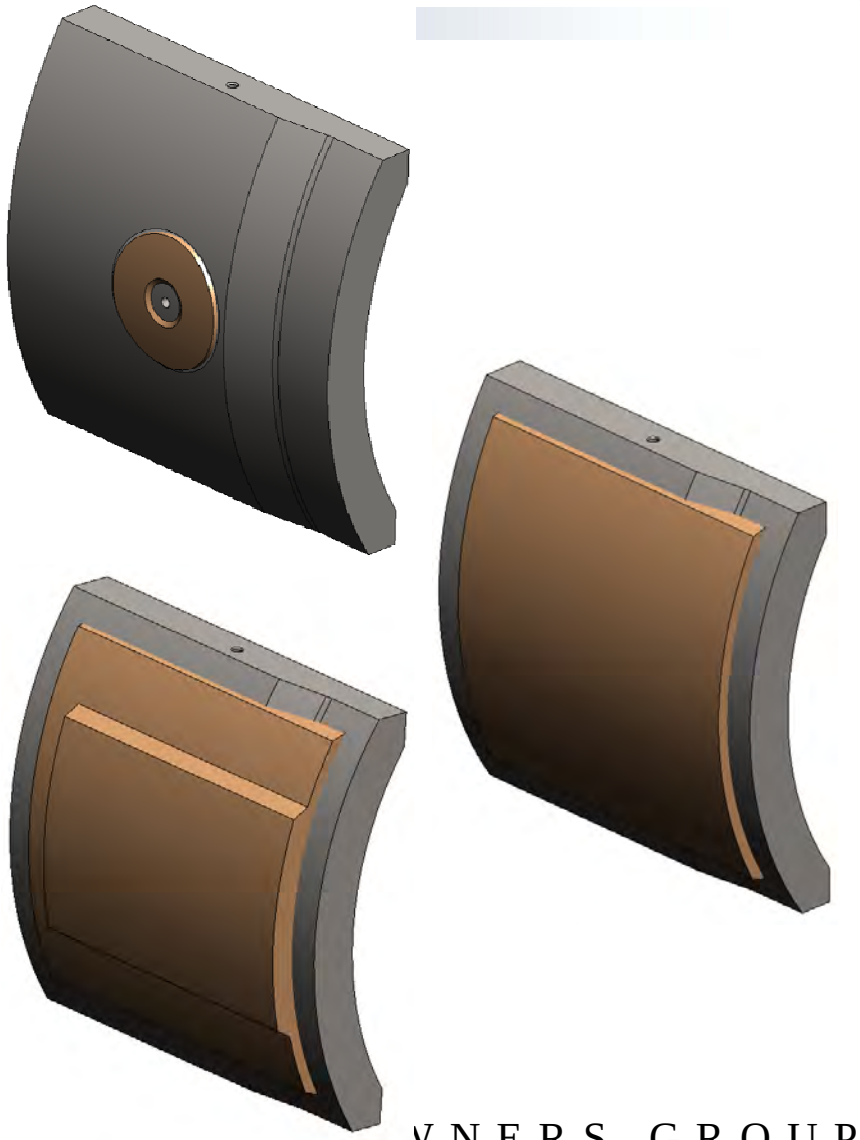




Weld Process Sequence

PA-MSC-1283/1294

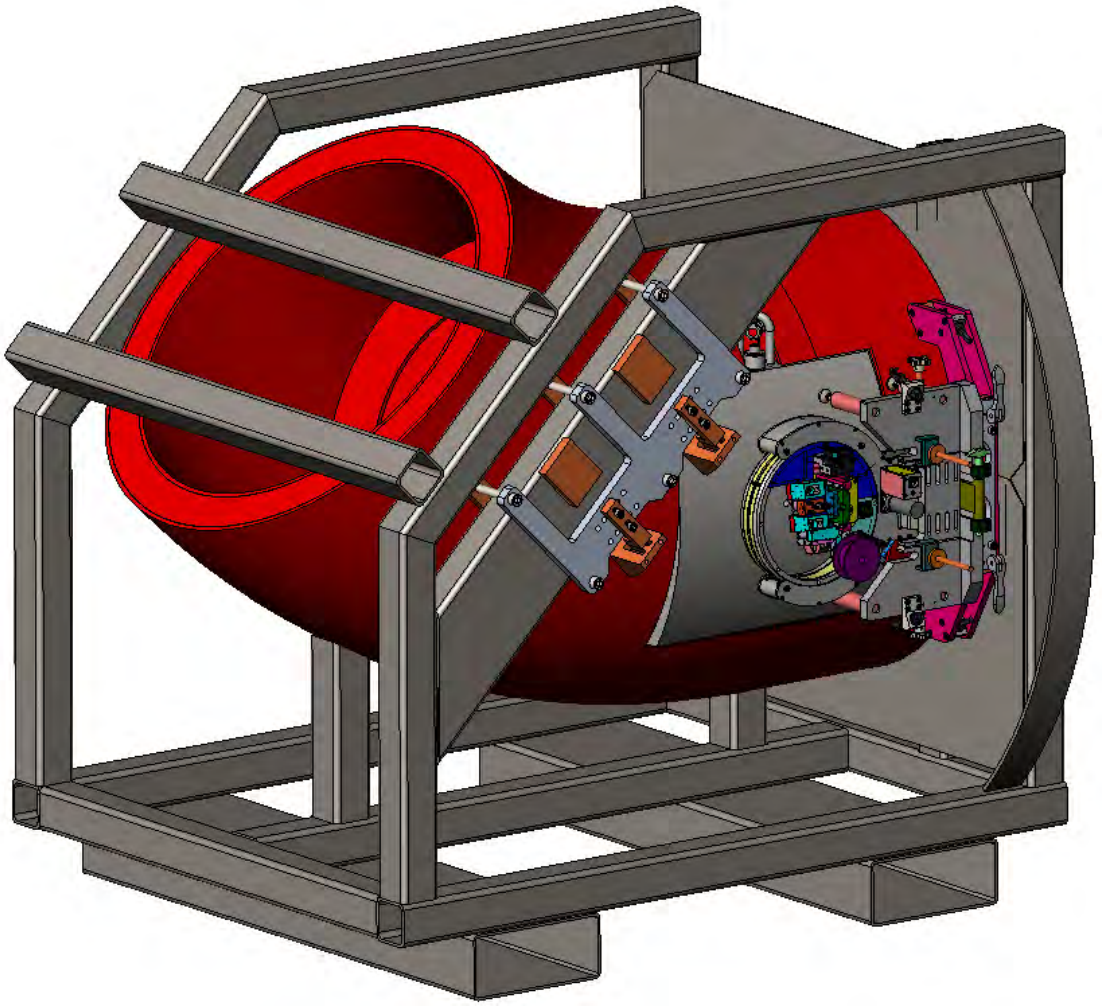
- Alloy 82 Mitigation Layer
  - Single Layer Over Simulated Alloy 182 Weld
- Alloy 52M Weld Pad
  - First 3 Layers
    - Full Scale
    - Demonstrate Temper bead Technique
    - Bead Sequencing
    - Weld Tool Capabilities Over Elbow O.D. Transition
  - Sub-sized Full Thickness Pad
    - Layer-to-Layer Grinding
    - Eliminate Peaks / Valleys
  - Weld Profiling
  - Grind Starts and Stops
  - Remove HAZ at Starts and Stops



Pad Weld Tool

PA-MSC-1283/1294

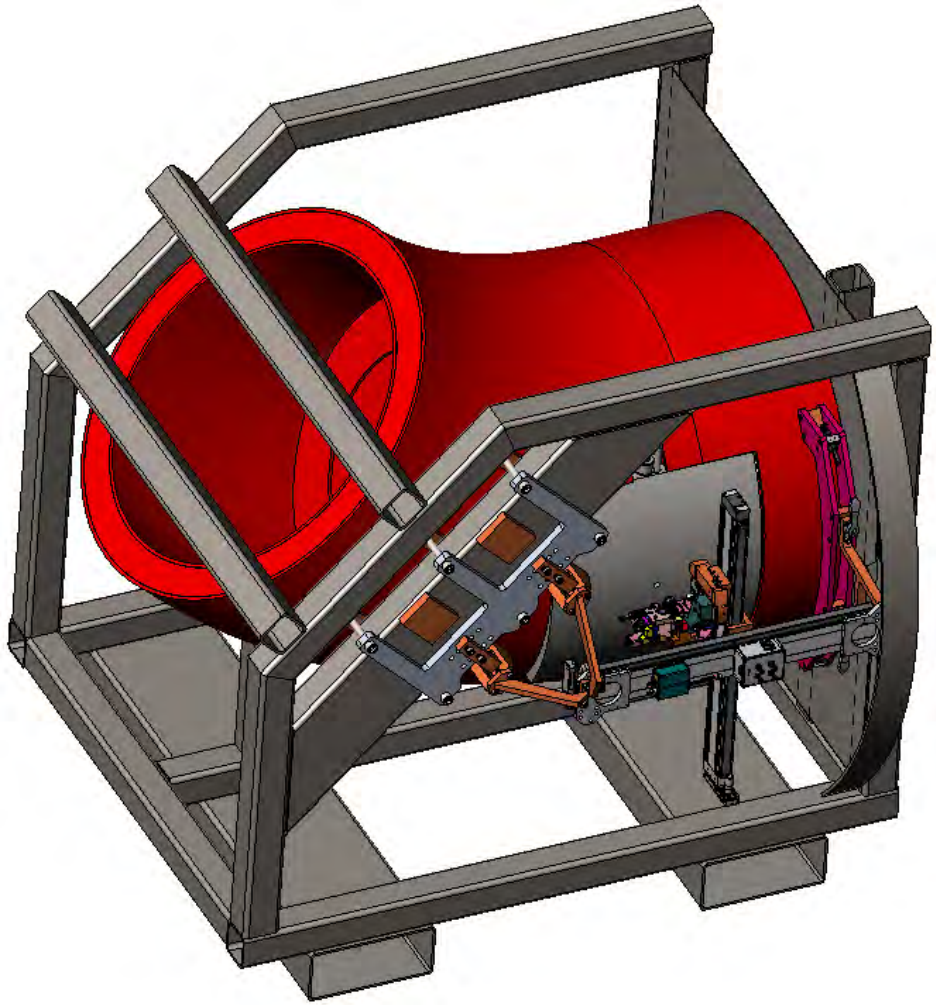
- Weld tool
  - Used to weld a round mitigation layer over the Alloy 600 weld material
  - Attaches to the datum tool mount
  - STD pad Weld head
  - Additional chain mount if required
  - Remotely operated via fiber
  - Fast and easy to deploy



Dual Wire GTAW Weld Head

PA-MSC-1283/1294

- Weld tool
  - Used to form the mega square weld metal buildup
  - Attaches to the datum tool mount in three locations
  - STD Hot wire weld head
  - Wire spools sit on the floor
  - Long version of slides have been used before
  - Uses F-head umbilical cable
  - Remotely operated via fiber

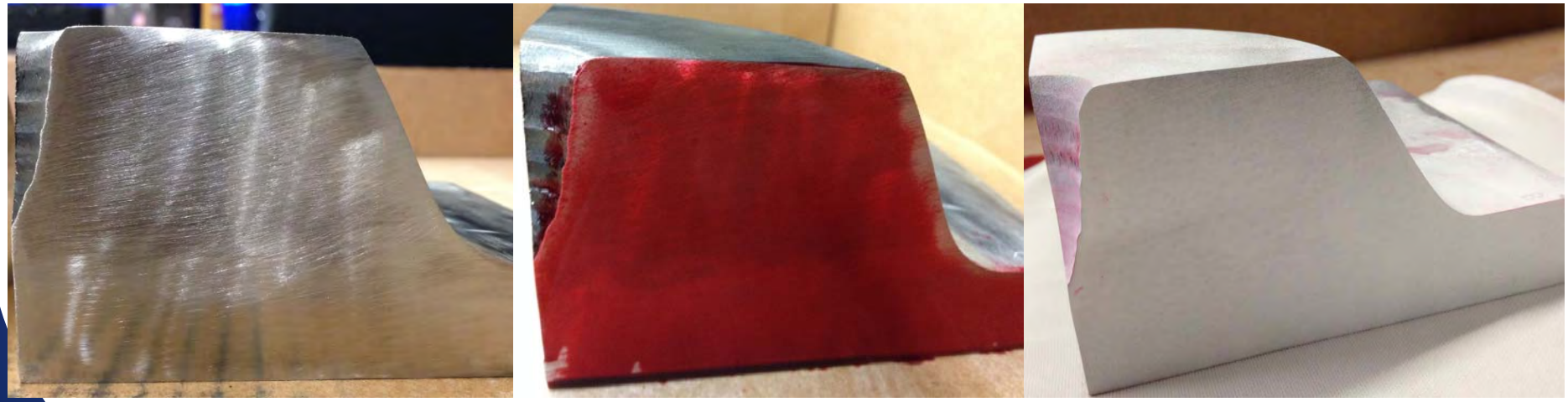


Weld Process Evaluation

PA-MSC-1283/1294

- Weld Pad
  - Non Destructive Evaluation (NDE)
    - Liquid Penetrant Testing (PT)
    - Ultrasonic Inspection (UT)
  - Destructive Evaluation (DE)
    - Cross Section Macro Evaluation
    - Cross Section PT

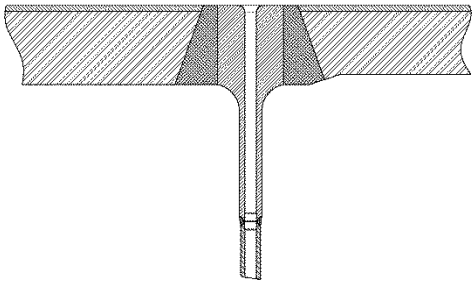
Example: Full Thickness Cross Section PT Evaluation



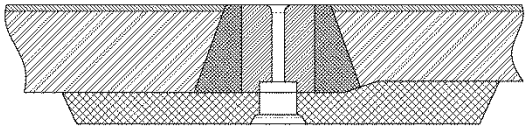
Nozzle Repair Mockup

Proposed NDE for Contingency Repair

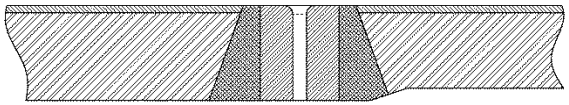
PA-MSC-1283/1294



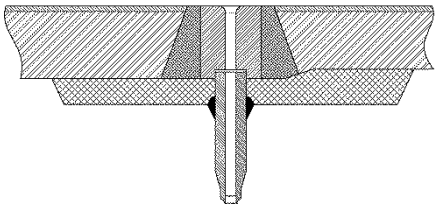
Existing Configuration



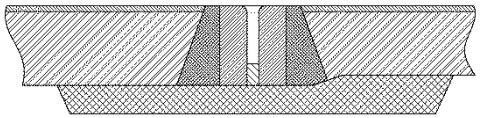
PT Machined j-prep



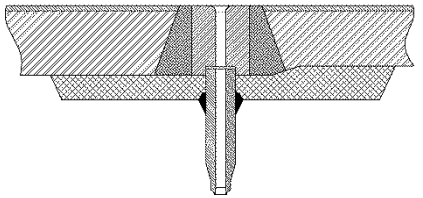
PT Entire Surface to Be Welded UT CS pipe for laminations per Section III



Section III Progressive PT & Final Weld



PT & UT entire build-up for defect & bond and CS HAZ per Section III & N-638-4



Periodic BMV Section XI ISI

Questions?

PA-MSC-1283/1294

The Materials Committee is established to provide a forum for the identification and resolution of materials issues including their development, modification and implementation to enhance the safe, efficient operation of PWR plants.

Global Expertise • One Voice
www.pwrog.com