Weld Overlay Process in Angra 1

Application to Pressurizer Nozzles

Cracking and Structural Integrity of Components
in Light Water Reactors Workshop

Meeting on Structure, Systems and Components Integrity in Nuclear Plants

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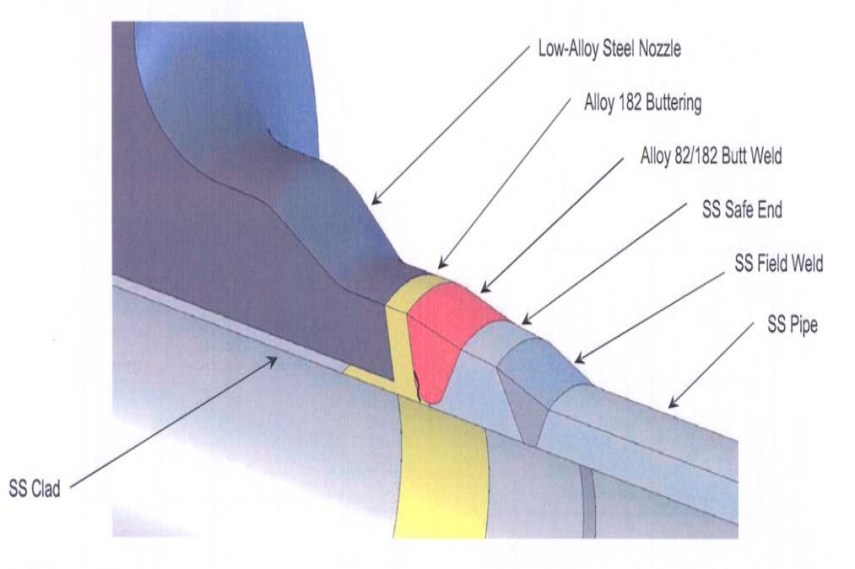
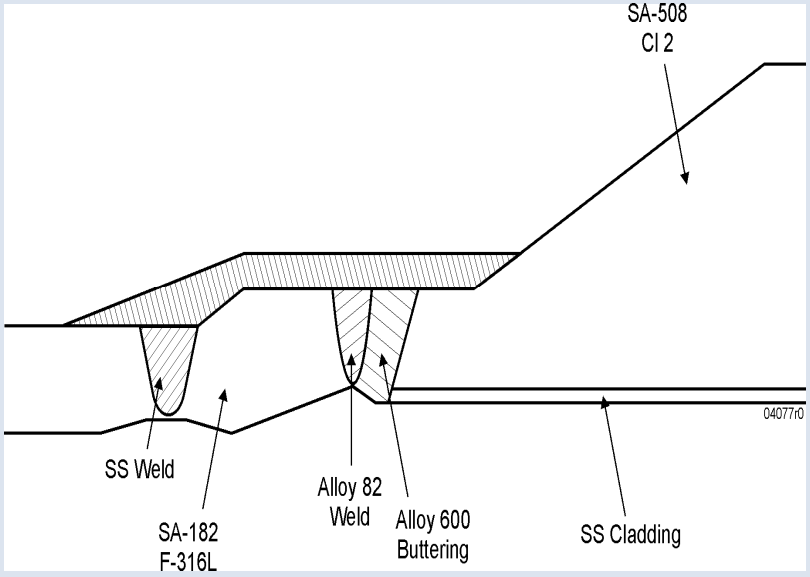
Introduction

Definition:

Weld Overlay (WOL) is a mitigative/repair process to avoid or eliminate the stress corrosion cracking (PWSCC) in alloy 600 material.

The WOL uses a resistant material deposited in the existing weld, which is specified to induce a compressive residual stress in the inner portion of the weld. The residual and operational stress is lower than the threshold to PWSCC.





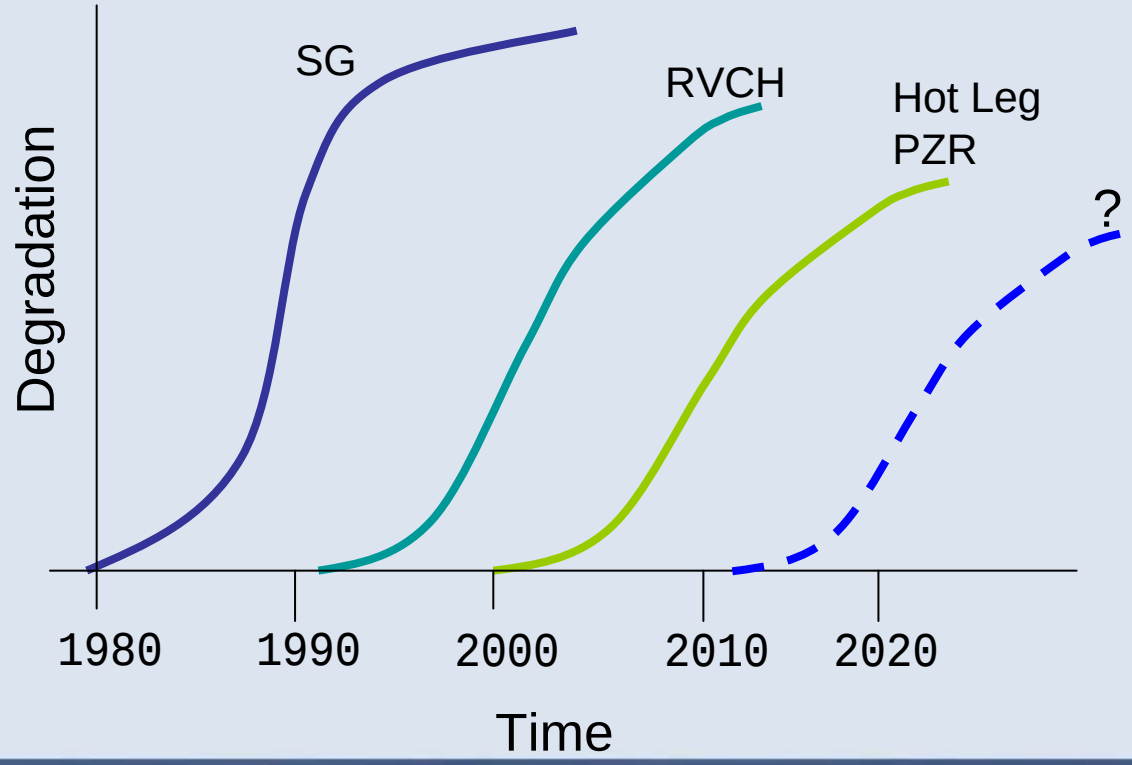
Introduction

Alloy 600 Stress Corrosion Cracking (SCC) Degradation:

1980 – Steam Generator (tubes)

1990 – Reactor Vessel (head penetration)

2000 – Reactor Coolant Piping (dissimilar weld at RV and PZR)



Introduction

Typical Solution to Alloy 600 Degradation:

– SG Tubes → Replace Steam Generator

– RV Penetrations → Replace the Reactor Vessel Closure Head

– Dissimilar welds → Use a mitigative/repair process

Mitigative/Repair processes:

- Weld Overlay (WOL)
- Weld Inlay (WIL)
- Mechanical Stress Improvement Process (MSIP)

Objective

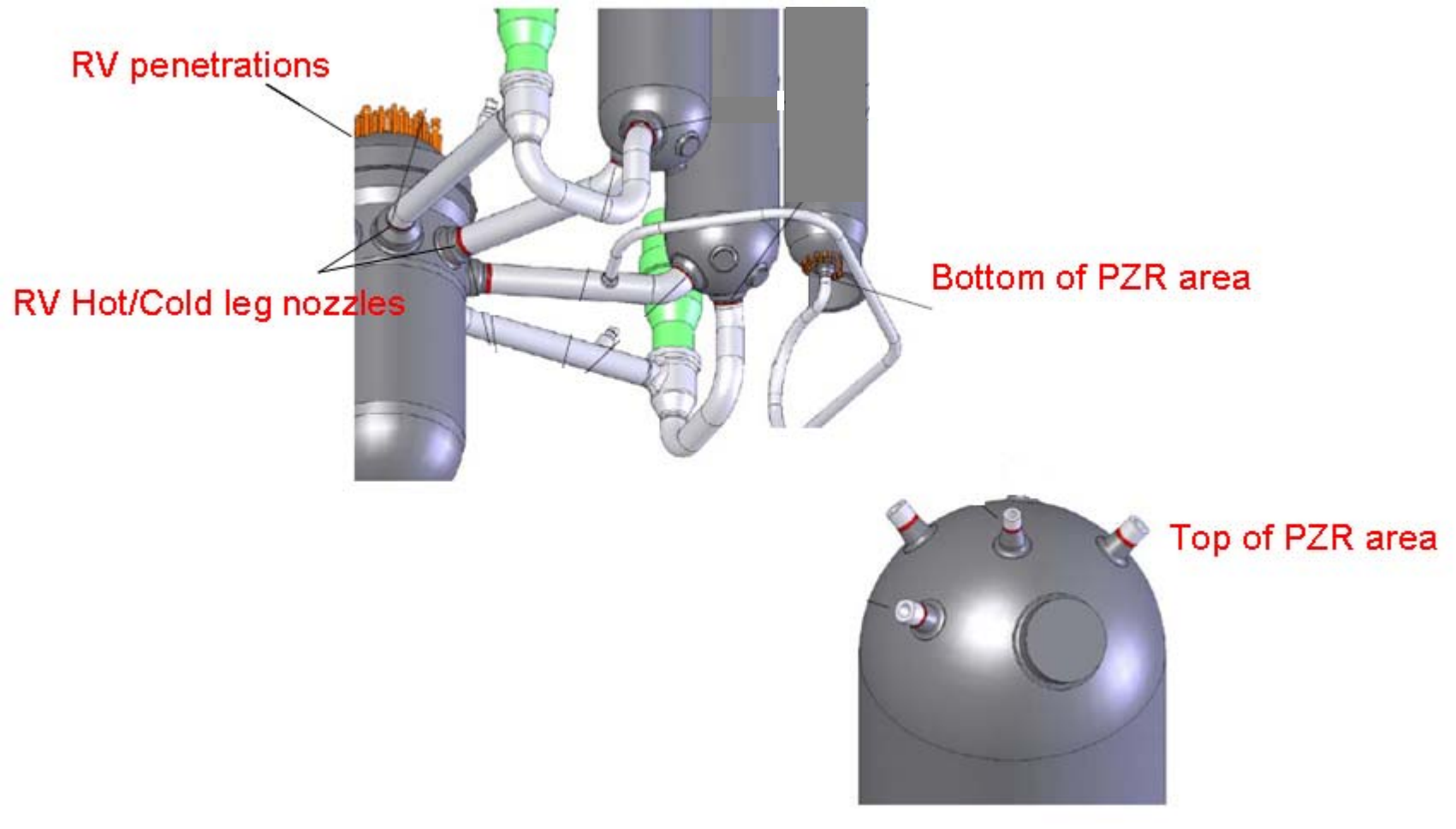
Show how the Alloy 600 issue is managed in Angra 1. Focus of this presentation is the WOL of the pressurizer nozzles.

Angra 1 strategy to control the problem:

- Conduct research
  - √ Eletronuclear – numerical simulations for RVCH penetration
  - √ CDTN – mock up development to qualify the WOL process
- Map the Alloy 600 locations
- Perform the weld dimensional measurements (RV and PZR nozzles)
- Prepare Technical Specification (apply WOL for the PZR nozzles)
- Install WOL in the pressurizer nozzles
- Install mitigative/repair process (WOL, MSIP) in the RV nozzles

Alloy 600 in Angra 1

Typical Location of Alloy 600:



Alloy 600 in Angra 1

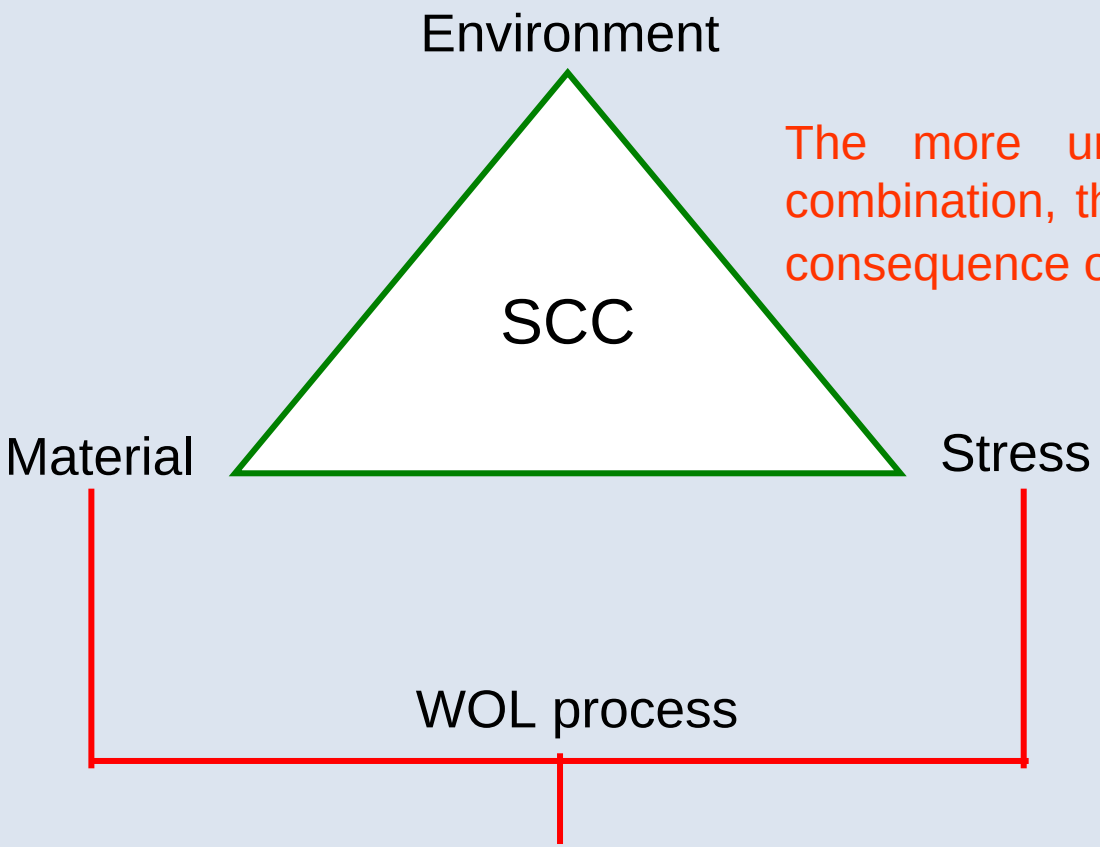
Where there is Alloy 600 and Solutions:

- Steam Generator Tubes - SG replaced in 2009
- Reactor Vessel Penetrations - will be replaced in 2011
- Reactor Vessel Nozzles
  - Hot and Cold legs - WOL or MSIP in 2012-2013
  - Safety Injection line - not decided
- Pressurizer Nozzles
  - Surge line
  - Safety lines
  - Relief line
  - Spray line

  } WOL in 2011

Alloy 600 Degradation

Stress Corrosion Cracking Causes:



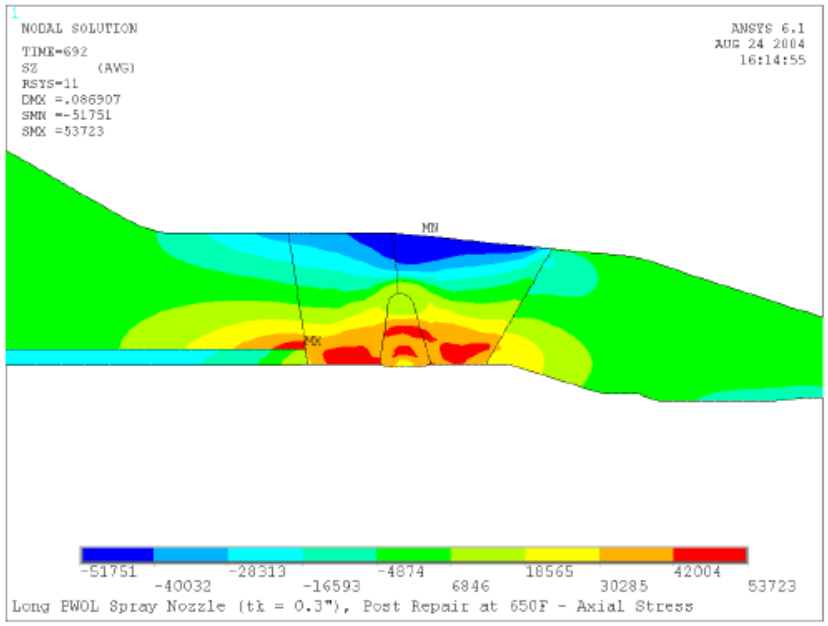
The more unfavorable is this combination, the worst will be the consequence on the material

Resistant material – Alloy 600 replaced by Alloy 690

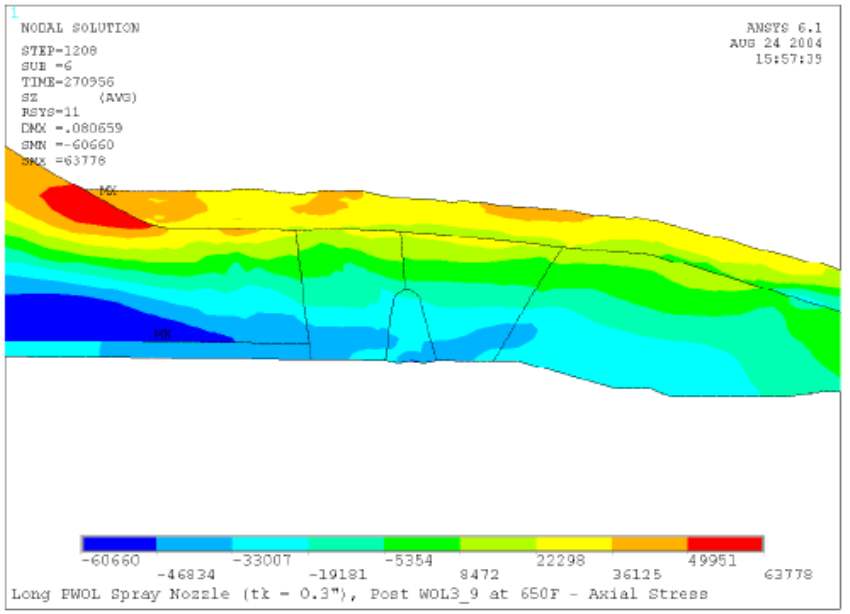
Residual stress – high tensile stress reversed by compressive one

Stress Analysis Results

Pre and Post WOL Residual Stress (axial stress):



Post-WOL (T_{WOL}=0.3” L_{WOL}=7.2”)
Stress field at inner portion of the weld:
-46 to -30 ksi

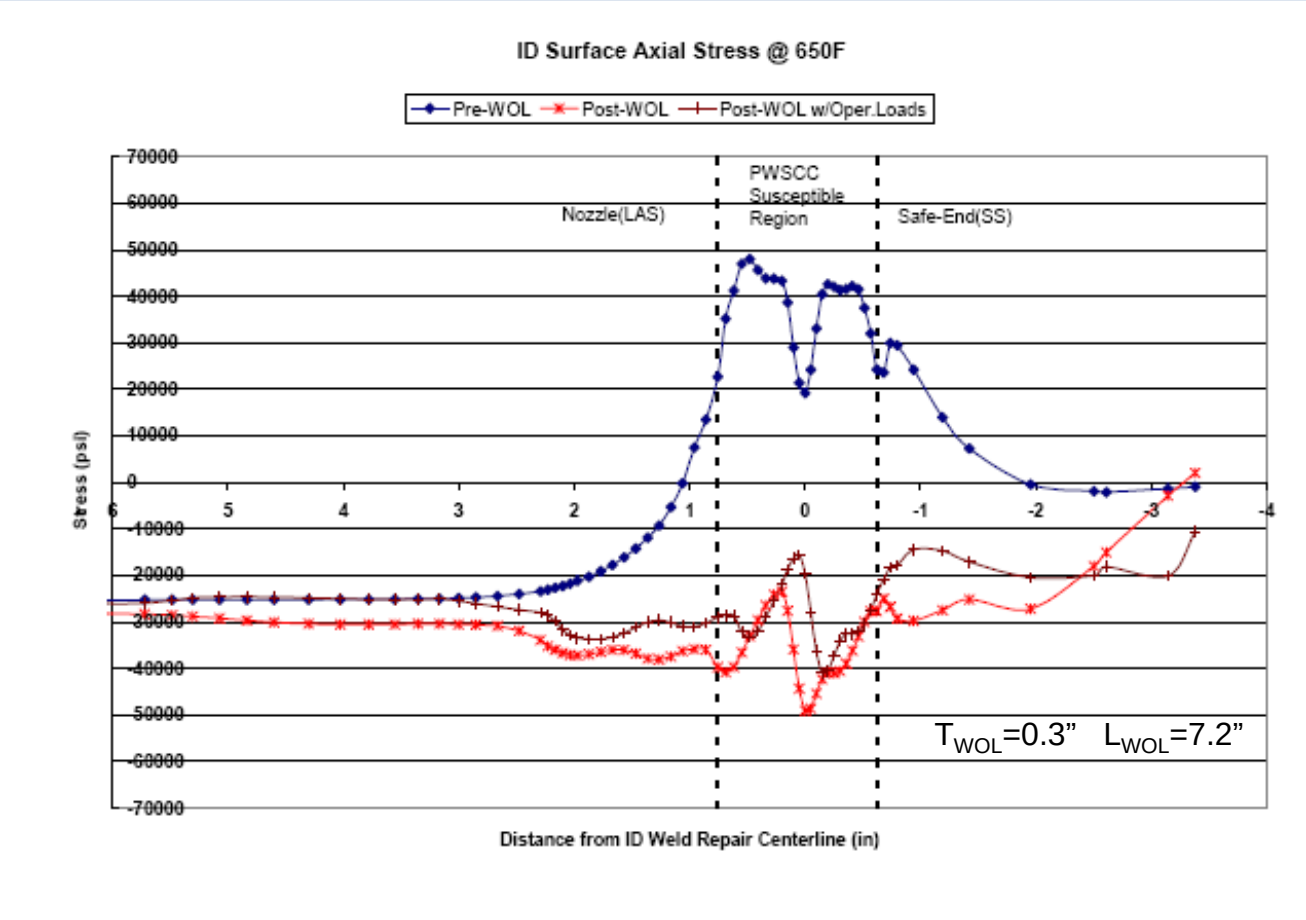


Pre-WOL
Stress field at inner portion of the weld:
40 to 50 ksi

Results are from EPRI MRP-169

Stress Analysis Results

Pre and Post WOL Residual plus Operational Stress (axial stress):



Spray nozzle (typical of the results for all nozzles)

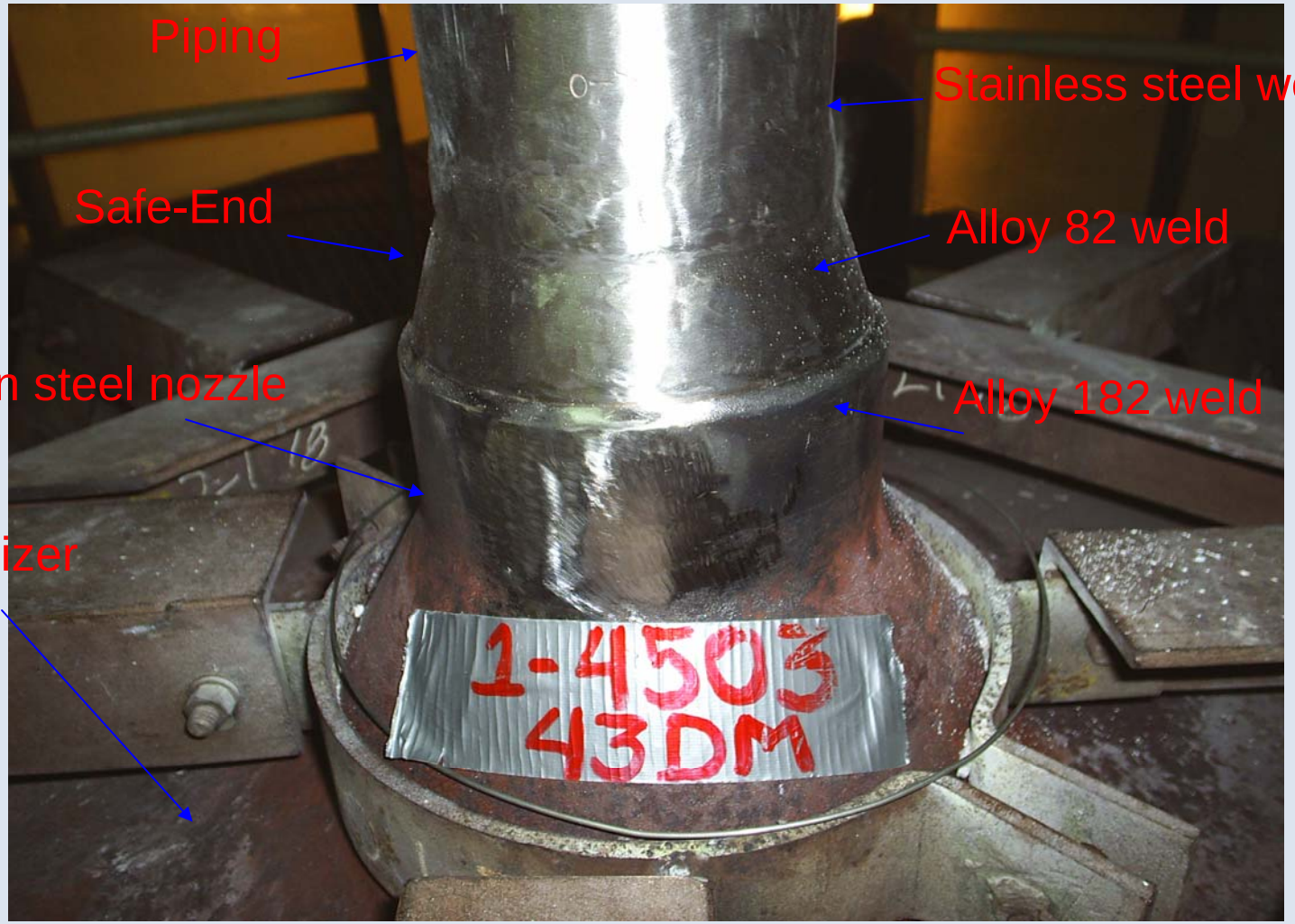
Results are from EPRI MRP-169

Welds Measurements

Angra 1 top of the PZR area

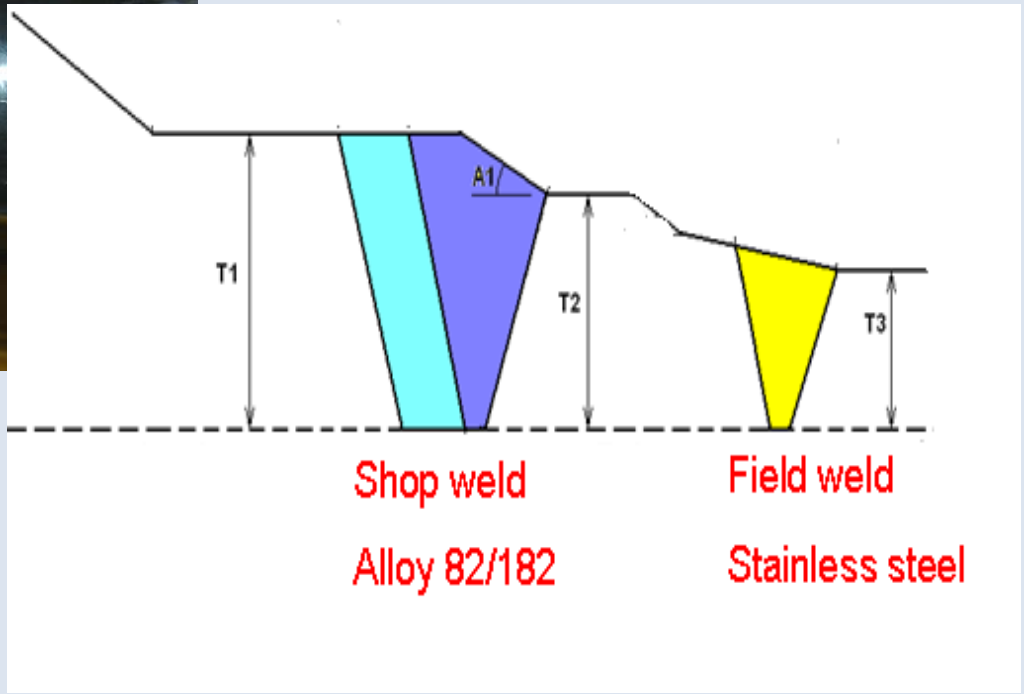
Welds Measurements

Spray Nozzle (4 in. diameter)



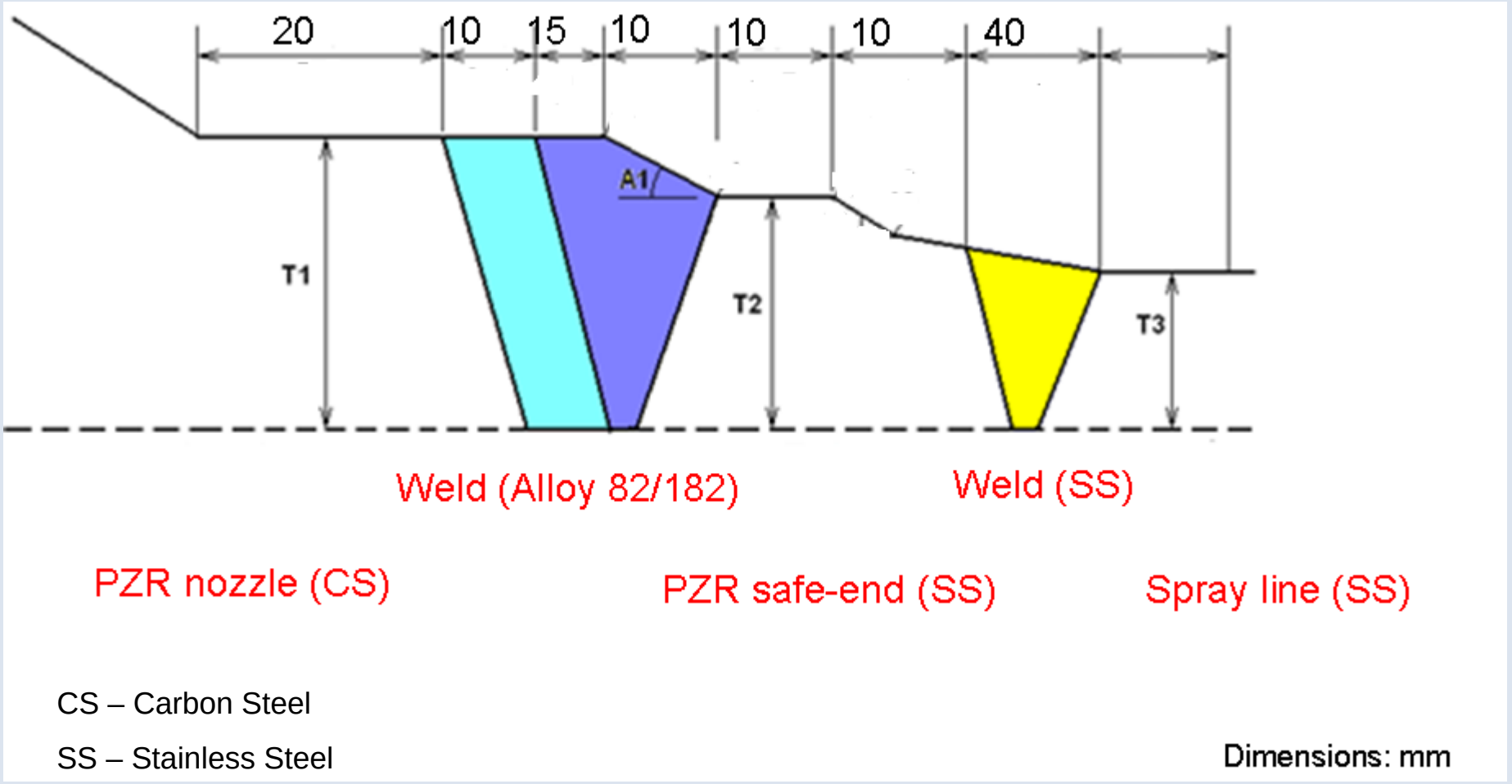
Welds Measurements

Spray Nozzle (weld as built)



Welds Measurements

Spray Nozzle (weld as built)



CS – Carbon Steel

SS – Stainless Steel

Dimensions: mm

Technical Specification

Objective:

Establish requirements to contract a vendor to conduct the weld overlay on the five PZR nozzles. The Contractor has to be responsible for the design, installation, and nondestructive examination of the modification.

– Pre-Outage

- Define WOL thickness, stress analysis, fracture mechanics
- Training (mock up) to qualify the WOL process
- Design reports and procedures (installation/examination)

– Outage

- Installation
- Nondestructive examination (visual/ultrasonic)

Conclusions

– Present work has shown how the Alloy 600 issue is managed in Angra 1.

– Current actions adopted by Eletronuclear:

- Research (develop methodology to determine residual stress in RVCH penetrations and construct mock ups to qualifiy WOL)
- Field activities (welds measurements)
- Technical Specification to contract WOL service

– Eletronuclear will present in the next workshop the result of WOL application for the Angra 1 pressurizer nozzles.