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# *Inspection of Alloy 600 RPV penetrations and nozzles in Spain*

SMIRT 16 Workshop on Alloy 600 Vessel Head Penetrations and Dissimilar Metal Welds

August 15, 2001, Washington DC

# Main areas of concern



Main areas of concern due to SCC of Alloy 600/182:

- ✓ CRDM penetrations in PWRs
- ✓ Bottom Mounted Instrumentation (BMI) penetrations in PWRs.
- ✓ CRDH and ICMH in BWRs
- ✓ Bimetallic welds.

# Status in Spain. PWRs



- PWR PENETRATIONS: Since early nineties.
  - ✓ CRDMs
    - ✓ Inspections performed at all seven Spanish PWR plants.
    - ✓ Diverse scope and frequency depending on particular circumstances.
    - ✓ One RPV Head repaired (and later replaced)
    - ✓ Two other RPV Heads replaced
  - ✓ BMIs
    - ✓ Inspection techniques and equipment developed and demonstrated for 9 and 15 mm ID penetrations.
    - ✓ Full inspection performed at one plant.

# Status in Spain. BWRs



- BWR PENETRATIONS: Since early eighties.
  - ✓ CRDHs
    - ✓ Large scope inspection every outage at one plant.
    - ✓ Reduced scope inspection every outage at another plant.

# Status in Spain. PWRs and BWRs



- BIMETALLIC WELDS.
  - ✓ Close follow-up of recent events.
  - ✓ Industry/Regulator initiative expected in the coming months.

# CRDMs in PWRs (I)



- After the Bugey 3 leak in 1991, the Spanish Safety Authorities (CSN), required to inspect by NDE the outer peripheral rows of CRDM penetrations on a four year basis.
- Lately, the examinations are required on a seven year basis (in plants having VHP made of Alloy 600/182).

# CRDMs in PWRs (II)



- In 1992, Industry launched the project PETAVA focussed in CRDM penetrations and aimed at having available:
  - ✓ NDE system
  - ✓ Defect acceptance criteria
  - ✓ Repair techniques.

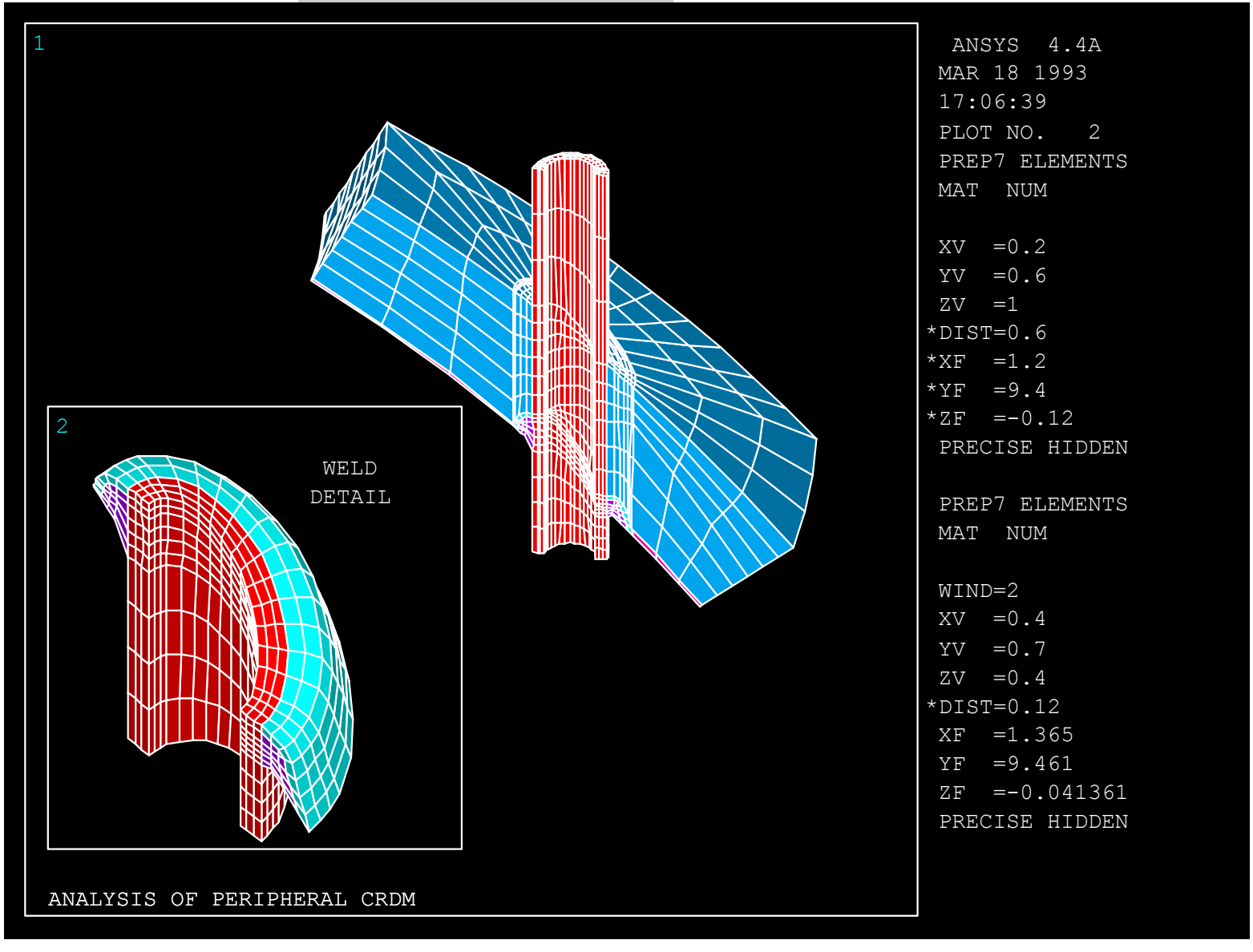
# NDE Equipment



- The PETAVA equipment is capable to perform exams by EC in the gap between the CRDM penetrations and the thermal sleeve.
- Applied in all Spanish PWRs.
- First inspection carried out in 1993.

# Development of acceptance criteria

Alloy 600/182 in LWRs



# Mitigating measures (I)



- Ascó 1 modified the flow inside the vessel to have cold leg temperature in the upper plenum.
- Almaraz 1 & 2 replaced vessel heads. The new ones have CRDM penetrations made of Alloy 690/152.

  Replacements performed during the same outage than the SG replacements (containment equipment hatch too narrow for the head replacement to be carried out at later time).

# Mitigating measures (II)



- In 1994, the Zorita vessel head showed extensive cracking due to IGSCC (not PWSCC) caused by resins incursion in primary circuit occurred many years before. (US NRC Information Notice 96-11).
- Zorita vessel head repaired and finally replaced with a new one with CRDM penetrations made of Alloy 690/152.

# STAR system for CRDM inspections



- Developed in 1997 for CRDM penetrations inspections.
- Adapted to VVER RPV Head penetrations in 1998.
- Loviisa inspection performed in 1998.

# STAR system for CRDM inspections



- Integrated multi-task tool **STAR**
  - Robotic arm with diverse modules
  - Gap scanner
  - Inspection tools (VT, UT, PT)
  - SIROCO as integrated controller
  - Up to eight TV cameras support
- ✓ Advanced UT (SUMIAD-MASERA) and ET (TEDDY) data acquisition systems
- ✓ Customized data analysis tools
- ✓ Validated to ENIQ Methodology
  - Technical Justification
  - Full mock-up
  - Open demonstration trials

# STAR system: Main advantages

- ✓ System installed on the vessel stand (no lifting of the RPV head needed).
- ✓ Dismantling of equipment without moving the RPV head.
- ✓ Simplified equipment based on Steam Generator's mechanical manipulator.
- ✓ High inspection speed.
- ✓ Reduced personnel and dose.

# STAR system applied in Loviisa

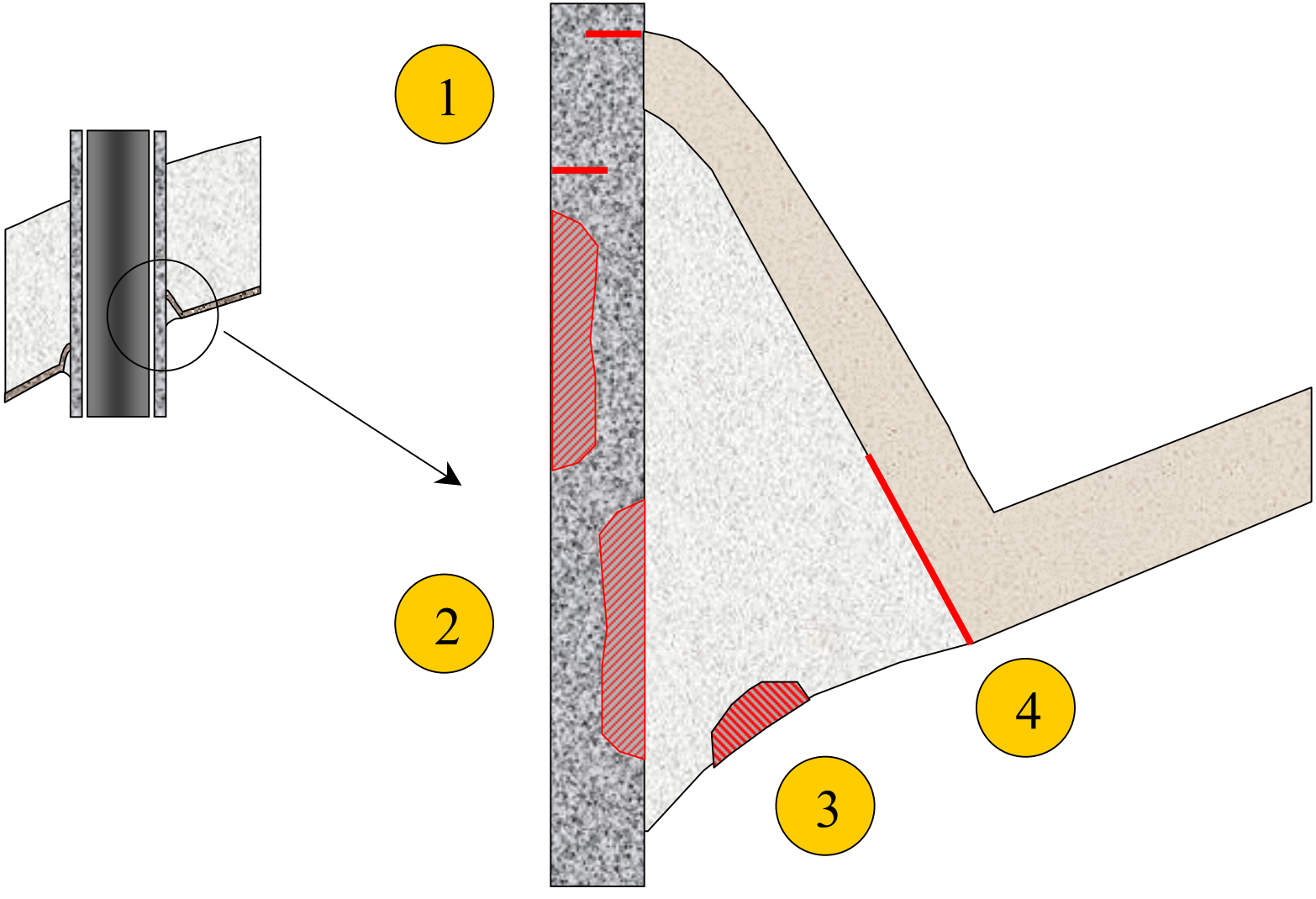


- LOVIISA HIGHLIGHTS
  - ✓Fixing weld (UT, VT & ET)
  - ✓Sealing weld (VT & ET)
  - ✓Gap between sleeve and penetration: corrosion tube (ET)
  - ✓Cladding (VT)
  - ✓Sleeve. Inner surface (VT)

# STAR inspection scope



- With or Without Thermal Sleeve



# STAR system NDE methods



| CRACK TYPE | DETECTION | SIZING |
|---|---|---|
| 1 OD (circ) | UT Gap | UT Gap (TOFD) |
| 1 ID (circ) | ET Gap | UT Gap (TOFD) |
| 2 OD (axial) | UT Gap | UT Gap (TOFD) |
| 2 ID (axial) | ET Gap | UT Gap (TOFD) |
| 3 (radial) | ET weld scanner | UT Gap (TOFD) |
| 4 (concentric) | ET weld scanner | UT Gap (0º) |

Immediately available

Pending qualification

Pending qualification and development

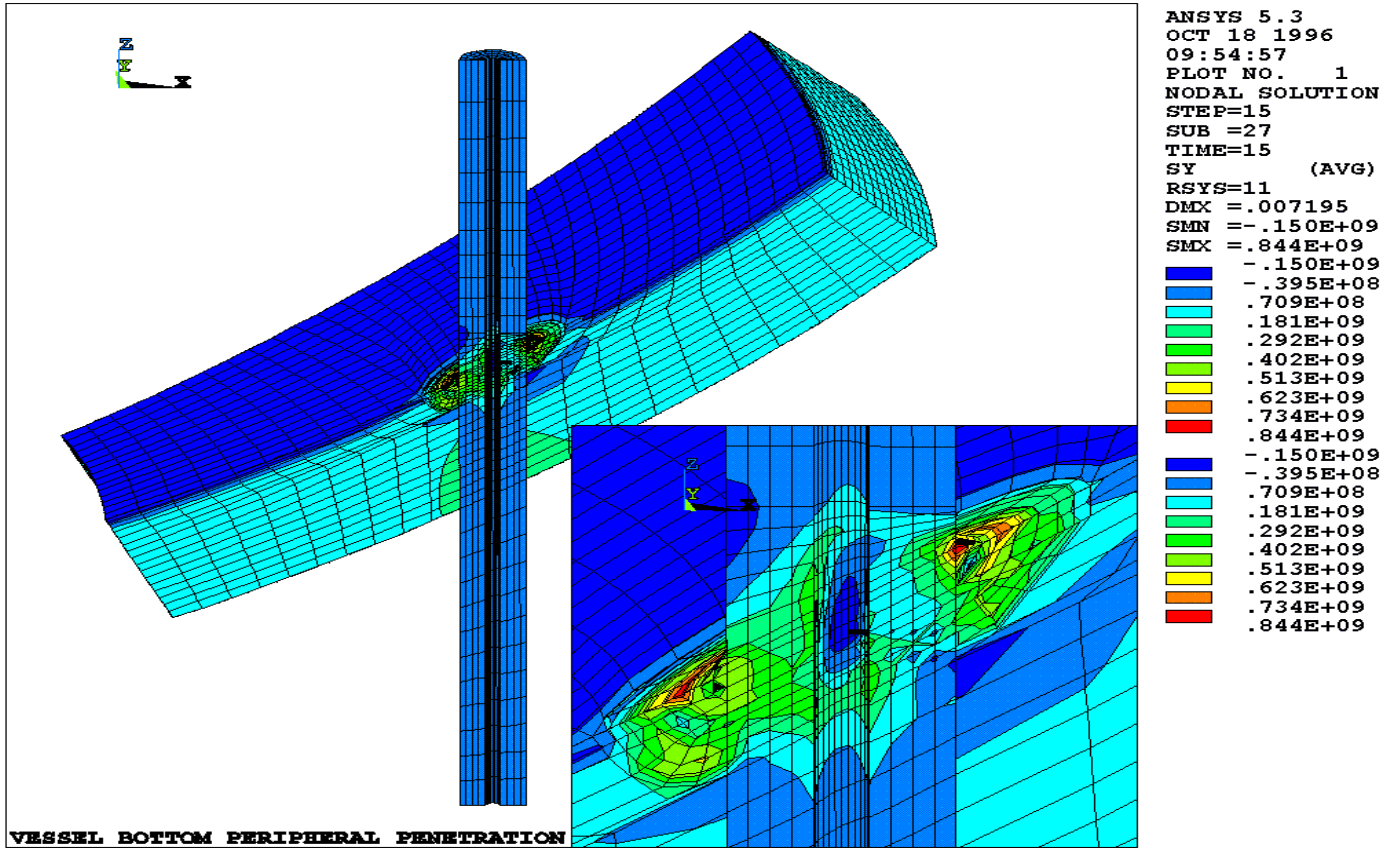
# BMI penetrations in PWRs



- The Spanish Safety Authorities required to exam by NDE the bottom instrumentation penetrations of the Zorita´s vessel.
- The PIV equipment developed for this purpose.
- Acceptance criteria developed.

# Development of acceptance criteria

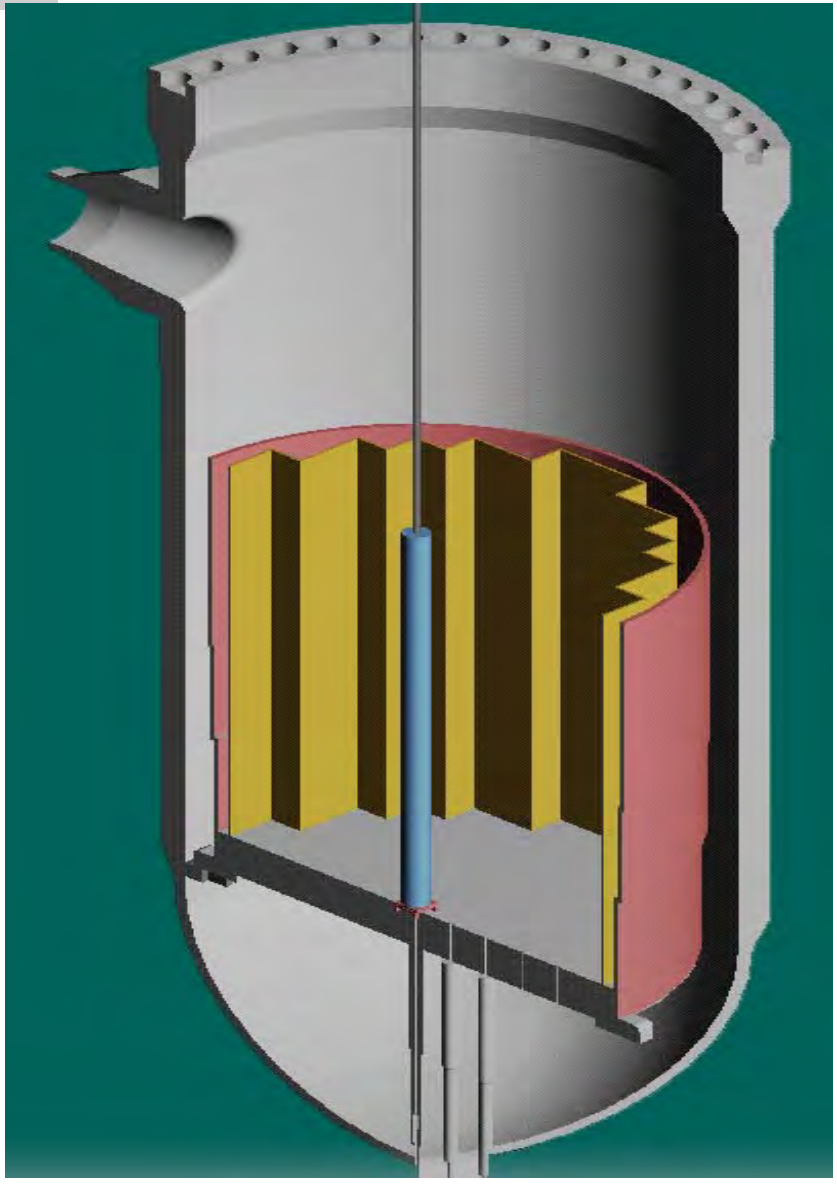




# PIV system design criteria

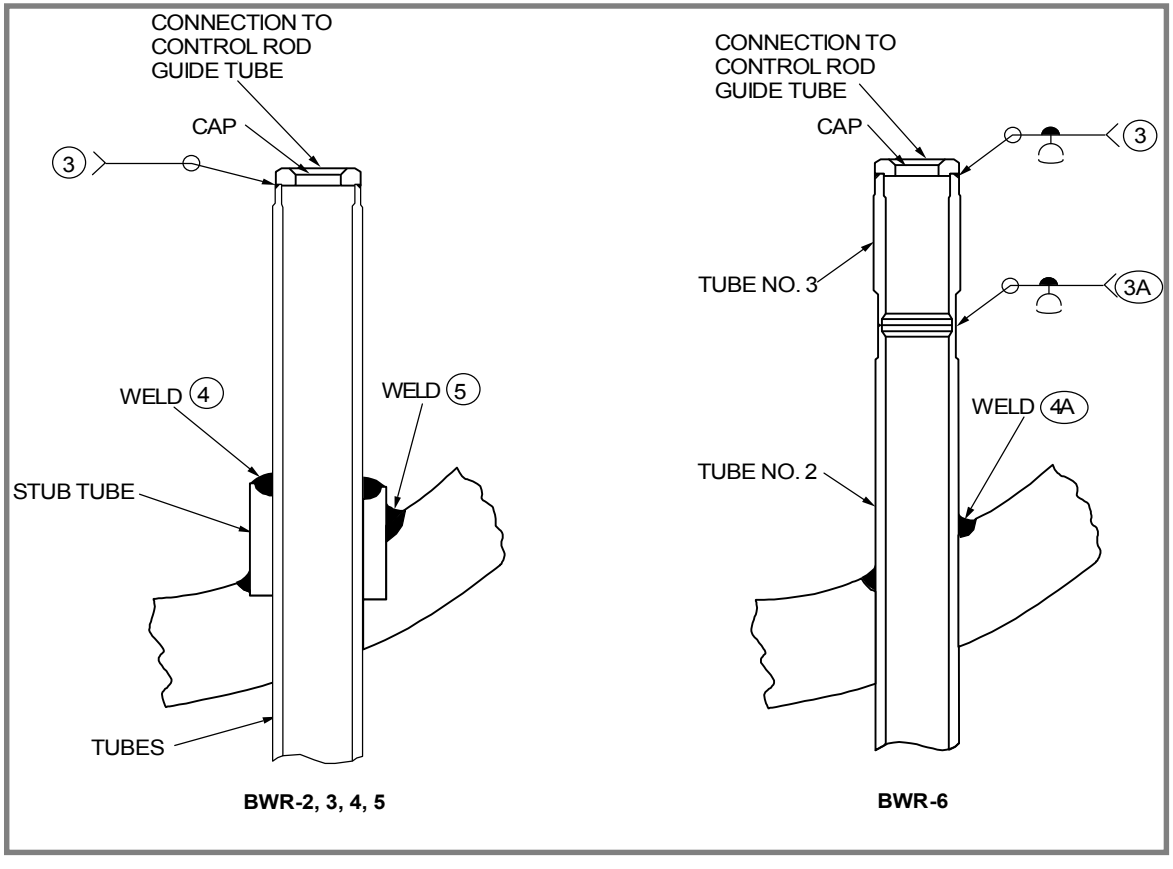


- ✓ Core Barrel in place
- ✓ Positioned upon lower core plate
- ✓ Using fuel elements' positioning pins
- ✓ Common layout to all types of PWR
- ✓ Remote control and operation (outside of containment building)



# CRDHs in BWRs (I)






From RPV Bottom Area & from Refueling Platform

# CRDHs in BWRs (II)



- Housing base material.
  - ✓ Rolled area.
  - ✓ Sealing area of mechanical seal.
- Housing base metal to cap weld.
- Lower housing circumferential weld.
- "J" weld.
- Stub tube base material.
  - ✓ Sealing area of mechanical seal.
- Stub tube to RPV Bottom dome weld.

# BWR CRDHs inspections



- ✓ First inspection in 1983.
- ✓ From Under Vessel & Refueling Floor access.
- ✓ Standard combined (UT+ET) techniques.
- ✓ Advanced techniques for accurate sizing.
- ✓ Applied in both BWRs in Spain (with different scope and frequency).
- ✓ Applied also in Leibstadt and Mülherberg since 1993.
- ✓ Also inspections of ICMHs in Switzerland and Japan (not in Spain).