Dissimilar Metal Butt Weld Status in Maanshan NPS

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AEC

Background: MRP-139

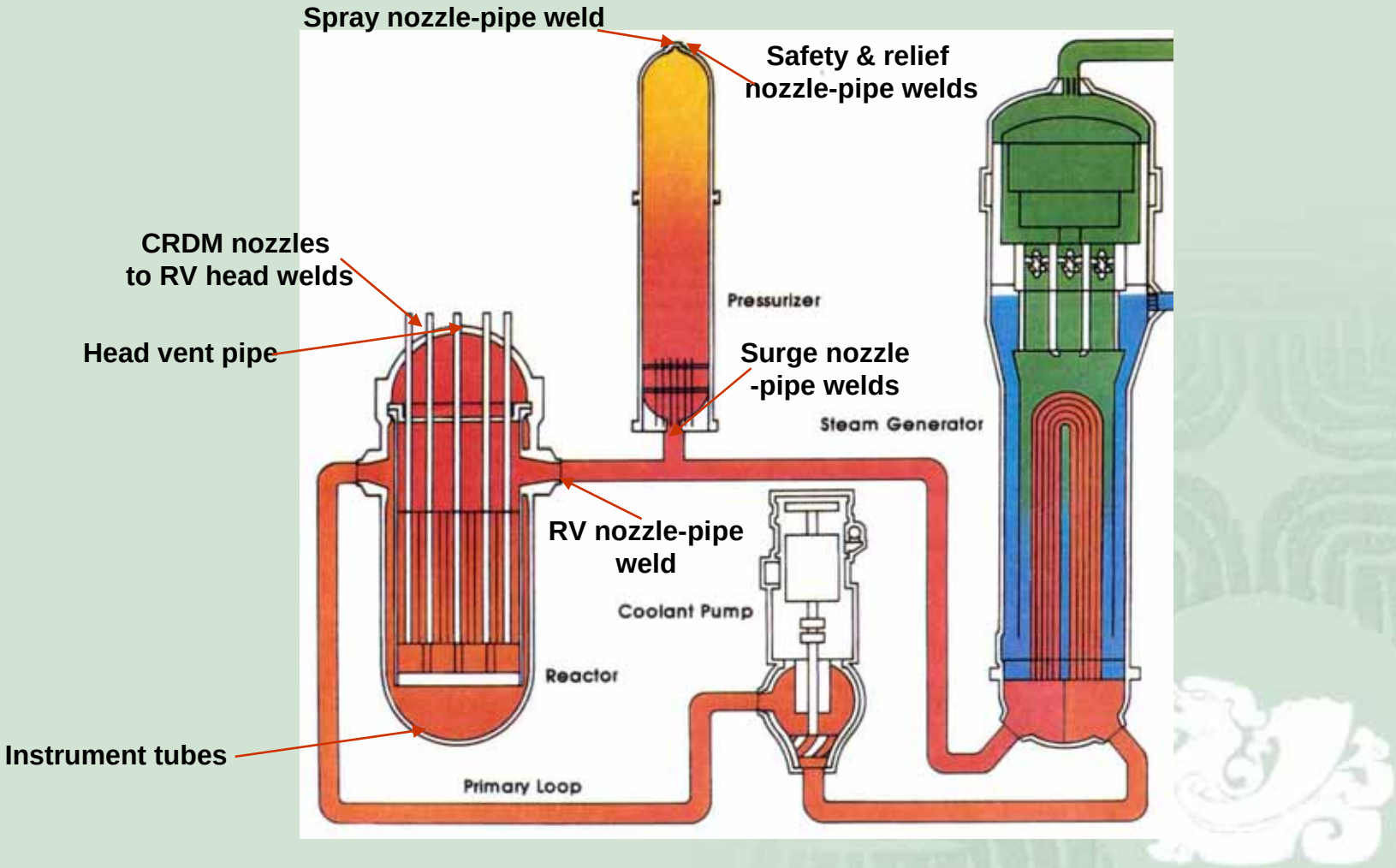
"Materials Reliability Program: Primary System Piping Butt Weld Inspection and Evaluation Guidelines."

Developed by EPRI and the industry

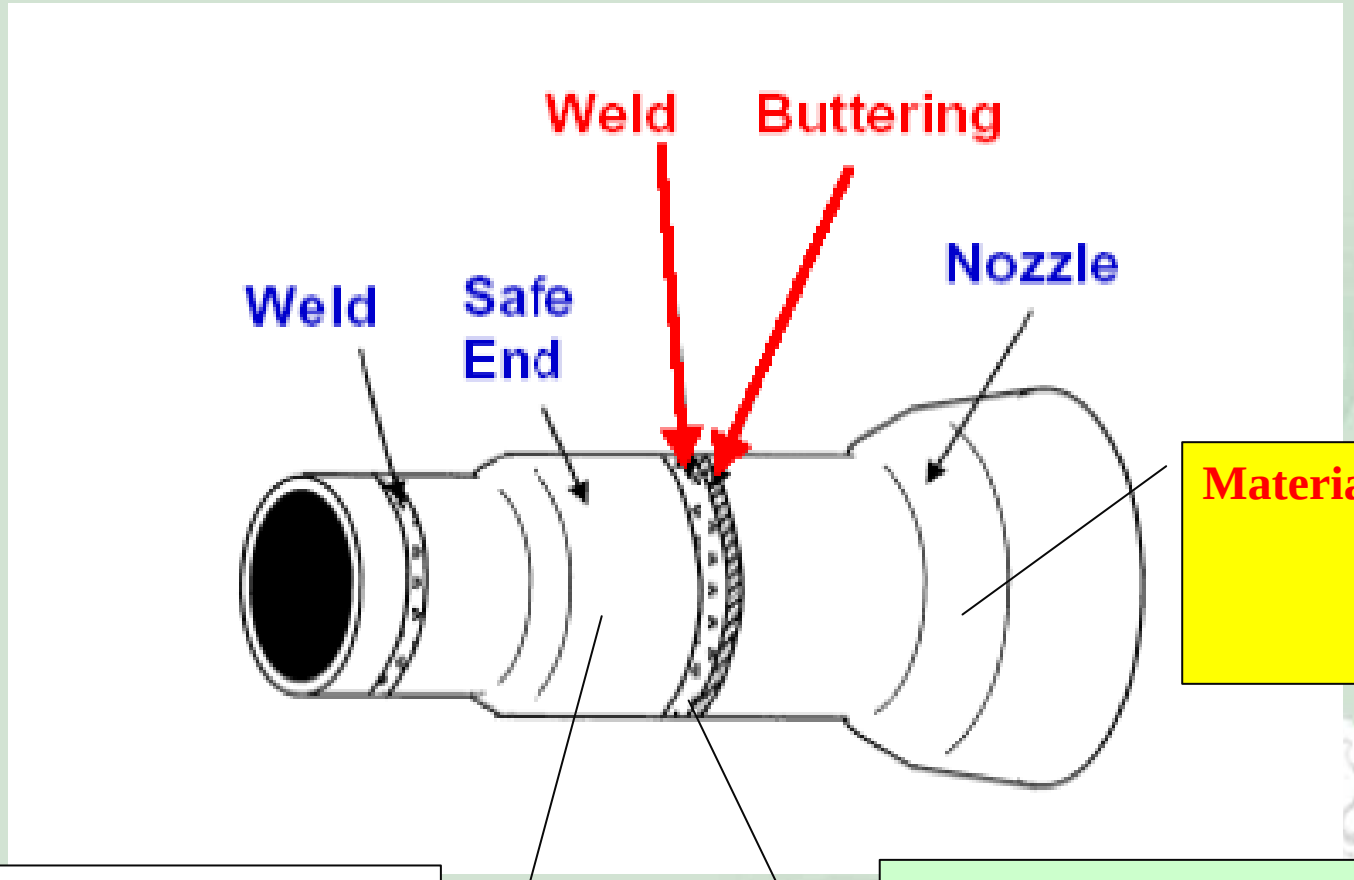
- Committed to by the industry through NEI protocols ("Mandatory" program under NEI 03-08, "Guideline for the Management of Materials Issues")
- Provides guidance for volumetric and visual inspection of Alloy 82/182 butt welds in PWR RCS
- It establishes a time line for initial and periodic examination based on:
  - Weld location
  - Weld condition (cracked or uncracked)
  - Mitigation that has been applied

- First priority is pressurizer weld locations, followed by hot leg and then cold leg welds

Dissimilar metal butt weld at Maanshan NPS



Material of DM welds in Primary System Nozzles



Material：SA-508 CL2，P3，Ferritic

Material：SA-182 GR316，P8，Austenitic

Material：Alloy 82/182，P43，Nickel Alloy

Overview of DM welds of the Primary System at MNPS

Nozzle/ System	Name	Nozzle /Material 1	P No	Weld Material	P No	Safe-end /Material 2	P No	Nominal Size	Quanties
RPV Inlet Nozzle	**Safe-end to Inlet Nozzle**	**SA508 CL2**	**P3**	**Alloy 82/182**	**P43**	**SA182 GR316**	**P8**	**27.5“ID**	3 /Unit x 2 = 6
RPV Outlet Nozzle	**Outlet Nozzle to Safe-end**	**SA508 CL2**	**P3**	**Alloy 82/182**	**P43**	**SA182 GR316**	**P8**	**29“ID**	3 / Unit x 2 = 6
PZR Safety Nozzle	**Safety Nozzle to Safe-end**	**SA508 CL2**	**P3**	**Alloy 82/182**	**P43**	**SA182 GR316**	**P8**	**6"**	3 / Unit x 2 = 6
PZR Relief Nozzle	**Relief Nozzle to Safe-end**	**SA508 CL2**	**P3**	**Alloy 82/182**	**P43**	**SA182 GR316**	**P8**	**6"**	1 / Unit x 2 = 2
PZR Spray Nozzle	**Safe-end to Spray Nozzle**	**SA508 CL2**	**P3**	**Alloy 82/182**	**P43**	**SA182 GR316**	**P8**	**4"**	1 / Unit x 2 = 2
PZR Surge Nozzle	**Safe-end to Surge Nozzle**	**SA508 CL2**	**P3**	**Alloy 82/182**	**P43**	**SA182 GR316**	**P8**	**14"**	1 / Unit x 2 = 2

Table 2-2 ASME Chemical Composition Requirement (wt%) [23-28]

Alloy	Ni	Cr	Fe	C	Mn	Si	S	Ti	Nb + Ta	Cu	P	Al	Mo	Other
690	58.0 min	27.0-31.0	7.0-11.0	0.05 max	0.50 max	0.50 max	0.015 max	--	--	0.50 max	--	--	--	--
600	72.0 min	14.0-17.0	6.0-10.0	0.15 max	1.0 max	0.50 max	0.015 max	--	--	0.50 max	--	--	--	--
152 (a)	Bal.	28.0-31.5	7.0-12.0	0.05 max	5.0 max	0.75 max	0.015 max	0.50 max	1.0-2.5	0.50 max	0.03 max	0.50 max	0.50 max	0.50 max
182	59.0 min	13.0-17.0	10.0 max	0.10 max	5.0-9.5	1.0 max	0.015 max	1.0 max	1.0-2.5	0.50 max	0.03 max	--	--	0.50 max
52 (a)	Bal.	28.0-31.5	7.0-11.0	0.04 max	1.0 max	0.50 max	0.015 max	1.0 max	0.10 max	0.30 max	0.02 max	1.10 max	0.50 max	0.50 max
82	67.0 min	18.0-22.0	3.0 max	0.10 max	2.5-3.5	0.50 max	0.015 max	0.75 max	2.0-3.0	0.50 max	0.03 max	--	--	0.50 max

(a) It is noted that modified versions of Alloy 152/52 with improved weldability are currently being developed.

Alloy 52M：Alloy 52+B+Zr

- Alloy 600/82/182(NiCrFe-type)：
  - susceptible to PWSCC
- Alloy 690/52/152(NiCrFe-type)：
  - Resistant to PWSCC, better than Alloy 82/182。
  - **Weld Pitfalls** such as **oxide floaters**, **hot cracking**, **ductility dip cracking**, **lack of interbead bonding and interface fusion**, and **porosity**
- Alloy 690/52M/152M(NiCrFe-type)：
  - New generation of nuclear welding products
  - 30% Cr with addition of B+Zr to resist DDC （**ductility dip cracking**）

PWSCC of DM
Tsuruga-2 PZR safety nozzle (2003)

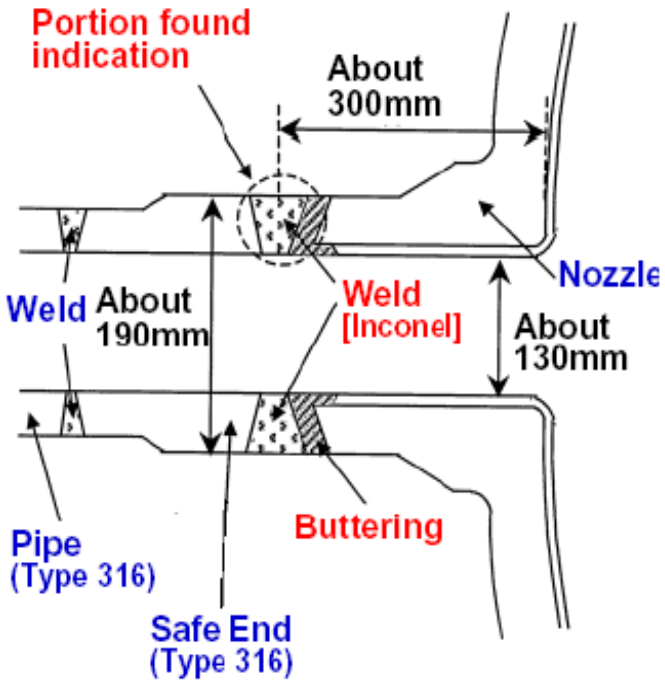


Figure 3. Nozzle Materials (Courtesy of Japan Atomic Power)

PWSCC
Indications found in the susceptible Alloy 82/182
Cracks initiate from ID
Indications characterized as “branched with multiple facets”

Current U. S. Environment and Impact of Inspection Findings

Fall 2006: Inspection Findings of Pressurizer Welds at Wolf Creek and impact from NRC:

- First large/multiple circumferential flaws which decrease time to leak and time between leak and rupture. (Expected to see small axial indications).
  - NRC required enhanced leakage monitoring requirements, and considered requiring 11 plants to inspect/mitigation earlier than planned

Examination Results and Plan: Maanshan-1

Item	Name	Examination Results of 2nd ISI	Examination Results and Plan of 3rd ISI
1	PZR Safety Nozzle A	EOC-9、15, Accepted	EOC-17, Accepted
2	PZR Safety Nozzle B	EOC-9、15, Accepted	EOC-17, Accepted
3	PZR Safety Nozzle C	EOC-9、15, Accepted	EOC-17, Accepted
4	PZR Relief Nozzle	EOC-9、15, Accepted	EOC-17, Accepted
5	PZR Spray Nozzle	EOC-11、15, Accepted	EOC-17, Accepted
6	PZR Surge Nozzle	EOC-11、15, Accepted	EOC-17, Accepted
7	RPV H/L Nozzle A	EOC-14, Accepted	EOC-17, Accepted
8	RPV H/L Nozzle B	EOC-14, Accepted	EOC-17, Accepted
9	RPV H/L Nozzle C	EOC-14, Accepted	EOC-17, Accepted
10	RPV C/L Nozzle A	EOC-14, Accepted	EOC-18 Planned
11	RPV C/L Nozzle B	EOC-14, Accepted	EOC-18 Planned
12	RPV C/L Nozzle C	EOC-14, Accepted	EOC-18 Planned

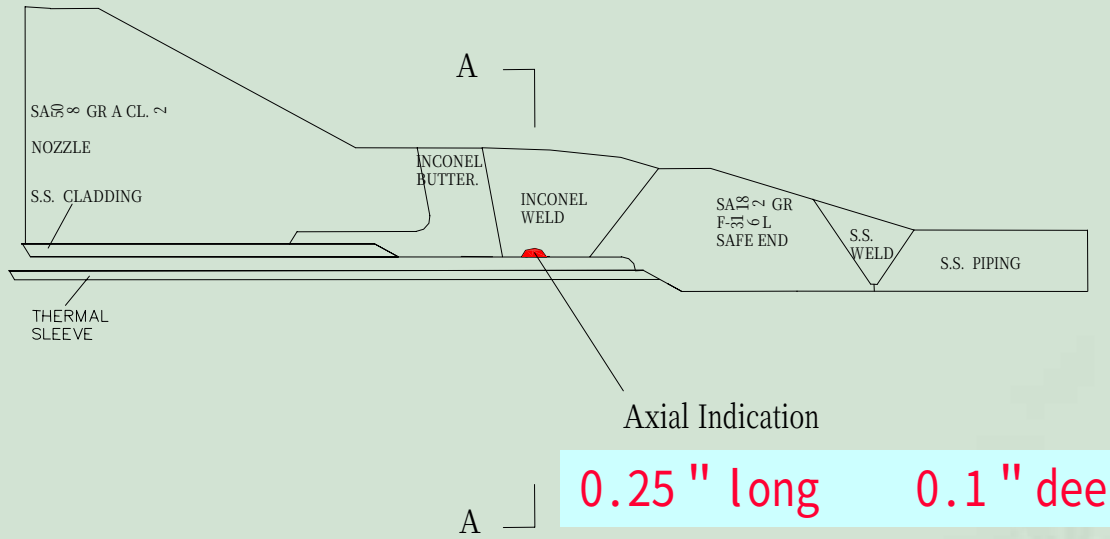
Note: Examination of PZR Nozzles during EOC-15 was an extra-exam in response to Tsuruga-2 event

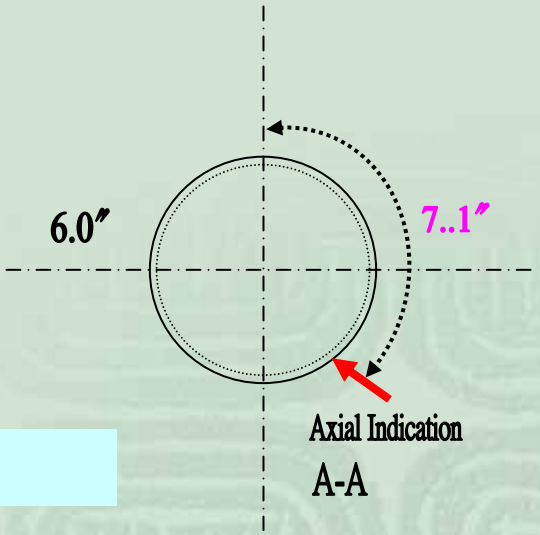
Examination Results and Plan: Maanshan-2

Item	Name	Examination Results of 2nd ISI	Examination Results and Plan of 3rd ISI
1	PZR Safety Nozzle A	EOC-9、14, Accepted	EOC-17, Accepted
2	PZR Safety Nozzle B	EOC-9、14, Accepted	EOC-17, Accepted
3	PZR Safety Nozzle C	EOC-9、14, Accepted	EOC-17, Accepted
4	PZR Relief Nozzle	EOC-9、14, Accepted	EOC-17, Accepted
5	PZR Spray Nozzle	EOC-9、14, Accepted	March 22, 2007, an axial indication with 0.25“ long, 0.1“ deep found, Accepted after Evaluation, EOC-17, Accepted
6	PZR Surge Nozzle	EOC-11、15, Accepted	EOC-17, Accepted
7	RPV H/L Nozzle A	EOC-14, Accepted	EOC-17, Accepted
8	RPV H/L Nozzle B	EOC-14, Accepted	EOC-17, Accepted
9	RPV H/L Nozzle C	EOC-14, Accepted	EOC-17, Accepted
10	RPV C/L Nozzle A	EOC-14, Accepted	EOC-18 Planned
11	RPV C/L Nozzle B	EOC-14, Accepted	EOC-18 Planned
12	RPV C/L Nozzle C	EOC-14, Accepted	EOC-18 Planned

Note: Examination of PZR Nozzles during EOC-14/15 were extra-exams in response to Tsuruga-2 event

PZR-121-ESE SPARY NOZZLE TO SAFE-END WELD





0.25 " long 0.1 " deep

Acceptable per Table IWB-3514-2「Allowable Planar Flaws」, ASME CODE SEC.XI

Enhanced RCS Leakage Monitoring Program

- RCS Leakage Test frequency from once per 3 days to everyday
- Criteria for unit shutdown：
  - Leakage found on PZR welds
  - Unidentified Leakage ＞ 0.1gpm/d for 3 consecutive days
  - Unidentified Leakage ＞Base value leakage +0.25gpm for 3 consecutive days（Base value leakage ：Average leakage for 7 tests after full power）

Pre-emptive Weld Overlay

- Full Structural Weld Overlay
- ASME Code, Section XI, Code Case **N-504-2**, "Alternative Rules of Repair of Class 1, 2 and 3 Austenitic Stainless Steel Piping"
- Code Case **N-638-1** "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique"
- GTAW(**Temper Bead Welding**： ASME Code Case N-638 provides for the use of ambient temperature temper bead welding and has been used extensively in the industry to weld carbon and low alloy steels where the required PWHT is either undesirable or impractical)
- Application still under review by AEC

Pre-emptive Weld Overlay(cont'd)

- 2009~2012 to complete the Pressurizer nozzles (total of 12 for two units) during 2 refueling outages
- 2013~2020 to complete the RPV nozzles (total of 12 for two units) during 5 refueling outages