

Priority Evaluation of Nuclear Materials Aging and Degradation Management

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1. Introduction

According to increasing years of nuclear power plant operation, nuclear materials degradation has emerged as a key issue for a long-term operation and periodic safety evaluation. Therefore, the status of the material degradation management in advanced nuclear power nations was investigated to determine the level of research and development gap. Five national experts involved in the evaluation of materials degradation in reactor coolant system (RCS) of Korean Standard Nuclear Power plant (KSNP). Based on this evaluation, the priorities of materials degradation management were determined in KSNP.

2. Review of Overseas Nuclear Materials Degradation Evaluation

Nuclear materials degradation evaluation results performed by international experts panel in NUREG/CR-5923 report was reviewed in this paper. The most susceptible and least known degradation mechanisms in RCS, engineered safety feature & emergency core cooling system (ESF & ECCS) and steam & power conversion system are shown in Fig. 1.

Subgroup Description	Degradation Mechanism											
	BAC	CREEP	CREV	FAC	FAT	FR	IC	PIT	SCC	SW	WEAR	
Type 304/316/308 SS Socket Welds												
1.7 SS 304/308/316 Socket Welds												
2.7 SS 304/308/316 Socket Welds												
3.7 SS 304/308/316 Socket Welds												
5.6 304/308/316 Socket Welds												
6.6 304/308/316 Socket Welds												
7.6 304/308 Socket Welds (Stagnant)												
Type 308/309 SS Dissimilar Metal Welds												
1.9 308/309 Dissimilar Weld - Ext.												
2.9 308/309 Dissimilar Weld - Ext.												
3.9 308/309 Dissimilar Weld - Ext.												
Inconel Alloy 82/182 Dissimilar Metal Welds												
4.6 Alloy 82/182 Dissim. Welds - Int.												
10.8 Alloy 82/182 Dissim. Welds - Int.												
11.16 Alloy 82/182 Dissim. Welds - Int.												
Inconel Alloy 600 Components												
4.7 Forged Alloy 600 Nozzles												
4.14 Alloy 600 (CW) Heater Clad/Welds												
10.9 Forged Alloy 600 Nozzles												
11.5 Alloy 600 MA SG Tubes etc.												
11.6 Alloy 600 MA SG Tubes Sec. Side												
11.9 Alloy 600 Divider Plate												
11.12 Alloy 600 TT SG Tubes etc.												
11.14 Alloy 600 TT SG Tubes Sec. Side												
11.22 Alloy 600 SA Sensitized SG Tubes												
11.23 Alloy 600 SA Sens. SG Tube Sec.												
High-Strength Components												
9.3 High Strength Parts												
12.7 High Strength Fasteners/Springs												
12.12 High Strength Bolts (high fluence)												
Carbon and Low-Alloy Steel Components												
10.2 Shell/Pipes, Forgings, Welds												
11.20 CS Drilled Hole TSP												
Type 304/316/308 SS Components												
10.10 304/308 CRDM Housing (Stagnant)												
12.4 Type 316 CW SS Comp. (low fluence)												
12.8 304 SS Plates/Tubes (high fluence)												
12.9 Type 304 SS HAZ (high fluence)												
12.10 308 SS Weld Metal (high fluence)												
12.11 316 CW SS Comp. (high fluence)												

NOTES: * Susceptibility at outer interface with one or more scores higher than this interface; * Susceptibility inside color box with one or more scores higher than outer interface.

Fig. 1. Degradation Mechanism considered in the Subgroup

This information was used in priority evaluation of degradation management of RCS in KSNP performed by five national experts.

3. Priority Evaluation of Degradation Management

Five national experts involved in the evaluation of materials degradation in RCS of KSNP. Priority evaluation results of degradation in RCS are shown in Table 1.

Table 1. Evaluation Results of Degradation Management in RCS

Component	Subgroup	Degradation Mechanism Consider	Expert Rating Rank					
			1	2	3	4	5	T
Type 304/316/308 stainless steel socket welds	1.7, 2.7, 3.7, 5.6, 6.6, 7.6	•Fatigue •Stress corrosion cracking	3	3	3	3	3	3
Type 308/309 stainless steel	1.9, 2.9, 3.9	•Stress corrosion cracking of the external surface	5	7	6	4	4	5
Alloy 82/182 stainless dissimilar metal welds	4.6, 10.8, 11.16	•Stress corrosion cracking	1	2	1	1	2	1
Alloy 600 components	4.7, 4.14, 10.9, 11.5, 11.6, 11.9, 11.12, 11.14, 11.22, 11.23	•Stress corrosion cracking •wear	2	1	2	2	1	2
High Strength Components	9.3, 12.7, 12.12	•Fatigue •Reduction in fracture resistance •Irradiation creep •Stress corrosion cracking •Swelling	7	5	5	7	6	6
Carbon and Low Alloy Steel Components	10.2, 11.20	•Boric acid corrosion •Flow-accelerated corrosion	6	6	7	6	7	7
Type 304/308 Stainless Steel Components	10.10, 12.4, 12.8, 12.9, 12.10, 12.11	•Reduction in fracture resistance •Irradiation creep •Stress corrosion cracking •Swelling	4	4	4	5	5	4

A management priority order is as followings;

- 1) SCC of Alloy 82/182 stainless dissimilar metal welds

- 2) SCC of Alloy 600 components
- 3) Fatigue of Type 304/316/380 stainless steel socket welds

4. Evaluation of the Domestic Nuclear Materials Degradation Management Measures

The evaluation results of the domestic measures of reactor coolant system in KSNP and research status are shown in Table 2.

Table. 2. The evaluation results of the reactor coolant system of domestic measures and research Status

	SCC of Alloy 82/182 stainless dissimilar metal welds	SCC of Alloy 600 components	Fatigue of Type 304/316/380 stainless steel socket welds
Domestic measures	<ul style="list-style-type: none"> •Executing of the MRP(Material Reliability Program) •Suggestion of measuring term and method for Alloy 600 in MRP •Alloy 600 instrument Comprehensive Management Plan / Pre-Management 	<ul style="list-style-type: none"> •SGMP(Steam generator integrated management program) performed •SGMP performed in all areas of the steam generator •Executing reliability of the MRP 	<ul style="list-style-type: none"> •Establishment of measures to improve nuclear safety welding
Research Status	<ul style="list-style-type: none"> •Surface stress distribution of the reactor head inspection system development underway •LBB application of dissimilar metal weld integrity assessment of the PWSCC underway •Ultrasonic testing of nuclear piping dissimilar metal weld build skills verification system underway •Non-destructive inspection systems for nuclear verification service skills performing 	<ul style="list-style-type: none"> •nozzle base metal and weld residual stress assessment data produced •BMI Mockup defective control technology as part of the hydrogen and temperature control technology, variable defects is in development •Boric acid concentration simulations underway •High Nickel Alloy Welding Residual Stress Analysis of Dissimilar Metal Siding •Structural Integrity Assessment of Welding Defects •Degradation of mitigation program implementation 	<ul style="list-style-type: none"> •Ultrasound guided technique under development •Non-destructive inspection systems for nuclear verification services skills Perform •Small enough to mitigate the degradation of nuclear piping are promoting for the facility improvement projects •UT-socket weld pipe small enough nuclear equipment and evaluation technology development tasks performed

Research on non-destructive examination (NDE), water chemistry, maintenance techniques related to Alloy 82/182 stainless dissimilar metal welds and on improved inspection techniques for fatigue of type 304/316/380 stainless steel socket welds are being performed.

5. Conclusions

According to the experts' evaluation results, alloy 82/182 dissimilar metal welds is the most susceptible

components and should be managed first among various components and piping system in KSNP.

There are currently many researches performed for this dissimilar metal weld in Korea, but the endeavors should be still collected in worldwide nuclear fields.

REFERENCES

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