Development of Managing Program for Small Bore Piping Socket Weld on the Secondary System of NPP

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1. Introduction

Kori unit 3 had stopped operation due to leakage at steam generator drain line socket weld on June 6th, 2008[1]. The cause of socket weld damage was known as welding defect and fatigue by vibration under normal operation. With above reason, the government has been required developing management program for small bore piping socket weld. Therefore, we have developed the socket weld management program to secure reliability and soundness of socket welds which are located at all domestic NPPs.

2. Methods and Results

2.1 Definition of socket weld

Socket welds are commonly used in the piping systems less than 2-inchs[2]. Fig.1 shows the cutaway view of socket weld and the typical installation type of socket weld in shown in Fig.2

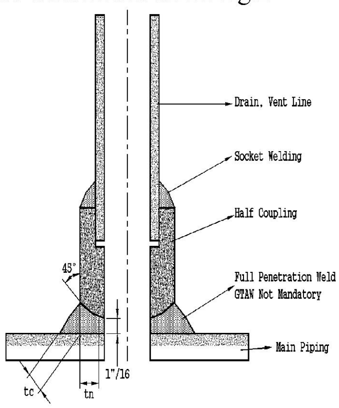

Fig. 1. Schematic of small bore pipe socket weld

-Materials : CS, SS, Cr-Mo
-Purpose : temperature/pressure measurement, drain, sampling etc.
-Cause of failure : vibration, weld defects
-Failure mechanism : high cycle fatigue
-Failure area : socket weld root or toe

2.2 Classification of socket weld

Socket welds are classified into cantilevered type and complex type based on configuration.

-Cantilevered type : cantilever type small bore socket weld
-Complex type : all kinds of type except cantilever

Fig. 2. Cantilevered type socket weld(left), complex type socket weld(right)

2.3 Fatigue characteristic of socket welds

Weld root cracking
-High cycles, low load
-Vibrational fatigue failure
-Crack growth : inner side to outside

Weld toe cracking
-Low cycles, high load
-Vibrational fatigue failure
-Crack growth : weld toe to inside

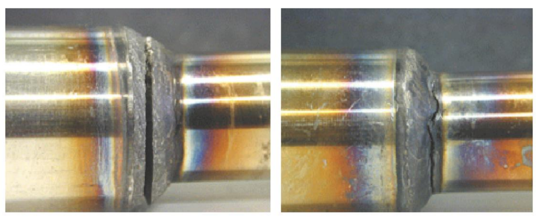

Fig. 3. Root failure (left), Toe failure (right)

2.4 Risk evaluation

Risk evaluation was performed by EPRI socket weld evaluation formula[3] .

Cantilevered type socket weld
-Method : max. acceleration
-formula :

$$\ddot{y}_m = A\Omega^2 \le y_a = \frac{2IS_{el}}{LD(M+0.55M_b)C_2K_2}$$

Complex type socket weld

- Method : max. velocity
-formula :

$$\dot{y}_a = A\,\omega = \frac{1.62\,S_{el}}{DC_2K_2F_c}\sqrt{\frac{I}{Em_b}}$$

2.5 Non-destructive socket weld inspection method

Applicable non-destructive inspection methods are as follows:

-VT : pressure boundary condition
-PT : surface and toe crack
-UT : fatigue crack, LOP
-VC : vibration check

2.6. Risk group classification

Risk group were classified considering vibration risk and pipeline importance. Risk groups consist of nine risk areas which have a different inspection methods and interval.

Table. 1 Risk Group

		Vibration Risk		
		A	B	C
Pipeline Importance	I	①	④	⑦
	II	②	⑤	⑧
	III	③	⑥	⑨

Vibration risk

-A : rr ≥ 100
-A : 50 ≤ rr < 100
-C : 0 ≤ rr < 50
*rr(risk rate)= (measured /allowable)*100

Pipeline importance

-I : importance grade 1
-II : importance grade 2
-II : importance grade 3

Table 2 shows the method and period of NDE for each risk group. All available kinds of NDE are applied for Socket welds at vibration risk and critical pipe. Socket welds at the others pipe were inspected by operation condition based on vibration analysis.

Table. 2 NDE methods and interval according to risk group area

	Region	Inspection period(yr)	Inspection mthods	Remarks
Ⅰ+A	①	1	VT, PT, UT	
Ⅱ+A	②	1	VT, PT, UT	
Ⅲ+A	③	3	VT, PT, UT	
Ⅰ+B	④	2	VT, UT	
Ⅱ+B	⑤	2	VT, UT	
Ⅲ+B	⑥	3	VT, UT	
Ⅰ+C	⑦	6	VT, PT	100% inspection within 10years
Ⅱ+C	⑧	6	VC	
Ⅲ+C	⑨	6	VC	

번호	태그번호	밸브번호	배관크기	스케쥴	타입	P&ID	배관 중요도	진동 위험도	검사방법	검사주기						비고
										1차	2차	3차	4차	5차	6차	
49	Y5-TA-V2011-W000	V2011	1	80	CAN	9-511-M105-001	II	C	VC			●				
50	Y5-TA-V2012-W000	V2012	1	80	CAN	9-511-M105-001	II	C	VC							
51	Y5-TA-V2013-W000	V2013	1	80	CAN	9-511-M105-001	II	C	VC						●	
52	Y5-TA-V2014-W000	V2014	1	80	CAN	9-511-M105-001	II	C	VC				●			
53	Y5-TA-068701-W001	V2029	0.75	80	CAN	9-511-M105-001	II	C	VC		●					
54	Y5-TA-068702-W001	V2030	0.75	80	CAN	9-511-M105-001	II	A	VT,PT,UT	●	●	●	●	●	●	
55	Y5-TA-068703-W001	V2031	0.75	80	CAN	9-511-M105-001	II	C	VC				●			
56	Y5-TA-068704-W001	V2032	0.75	80	CAN	9-511-M105-001	II	B	VT,UT		●		●		●	
57	Y5-TA-069701-W001	V2033	0.75	80	CAN	9-511-M105-001	II	B	VT,UT	●		●		●		
58	Y5-TA-069702-W001	V2034	0.75	80	CAN	9-511-M105-001	II	B	VT,UT	●		●		●		
59	Y5-TA-069703-W001	V2035	0.75	80	CAN	9-511-M105-001	II	C	VC			●				
60	Y5-TA-069704-W001	V2036	0.75	80	CAN	9-511-M105-001	II	C	VC					●		
61	Y5-TA-073701-W001	V2040	0.75	80	CAN	9-511-M105-001	II	A	VT,PT,UT	●	●	●	●	●	●	
62	Y5-TA-073702-W001	V2041	0.75	80	CAN	9-511-M105-001	II	B	VT,UT		●		●		●	
63	Y5-TA-073703-W001	V2042	0.75	80	CAN	9-511-M105-001	II	B	VT,UT		●		●		●	
64	Y5-TA-073704-W001	V2043	0.75	80	CAN	9-511-M105-001	II	B	VT,UT	●		●		●		
65	Y5-TA-V2046-W000	V2046	1	80	CAN	9-511-M105-001	II	A	VT,PT,UT	●	●	●	●	●	●	
66	Y5-TA-V2047-W000	V2047	1	80	CAN	9-511-M105-001	II	A	VT,PT,UT	●	●	●	●	●	●	
67	Y5-TA-V2048-W000	V2048	1	80	CAN	9-511-M105-001	II	A	VT,PT,UT	●	●	●	●	●	●	
68	Y5-TA-091701-W001	V2100	1	80	CAN	9-511-M105-001	II	C	VC			●				
69	Y5-TA-093701-W001	V2101	1	80	CAN	9-511-M105-001	II	C	VC					●		
70	Y5-TA-092701-W001	V2102	1	80	CAN	9-511-M105-001	II	C	VC		●					
71	Y5-TA-090701-W001	V2103	1	80	CAN	9-511-M105-001	II	C	VC					●		
72	Y5-TA-090702-W001	V2104	1	80	CAN	9-511-M105-001	II	C	VC	●						
73	Y5-TA-098702-W001	V2105	1	80	CAN	9-511-M105-001	II	C	VC		●					
74	Y5-TA-091702-W001	V2106	1	80	CAN	9-511-M105-001	II	C	VC					●		
75	Y5-TA-093702-W001	V2107	1	80	CAN	9-511-M105-001	II	C	VC	●						
76	Y5-FW-057701-W001	V2380	1	80	CAN	9-541-M105-001	I	C	VT,PT						●	

Fig. 4. Inservice inspection plan for socket weld

3. Conclusions

Operational risk rate has been evaluated using the equation of risk rate for small bore piping socket weld. The rate of pipe importance was classified into 3 groups and nine risk regions were made. The method and period of NDE were set at each region with consideration of the pipe importance and vibration risk rate. Based on this criteria, The ISI plan was made as shown in figure 4. This program makes it possible to manage effectively small bore piping socket welds.

REFERENCES

[1] KINS "Event Report for Nuclear Power Plant" 2008-7(080606K3)
[2] ASME SECTION III NB-3661 (2007 ed)
[3] EPRI "Vibration Fatigue of Small Bore Socket-Welded Pipe Joints" EPRI TR-107455