

2003

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103-16

167

The feasibility study of Replacement in Reator Pressure Vessel(RPV) Top Head for Kori #1

1990 2003
 (PWSCC) 가
 가 (KINS) 가
 가 , Bulletin 가 ,
 , 1
 가 , Oconee#3 1
 , 1 High
 category plant Moderate category plant 가 1

1.

1991 Bugey 3 10 가
 1990 (USNRC)
 PWSCC Information Notice90-10 Alloy600(Inconel600)
 Alloy600 가 . 1997 NRC GL97-01 PWSCC
 PWSCC 가
 1993 가 3,4 Alloy600
 가
 3,4 Alloy690 TT
 WH
 1991 1992 , 2003
 1,2 1,2

(2000 (ECT) (UT)) , B&W 15
 CRDM and ANO #1) Davis Besse (Ocone#1,2, & 3
 (1,2) 가
 가 Bulletin 2001-01, 2002-01 2002-02 ,
 Ocone#3 (Grouping), , , .

STP-1 Lower head penetration leak Bulletin 2003-02
 Lower head & EPRI) EPRI Material Reliability Program(MRP) (, NEI

1) (' 02. 3. 22)

()가

2)

(' 02. 4. 10) 가 KINS

1

2.

2.1 (PWSCC)

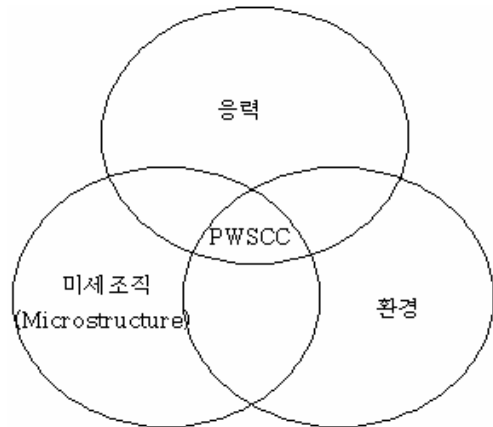
1 (Primary Water Stress Corrosion Cracking : PWSCC)

PWSCC

() 4

(10) 가 2

Carbide



2.2 1

2.2.1 1

1) ()

(1) ()
 ()

()

(Buckling Necking)

(Safety Factor)

(2) ()

Alloy600 가

()

()

: < E/300Ksi

: < E/150Ksi

E : Young's Modulus

(3) 1 3)

B&W

Inconel 600

Mill annealing

2) (Microstructure)

(1) ()

Mill annealing

carbide

가 ASTM9-11(Fine Grain Size)

B&W, W·H, EPRI

PWSCC

intragranular carbide가

Grain Boundary Carbide Chromium

(2) 1 3)

B&W

Alloy600

가

Mill

annealing

가 3-4

Grain boundry carbide

PWSCC

3)

(1)

1

가

(10 가

)

가 ,

, Lithium Hydroxide Boric Acid)

. 1

RCS

(2) 1

1

1

319

283

가

PWSCC

가

2.2.3. (1)

Material I.D	Yield ³⁾ strength(KSI)	⁴⁾ ()	Time-to-failure (hrs × 10 ³)	Service Time (HRS × 10 ³)	plant
H4830*	42.236*	593**	-	165.126	#1

2.3 가

1) ()

(1) General model

$$EDY = A \cdot \sigma_a^n \cdot M \cdot \exp\left(-\frac{Q}{RT}\right) \quad (1.1)$$

Nuclear Electric Sizewell B (' 99 600 - 019
PWSCC
KEPRI TM).

A : proportionality constant(가)

EDY :

σ_a : Applied stress(가)

n : exponent on stress(-4 ~ -5.33)

M_y :

M : ()

Q : apparent activation energy(60kcal/mole)

T : absolute temp($^{\circ}$ K)

R : Universal gas Constant

(2) Time-to-failure VS

- $EDY = A \sigma_a^n \cdot M_y$ (1.2)

PWSCC (가) 4
 . (n : -4)

(3) Time-to-failure VS

- $EDY = A \exp\left(-\frac{Q}{RT}\right)$ () (1.3)

PWSCC가 가 가 PWSCC 가
 .

2) 가

(1) EPRI model

1 NSSS W·H 가 B&W 가
Oconee NSSS B&W 가
가 PWSCC
가 EDY() (EPRI)가

- $EDY_{600} = EFDY \exp\left(-\frac{Q}{R}\left(\frac{1}{T_{\text{고려}}} - \frac{1}{T_{\text{Oconee}}}\right)\right)$ (1.4)

(2) EPRI model

1 1991 1992
2003 2 (VT) (UT ECT)
PWSCC

() Heat NO.
 () , 가 , ,

가 EPRI가
 : 3,4 가 (3,4 가) .

$$EDY = EFDY \cdot \frac{\bar{\sigma}_{\text{Oconee}}}{\bar{\sigma}_{\text{Oconee}}} \exp \left(-\frac{Q}{R} \left(\frac{1}{T_{\text{Oconee}}} - \frac{1}{T_{\text{Oconee}}} \right) \right) \quad (1.5)$$

2.4 가 (CRDM) 가
 1 Oconee3 가
 (1.4) (1.5) Table
 1 High category plant Low category plant(Moderate category plant)

	EFPY	PWSCC		EDY		
		(KSI)	()	1	2	
o Oconee#3	20.1	67	600	0	0	
o 1	18.85	42	593	11.98	7.48	

: 2003. 6. 30

2.5

1 (CRDM Assembly)
 (IHA)
 . 1 1970 Turnkey
 가 가
 가 EPRI가
 1 EPRI model 가 High category
 plant 가
 , 1
 (IHA() +)
) 200
 2 (IHA)
 Oconee#3 1 1 가
 PWSCC 가 1 가
 가 EPRI 가
 Moderate Category
 1 Oconee#1,2,&3 ANO#1(High Category)
 1990 2000

() 가
 CP0, CP1 CP2 () 가)
 가 가 (40)
 가

3

1 가 High Category plant
 ASME Code (UT ECT) EPRI NRC가
 2
 7

3.

1 (UT ECT) 1990 2000 2
) , 1 가 2-3 PWSCC 가 (Oconee#3
 PWSCC 가 Moderate
 Category plant
 , 1 (IHA) EPRI MRP 1
 EPRI , 1 .(가)
 가 가 1 가 High Category
 가 가 1
 (1)
 issue Inconel600 RCS integrity generic
 1
 가

< >

- 1) 71231 – 239('02. 3)
- 2) 71231 – 295('02. 4) 가
- 3) 1
- 4) Reactor Vessel Head Mean Bulk Fluid Temp. for Korean plants
 W·H LTR-EMT-03-72(2003.Feb.17)

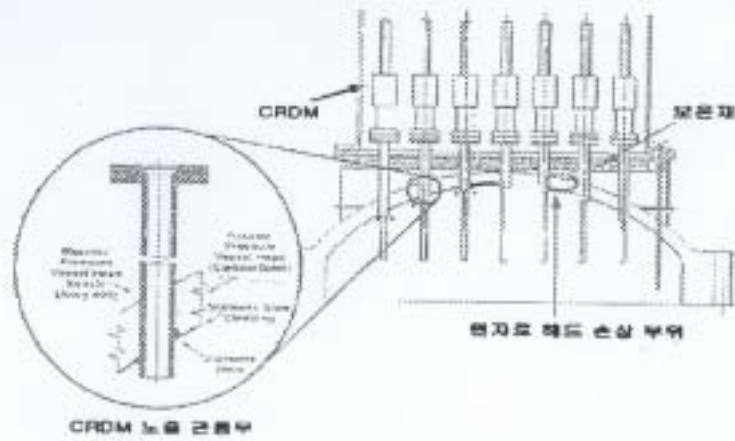


그림 1. Davis-Besse 원자로 헤드 손상부위 위치

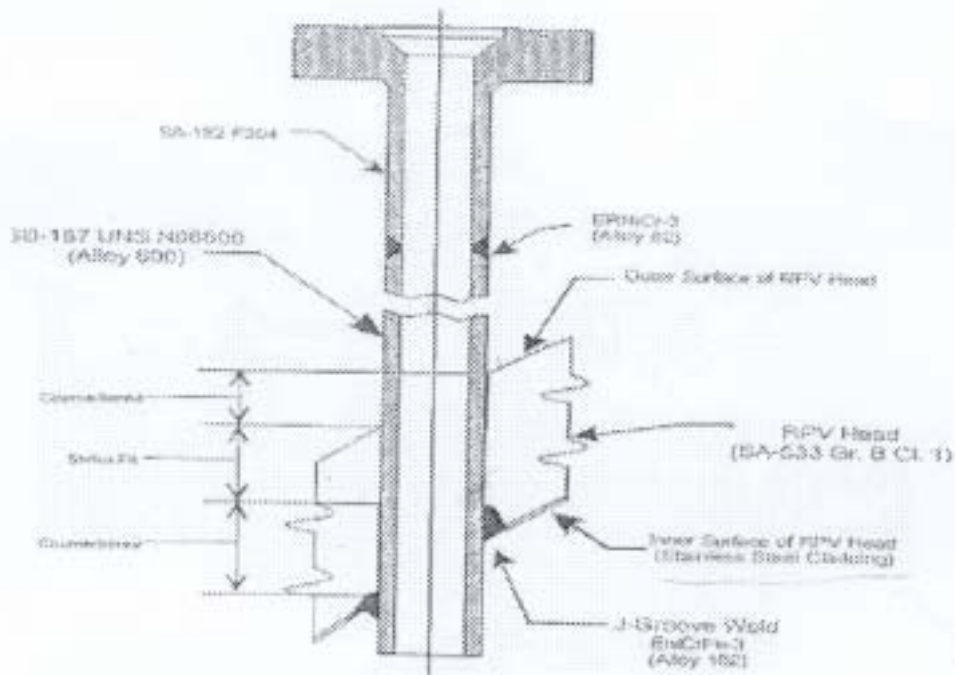


그림 2 원자로 헤드 CRDM 관통관 및 용접부 형상