

## CANDU Zr-2.5Nb

### DHC

# DHC Velocity Comparison of CANDU Zr-2.5Nb Pressure Tube for the Difference of Test Environments

\* • \* • \* • \* • \*

\*

150

Zr-2.5Nb  
 DHCV 가  
 가  
 .  
 DHC  
 DHCV 가  
 DHCV 가  
 , DHCV  
 . 250 , 86bar Zr-2.5Nb DHCV 가 ,  $8.42 \times 10^{-8}$   
 $1.22 \times 10^{-7}$  m/s 가 ,  $9.80 \times 10^{-8}$  m/s DHCV . 250  
 , DHCV . DHCV  
 , 가 .

### Abstract

Zr-2.5Nb Pressure tube was used in the distilled water under high temperature and pressure. However, the evaluation of DHCV for pressure tube was limited in the air until now. Therefore, it was necessary for DHCV both in the air and in the distilled water under high temperature and pressure to evaluate. In advance, new DHC equipment simulating the real operating condition in the distilled water under high temperature and pressure was developed and DHCV test was conducted by this equipment. The test was carried out under simulated condition using distilled water of 250 , 86bar and this result was compared

with that of DHCV in the air of 250 . DHCV of the distilled water was ranged from  $8.42 \times 10^{-8}$  to  $9.92 \times 10^{-8}$  m/s and the average value was  $9.01 \times 10^{-8}$  m/s. As compared with the air condition, it was found that characteristics of DHCV was not affected by the distilled water of high temperature and pressure. At the same temperature, DHCV of the irradiated pressure tube was faster than that of test result.

1.

가 Zr-2.5Nb 가  
 , Delayed Hydride Cracking (DHC) <sup>[1,2]</sup> DHC  
 가 , DHC  
 . DHC  
 , DHC  
 DHC . AECL COG(CANDU  
 Owners Group) DHC,  
 . , Zr-  
 2.5Nb 가 97 가  
 . Cold worked Zr-2.5Nb 가  
 , 1 가 .  
 DHC , rolled joint 가  
 가 DHC  
<sup>[2]</sup> DHC  
 가 가  
 , 가  
<sup>[3]</sup> 가 .  
 , , DHC  
 . DHC  
 . DHC  
 DHC  
 AECL Round-Robin test  
 DHC <sup>[4]</sup> , 가  
 가 .  
 DHC , 가

, 250 , 86bar 60ppm Zr-2.5Nb  
DHCV 가 , 250 , 가 .

## 2. DHC

### 2.1

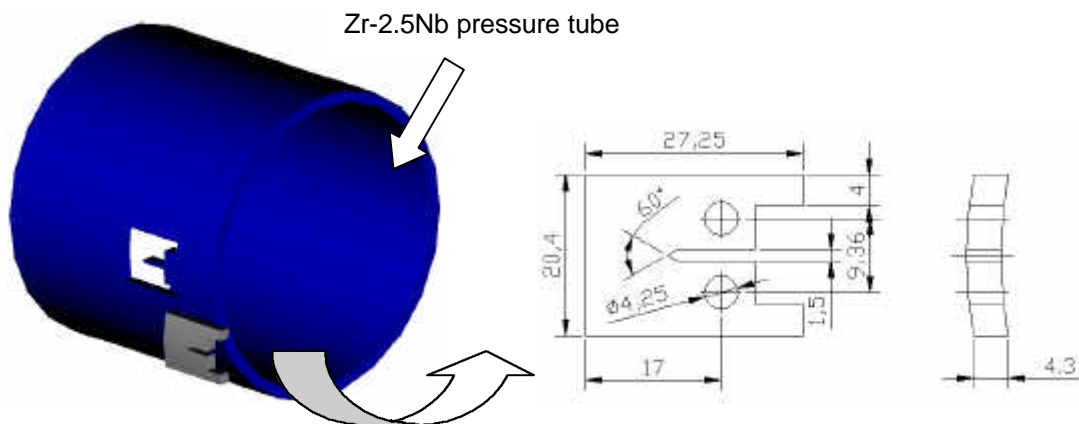
CANDU Zr-2.5Nb

Table 1

가 60ppm 가 <sup>[5]</sup>  
, 가 17 mm CCT(curved compact toughness)  
DHC . Fig. 1  
1.7 mm , a0/W 가 0.5 <sup>[4]</sup>  
0.5 tapered .

**Table 1** Chemical composition and mechanical properties of zr-2.5Nb pressure tube

Element	Nb	O	Fe	Sn	C	Zr
Content	2.7wt%	1020ppm	0.086wt%	24ppm	89ppm	bal.
Yield strength (MPa)		Ultimate tensile strength (MPa)			Elongation (%)	
625		841			17.8	



**Fig. 1** Configuration of specimen (unit : mm)

tapered bending stress

DHC

250, 310 1, 1 2 /min

250 undercooling 1 가

30 가

$K_I = 15 \text{Mpa} \cdot \text{m}^{1/2}$  가 Fig. 2 [6] 가

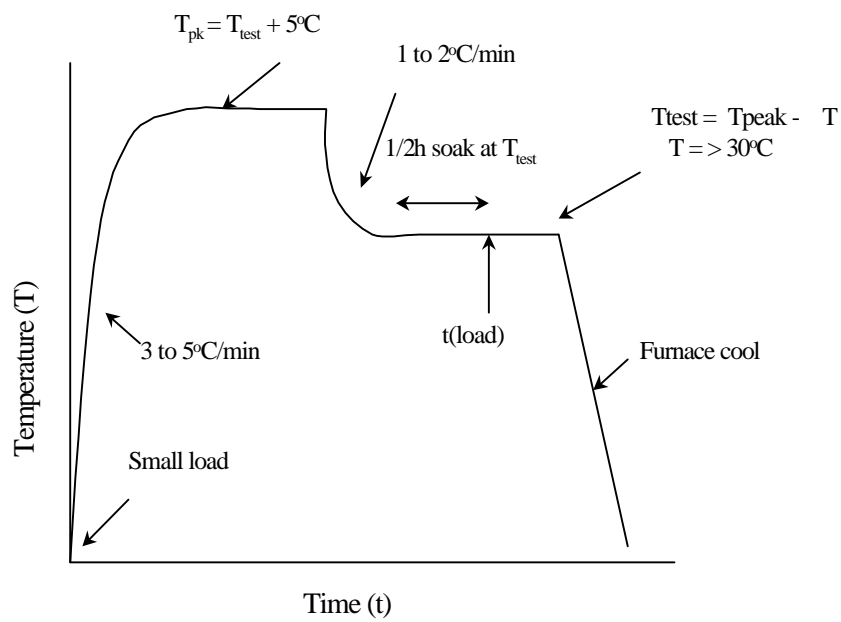


Fig. 2 Schematic diagram of temperature-time and loading schedule

[7] Fig. 3

4 DHC

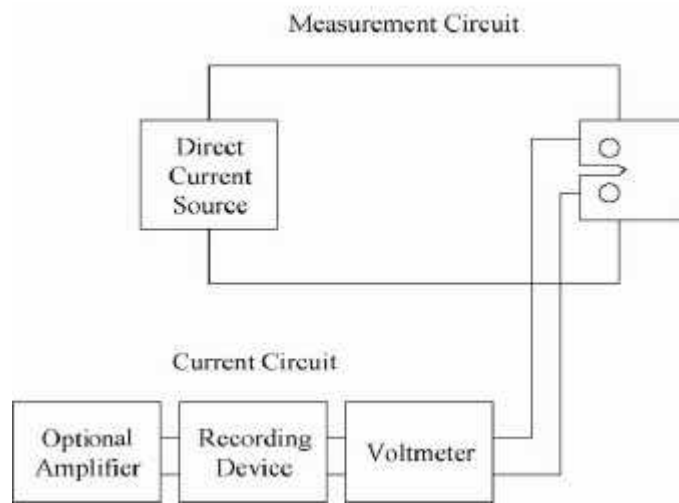
DHC 100 9 point [8]

DHC  $K_I$   $K_I$  [9]

DHC DHC (incubation time) DHC

DHC , (1)

$DHCV(m/s) = DHC / (DHC - DHC)$  (1)

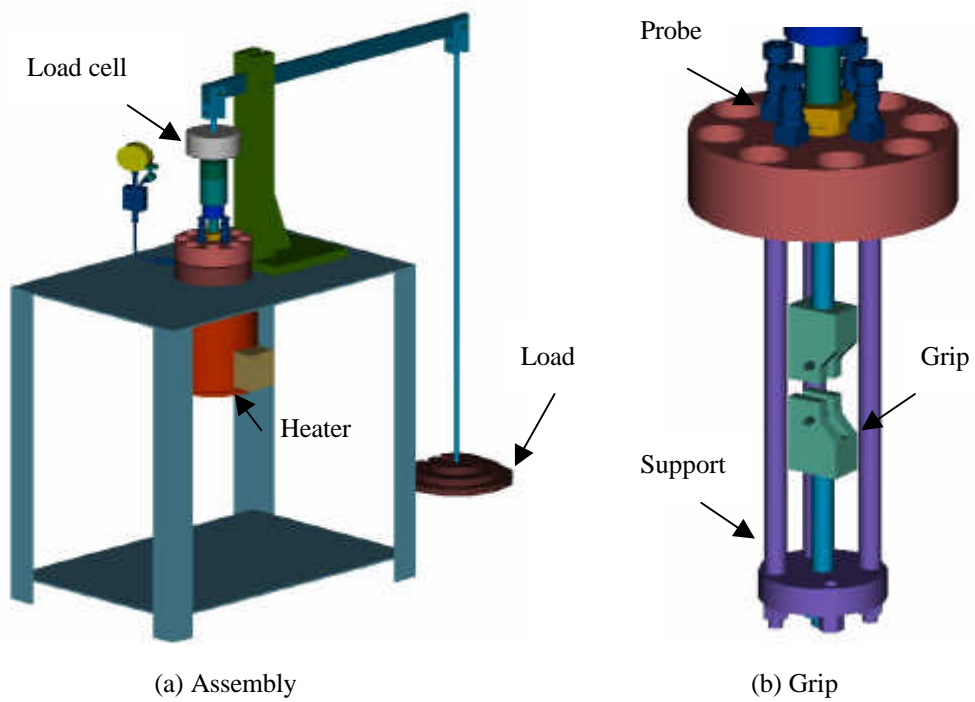


**Fig. 3** Schematic diagram of DCPD system

2.2 DHC

DHC

Fig. 4



**Fig. 4** DHC equipment for high temperature and pressure

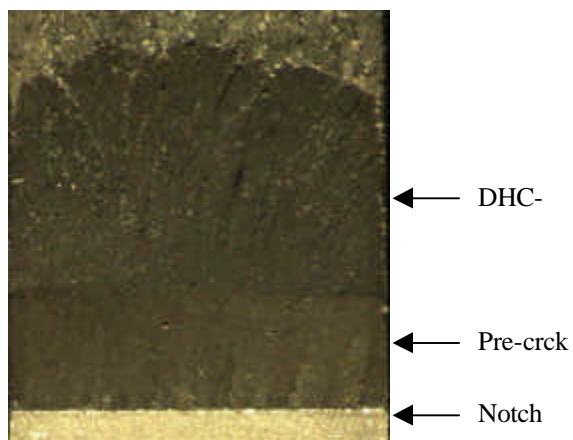
DHC , 가  
 , 3 (sealing)  
 (water jacket)  
 (pressure balancing)  
 (load cell)  
 (thermo-couple) (spot welding)  
 AD/DA , 가  
 138bar, 320 10 가 , ,

3.

300 ,  
 DHCV 가 ,  
 60ppm Zr-2.5Nb 가 250 ,  
 86bar DHCV 가 .

**Table 2** DHCV of Zr-2.5Nb pressure tube in distilled water of 250 , 86bar

	No.1	No. 2	No.3	No. 4
DHCV( $\times 10^{-8}$ m/s)	9.92	8.69	12.2	8.42



**Fig. 5** The fractured surface of Zr-2.5Nb pressure tube after DHCV test. (  $\times 50$  )

4 DHCV , Table 2  
 DHCV  $8.42 \times 10^{-8}$   $1.12 \times 10^{-7}$  m/s 가 ,  
 $9.80 \times 10^{-8}$  m/s DHCV 250 DHCV  
 , (10) 가 . 250 DHCV  $8.80 \times$   
 $10^{-8}$   $10.8 \times 10^{-8}$  m/s 가 ,  $10.1 \times 10^{-8}$  m/s . Fig. 5  
 DHCV 가 ,

(pre-crack) DHCV ,  
 DHC (striation)  
 DHC

. Fig. 5 striation  
 DHC 가

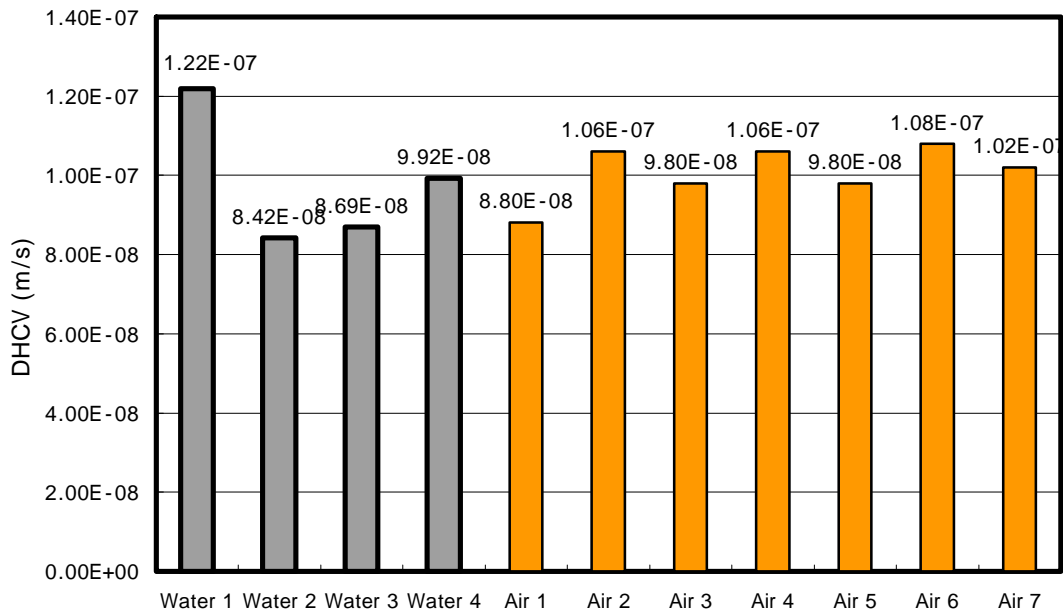
가 ,

DHC . Fig. 6 250 , 86bar 250

DHCV 250

86bar DHCV ,

250 DHCV DHCV 가



**Fig. 6** The comparison of DHCV between in air of 250 and in distilled water of 250 , 86bar.

2.5Nb 가 , DHCV 가 , DHCV Zr- 가 , 가 , 가 , DHC

5.

Zr-2.5Nb 가 , DHCV 가 , DHCV 가 , DHCV 가 , DHC

- 1) 250 , 86bar 60ppm Zr-2.5Nb DHCV 가 ,  $8.42 \times 10^{-8}$   $1.22 \times 10^{-7}$  m/s 가 ,  $9.80 \times 10^{-8}$ m/s DHCV
- 2) 250 , DHCV DHC
- 3) DHC 138bar, 320 10 가

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