

PWR Fuel Assembly Hydraulic Test Loop Design

, , , , ,

105

30 , 200 °C Reynolds 260,000

Abstract

A full-scale hydraulic test facility is being built for the design verification of a fuel assembly. This paper describes the design of test facility for measurement and control systems based on the loop operating condition. The facility will conduct the fuel assembly pressure drop, fuel assembly lift-off flow-rate, and flow-induced rod vibration and wear. The design limit of the facility is up to Reynolds number of 2.6×10^5 . The measured data could be extrapolated to predict the hydraulic characteristics on the reactor operating condition.

1.

가 (Full Scale)

가 가

[1,2,3], 1 가

가 ANF (Framatome Siemens) 1990
[4]. 1970
Loop 155 Bar, 343 °C ,
8.3 m³ / min Reynolds 5.0x10⁵ 가
10 Loop

Westinghouse 16X16 Plus7
Westinghouse NGF (Next Generation Fuel)

Westinghouse

Loop

Westinghouse FACT VIPER

(1)

2.

2.1

1 . 1
 , , Loop 가 가
 Makeup Bleed
 가 가 Loop
 Stainless 304 ASME Boiler and Pressure Vessel Code,
 Section VIII ANSI B31. 1.0 Power Piping Code 가
 가 12.8m 7.6m 가 7.5m 5.5m .
 3m, 2.5m 4.7m Platform . Loop
 5 ton 가 .

2.2

2
 Flow Diffuser
 , Full Size 가 Flow Housing,
 Flow Extension Assembly Instrumentation Shield . Flow
 Housing Instrumentation Head
 2 .
 16 x 16 ,
 , Housing
 HID-1L Housing 2mm
 [5].
 3 .
 1.58 mm 8 (DP8), (DP1),
 (DP7), 1 Span (DP3), 2 Span(DP4) (DP5)
 Tab
 150mm (211mm)
 가 가
 . span
 가 가 .

2.3

2.3.1 Parameter Indication

Sensor Control Panel 4
 Loop K type
 가 (Pressure
 Transmitter) 가 Inverter
 가

2.3.2 Loop Control

Sensor Control Panel
 Controller(PLC) , Indicator Data Acquisition ,
 Control Device Control, Indication
 Control Panel Indicating type Digital
 Indicator % 가
 5 Loop Heater, Pressurizer Heater Pump RPM
 Loop , , Indicating Controller PID

(1) Loop Heater

Loop Heater Loop , AC 440V 3P3W
 0 ~ 240 KW 가 가 SCR-01 0 ~ 120 KW Potentio
 Meter 가 , SCR-02 0 ~ 120 KW
 Loop 가
 Loop Cooling System Manual Loader

(2) Pressurizer Heater

Pressurizer Heater Loop AC 440V 3P3W
 40KW Heater SCR-03 PID 가
 Loop 가
 Heater 가 가 Process
 가

(3) Recirculation Pump

Recirculation Pump Loop . Centrifugal Type AC460V 3P3W 150KW
 4POLE 1775RPM Test Section DAS
 . 3 30 Bar,
 200°C, 8.3 m³/min 44x10⁴ Reynolds
 가 .

2.3.3 Data Acquisition System

DAS 6 . , ,
 , Filtering Amplify
 Conditioning . Digitalize AD Converter
 , HP VXI (E1513) [6].
 Agilent VEE [7]. Agilent VEE 가
 Spread Sheet 2 . 1/100

3.

3.1

5 가 40°C 120°C
 가 4 Reynolds
 3.7 ~ 26 x 10⁴ .

3.2

가 Flow Extension
 Hold Down
 5 40°C 가 가 3 DP-1
 가 가
 가

4.

- 가
- 가
- 1) 30 Bar, 200°C, 8.3 m³/min
44 x 10⁴ Reynolds 가
 - 2) 40°C 120°C 가 2.6 x 10⁵ Reynolds
 - 3) Tab 150mm
(211mm)
가 가
 - 4) Housing Fuel Assembly 2mm
 - 5) Control, DAS
가가 가 interlock

REFERENCES

1. Bruch, "Evaluation of Pressure Loss Test with Full Scale Fuel Assembly," U6 512/88/e045 (1988)
2. Imtiaz K. Madni, Lance G. Stephens, and Dave M. Turner, "Development of Correlations for Pressure Loss Coefficients Obtained from Flow Testing of Fuel Assemblies in Framatome ANP's PHTF," Proceedings of ICONE10, Arlington, Virginia, April 14-18 (2002)
3. Toshihiko Motomura, "The Debris Filter Test and Pressure Drop Test for KNFC Newly Developed Top and Bottom Nozzle in NFI Kumatori Works," (2002)
4. 11, " ," KAERI/RR-907/90
5. Paul F. Joffre, "16X16 Guardian Grid and HID-1B Hydraulic Test Data Reduction," 00000-5327-Q503, Rev 00, (1992)
6. Heulett Packard, "Test & Measurement," (2002)
7. Agilent Technologies, "Introduction to Agilent VEE 6.0" (2001)

Table 1. Full scale Hydraulic Test Facilities in Oversea

Fuel Vendor	Facility	Capacity	Test Parameters	No. of Fuel Assembly
Westinghouse (USA, South Carolina)	FACTS	121 °C 15.5 Bar $9.5 m^3 / min$ RE = 270,000	Pressure Drop Uplift Vibration	1
Westinghouse (USA, South Carolina)	VIVER	204 °C 24.1 Bar $22.6 m^3 / min$ RE = 500,000	Pressure Drop Fretting wear	2
FramatomeSiemens (Germany)	LBV [1]	340 °C 170 bar 160 kg/s RE = 700,000	Pressure Drop Uplift	1
FramatomeSiemens (USA, Washington)	RHTF [2]	148.9 °C 13.8 bar $11.4 m^3 / min$ RE = 340,000	Pressure Drop	1
NFI (Japan)	KUMATORY [3]	60 °C 1Bar $9 m^3 / min$ RE = 148,000	Pressure Drop Debris Trapping	1

Table 2. Housing and Bundle Flow Area

Parameters	Unit	Full Scale Fuel Assembly
Rod Array	---	16 X 16
Housing Width	mm	211.8
Fuel Assembly Pitch	mm	207.8
Fuel Rod Diameter	mm	9.5
Number of Fuel Rod	---	236
Fuel Rod Pitch	mm	12.85
Thimble Diameter	mm	23.27
Number of Guide Thimble	mm	4
Instrumentation Tube Diameter	mm	24.89
Number of Instrumentation Tube	mm	1
Housing Flow Area	mm ²	25,687
Bundle Flow Area	mm ²	24,009
Hydraulic Diameter	mm	12.57

Table 3. Pump Maximum Operating Condition

Pump Type	System Pressure [Bar]	Coolant Temperature [$^{\circ}C$]	Volume Flow Rate [m^3 / min]	RE (x10⁴)
Centrifugal	30	200	8.3	43

Table 4. Pressure Loss Test Condition

Test	RUN No	System Pressure [Bar]	Coolant Temperature [$^{\circ}C$]	Volume Flow Rate [m^3 / min]	RE (x10⁴)
Pressure Drop	101	5	40	3	3.7
	102	5	40	4	4.9
	103	5	40	5	6.1
	104	5	40	6	7.4
	105	5	40	7	8.6
	106	5	40	8	9.8
	107	5	120	3	9.8
	108	5	120	4	13.1
	109	5	120	5	16.4
	110	5	120	6	19.6
	111	5	120	7	22.9
	112	5	120	8	26.2
Lift-off Flow-rate	201	5	40	6	7.4
	202	5	40	6.2	7.6
	203	5	40	6.4	7.8
	204	5	40	6.6	8.1
	205	5	40	6.8	8.3
	206	5	40	7.0	8.6
	207	5	40	7.2	8.8
	208	5	40	7.4	9.1
	209	5	40	7.6	9.3
	210	5	40	7.8	9.6
	211	5	40	8.0	9.8
212	5	40	8.2	10.0	

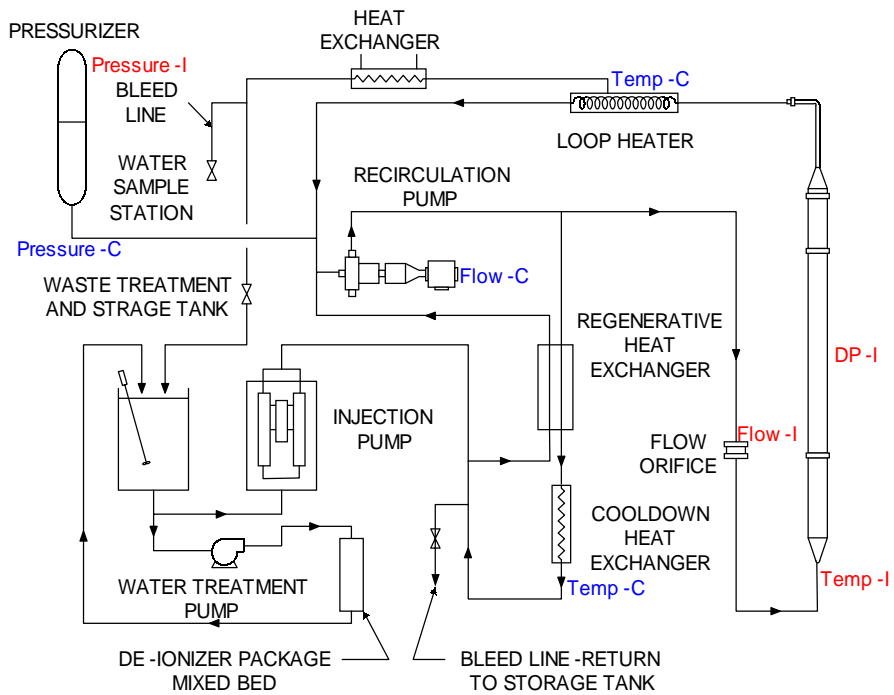


Figure 1. Schematic Diagram of Hydraulic Test Loop

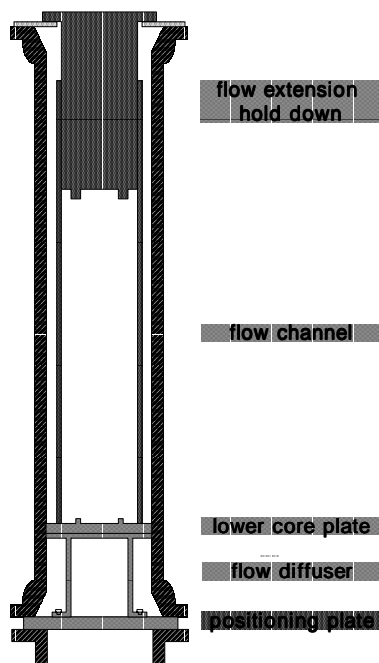


Figure 2. Test Section

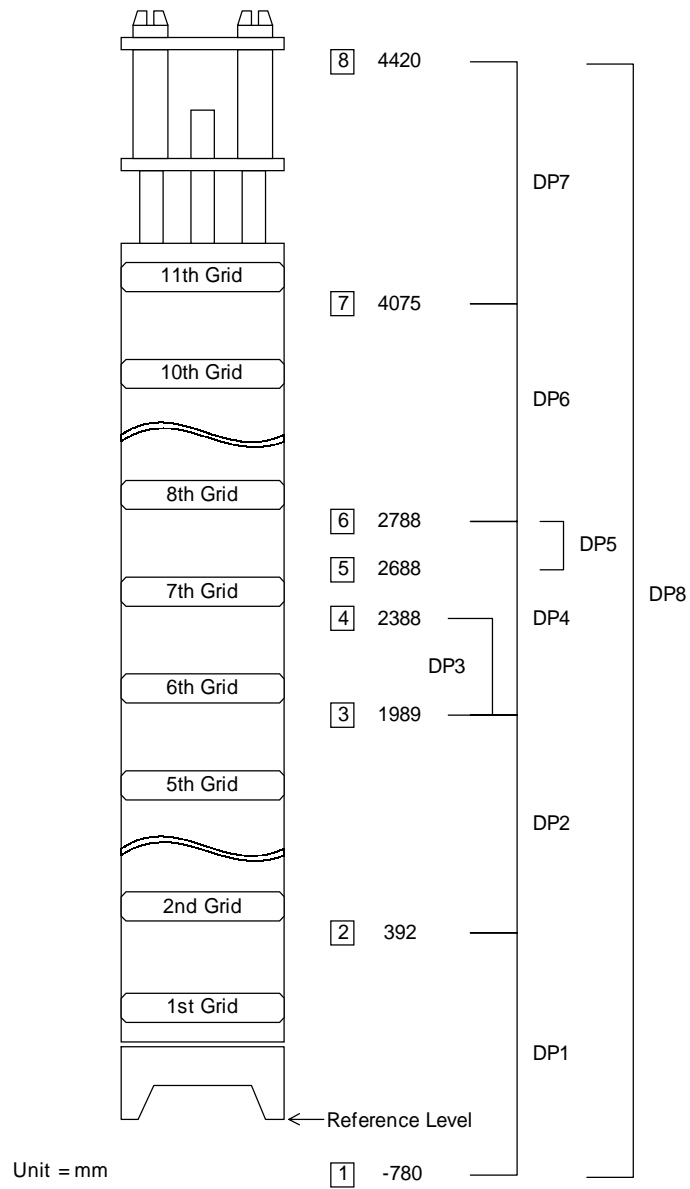


Figure 3. Pressure Tab Location

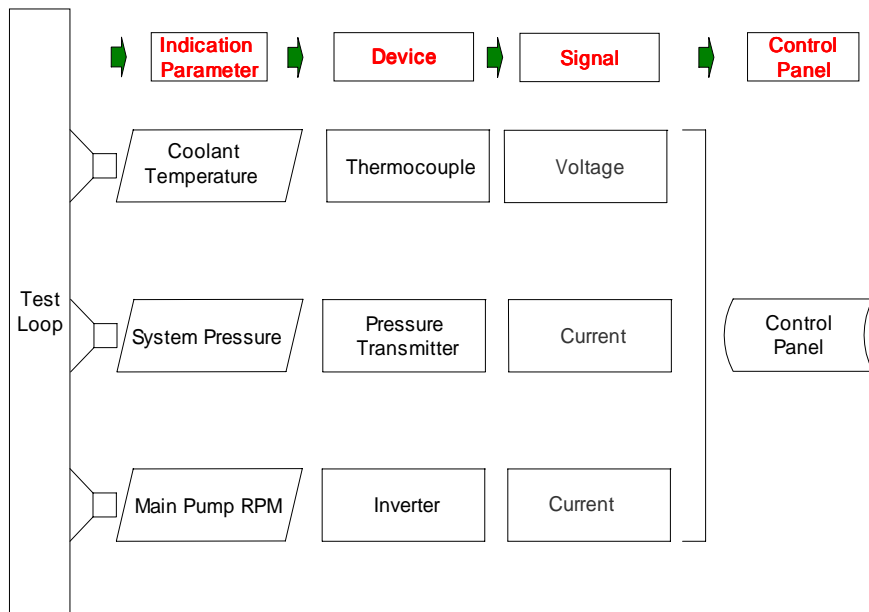


Figure 4. Indication System

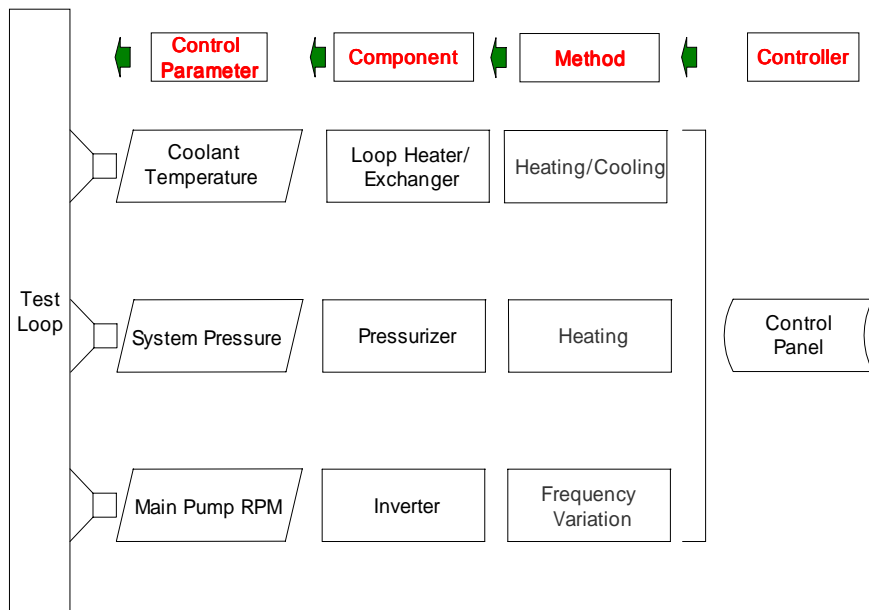


Figure 5. Control System

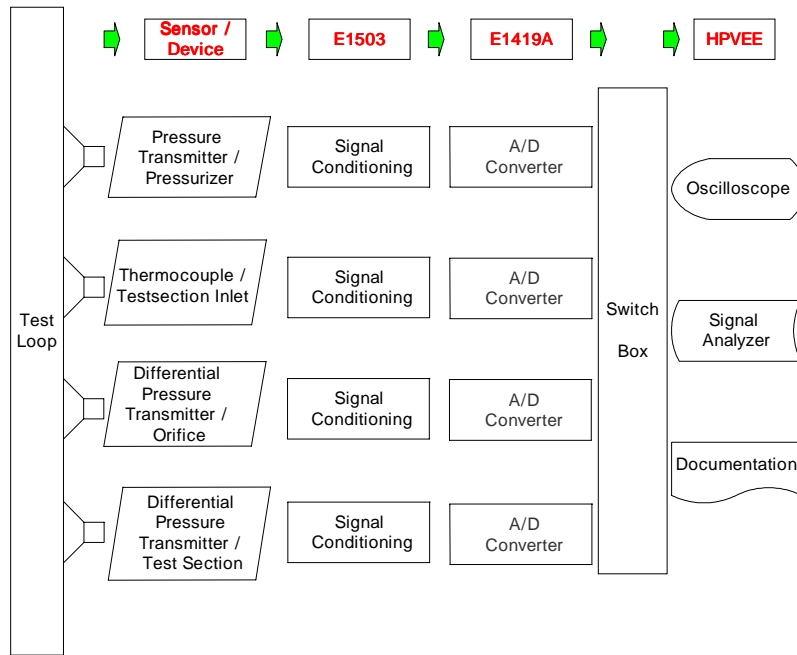


Figure 6. Data Acquisition System