Profile SFR-55

STELLA-1

Republic of KOREA

GENERAL INFORMATION

NAME OF THE FACILITY	STELLA-1
ACRONYM	Sodium Integral Effect Test Loop for Safety Simulation and Assessment
COOLANT(S) OF THE FACILITY	Liquid sodium
LOCATION (address):	Fast Reactor Demonstration Division, Korea Atomic Energy Research Institute, 989-111 Daedeok-daero, Yuseong-gu, Daejeon, Korea
OPERATOR	KAERI
CONTACT PERSON (name, address, institute, function, telephone, email):	Jewhan Lee, 989-111 Daedeok-daero, Yuseong-gu, Daejeon, Korea, KAERI, Fast Reactor Demonstration Division, Tel. +82 42 868 2221, leej@kaeri.re.kr

STATUS OF THE FACILITY In operation

Start of operation (date): 2014

MAIN RESEARCH FIELD(S)

- ☐ Zero power facility for V&V and licensing purposes
- ☐ Design Basis Accidents (DBA) and Design Extended Conditions (DEC)
- ☒ Thermal-hydraulics
- ☐ Coolant chemistry
- ☐ Materials
- ☒ Systems and components
- ☒ Instrumentation & ISI&R

TECHNICAL DESCRIPTION

Description of the facility

The STELLA-1 is a large-scale component test loop to V&V of heat exchanger design codes as well as the safety analysis system code. The main target of the test is DHX and AHX in PGSFR and additionally mechanical pump is installed in separate loop.

STELLA-1 consists of a main test loop, a sodium purification system, and a gas supply and related auxiliary systems. The main components are a sodium-to-sodium heat exchanger, sodium-to-air heat exchanger, mechanical sodium pump, loop heaters, cold trap, plugging meter, electromagnetic pumps, flow meters, and a sodium storage tank. The designed maximum temperature is 600°C, and the designed power capacity of the main heat exchangers is 1MWt. The maximum electric power is approximately 2.5MW, and the nominal liquid sodium flow rate is designed to be less than 10 kg/sec. During the mechanical pump test, more than 120kg/sec of liquid sodium circulates along 10-inch diameter pipes. The purification system consists of a cold trap, a blower, an electro-magnetic pump, and plugging meter sub-system. The plugging meter is an on-line measuring device for impurities.

On the basis of the comparison results of the full-height and reduced-height scaling, the overall scale ratio of the test heat exchangers is determined to be unity for the height (or length) and 1/9 for power level (or volume). The material of the shell- and tube-side of the DHX and AHX unit are Mod.9Cr-1Mo steel (ASME Grade 91; Gr.91) and austenitic stainless steel type 316, respectively. The general specifications of each scaled heat exchanger are summarized in Table 1.

Table 1 Major design parameters of the scaled heat exchangers

Parameters	Design value	
	DHX	AHX
Heat transfer tube arrangement	Straight type	Helical type
No. of tubes (No. of tube row)	42	36 (3)
Tube O.D / I.D, thickness (mm)	21.7 / 18.4, 1.65	34.0 / 30.7, 1.65
Active tube length (m)	1.73	23.76
Tube material	Mod.9Cr-1Mo	STS316
Shroud I.D (m)	0.298	1.53
Shroud length (m)	2.456	5.66
Unit total mass (kg)	~275	~3,483

For the mechanical sodium test pump, the design specifications of the model pump are summarized in Table 2.

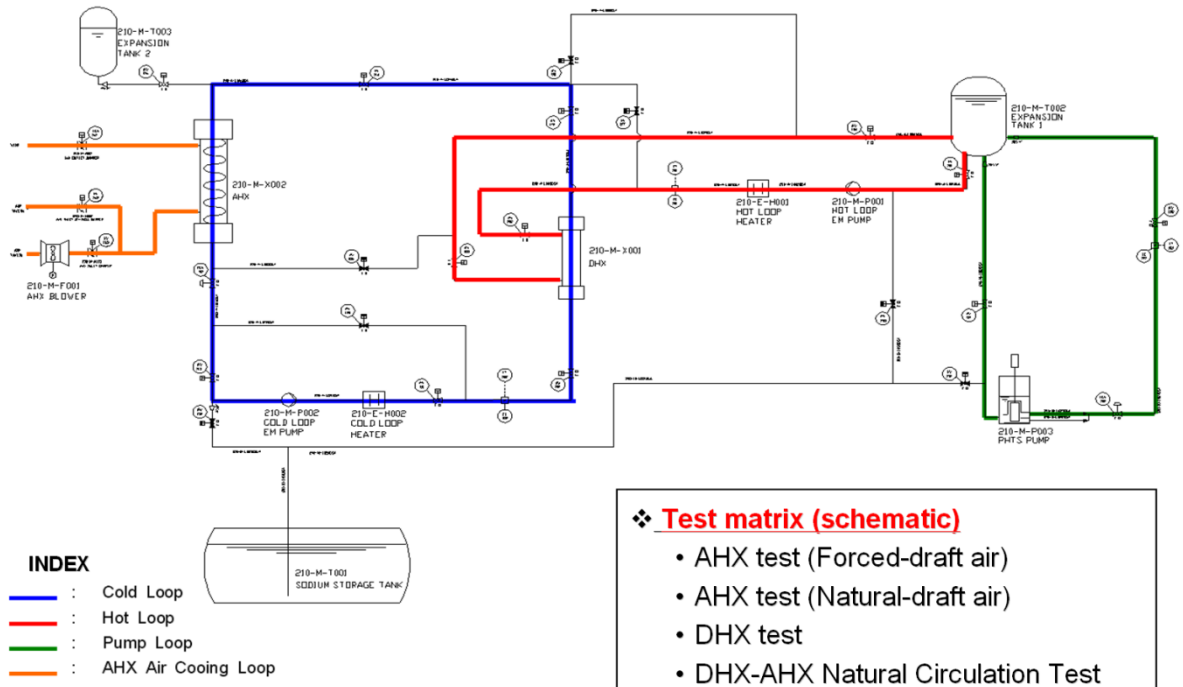
Table 2 Design parameters of the model sodium pump

Parameters	Prototype (P)	Model (P)	Ratio (M/P)
Impeller Type	Francis	Francis	-
Capacity (kg/sec)	4183	122.6	3 %
Head (m)	62.888	50.31	80 %
NPSH available (m)	14.702	11.76	-
Synchronous speed (rpm)	450	2235	497%
Impeller O.D.(mm)	1685	305.0	18 %
Pump speed (rpm)	433	2140	-
Specific speed (-)	330.3	330.3	-
WHP (kW)	2572.7	60.3	-
Pump efficiency (%)	80.0%	71.8%	-
Motor output (kW)	4000.0	110.0	-

Acceptance of radioactive material

No

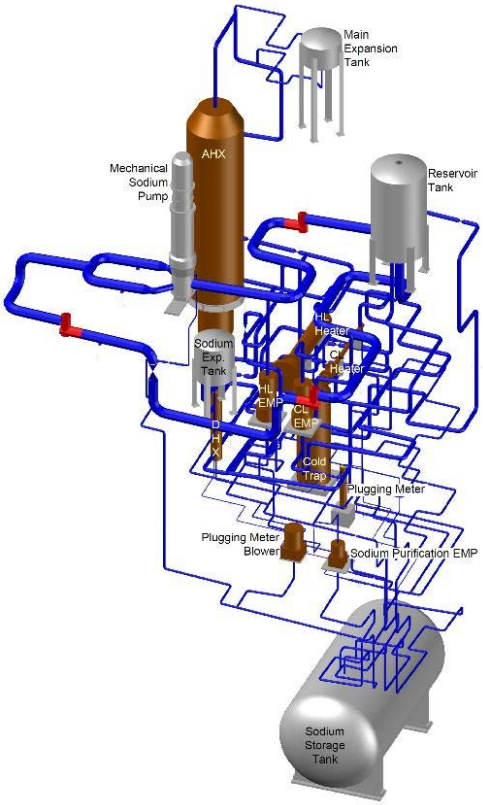
Scheme/diagram



❖ **Test matrix (schematic)**

- AHX test (Forced-draft air)
- AHX test (Natural-draft air)
- DHX test
- DHX-AHX Natural Circulation Test
- Mechanical sodium pump test

3D drawing/photo


Main
Expansion
Tank
AHX
Mechanical
Sodium
Pump
Reservoir
Tank
Sodium
Exp.
Tank
Cold
Trap
Plugging Meter
Plugging Meter
Blower
Sodium Purification EMP
Sodium
Storage
Tank

Parameters table

Coolant inventory	18 tons at maximum
Power	2.5 MW
Test sections	
TS #1 (DHX)	*Characteristic dimensions* Approximately, 0.3 m (diameter), 3.5 m (height)
	Static/dynamic experiment Dynamic
	Temperature range in the test section (Delta T) 0 ~ 350 ℃ (Shell-side, Na), 0 ~ 340 ℃ (Tube-side, Na)
	Operating pressure and design pressure Operating Pressure: 10 kPa ~ 200 kPa Design pressure: ~1 MPa
	Flow range (mass, velocity, etc.) 0 ~ 20 kg/s (Shell-side, Na), 0 ~ 20 kg/s (Tube-side, Na)
TS #2 (AHX)	*Characteristic dimensions* Approximately, 2.5 m (diameter), 7 m (height) Air stack: ~35 m
	Static/dynamic experiment Dynamic
	Temperature range in the test section (Delta T) 0 ~ 300 ℃ (Shell-side, Air), 00 ~ 320 ℃ (Tube-side, Na)
	Operating pressure and design pressure Operating Pressure: 10 kPa ~ 200 kPa Design pressure: ~1 MPa
	Flow range (mass, velocity, etc.) 0 ~ 3.00 kg/s (Shell-side, Air), 0 ~ 20 kg/s (Tube-side, Na)
TS #3 (mechanical pump)	*Characteristic dimensions* Approximately, 1.5 m (diameter), 5 m (height)
	Static/dynamic experiment Dynamic
	Temperature range in the test section (Delta T) Less than 1 ℃
	Operating pressure and design pressure Operating Pressure: 10 kPa ~ 200 kPa Design pressure: ~1 MPa
	Flow range (mass, velocity, etc.) ~130 kg/s
Coolant chemistry measurement and control (active or not, measured parameters)	For impurities control, a separate purification loop is installed with the plugging meter sub-system. The plugging meter measures the plugging temperature to calculate the impurities in liquid sodium and it is operated on-line with the cold trap.
Instrumentation	Thermocouples, 2 types of flowmeter (Coriolis, EMF), pressure transducer, leak detector, smoke detector, 3 types of level gauge (contact, weight pendulum, radar)

COMPLETED EXPERIMENTAL CAMPAIGNS: MAIN RESULTS AND ACHIEVEMENTS

The main tests were completed in 2015 and extended range of tests were finished in 2017 for heat exchanger V&V. The experiment results were in good agreement with the estimation of heat exchanger design code (SHXSA and AHXSA). The deviation of DHX test conditions was ~4.4% and AHX test conditions was ~12%, and IHX conditions was ~2.9%.

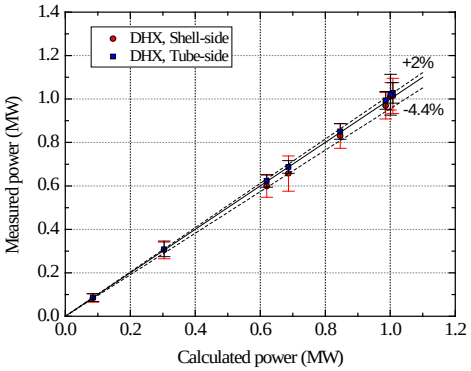


Figure 1 DHX test results(low Pe number)

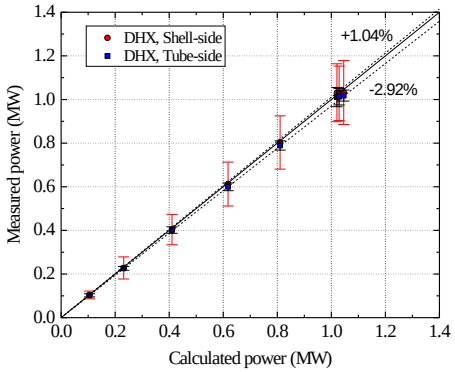


Figure 2 IHX test results(high Pe number)

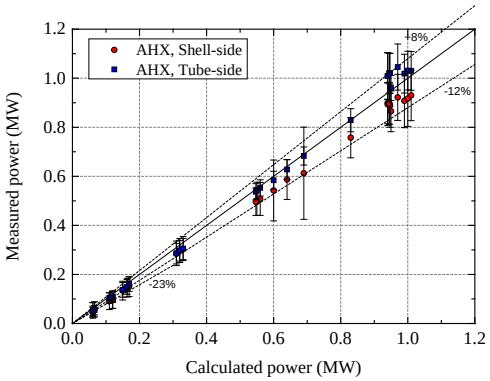


Figure 3 AHX test results

The experiment data was used as a base for design code V&V as well as the Safety Analysis Report for Prototype Gen IV Sodium-cooled Fast Reactor (PGSFR) designed by KAERI. The target codes were SHXSA, AHXSA, and MARS-LMR.

PLANNED EXPERIMENTS (including time schedule)

Natural circulation experiment to verify the heat removal capacity is planned to be conducted in October, 2014.

Mechanical pump test is scheduled to be starting in November, 2014.

TRAINING ACTIVITIES

Training activities can be arranged under the KAERI supervision.

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