Profile LFR-45

LIFUS5

ITALY

GENERAL INFORMATION

NAME OF THE FACILITY	LIFUS5/Mod2
ACRONYM	Lithium FUSion
COOLANT(S) OF THE FACILITY	Molten lead-bismuth eutectic, lead, molten lead-lithium eutectic
LOCATION (address):	Italian National Agency for New Technologies, Energy and Sustainable Economic Development, C.R. ENEA Brasimone, Italy
OPERATOR	ENEA
CONTACT PERSON (name, address, institute, function, telephone, email):	Alessandro Del Nevo, PhD ENEA UTIS-TCI C.R. Brasimone 40032 Camugnano (Bo) Tel. +39 0534 801 13 alessandro.delnevo@enea.it

STATUS OF THE FACILITY	In operation
Start of operation (date):	2000

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

LIFUS5[Error! Reference source not found.] is an experimental facility installed at ENEA CR Brasimone. It is one of the oldest facilities set at the research centre and due to its versatility was used in several experimental campaigns. It is designed to be operated with different heavy liquid metals like Lithium-Lead alloy, Lead-Bismuth eutectic alloy and pure lead. The refurbished LIFUS5/Mod2[1] facility, adopted in the frame of THINS project (FP7 EC), is currently involved in the LEADER project (FP7 EC) activities to investigate the Pb-Bi-water interaction following the simulation of a Steam Generator Tube Rupture (SGTR) event in a

configuration relevant for generation four Heavy Liquid Metal reactors (HLM) . LIFUS5 facility aims also to generate experimental data for developing and validating codes to support the design and safety analysis of innovative HLM reactors. In connection with these goals, the expected outcomes of the experimental campaigns are the generation of detailed and reliable experimental data, the improvement of the knowledge of physical behaviour and understanding of the SGTR phenomenon, the investigation of the dynamic effects of energy release on the structure, the enlargement of the database for code validation.

LIFUS5/Mod2 facility (see Figures **Error! Reference source not found.**, **Error! Reference source not found.** and **Error! Reference source not found.**) consists of four main parts: a vessel (S1), where LBE/water interaction occurs; a water tank (S2), pressurized by means of a gas cylinder connected on the top; a dump tank (S3), where the water and HLM might be transported as consequence of their interaction (connected to S1 during LEADER tests and disconnected for THINS campaign); a liquid metal storage tank (S4).

The main vessel S1 is about 100 litres, and it is partially filled with LBE during the tests. It has been deigned to work up to 200 bar and 500°C. The main diameter is 420 mm and the overall height is 780 mm. It has penetrations allowing the passage of the instrumentation that is constituted by five fast pressure transducers (PT), two thermocouples (TC) and six strain gages (SG), five of which set on the inner S1 surface and one on the outside. The water injection system is a dedicated tube entering the bottom of the vessel S1 in central position. The injector orifice is covered by a protective cap, which is broken by the pressure of the water jet at the beginning of the injection phase. Therefore, the system shall be substituted at the end of each test. To ensure that the protective cap rupture occurs at the scheduled pressure, a notch is performed by means of machine tools. The water injection line connects the tank S2 with the interaction vessel S1 (see Figures **Error! Reference source not found.**, **Error! Reference source not found.** and **Error! Reference source not found.**) and the vacuum pump line. In the middle a discharge valve is installed (V5), for draining the water at the end of the tests, and for removing steam formation during the conditioning heating phase. The water flows from S2 towards the valve V14, then the Coriolis flowmeter (see Figures **Error! Reference source not found.** and **Error! Reference source not found.**) and finally through valve V4, before it enters in S1.

The water tank S2 is a 4 inch sch. 160 pipe, closed at the edges with proper welded plugs. It has a volume of 15 litres (plus those in the near level meter). It is connected on the top with the gas line, which is used for setting and keeping the pressure of the water according with the test specifications. The water tank S2 is connected by means of two lateral flanges to a magnetic level measurement device. The dump tank S3 is part of LIFUS5/Mod2 facility. It is connected by means of a 3” line to the top flange of S1 in the LEADER tests and is disconnected during the THINS campaign (S1 is a closed volume). The S3 volume is equal to 2 m^3 and the design pressure is 1 MPa. It represents a safety volume used to collect the vapour and the gas generated by the interaction between LBE and water. During the phases in which the facility is not employed to perform tests, the overall mass of LBE is stored in the liquid metal storage tank S4 (see Figures **Error! Reference source not found.** and **Error!**

Reference source not found.*FIG. 1.*), which is connected to the bottom of the main vessel S1 using the same penetration of the water injection system.

Acceptance of radioactive material

No

Scheme/diagram

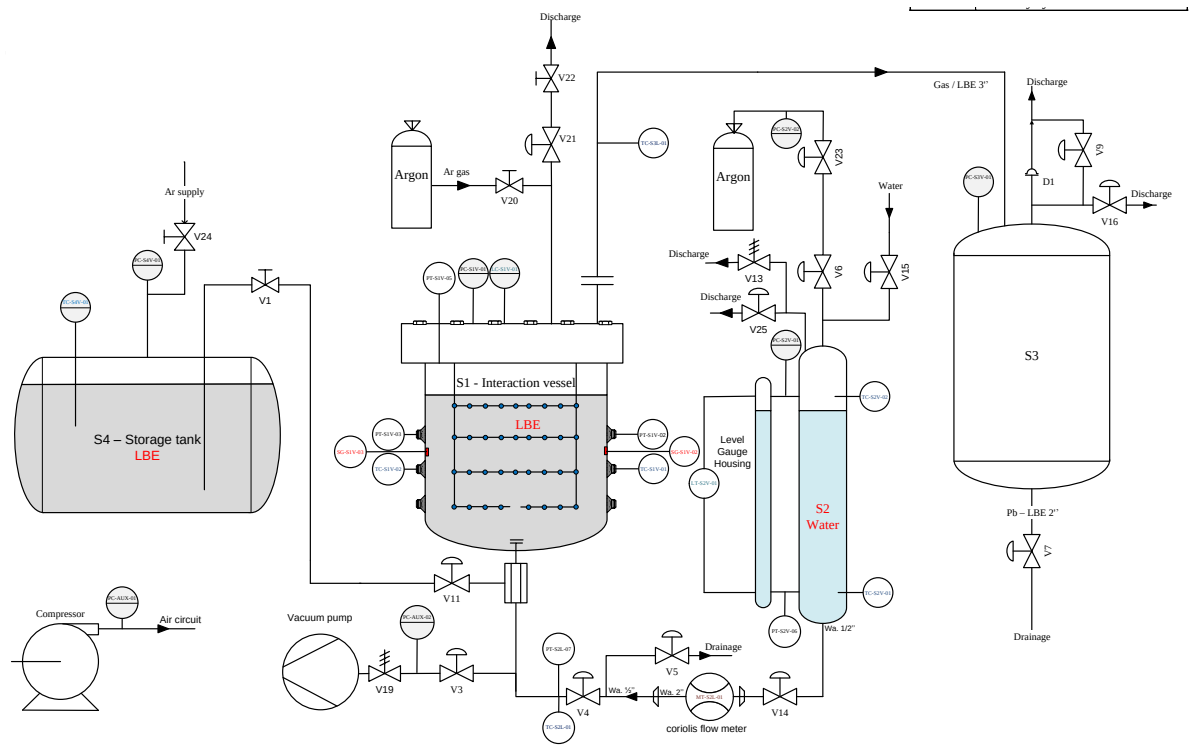

FIG. 1. LIFUS5/Mod2 P&ID, acquisition and control systems (from 111).

3D drawing/photo

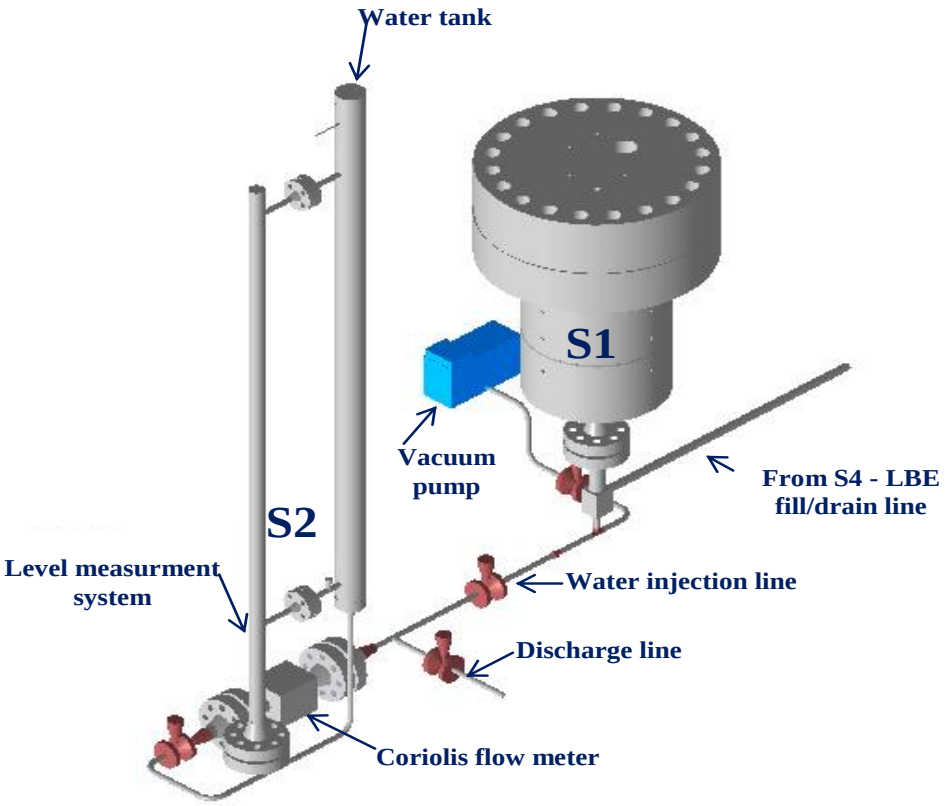

FIG . 2. LIFUS5/Mod2 overall sketch (from 1).

FIG. 3. View of LIFUS5/Mod2 facility.

Parameters table

Coolant inventory	Max LBE inventory 1000kg
Power	90kW
Test sections	
TS #1	*Characteristic dimensions* Outside diameter 540 mm Overall height 850 mm
	Static/dynamic experiment Dynamic
	Temperature range in the test section (Delta T) up to 220°C, water injected at 180°C into LBE pool at 400°C
	Operating pressure and design pressure Operating pressure 1.6 and 4 MPa (THINS) and 18 MPa (LEADER) Design pressure 20 MPa (gauge)
	Flow range (mass, velocity, etc.) Injected water mass flow rate up to 1 kg/s (THINS tests) and to be measured (LEADER tests)
Coolant chemistry measurement and control (active or not, measured parameters)	The THINS and LEADER configuration of LIFUS5/Mod2 facility, aiming to investigate the water-LBE interaction following an SGTR event, is not involved in the technology development of coolant chemistry.
Instrumentation	Thermocouples, fast pressure transducers, absolute pressure transducers, flow meter (Coriolis), level measurement gauge, strain gauges.

COMPLETED EXPERIMENTAL CAMPAIGNS: MAIN RESULTS AND ACHIEVEMENTS

Aiming to achieve the goals foreseen in the frame of the THINS Project, #8 tests have been performed. The objectives of the experimental campaign are fulfilled and the experimental data are available for evaluating the performances of the codes in reproducing the phenomena and processes observed in the experiment. The acquired data constitute an enlargement of the database for codes' validation in relation to HLM-water interaction phenomena. This represents an advancement in supporting the design of innovative HLM reactors. Moreover, the availability of the strain gauges data give information of the dynamic effects and of the energy release in the structures of the facility.

PLANNED EXPERIMENTS (including time schedule)

In 2015 #9 tests are planned in the frame of LEADER Project (water injection pressure at 180 bar, with different level of sub-cooling). The overall lapse of time foreseen to perform the LEADER campaign is estimated to be almost 6 months. The SGTR event investigation in a configuration relevant for the spiral steam generator of ELSY reactor and the acquisition of high quality data (pressures, temperatures and stresses) constitutes the main accomplishments pursued by the LEADER configuration of LIFUS5/Mod2 facility.

In 2015-2016, a new experimental campaign will be performed through a new up-grade of the LIFUS5 facility, related to the assessment of a steam generator tube rupture (SGTR) event. Instrumentation able to promptly detect the presence of a crack in the HX's tube will be tested aiming to monitor the break before leak. Indeed, the application of the leak before break concept is relevant for improving the safety of a reactor system. In particular, it decreases the probability of the pipe break event. The goal of this task is to implement an experimental activity, supported by the numerical simulations, that will characterise the leak rate and bubbles sizing through typical cracks occurring in the pressurized tubes. The acquisition is carried out by means of acoustic detectors. Objective of the experiments is to correlate the size of the crack and the acoustic signals.

TRAINING ACTIVITIES

Training activities could be agreed with ENEA Brasimone RC for the operation of the experimental campaign under the supervision of ENEA qualified staff.

REFERENCES (*specification of availability and language*)

1. DEL NEVO A., NERI A., CATI S., PESETTI A., GIANNINI N., SERMENGHI V., GIANOTTI D., VALDISERRI M., LIFUS5/MOD2 FACILITY – TEST A1.2 EDTAR, FP7 EC THINS - Task 4.1.2, ENEA Technical report L5-T-R-039 Rev. 0, 26 July 2013.
2. PESETTI, A. DEL NEVO, FORGIONE N.; "WATER/PB-BI Interaction Experiments in LIFUS5/Mod2 Facility Modelled by SIMMER code"; Proceedings of ICONE22, Prague, Czech Republic, July 7-11, 2014
3. GIANNINI N., PESETTI A., NERI A., CATI S., SERMENGHI V., GIANOTTI D., VALDISERRI M., DEL NEVO A.; "LEADER Test Section Implemented in LIFUS5/Mod2 Facility"; ENEA report, Ref. L5-T-R-072, Sept. 2013
4. GIANNINI N., FORGIONR N., MANNORI S., DEL NEVO A., "LIFUS5/MOD2B TEST SECTION DESIGN" ENEA Report, Ref. L5-T-R-132, March 2015.