**Profile LFR-10**

**LIMETS4**

**BELGIUM**

## GENERAL INFORMATION

| | |
|---|---|
| NAME OF THE FACILITY | LIquid MEtals Test Stand 4 |
| ACRONYM | LIMETS4 |
| COOLANT(S) OF THE FACILITY | Lead-Bismuth Eutectic (LBE) |
| LOCATION (address): | SCK•CEN, Boeretang 200, 2400, Mol, Belgium |
| OPERATOR | SCK•CEN |
| CONTACT PERSON (name, address, institute, function, telephone, email): | Dr. Serguei Gavrilov<br>Structural Material Research<br>Laboratory for High and Medium Activity<br>Tel. +32 (0) 1433 3067<br>Fax. +32 (0) 1432 1216<br>Email serguei.gavrilov@sckcen.be<br><br>Cc to:<br>Dr. Marlies Lambrecht<br>Structural Material Tests<br>Laboratory for High and Medium Activity<br>Tel. +32 (0) 1433 3013<br>Fax. +32 (0) 1432 1216<br>Email marlies.lambrecht@sckcen.be |
| **STATUS OF THE FACILITY**<br>Start of operation (date): | In operation |
| **MAIN RESEARCH FIELD(S)** | ☐ Zero power facility for V&V and licensing purposes<br>☐ Design Basis Accidents (DBA) and Design Extended Conditions (DEC)<br>☐ Thermal-hydraulics<br>☐ Coolant chemistry<br>☒ Materials<br>☐ Systems and components<br>☐ Instrumentation & ISI&R |

## TECHNICAL DESCRIPTION

**Description of the facility**

LIMETS4 is an experimental set-up designed for mechanical testing of materials in an LBE environment in order to investigate mechanisms and kinetics of material/liquid metal interactions that influence mechanical properties of the material. The design is based on LIMETS1 and has similar features albeit that the range of possible experiments has been increased. The vessel consists of an autoclave in which the experiments are performed and a dump tank. Oxygen control is done via a controlled gas flow of an adjustable argon Hydrogen mixture with an $H_2$ concentration of up to 20%. Oxygen control can be performed in both the autoclave and the dump tank. Each of these are equipped with two Bi/BiO2 oxygen sensors. The autoclave houses a mechanical testing device that can be operated in a gas atmosphere or under stagnant LBE. Possible tests include tensile tests, fracture toughness tests, slow strain rate tests, constant load tests and crack growth rate experiments. The maximum load of the device is 25kN and the displacement rates range between $1{,}9.10^{-6}$ to $1{,}3.10^{-1}$ mm/s. The temperature range from 550°C down to room temperature. Obviously, below the melting point of the coolant only experiments in a gas atmosphere are possible.

**Acceptance of radioactive material**

No

**Scheme/diagram**

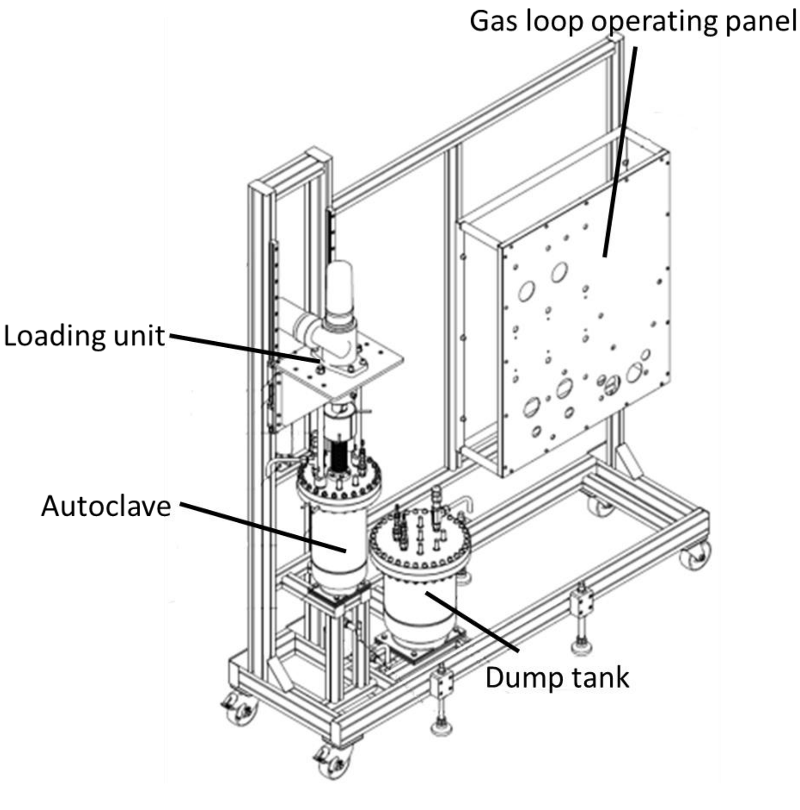


*FIG. 1. Scheme of the LIMETS4 facility*

**3D drawing/photo**

*FIG. 2. View of the LIMETS4 facility*

**Parameters table**

| | |
|---|---|
| Coolant inventory | |
| Power | |
| Test sections | |
| TS #1 | *Characteristic dimensions* |
| | *Static/dynamic experiment*<br>Static |
| | *Temperature range in the test section (Delta T)*<br>550°C-RT |
| | *Operating pressure and design pressure*<br>**Atmospheric pressure (no pressure vessel)** |
| | *Flow range (mass, velocity, etc.)*<br>Stagnant LBE |
| Coolant chemistry measurement and control | Oxygen control via controlled gas flow Ar, Ar+5% $H_2$, Ar+20% $H_2$.. Double set of Bi/Bi0$_2$ sensors installed in both tanks |

| | |
|---|---|
| (active or not, measured parameters) | |
| Instrumentation | Thermocouples, Oxygen sensors, Direct measurement of displacement on specimens, strain rate, load and frequency |

**COMPLETED EXPERIMENTAL CAMPAIGNS: MAIN RESULTS AND ACHIEVEMENTS**

LIMETS-4 is used in the MYRRHA materials qualification programme and for various EU projects including FP7 GETMAT and FP7 MATTER. The work focused on the assessment of Liquid metal embrittlement (LME) of austenitic and ferritic martensitic steels in LBE. An extensive set of tests were performed on various samples of T91- ferritic-martensitic steel and on 316L austenitic steel. Various possible influencing factors for LME embrittlement such as the applied strain rate, the surface preparation of the sample,the oxygen concentration of the melt, the test temperature and crack pretreatment were investigated. No evidence for the susceptibility of austenitic steels for LME embrittlement was found. Ferritic-martensitic steels do show LME albeit that significant plastic deformation is necessary to initiate LME.

**PLANNED EXPERIMENTS (including time schedule)**

The planned experiments in LIMETS I are the following

- Mechanism of LME
- LBE effects on tensile, fracture toughness, s
- Screening tests for SCC
- Effect of irradiation on LME susceptibility
- Demonstration of austenitic stainless steel immunity to LME
- Usability range of T91

**TRAINING ACTIVITIES**

Training activities are possible, availability allowing and after prior agreement under supervision of SCK•CEN Qualified staff.

**REFERENCES (*specification of availability and language*)**


1. VAN DEN BOSCH J., BOSCH R.W., SAPUNDJIEV D., ALMAZOUZI A. " Liquid metal embrittlement susceptibility of ferritic–martensitic steel in liquid lead alloys" Journal of Nuclear Materials 376 (2008) 322–329
2. VAN DEN BOSCH J., COEN G., VAN RENTERGHEM W., ALMAZOUZI A. "Compatibility of ferritic–martensitic steel T91 welds with liquid lead–bismuth eutectic: Comparison between TIG and EB welds" Journal of Nuclear Materials 396 (2010) 57–64
3. VAN DEN BOSCH J., HOSEMANN P., ALMAZOUZI A., MALOY S.A. "Liquid metal embrittlement of silicon enriched steel for nuclear applications" Journal of Nuclear Materials 398 (2010) 116–121

4. COEN G., VAN DEN BOSCH J., ALMAZOUZI A., DEGRIECK J."Investigation of the effect of lead–bismuth eutectic on the fracture properties of T91 and 316L" Journal of Nuclear Materials 398 (2010) 122–128