Profile LFR-22

CALLISTO

CZECH Republic

GENERAL INFORMATION

NAME OF THE FACILITY	CALLISTO
ACRONYM	
COOLANT(S) OF THE FACILITY	Pb, PbBi
LOCATION (address):	Morseova 1245/6, 301 00 Plzeň, Czech Republic
OPERATOR	Centrum výzkumu Rez, CVR
CONTACT PERSON (name, address, institute, function, telephone, email):	Ing. Josef Strejcius, Morseova 1245/6, 301 00 Plzeň, Czech Republic, CVR, Head of Material Program, SUSEN, tel.: +420 720 733 107, josef.strejcius@cvrez.cz

STATUS OF THE FACILITY	In operation
Start of operation (date):	Upgrade to 4 test sections in Sep 2015

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 first cell was designed to contain Heavy Liquid Metals, HLM, and carry out mechanical tests with specimens immersed in HLM. The cell is mounted on a hydraulic loading machine with a max loading capacity of 50kN. The maximum volume of the cell is about 900cm^3 (internal diameter about 100mm) and its height was designed for a maximum specimen size of about 65mm. The cell was manufactured with austenitic AISI 316 steel.

3 new cells are being built and will be installed on 3 servo-mechanic testing machines for creep, creep-fatigue, tensile and tensile-compression, with capacity 50 kN. This system foresees the use of a conditioning chamber, where the liquid metal will be prepared (Temperature and oxygen content). 1 oxygen sensor is in the conditioning chamber and 1 sensor in the CALLISTO cell. The oxygen sensors used are based on the Bi/Bi_2O_3 reference electrode.

Inside the CALLISTO cell, specimens and grips are totally immersed into the HLM. A thermocouple measures the inner temperature at a distance of about 10mm from the specimen surface. A maximum operating temperature of about 600°C can be reached. The oxygen content into the cell can be controlled through gas dosing and the Mass Flow Control is automatically switching the right amount of gas, based on the signal of the oxygen sensor.

Acceptance of radioactive material

No, but it is a simple device that can be built and introduced in hot cells.

Scheme/diagram

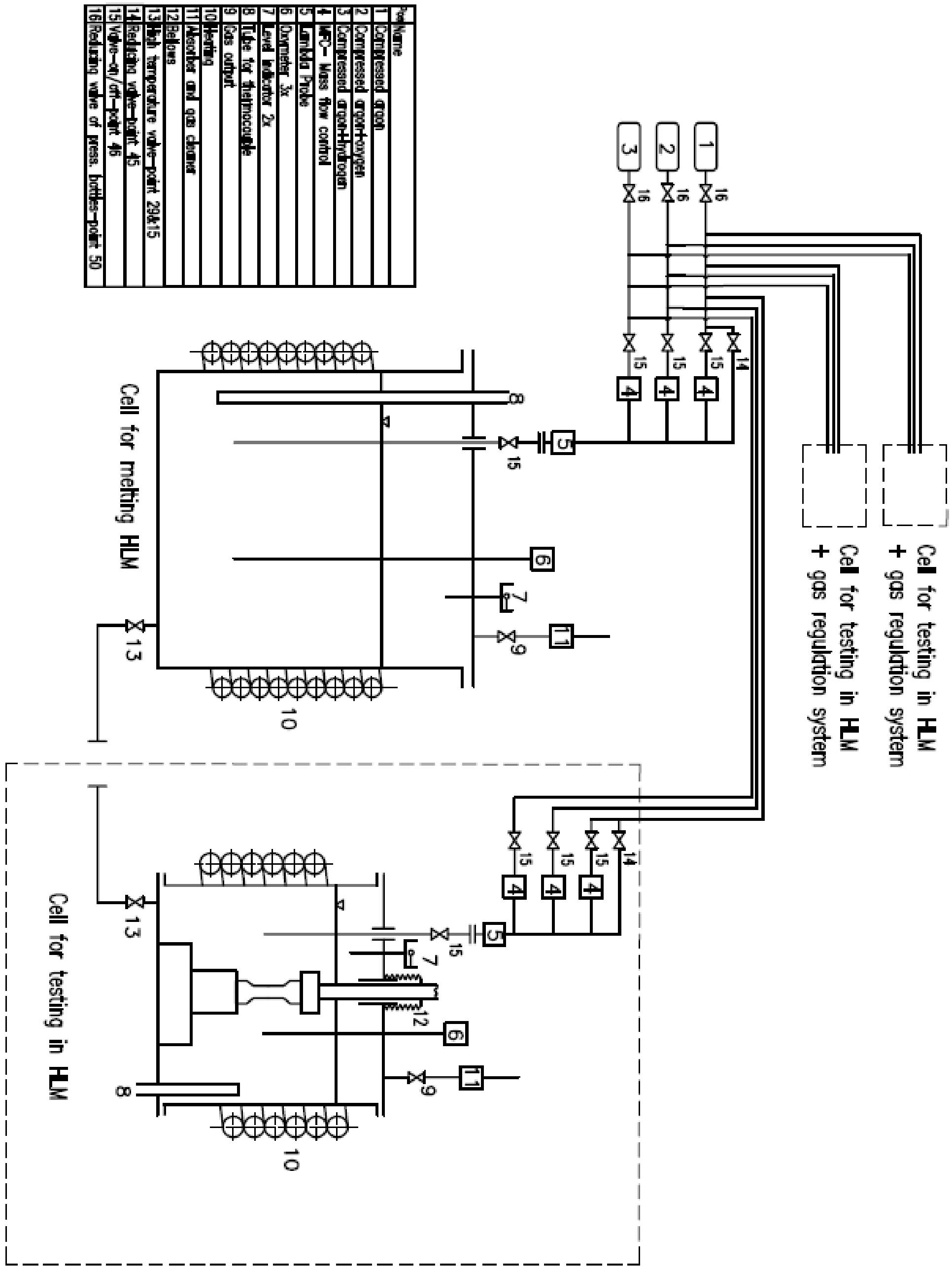

FIG. 1. Scheme of the CALLISTO facility

3D drawing/photo

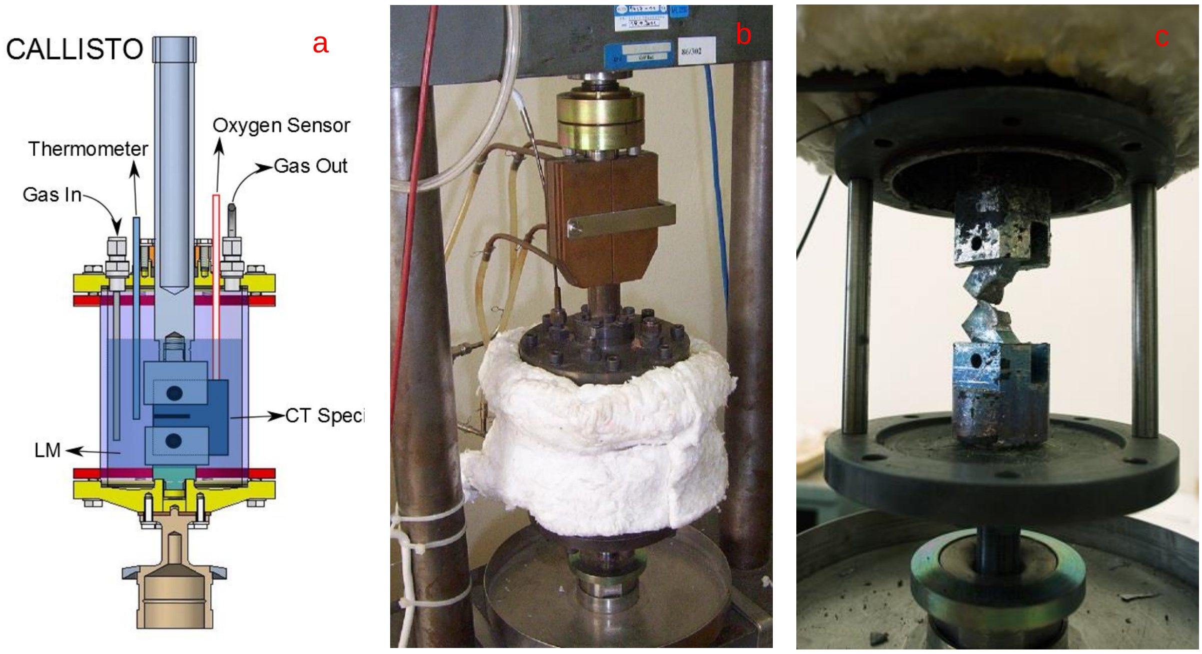

FIG. 2. CALLISTO facility: schematic of the experimental set-up (left), view of a cell closed in operation (middle) and view of a cell opened after test with a broken specimen (right)

Parameters table

Coolant inventory	500-700cm^3
Power	4kW
Test sections	
TS #1	*Characteristic dimensions* Samples: 1/2CT, 1/4CT, round tensile (4 mm diam., 20mm gauge)
	Static/dynamic experiment static
	Temperature range in the test section (Delta T) Up to 600°C
	Operating pressure and design pressure **2 bar**
	Flow range (mass, velocity, etc.) -NA
Technical parameters	Test speed range 0,001 mm/h to 100 mm/min, max. displacement ca. 25 mm
Coolant chemistry	Measurement of oxygen content with Bi/Bi_2O_3 sensors; oxygen content

measurement and control (active or not, measured parameters)	can be controlled by bubbling of ArH_2. Mass Flow Control is installed and automatically switching the right amount of gas, based on the signal of the oxygen sensor.
Instrumentation	50 kN (tensile, tensile-compression) servo-mechanic testing machine for creep, creep-fatigue tensile specimen fittings (in HLM) for ½ CT and ¼ DCT and round tensile rods (4 mm diam., 20mm gauge, ca. 45 mm total length)

COMPLETED EXPERIMENTAL CAMPAIGNS: MAIN RESULTS AND ACHIEVEMENTS

FP6-EUROTRANS-DEMETRA – ferritic/martensitic steel T91 and austenitic 316L in PbBi eutectic (LBE). Tensile and Round Compact Test (RCT) specimens were tested.

Tensile: experiments were carried out at different temperatures (300-500°C) and strain rates (10^{-4} – 10^{-6} s^{-1}), without oxygen control.

The 316L was not affected by the LBE.

The T91 has a characteristic brittle fracture surface when tested at 300°C. The phenomena was classified as Liquid Metal Embrittlement.

RCT: J-integral tests were carried with 8RCT and 6RCT T91 specimens at 300°C, to evaluate the fracture toughness of the material. Several specimens failed during pre-cracking because of fast crack growth; in particular, the most sensitive specimens were those pre-exposed in LBE (1000h at 500°C in flowing LBE). Moreover, pre-cracking in LBE incremented the data scatter. In case of rapid failure the specimens had quasi-cleavage features, with intergranular and transgranular fractures. The sensitivity of T91 in LBE to the LME was confirmed.

FP6-VELLA: ferritic/martensitic steel T91 in Pb. Tensile specimens were tested. Experiments were carried out at 350°C and various strain rates (10^{-2} – 10^{-6} s^{-1}), without oxygen monitoring. Specimens were tested in the as-received state and also after pre-exposure in flowing Pb for 400h at 600°C, with oxygen content <10^{-6}wt%. Tensile tests, in all the experimental variables, did not reveal any effect of the Pb on the mechanical properties of the T91. No evidence of LME was observed.

FP7-LEADER: ferritic/martensitic steel T91 in Pb. Tensile specimens were tested. Experiments were carried out at different temperatures (400-450°C) and strain rate 10^{-6} s^{-1}, without oxygen monitoring. Specimens were tested in the as-received state and also after pre-exposure in flowing Pb for 1000h at 600°C and 500h at 650°C. Tensile tests, in all the experimental variables, did not reveal any effect of the Pb on the mechanical properties of the T91. No evidence of LME was observed.

CZ national grant- MPO-REJEZ: ferritic/martensitic steel T91 in Pb. Tensile specimens were tested. Experiments were carried out at different temperatures (350°-450°C) and various strain rates (10^{-2} – 10^{-6} s^{-1}), with oxygen monitoring (gas bubbling + oxygen sensors). Specimens were tested in the as-received state and also after removal of surface oxides with a chemical flux (to promote wetting). Several tensile specimens were smooth and several were notched in the centre. Tensile tests, in all the experimental variables, did not reveal any effect of the Pb on the mechanical properties of the T91 for smooth specimens. On the other hand, the notched specimens, after wetting with the flux, underwent brittle fracture for temperatures below 400°C. It was the first time that it was highlighted that wetting and multiaxial loading induced LME in the steel T91 in contact with Pb.

FP7-MATTER: T91 in LBE. Fracture toughness tests; 0.5TCT specimens at 350°C; work in progress.

PLANNED EXPERIMENTS (including time schedule)

FP7-MATISSE: experiments will start in 2015 (till 2017) and they foresee the characterisation of FeCrAlY coatings under loading in HLM.

Moreover, there will be fatigue tests of T91 in LBE at 350°C (2015-2017).

GACR-Cz national grant-AVOCADO: crack initiation in LBE for ODS materials. Specimens will be pre-loaded and inserted for short periods of time in flowing LBE for the study of crack initiation and fracture mode of newly developed ODS steels (2015-2017).

TRAINING ACTIVITIES

Training for internal operators. Available for training of external users, previous planning.

REFERENCES (*specification of availability and language*)

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2. GABRIELE F.DI, DOUBKOVA A., Sensitivity to environmentally assisted cracking of ferritic martensitic T91 in contact with liquid Pb-Bi eutectic, Proc. 1st International Conference CORROSION AND MATERIAL PROTECTION, Prague 2007. (En)
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4. GORSE D., AUGER T., VOGT J.-B., SERRE I., WEISENBURGER A., GESSI A., AGOSTINI P., FAZIO C., HOJNA A., GABRIELE F. DI, VAN DEN BOSCH J.,. COEN G, ALMAZOUZI A., SERRANO M., Influence of liquid lead and lead–bismuth eutectic on tensile, fatigue and creep properties of ferritic/martensitic and austenitic steels for transmutation systems, Journal of Nuclear Materials 415, 284-292 (2011). (En)
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