Profile LFR-24

COLONRI II

CZECH Republic

GENERAL INFORMATION

NAME OF THE FACILITY	COnvection LOop NRI II
ACRONYM	COLONRI II
COOLANT(S) OF THE FACILITY	COLONRI II – Pb
LOCATION (address):	CVR, Hlavni 130 250 68 Husinec-Rez Czech Republic
OPERATOR	Centrum vyzkumu Rez s.r.o., CVR
CONTACT PERSON (name, address, institute, function, telephone, email):	Fosca Di Gabriele, Hlavní 130, 250 68 Husinec-Rez, Czech Republic, CVR, Senior Researcher, +420 266 17 2127, Fosca.Di_Gabriele@cvrez.cz

STATUS OF THE FACILITY	In operation
Start of operation (date):	2007

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 **COLONRI II** (**CO**nvection**LO**op **NRI**) is a test facility designed to perform experiments to investigate the interaction of materials with flowing Pb. This is a vertical, natural convection loop. The loop was manufactured from the austenitic stainless steel AISI 321. The inner surface of the tube working at the highest temperature was covered with a molybdenum plate. The loop contains pure Pb and, though in the past it worked up to 650°C, in its present state it can work up to a maximum of 550°C.

The facility (schematic below) consists of:

- High temperature experimental section and low temperature experimental section. The temperature difference maintained between two sections allows the liquid metal movement at the velocity up to about 2 cm/s. The two experimental sections can work at different temperatures with differences between T=50-100°C.
- Heating elements, thermocouples.
- Conditioning/drain tank.
- Facilities for the control of the gaseous mixture atmosphere inside the tubes that allow dosing of the inlet $Ar + H_2 + O_2$ mixture.
- An equalizing upper tank used also as a cold trap, where the oxides precipitates and float on the free surface of the liquid metal.
- Two sections to immerse specimens where the temperature is maintained constant. The specimen holders (4 for each experimental chamber) can contain three rows of specimens, for a total length of almost 200 cm.
- Thermocouples monitor the temperature along each leg with an accuracy of ± 1°C for testing legs and ± 3°C in the expansion tank
- Oxygen sensors monitor the oxygen content in the medium in the dosing tank and at least in one position along the main loop. These sensors are based on the Bi/Bi_2O_3 reference electrode.

Acceptance of radioactive material
No

Scheme/diagram

COLONRI II (Pb loop)

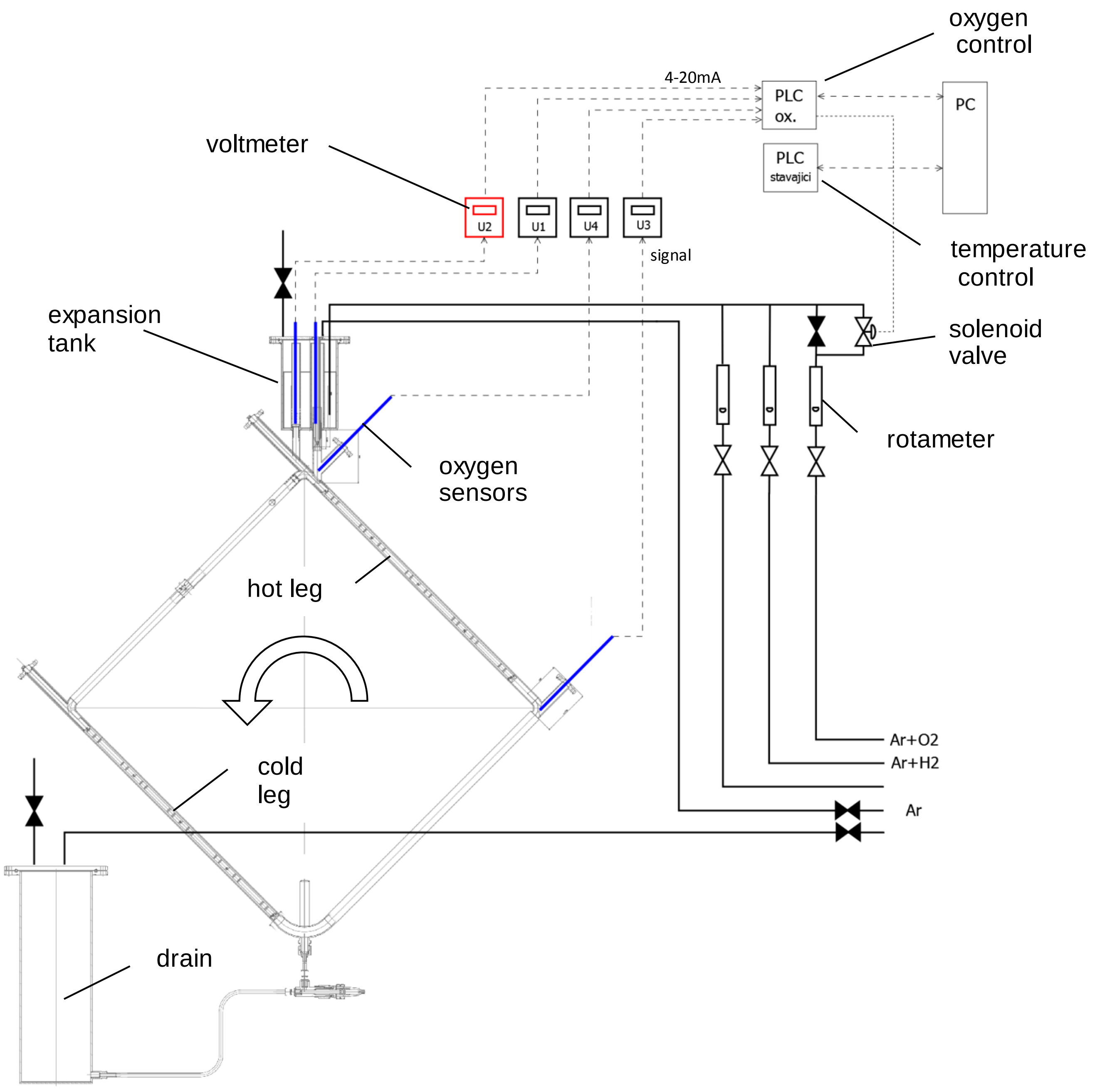

FIG. 1. Scheme of the COLONRI II facility

3D drawing/photo

FIG. 2. View of the COLONRI II facility

Parameters table

Coolant inventory	5.84 l
Power	Max. 7kW
Test sections	
TS #2	*Characteristic dimensions* 68cm (4 specimen holders per section), specimen cross-section 14.5x6 mm
	Static/dynamic experiment dynamic
	Temperature range in the test section (Delta T) COLONRI II (Pb): Hot leg 550°C Cold leg 400°to 500°C
	Operating pressure and design pressure Atmospheric pressure
	Flow range (mass, velocity, etc.)

	1-2 cm/s
Coolant chemistry measurement and control (active or not, measured parameters)	Simplified active oxygen control consisting of 3 YSZ electrochemical sensors (Bi/Bi2O3 ref) and PLC dosing Ar-O_2 gas into Ar/Ar-H_2 stream
Instrumentation	Thermocouple field and 3 to 4 YSZ oxygen sensors

COMPLETED EXPERIMENTAL CAMPAIGNS: MAIN RESULTS AND ACHIEVEMENTS

FP6-VELLA: Corrosion of various alloys in COLONRI II (1000h at 500° and 650°C). Among the first experiments in pure Pb. Very low oxygen content, therefore, due to the lack of protective oxides heavy damage was observed in most of the materials.

A first attempt to develop FeCrAlY coatings was made. The HVOF deposition combined with laser melting was used for depositing FeCrAlY coating on the T91. Results of short-term tests revealed the need for a complete and homogeneous melting of the coating and substrate, in order to protect properly the material against damage from Pb.

GACR Cz national grant: Corrosion of T91, 316L, and ODS steel in Pb (650°C, 400h, O=10^{-7}). The specimens were pre-oxidised in order to observe the effect of a protective oxide layer or the corrosion rates of the material. The steels with an initial layer of Cr_2O_3 performed the best.

FP7-GETMAT: Development of FeCrAlY coatings (5 and 11% Al) on T91, by HVOF+laser, and tests in d COLONRI II (500h at 600°C). The coating deposition was able to produce thick coatings and overall improved the performance of the materials (T91 heavily damaged against coatings resistant to liquid metals).

ODS materials (12wt% Cr) were tested for 2000h at 600°C in COLONRI II. Tests were carried out with an oxygen content of about 10^{-7} wt% and showed the capability of the materials to oxidise and, therefore, making the ODS alloys a suitable choice for applications in HLM. Comparisons were made with static tests in Pb.

CZ national grant-MPO-REJEZ: Further development of coatings with reduced thickness. FeCrAlY (5% Al) deposited by HVOF+laser melting was further investigated in order to reduce the thickness of the coatings and the amount of material thermally affected by the laser treatment. A marked improvement was reached, by adjusting the deposition and laser parameters. Tests in COLONRI II, at 600 and 650°C for periods up to 2000h confirmed the good protection properties of the coated layers. The technical limits of the techniques are, however, limiting this application to structural materials were thickness and modification of surface layer microstructure are not critical. HVOF combined with laser melting is not suitable to use for coating of cladding tubes.

PLANNED EXPERIMENTS (including time schedule)
GACR-AVOCADO (Cz national grant): oxidation/corrosion of ODS materials in COLONRI I and II. 2014-2017.

FP7-MATISSE: Oxidation/corrosion of coatings in COLONRI II, 2015-2017.

Students projects:

-Corrosion of coatings in COLONRI II at 550°C, 2015 (Uni. Of Liberec)

-Study of heat removal system (Uni of Genoa)

TRAINING ACTIVITIES
Internal training for operators. Available for external users.

REFERENCES (*specification of availability and language*)

1. GABRIELE F. DI, AMORE S., SCAIOLA C., ARATO E., GIURANNO D., NOVAKOVIC R., RICCI E., Corrosion behaviour of 12-Cr ODS steel in molten Pb, Nuclear Enginerring and Design, in press 2014.
2. GABRIELE F.DI, HOUDKOVA S., SOUKUP O., KARNIK D., Characterisation of FeCrAlY coatings for Application in Pb Environment, Proc. ICONE22, Czech Republic 2014.
3. HOUDKOVA S., SPLÍTEK R., KASPAROVA M., HRUSKA M., GABRIELE F. DI, Technology of creation coatings based on FeCrAlY, METAL2012, 21st Int. Conf. on Metallurgy and Materials, Brno, May 2012. (En)
4. GABRIELE F.DI, KLECKA J., CRISTALLI C., GESSI A., S.HOUDKOVA, D.KARNIK, A.BELLUCCI, Characterisation of coatings methods for HLM applications, NENE2013, Slovenia Sep.2013.