

# Post-doctoral position - Creep-fatigue behaviour of 316L in liquid lead

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– Research proposal –  
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**Topics** — Materials and mechanical sciences

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**Application deadline** September 12th, 2025

**Location** Unité Matériaux et Transformations, CNRS UMR 8207, Université de Lille, 59000 Lille, France

**Starting date** First quarter of 2026

**Duration** 24 months

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## Context

newcleo develops an Advanced Modular Reactor of 4th Generation, a Lead Fast Reactor (LFR). These reactors are characterized by their use of liquid metal coolants, specifically lead, which presents unique challenges and opportunities for material performance under extreme operational conditions.

One of the key research challenges lies in understanding the influence of the liquid metal environment on the structural materials used in the reactor components. The liquid lead coolant interacts with the metallic materials, potentially altering their properties over time. As part of ongoing R&D efforts, it is crucial to evaluate the effects of this interaction on the mechanical and corrosion properties of these materials, which are vital for ensuring the long-term safety, reliability, and efficiency of LFR systems.

While the open literature provides few mechanical results in molten lead, conclusions exist in

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Lead-Bismuth Eutectic (LBE) environments, in particular regarding fatigue behavior. These studies indicate a distinctive initiation behavior for the same material compared to tests conducted in air and vacuum, with significant nucleation of initiation sites and propagation of fewer main cracks [1] but with higher propagation rates [2]. Meanwhile, the number of cycles to failure remains unchanged in air or in LBE for the lower plastic deformation but not for the highest [3]. In addition, the influence of pre-corrosion in liquid metal and in particular the presence of corrosion defects was studied. The results show that the defects do not propagate very significantly due to the material's ability to deform plastically, even in the presence of liquid metal.

For some mechanical transients cumulating holding periods between fatigue cycles, those main fatigue cracks could be held opened to the corrosive environment and creep-fatigue design curves could be reduced compared to the one used for the mechanical design of the components.

## Description

This postdoctoral research opportunity aims to understanding the creep-fatigue behavior of 316L austenitic stainless steel when exposed to liquid lead, focusing on the understanding of material degradation mechanisms.

The identification of potential thresholds for crack opening, length and/or holding time would be particularly crucial to identify operating domains where the environment would have a non-negligible effect on the mechanical behavior of the structure.

Fatigue tests to failure, aiming at quantifying the interactions between fatigue and creep, will be complemented by interrupted tests to highlight the effect of the environment on crack propagation.

## Work plan

The following tasks should be carried out for the study:

- a) Literature review and retrieval of the existing work,
- b) Definition of the test matrix,
- c) Mechanical tests,
- d) Characterization of the mechanisms involved through characterization techniques (SEM-EDS-EBSD, FIB, STEM),
- e) Publication and participation to international congress,
- f) Preparation of a technical report.

## Applicant profile

The applicant must have a PhD in Mechanical or Material Sciences.

A previous professional experience with liquid metals will be greatly appreciated.

You have a good level of English (B2 level minimum). You have a proactive attitude, an aptitude for teamwork, good oral communication skills and an interest in experimental work.

The postdoctoral researcher will be employed by newcleo in Lyon (France), and the actual workplace will be the UMET lab in Lille (France).

The position is located in a sector falling under the protection of scientific and technical potential (PPST) and therefore requires, in accordance with regulations, that your arrival be authorized by the competent authority of the French Ministry of Higher Education and Research (*MESR*).

## References

- [1] N. O. Fuentes Solis, S. Gavrilov, M. Seefeldt, and M. Wevers, "Fatigue crack initiation in lead-bismuth eutectic and its effect on the cyclic stress behaviour of austenitic stainless steel 316L," *Journal of Nuclear Materials*, vol. 600, p. 155 282, Nov. 2024, ISSN: 0022-3115. DOI: 10.1016/j.jnucmat.2024.155282.
- [2] X. Gong, P. Marmy, L. Qin, B. Verlinden, M. Wevers, and M. Seefeldt, "Effect of liquid metal embrittlement on low cycle fatigue properties and fatigue crack propagation behavior of a modified 9Cr–1Mo ferritic–martensitic steel in an oxygen-controlled lead–bismuth eutectic environment at 350 °C," *Materials Science and Engineering: A*, vol. 618, pp. 406–415, Nov. 2014, ISSN: 0921-5093. DOI: 10.1016/j.msea.2014.09.003.
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