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Preliminary testing of ALFRED DHR System

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Lead fast reactors are of particular interest thanks to the characteristics of the coolant which simplifies numerous plant choices while maintaining high levels of safety and reliability. In Europe, ALFRED is the main technology demonstrator and leveraging on the knowledge developed in the evolutionary generation III+ plants it makes use of passive safety systems, for example for the decay heat removal. One of the main limitations of passive safety systems is the lack of an intrinsic control power removal. This is particularly restraining when they are applied to liquid metal reactors because the coolant solidifies at a higher temperature than the external environment, which commonly constitutes the final heat sink. Coolant solidification poses the risk of inhibiting the natural circulation of the primary coolant and with it the decay heat removal, as well as possible mechanical stresses induced by the volume change from liquid to solid states. Ansaldo Nucleare patented a passive safety system for decay heat removal able to passively control the power removed to the final heat sink, exploiting the presence of non-condensable gases in strategic positions of the circuit. The system consists of 3 loops, each one is connected to one steam generator and is equipped with an Isolation Condenser immersed in a pool and connected to a gas storage tank. In 2016, thanks to a partial funding from the Italian Ministry for Economic Development, Ansaldo Nucleare together with ENEA, SIET and SRS started a project called SIRIO to design, build and test an experimental facility scaled with respect to ALFRED's DHR system to qualify the operating principle. Scaling is carried out by keeping constant power density and adopting the same operating conditions of pressure and temperature, together with the height of the real system. This paper aims to describe the facility by showing the scientific scaling aspects and discuss the first experimental campaign carried out on the facility. The behaviour of the main parameters of interest for the safety system are reported, such as the total pressure and temperature in the various areas of the system, which allow us to infer the concentration and transport of non-condensable gases. The results also guarantee to quantify the regenerative heat transfer of the bayonet steam generator that contribute to the operation of the passive power control system. The experimental data will be used for the qualification of the operating principle and the detailed design of the full scale system.

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