ALFRED (Ansaldo Nucleare, Europe/Italy)

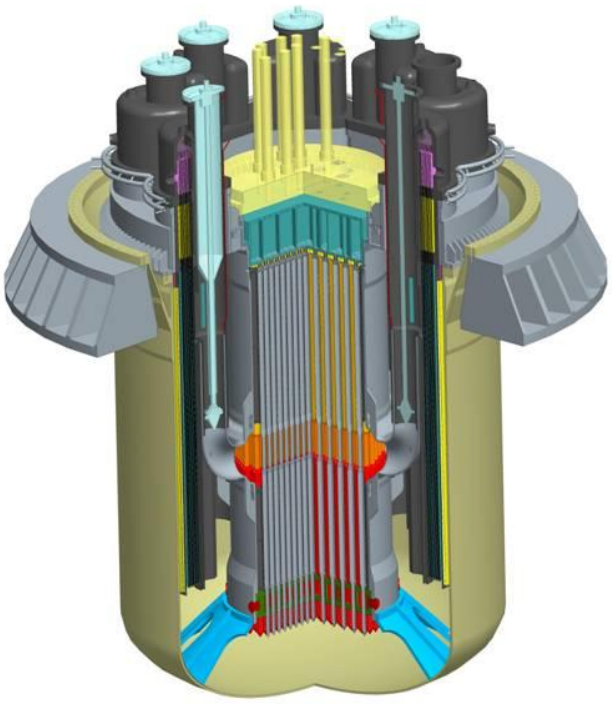

FIG. 18. ALFRED primary system.

Full name:	*Advanced Lead Fast Reactor European Demonstrator*
Designer:	*Ansaldo Nucleare*
Reactor type:	*Lead-cooled Fast Reactor*
Electrical capacity:	*125MWe*
Thermal capacity:	*300MWth*
Primary Coolant	*Lead*
Primary Circulation	*Forced*
Primary System Pressure:	*< 0.1MPa*
Primary System Temperature:	*400÷480 °C*
Secondary Coolant:	*Water/Superheated-Steam*
Secondary System Pressure:	*18 MPa*
Superheated Steam Temperature:	*450 °C*
Fuel Material:	*MOX*
Fuel Cycle/Residence time:	*12 Months / 5 Years*
No. of safety trains:	*4 trains*
Emergency safety systems:	*No injection safety systems are needed*
Residual heat removal systems:	*2 DHR systems, 4 loops each - Passive*
Design Life:	*40 Years*
Design status:	*Conceptual Design*
Planned deployment/1st date of completion:	*2025*
New/Distinguishing Features:	*Demonstrator reactor for European LFR*

Introduction

The Advanced Lead Fast Reactor European Demonstrator (ALFRED) conceptual design has been carried out in the frame of the EU FP7 LEADER (Lead-cooled European Advanced Demonstration Reactor) Project. ALFRED is a 300 MWth pool system developed to demonstrate the viability of the European LFR (ELFR) technology for use in the future commercial power plant. ALFRED design is as close as possible to the reference ELFR using proven and already available technical solutions to proceed to construction in the short term.

Description of the Nuclear System

ALFRED primary system configuration is a pool-type with all components removable. It presents a simple flow path and a low pressure drop of the primary coolant allowing an efficient natural circulation. The primary coolant leaving the core flows upward through the Primary Pump (PP) vertical duct and then, through the Steam Generator (SG) inlet holes, flows downwards in the SG shell and feeds the cold plenum back to the core. The volume between the primary coolant free levels and the reactor roof is filled with Argon. The Reactor Vessel (RV) is cylindrical with a torispherical bottom head and it is anchored to the reactor cavity from the top. A cone frustum, welded to the bottom head, provides radial restraint of the Inner Vessel (IV). A steel liner covering the reactor pit constitutes the Safety vessel (SV). The volume between the RV and SV is such that, in case of RV leak, the primary coolant still covers the SG inlet window maintaining the natural circulation flow path. The IV has the main functions of core support and hot/cold plena separation. It is fixed to the cover by bolts and it is radially restrained at bottom. The Core Support plate is mechanically connected to the IV with pins for easy removal/replacement. The core, with a total power of 300 MWth, is constituted by 171 wrapped hexagonal Fuel Assemblies (FAs), 12 Control Rods (CRs) and 4 Safety Rods (SRs), surrounded by 108 Dummy Elements. Hollow pellets of MOX fuel with maximum Plutonium enrichment of 30% are used. Each FA extends to the cover gas plenum, is long about 8 m and it consists of 127 fuel pins restrained by spacer grids. A Tungsten ballast in the upper part of the FA is used to overcome buoyancy forces. The SG and PP are integrated into a single vertical unit. Eight SG/PP units are located in the annular space between the IV and the RV walls. SGs are bayonet type with double walls. The double wall gap is filled with Helium and high thermal conductivity particles. The double wall concept prevents water/lead interaction in case of break of one tube wall and, moreover, a tube wall break event can be easily detected by the continuous monitoring of the Helium gap pressure.

Description of the Safety Concept

ALFRED is equipped with two diverse, redundant and separate shutdown systems: the first system, which performs also the control function, is made of absorber rods passively inserted by buoyancy from the bottom of the core; the second is made of absorbers rods passively inserted by a pneumatic system (using depressurization) from the top of the core. The Decay Heat Removal (DHR) system consists of two passive, redundant and independent systems, each one composed of four Isolation Condenser systems (ICs) connected to four SGs secondary side. Three out of four ICs are sufficient to remove the decay heat power. Both systems are passive, with actively actuated valves, equipped with redundant and locally stored energy sources. 2D seismic isolators are installed below the reactor building to cut the horizontal seismic loads.

Deployment Status and Planned Schedule

ALFRED reached the conceptual design maturity level in 2013. ALFRED is an essential step in the evolution of the LFR technology. The Road Map for the realization of the Industrial scale First-Of-A-Kind European LFR (the ELFR) requires the realization of the ALFRED demonstrator around 2025.