TITLE

Technical specification of the ATHENA Main Circulation Pump

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CONTRIBUTORS

SUMMARY The present document deals with a technical specification of the ATHENA Main Circulation Pump. ATHENA facility will host a mechanical axial type vertical pump, working in pure lead, located in the hot leg of the test section.

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LIST OF REVISION

Revision	Date	Scope of revision	Page
0	29/04/2022	First Issue	11
1	10/05/2022	Lead TCs at impeller inlet and outlet added	11

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INTRODUCTION

The ALFRED Project aims to the development, up to the full demonstration, of the Lead-cooled Fast Reactor (LFR) technology, one of the most promising concepts of Gen-IV being significantly safe, sustainable, competitive, and non-proliferating.

To support the ALFRED Project, the Fostering ALFRED Construction (FALCON) consortium, is coordinating the development and deployment of ALFRED. A first step to support ALFRED development is the improvement and enlargement of experimental facilities and laboratories dedicated to lead technology R&D.

An ALFRED Research Infrastructure (RI) is going to be realized in Romania, to cover research aspects presently missing in the European landscape, but required for supporting the design of an LFR.

At present, several R&D efforts address the open issues of the LFR technology, including studies on materials and physics-chemistry of the coolant, corrosion, erosion and degradation of structural materials, pool thermal-hydraulics, fuel assembly thermal-hydraulics and postulated accidental scenarios. Taking into account existing installations, four new experimental facilities have been identified to investigate the key points related to the heavy liquid metals and to support the technological development of the LFRs.

One of the most relevant facility of the ALFRED-RI is ATHENA (Advanced Thermo-Hydraulics Experiment for Nuclear Application) facility.

ATHENA is a 2.21 MW pool type multipurpose facility representative of Lead cooled Fast Reactor technology. Its main features are represented by a large size vessel (3.2 m diameter, 10 m in height, lead inventory of about 800 tons) which is capable to host and test single and coupled full scale components relevant for ALFRED.

1. OBJECT OF THE SUPPLY

The main objective of this technical specification is the detailed design, construction, factory testing and supply to RATEN-ICN, Mioveni (Romania) of a vertical axial /mixed type pump working in pure lead to be installed in the ATHENA facility.

2. PURPOSE

The purpose of this technical specification is the supply description of a vertical axial /mixed type pump working in pure lead, fixing the working conditions, the main features/characteristics and the required performance.

The mechanical pump includes the hydraulic components, the bearings, the shaft sealing system, the "heat shield" (if required), the shaft, the external case, the coupling joint, the instrumentation and the control system.

In particular, the supply shall include the following items.

- The general pump design and in particular:
  - ✓ the definition of the whole component and its positioning;
  - ✓ the sizing of the shaft sealing;
  - ✓ the sizing of the bearings and the hydraulic components;
  - ✓ the design of the "heat shield", taking into account the turbulent heat dissipation of the hydraulic components;
  - ✓ the sizing of the required auxiliary systems;
  - ✓ the supporting to ENEA during the choice and installation of the instrumentation;
  - ✓ the definition of the electrical and mechanical interfaces;
  - ✓ the choice of appropriate materials and the appropriate anticorrosion strategy;
  - ✓ the definition of the control scheme
- The detailed design of the pump, and in particular:
  - ✓ CFD analyses of the hydraulic components;
  - ✓ Structural/mechanical verification of the whole component;
  - ✓ Thermo-mechanical verification of the pump;

- The manufacture of all the components.
- The assembly of the pump.
- The factory testing at the supplier workshop.
- The delivery in Romania, Mioveni site.
- On-site assistance.

3. DESCRIPTION OF THE SUPPLY

The pump shall be a vertical one, axial type with axial suction and discharge. The impeller material shall be in AISI 316L/316/304/304L/321/321H.

The pump shell and any other part in contact with the heavy liquid metal (except the impeller and the sealing), shall be realized in austenitic stainless steel (AISI 316L/316/304/304L/321/321H).

The pump impeller and pump shaft will be alumina coated by chemical vapour deposition (pack cementation).

The pump shall have an electric engine with 400 V and 50 Hz electric supply specification.

The pump shroud will have 6 rounded buttonholes vertically oriented with a total heigh of 165 mm and a radius of 32 mm. The buttonholes will be placed 2226 mm beneath the pump coupling flange.

The pump will be inserted inside the facility within a 16” 40S external pipe with a centring device.

4. MAIN DESIGN DATA

The pump shall be designed and realized in compliance with the following design data:

- Working fluid — Lead
- Working temperature: — 480°C – 520°C
- Design temperature: — 520°C
- Nominal mass flow rate (BEP) — 45 m^3/h
- Pressure head (BEP) — 2.0 bar
- Minimum mass flow rate: — 35 m^3/h
- Maximum mas flow rate: — 55 m^3/h

- Cover gas: Argon
- Type Axial / mixed
- Cover gas pressure: 150 mbar(g)
- Coupling flange 20”- 300 lb
- Shroud external diameter 330 mm, 5mm thickness
- Total length (beneath the flange) 3380 mm

The definition of the start-up procedures for the pump circulation from the stand-by condition to the nominal working condition is a Supplier’s responsibility.

5. PUMP INSTRUMENTATION

The following section is devoted to the description of the instrumentation that shall be installed on the pump.

Instrumentation:

- Temperature measurement:

  Motor coils, motor bearings, pump bearings, inlet / outlet pump bearing lubrification oil, shaft sealing, inlet / outlet impeller lubrification oil, inlet / outlet “heat shield” lubrification fluid, lower pump bearings, shaft, lead TCs at the inlet/outlet of the impeller section (3 TCs at the inlet, 3 TCs at the outlet)

- Pressure measurement

  Lubrification system, gas sealing system.

- Mass flow measurement

  Gas cooling system, gas sealing system, lubrification system

- Level measurement

  Pump main body, lubrification oil in the bearing system

6. SCOPE OF SUPPLY

The scope of supply shall include:

1. Main Circulation Pump, including motor pump.

2. Coating on pump impeller
3. Instrumentations
4. Documentation
5. Packing
6. Shipment (DAP Romania)

7. DELIVERY TIME

The delivery time Ex Works is 10 months after reception of the PO.

8. TERMS OF INVOICING

The terms of invoicing are the following:

- Invoice n°1: 30% of the total amount of the PO at the submission of the general drawings.
- Invoice n°2: 50% of the total amount of the PO at the shipment of the Pump.
- Invoice n°3: 20% of the total amount of the PO at the acceptance of the Pump on site (visual and electrical check)

9. TERMS OF PAYMENT

The payment terms are the following: within 30 days from the invoice date.

ANNEX

- ATHENA_MCP.step (General Drawings)
- ATHENA_MCP.pdf

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