ALFRED Project

Energy Conversion System

M. Tarantino on behalf of Falcon Consortium
(mariano.tarantino@enea.it)

Biennal Conference, 17-18-19 March 2015, Brussels, Belgium

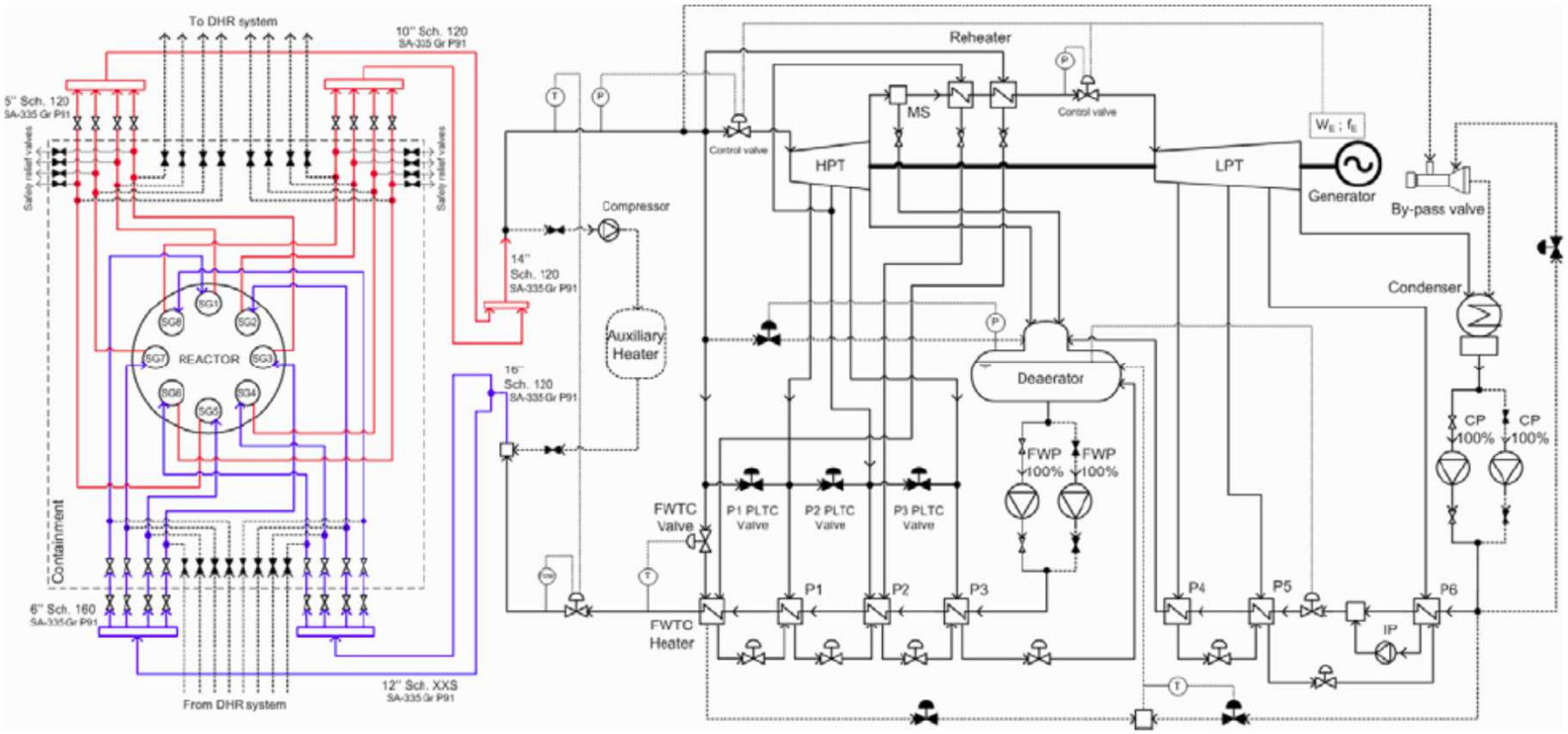
Outline

- **ALFRED Secondary System**
- **Open Issues**
- **DWBT ALFRED**
- **Remarks**

ALFRED - Secondary System

Power conversion system based on superheated cycle with dual turbine configuration, three extractions in the HP and in the LP with an axial outlet

Plant net output, MWe	125
Cycle Net Efficiency, %	41
Mass Flow, kg/s	193
Pressure, MPa	18
Steam Temperature, °C	450



Open Issues

Steam Generator

- Design validation
- Material selection
- Component behavior in forced and natural convection
- Tube rupture/leakage detection
- Tube rupture mitigation
- Reliability and performance assessment
- Replacement
- SG type: spiral-tube, helical-tube, bayonet-tube

Open Issues

A comprehensive R&D program is necessary because of:

- **Innovations which require validation programs of new components and systems, as the SG and its integration inside the reactor vessel.**

- **The use of a new coolant and associated technology, properties, neutronic characteristics, and compatibility with structural materials.**

Open Issues

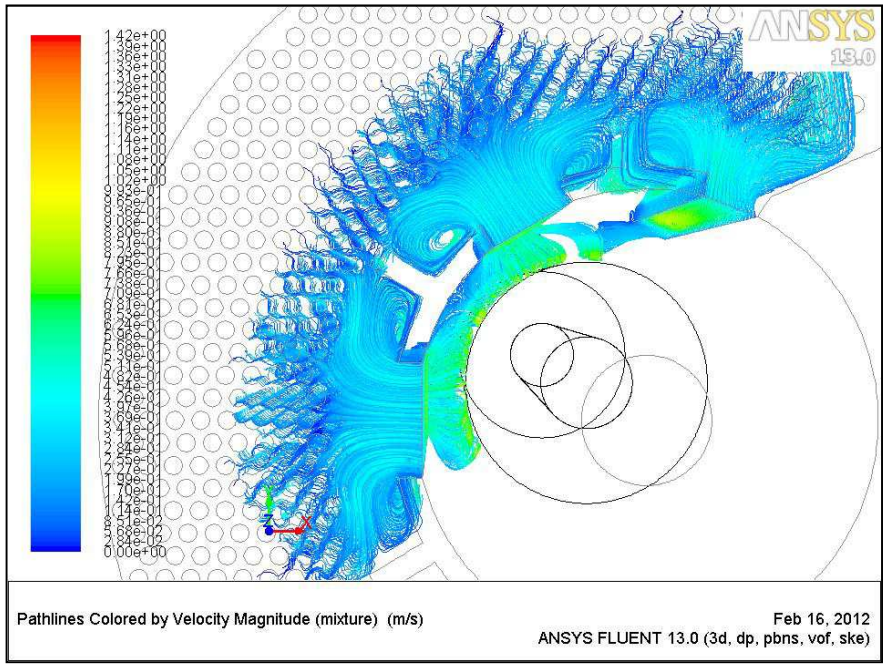
	Status of knowledge/ development	*Feasibility confirmation*	*Performance confirmation & code qualification*
Bayonet tube SG	Medium	P-(f)s	P-(f)s
Dip coolers of DHR System	High	Available	Ongoing-s
SGTR mitigation devices	medium	TBP-s	TBP-s
	TBP = To Be Planned **P = Proposed** **fs = full scale (with respect to Demo design)** **s = scaled (with respect to Demo design)**		

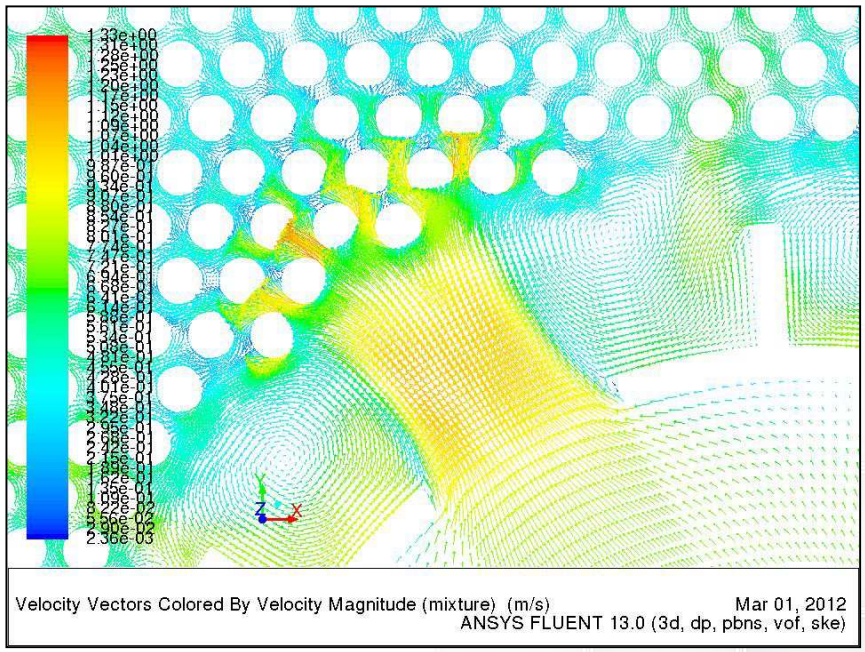
Open Issues

LEADER Design Issue: SG C-shaped tube bundle

Flow maldistribution

gas entrainment due to free level

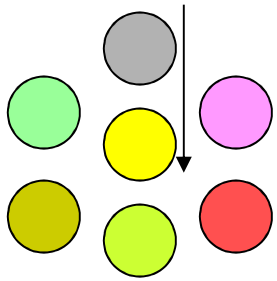




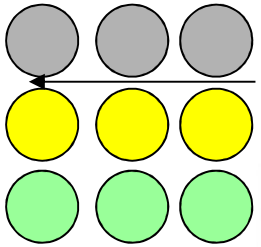
Open Issues

Feature for mitigation of the SGTR accident

- **Double Wall Monitored tubes**
- **"Wastage" Effect not mitigated**
- **Feed water and steam collectors outside the reactor vessel.**
- **Feed water tubes with Venturi nozzle and steam tubes with check valve for leak-flow limitation.**
- **Feed water and steam loops depressurized and isolated.**
- **Reactor cover gas plenum depressurized by rupture discs in ducts connected to the Above-Reactor Enclosure.**
- **Steam Trapping and migration through the core**
- **The tube bundle is deeply positioned in the reactor vessel. In case of SGTR steam is released far from the lead free level increasing lead displacement, with downward steam jet.**

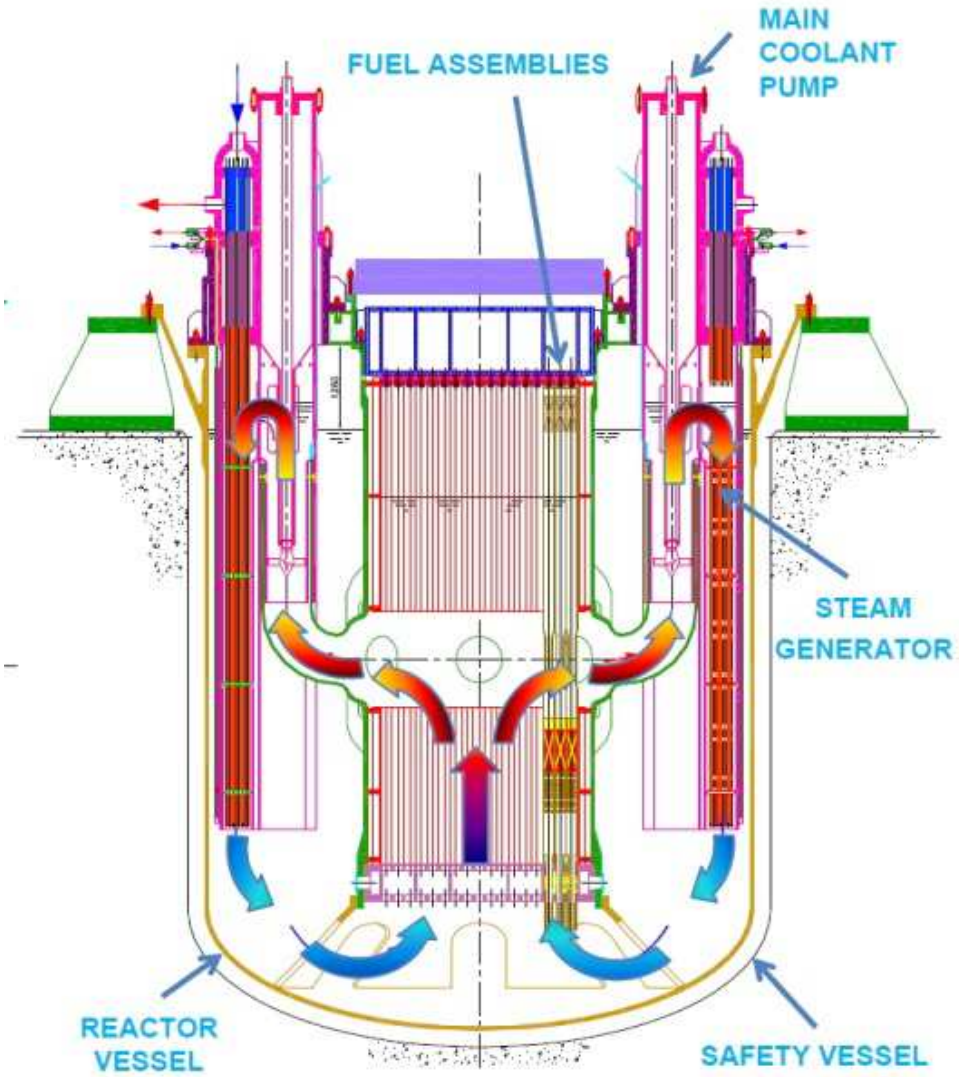


Each tube is surrounded by six other tubes in the helical and bayonet tube SG



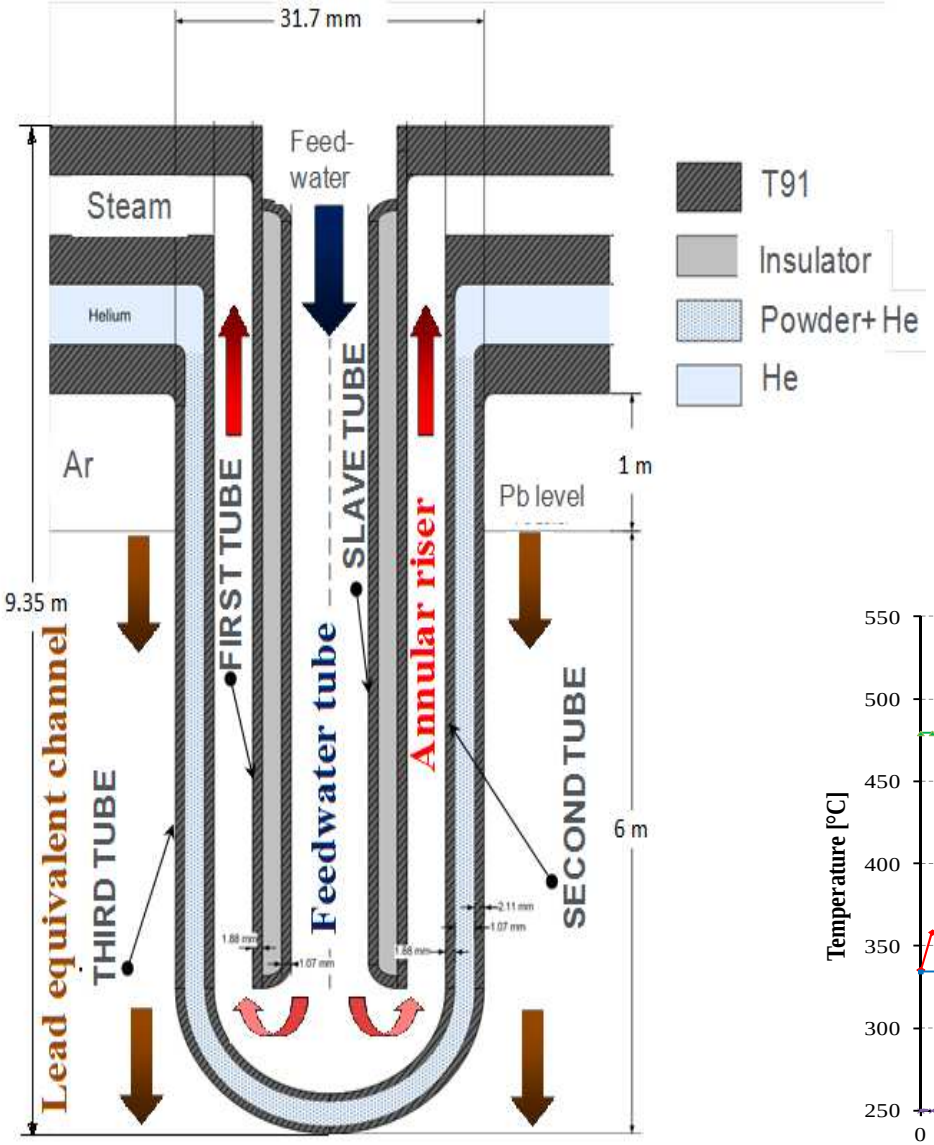
Each tube is surrounded by two other tubes in the spiral tube SG. (reduced risk of fast wastage propagation)

Open Issues



- Pool lead above SG outlet do not participate at the main circulation flow path.
  - → Thermal Stratification in the downcomer
  - → Coolant chemistry issue (lead is semi-stagnant)
  - → Needs to cool RPV (Lead is hotter due to heat losses)
- SG layout strongly impacts on the RPV dimension (height!!)
- Pump integrated with the SG, placed in the hot leg, is shorter with no bearings in lead.
- Core feed by difference in level between cold collector and hot collector (higher pump inertia during PLOF+PLOH)

DWBT ALFRED

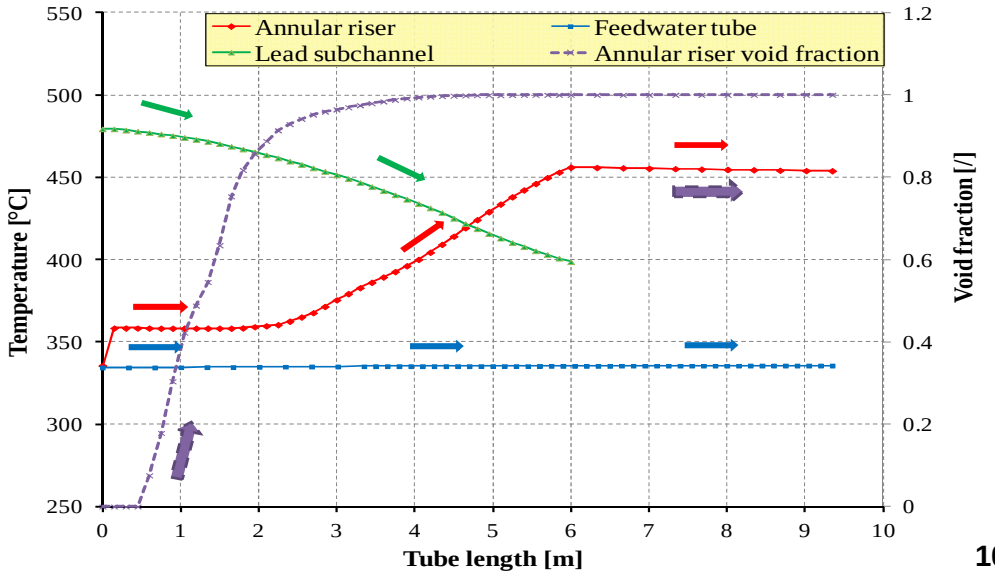


Assessment of the SGBT by RELAP-5

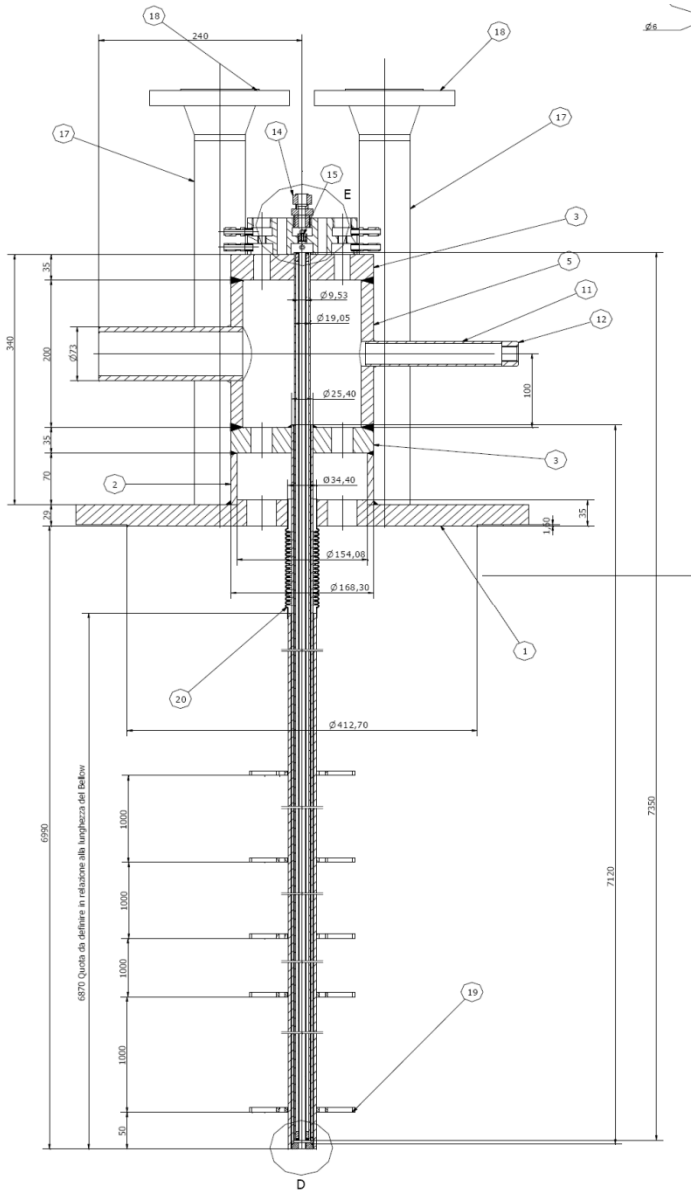
The maximum steam temperature is predicted in the range 438-456 °C depending on the diamond conductivity.

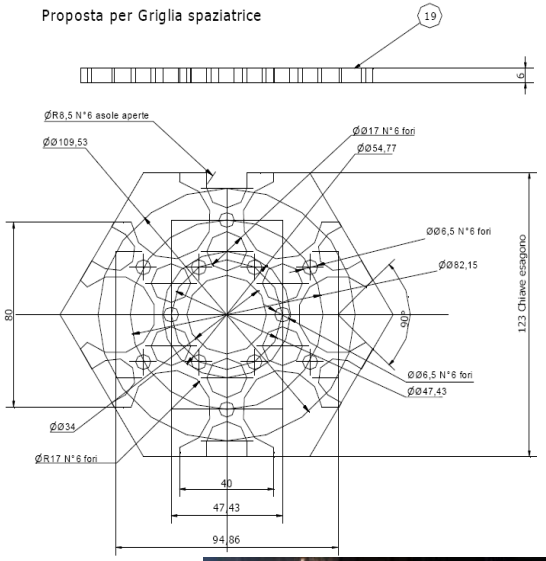
Superheated steam is always predicted, a void fraction close to 1.0 is reached within the first 3 m of the annular riser.

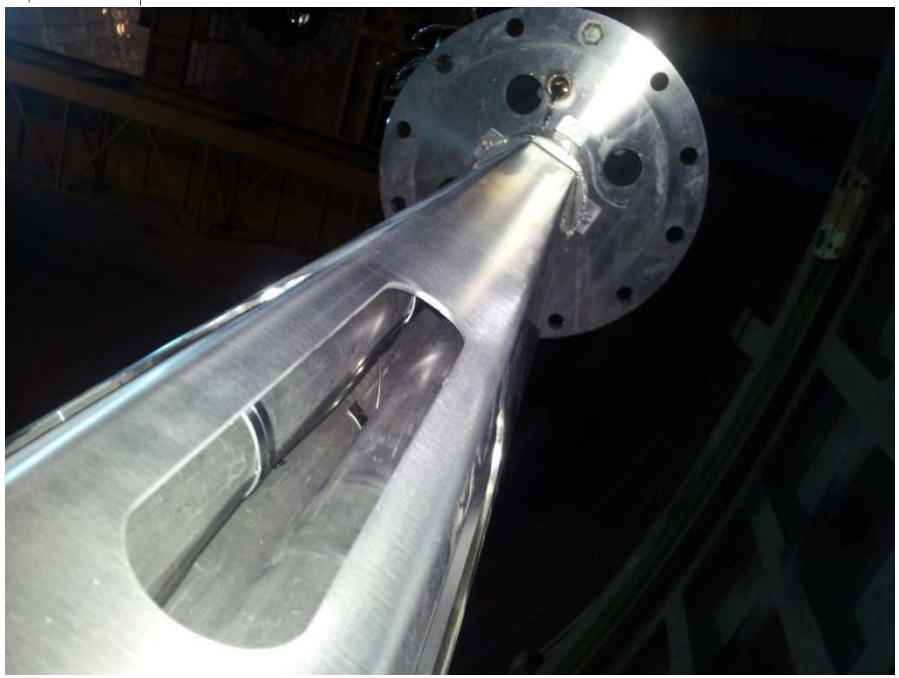
The lead temperature drop is about 80 °C.



DWBT ALFRED


240
Ø6
E
Ø9,53
Ø19,05
Ø25,40
Ø34,40
Ø154,00
Ø168,30
Ø412,70
340
200
Ø73
100
140
6990
6870 Quota da definire in relazione alla lunghezza del Below
1000
7120
7350
50
D


Proposta per Griglia spaziatrice
6
ØR8,5 N°6 asole aperte
ØØ109,53
ØØ17 N°6 fori
ØØ54,77
ØØ6,5 N°6 fori
ØØ82,15
90°
123 Chiave esagono
80
ØØ6,5 N°6 fori
ØØ47,43
ØØ34
ØR17 N°6 fori
40
47,43
94,86



REMARKS

- ☑ Innovative design solutions have to be adopted to exploit favorable properties of lead and overcome most of the unfavorable properties (i.e. SG in the primary system)
- ☑ Simple internals have to be used (to be all removable)
- ☑ The primary system design would improve compactness (m^3/MWe<2)