

Experimental program with Hot FLIBE Zone at LR-0 reactor

(Invitation to continue in bilateral collaboration in the development of
MSR/FHR technology)

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R&D on Molten Salt Reactor technology

The technology of Molten Salt Reactor system has been studied and experimentally developed in the Czech Republic from 2000. The program has been solved by a consortium of Czech research institution and industrial companies.

Right from the start, the R&D activities included a significant experimental program.

Main aims of the program have been following:

- To appropriately contribute to the knowledge of MSR reactor physics, core design and safety, structural material development and to the technology of Th – U fuel cycle.
- To focus on R&D of technologies applicable within the MSR on-line reprocessing of liquid fuel.
- To verify experimentally selected important areas of MSR technology and to solve existing bottlenecks.



MoU – The platform for collaboration with ORNL

The international scientific contacts have been an important part of our program. Collaboration with the United States is one of the most important for us.

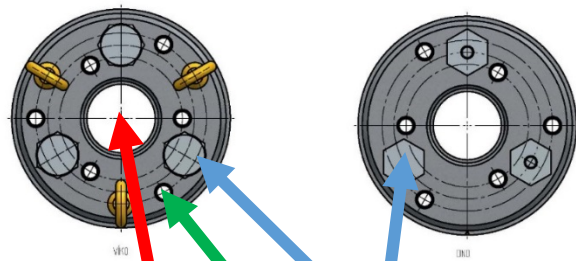
In 2012, Memorandum of Understanding about the collaborative R&D on Molten Salt Reactor and Fluoride-salt-cooled High-temperature Reactor systems was concluded between the Ministry of Industry and Trade (MPO) and US – Department of Energy.

Under this MoU, in 2013, ORNL provided ÚJV Řež and CV Řež about 75 kg of FLIBE salt containing highly pure Li-7 isotope for collaborative experimental program realized at LR-0 reactor of CV Řež (Research Centre Řež).



Previous „cold“ FLIBE inserted zone

Inserted zone for Li-7 FLIBE neutronics measurement at room temperature

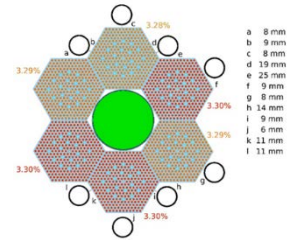
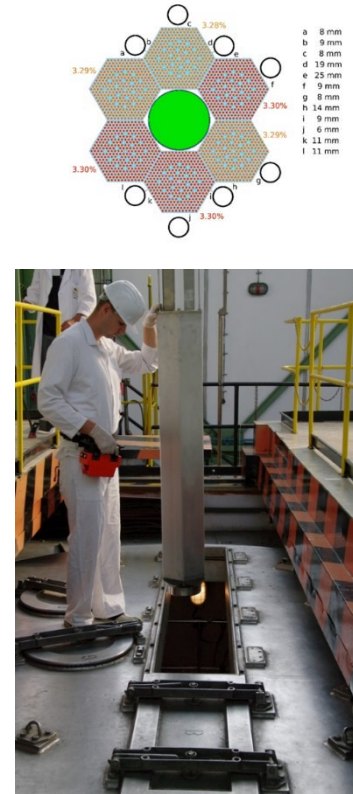
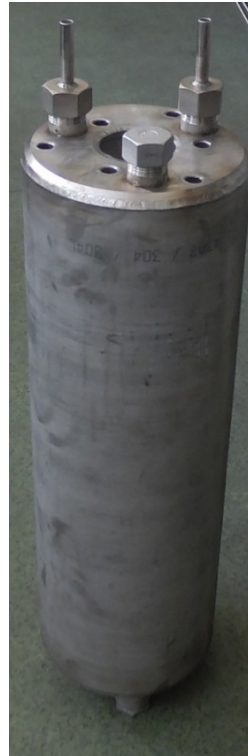


mouths

Filling / emptying

Slot for fuel pin

Slot for neutron spectrum measurement (recoiled proton method)



Measurements with FLIBE showed perfect agreement in neutron spectrum, the results of k_{eff} are influenced by content of ${}^6\text{Li}$ residuum in supplied salt.

R&D of MSR/FHR neutronics realized under the MoU

- The first group of experiments with “Cold Inserted FLIBE Zone” was realized in 2014, 2015 and 2016 and was successfully finished and commonly evaluated by experts from CV Řež and ORNL.
- Laboratory reports (CV Řež and ORNL) , joint journal articles and joint conference presentations were written and presented in following years



In addition to collaboration with ORNL, we opened the informal scientific contacts with other US organizations and companies involved in MSR/FHR R&D: Kairos Power, Flibe Energy, UCB, Georgia Tech., MIT, Univ. of Wisconsin Madison, PNNL ...

Current status of Czech R&D in MSR technology

A new domestic MSR/FHR project is under realization from 2017.

Project is granted by the Technological Agency of the Czech Republic and supervised by the Ministry of Industry and Trade. The planned collaboration with US partners is an integral part of the project.

The project covers:

- **Reactor physics and neutronics of MSR/FHR**
- MSR fuel cycle including the liquid fuel processing
- Material research and development of components for MSR and/or FHR

The project is solved by a consortium of Czech institutions and companies under the leadership of CV Řež.

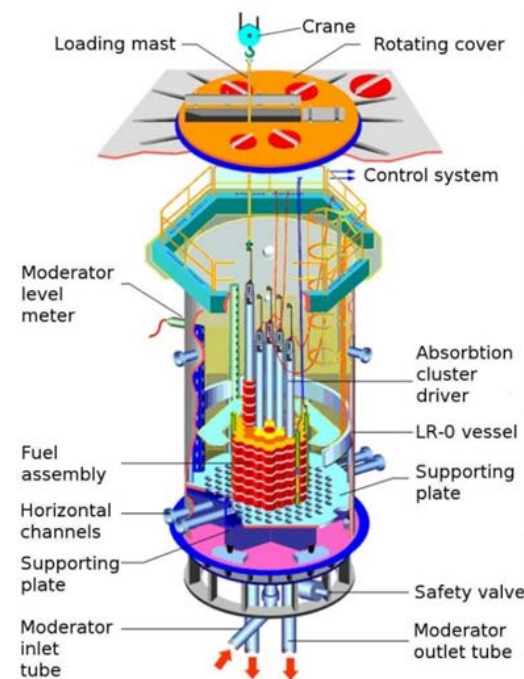


Results achieved in MSR physics and salt neutronics

After the measurement of neutron spectra in graphite, FLiNa and FLiBe, the effort was focused on the evaluation of neutronic characteristics of FLiBe (Li-7) and fluorine.

- Till now, the measurement was realized for inserted zones with FLIBE and Teflon – influences on multiplication factor
- Also the fission rate indexes of ^{235}U and ^{238}U in FLIBE were measured and evaluated
- The new heated inserted FLIBE zone (for the measurement at the temperature range 500 – 750 °C) is under development

The experiments have been done at LR-0 reactor



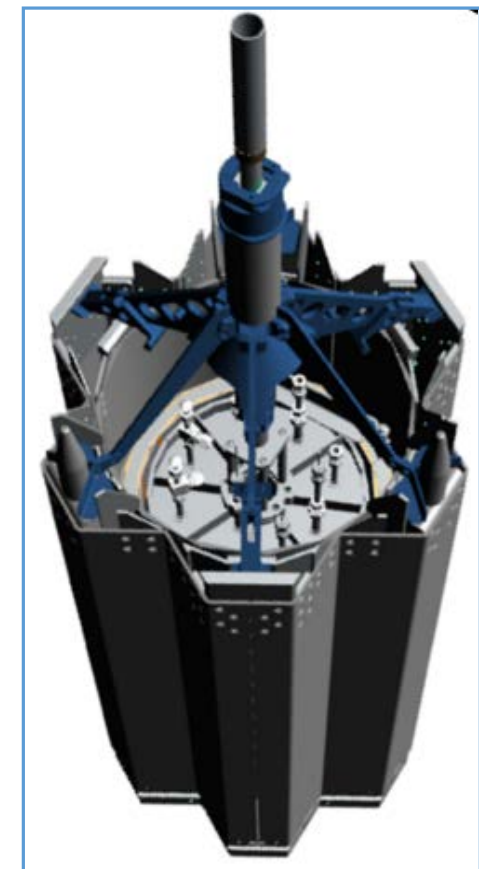
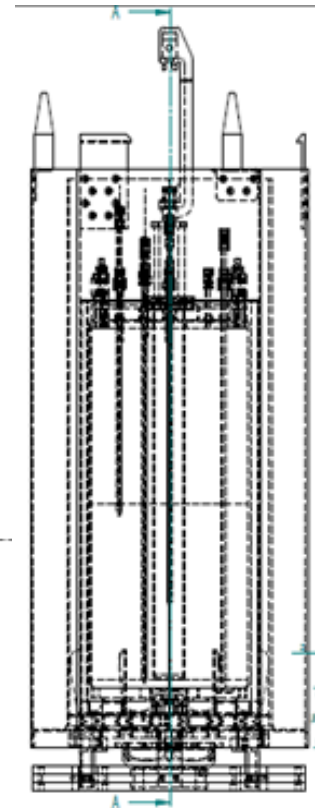
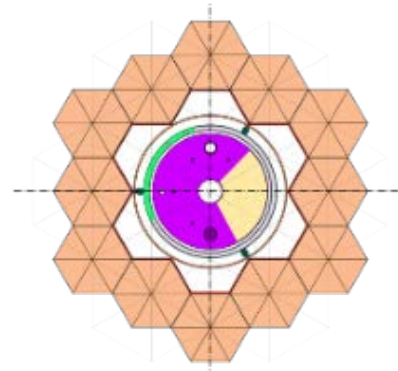
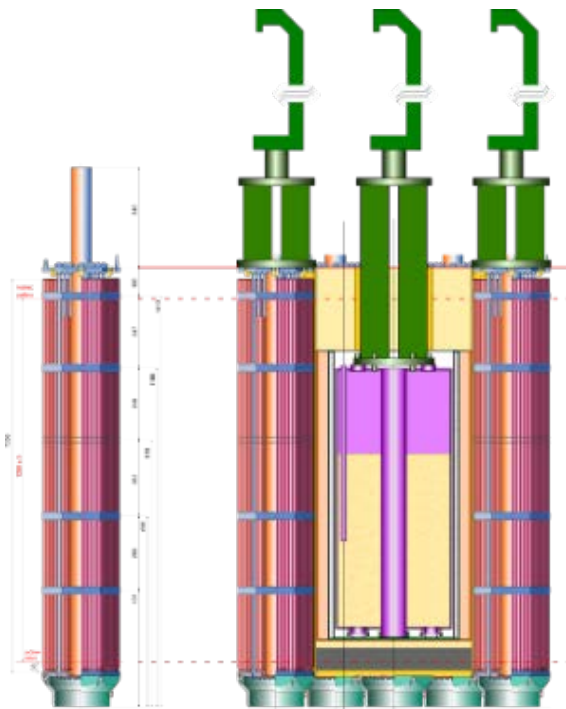
Losa, E., Košťál, M., Juříček, V.; Neutronic tests of fluoride salt based MSR/FHR coolants; Transactions of the American Nuclear Society; 2017; 116, pp. 1167-1169

Košťál M., Rypar V., Milčák, J., Study of graphite reactivity worth on well-defined cores assembled on LR-0 reactor; Annals of Nuclear Energy; 2016; 87, p. 601

Košťál, M., Veškna, M., Cvachovec, Forget, B., Harper, S.: Comparison of fast neutron spectra in graphite and FLiNa salt inserted in well-defined core assembled in LR-0 reactor, Annals of Nuclear Energy 83, pp. 216-225, 2015

Present R&D of MSR/FHR neutronics which arise from MoU

- Now, the second series of experiments with FLIBE is under preparation with new “hot” inserted zone at LR-0 reactor. The experiments are focused on MSR/FHR neutronics measurement at the working temperatures of MSR systems (500 – 750 °C).
- The aim is to determine the feedback temperature reactivity coefficients at the working temperature of MSR or FHR (500 – 750 °C)



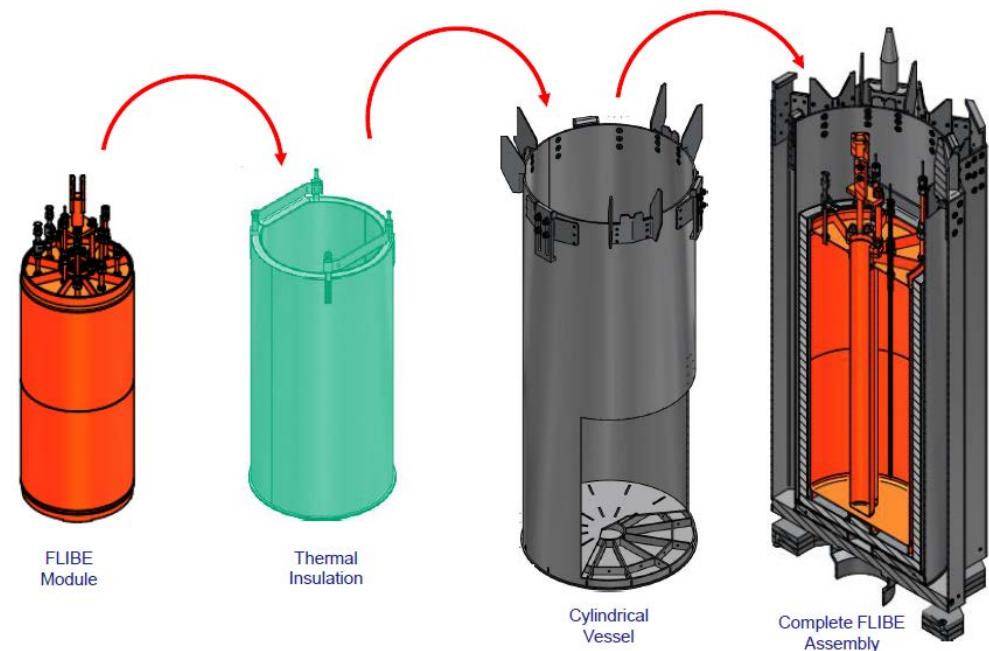
Experimental program for FLIBE neutronics prepared for 2021 - 22

Today the main effort is focused on the preparation of “hot” FLIBE zone which could enable to realize the neutronics experiments at the temperature range of 500 – 750 °C (working temperature range of MSR and FHRs).

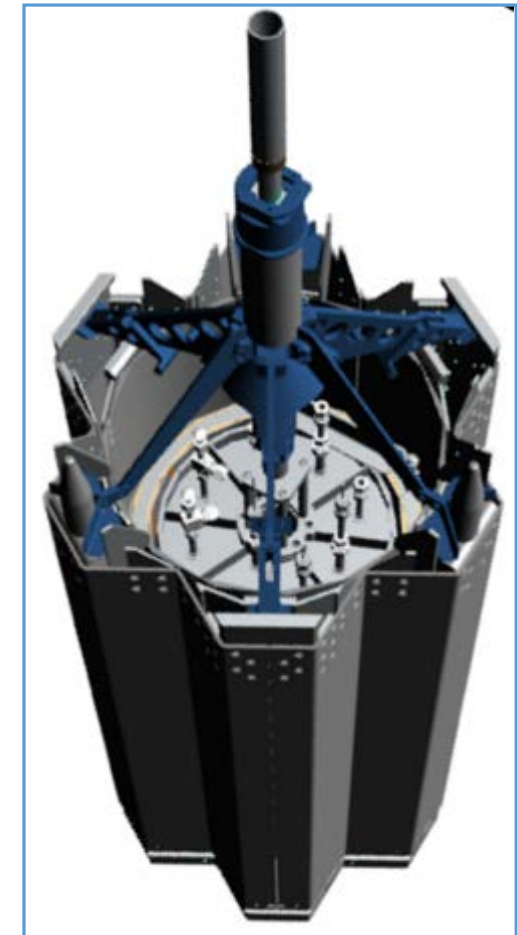
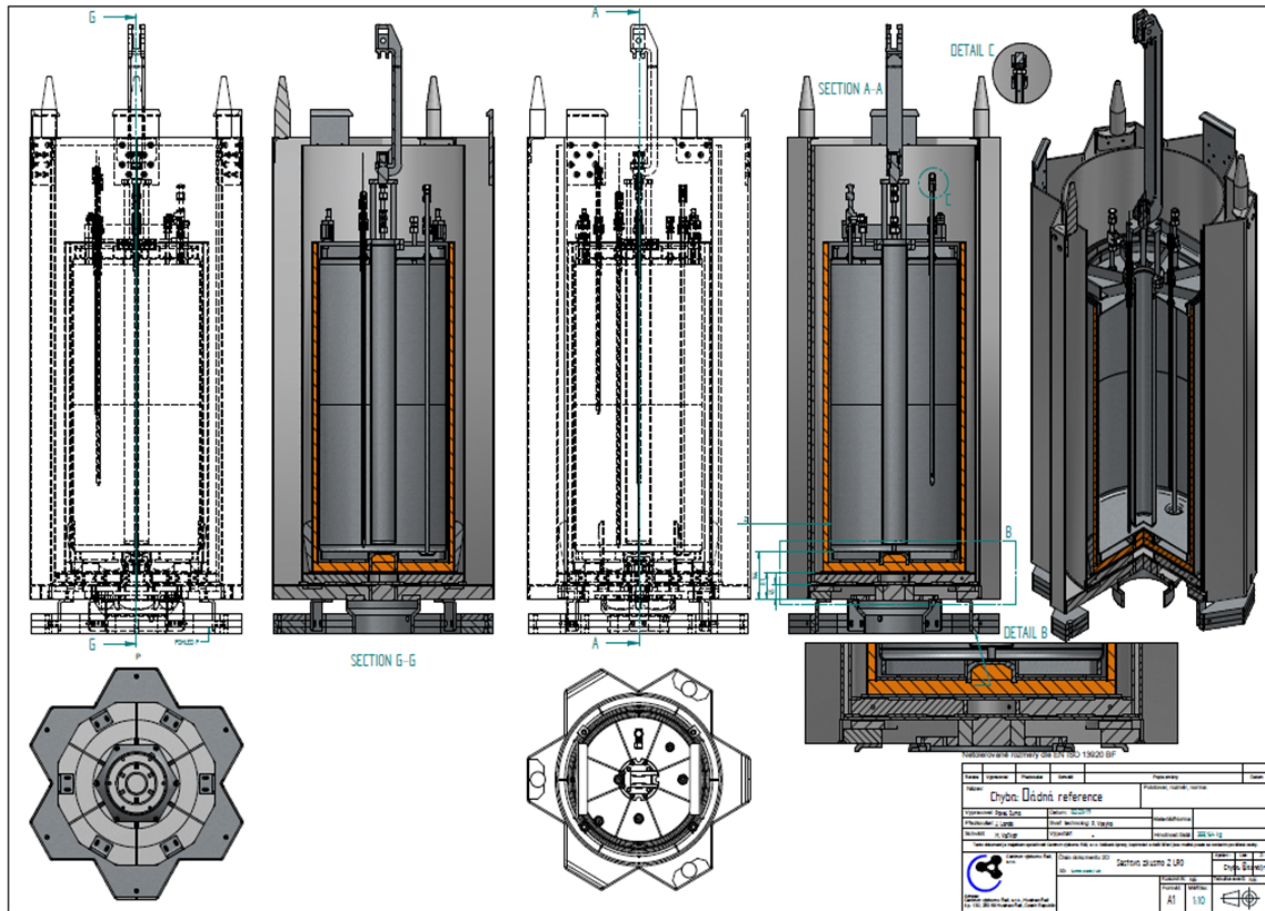
The way to perform the experiments will be following (after filling the container by FLIBE):

1. Preheating of the new FLIBE container in the oven outside the reactor to about 800 °C (Container is designed for about 70 kg of FLIBE)
2. Insertion of the container of the vessel into the experimental channel (the experimental channel takes up the space of seven VVER fuel assemblies into insulation vessel
3. Insertion) and connecting with the necessary instrumentation
4. Insertion of the experimental channel into the central part of LR-0 reactor
5. Pumping the water into reactor to reach the criticality

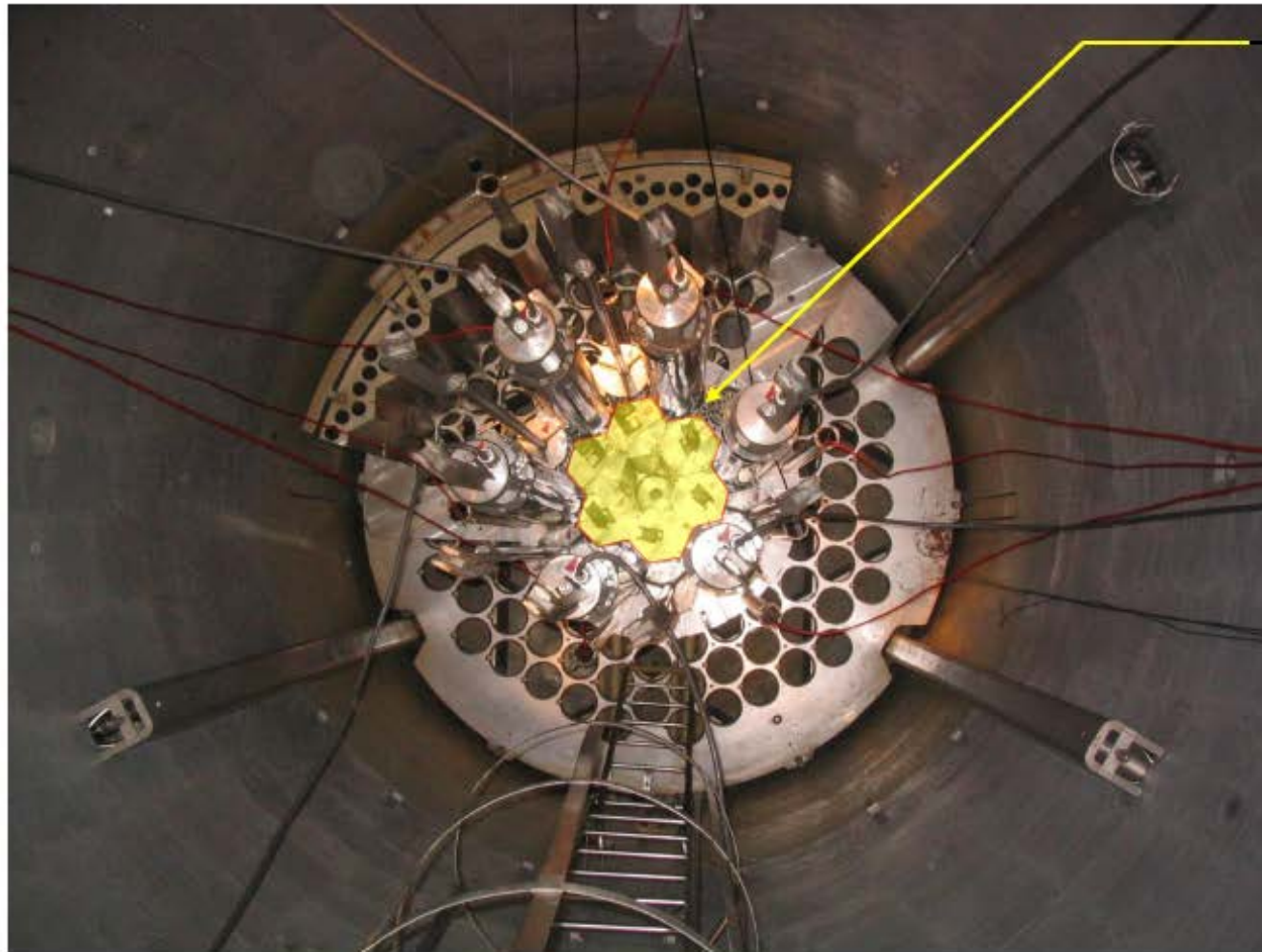
The series of measurement will be done at several temperatures reached by gradual cool down of the salt in the container in LR-0. Typical time for individual experiment will be about 2 – 4 hours.



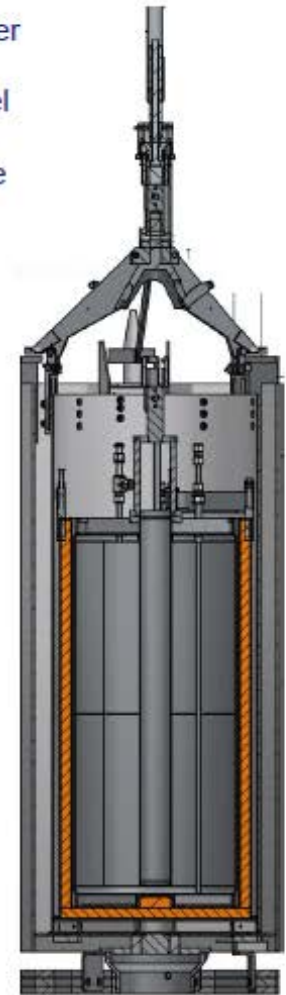
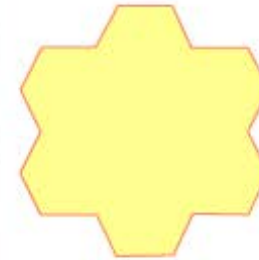
Assembly of the hot inserted FLIBE zone for LR-0



Position of the zone in LR-0 reactor



Placement of outer water-proof polyhedron vessel for FLIBE modul into the LR-0 core ~ 7FA



Complete module for insertion to the reactor core

All main components were manufactured and will be finally now tested

The complete “Hot Inserted Zone” and the whole experimental test program with new zone is now under the approval process of the State Office for Nuclear Safety.



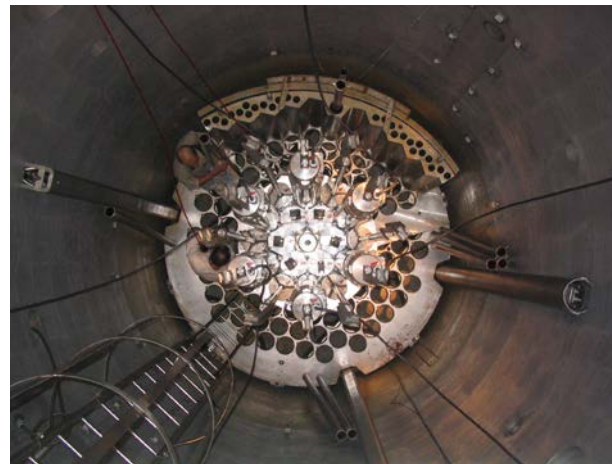
Conclusion

The program is running at LR-0 experimental reactor - FLIBE zone should take up the central part of the reactor core instead 7 fuel assemblies and is enclosed by standard VVER fuel, which serves as a neutron driver.

All apparatuses of “Hot FLIBE Zone” were already manufactured and the „cold“ experiments with the Zone just started.

The launch of actual „hot“ experiments are planned for the next year.

We would like to invite our ORNL colleagues again to participate in the experiments and their evaluation!





Thank you for your attention

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