ENEEP Member: Budapest University of Technology and Economics

Synthesis of implementation workflow and conditions for novel activities

February 2024

Contents

1. Administrative procedure

1.1. Submission of proposals for use

Proposals for use – according to internal regulation No NTI-SZ-30 (Regulation for external experimental activities) – must be submitted in writing to the Director of the Institute on the Proposal for Use form, shown in Figure 1, and include all parameters of the requested access that affect feasibility and a description of the scientific excellence of the proposal. The technical parameters of the research infrastructures that can be used.

1.2. Consideration of use proposals

Proposals for use are evaluated by the director of the institute with the help of the internal staff of the BME NTI, in accordance with the internal regulations of the BME NTI. If there is a need for external user capacity of the research infrastructure, which is adequate in terms of feasibility, the director of the institute shall set up a committee of independent reviewers to assess the proposals in terms of scientific excellence. If the proposal is accepted, the Director of the Institute appoints a supervisor for the experiment from the staff of BME NTI.

During the publication of the research results obtained using the research infrastructure operated by the BME NTI, the research infrastructure used must be named.

1.3. Permission to use the reactor or radiation sources

In the BME NTI every experiment which uses the reactor or any radiation source has to be approved by the reactor manager, the safety engineer and the director. The appointed supervisor will fill out the form needed to start the experiment (Figure 2) and start the approval procedure according to internal regulations. The supervisor submits the form through the official channels in written form and the experiment can be carried out after all the responsible persons have approved the experiment.

Proposal for Use of the infrastructure of BME NTI
Date of the proposal:
Name of the proposer (individual or institution):
Address of the proposer:
Name of the proposal:
Experimental devices to be used:
Reactor time needed:
Purpose of the use (experiment, thesis, applied sciences, etc.):
Short description:
Short description of the expected results:

Figure 1: Proposal for Use form.

BME INSTITUTE OF NUCLEAR TECHNIQUES	**Experiement request form**	No: / 2024.	
Name of the experiment:			
Name of the user:		Institution/workplace:	
Type of the experiemt	One time ☐ standard ☐		
Radiation source (reactor/other):			
Experiemntal devices used:			
Reactor power:			
Short description of the experiment:			
Supervisor from the institute:			
participants:	☐ supervisor ☐ students ☐ other		
ID of the safety analysis:			
Start date of experiment:		Est. duration:	
End date of experiment:			
Note:			
supervisor	**reactor manager**	**safety engineer**	**director**
Date:	Date:	Date:	Date:

Figure 2: Experiment request form.

2. Description of the Training Reactor and the connected experimental devices

The reactor block, shown in Figure 3, consists of two main parts. A cylindrical reactor vessel is located in the center of a large block of concrete. The vessel is approximately 6 m high and its diameter is 1.4 m. The reactor core is situated at the bottom of the vessel so that there is a water layer of a height of nearly 5 m ensuring radiation protection in vertical direction. The horizontal shielding is provided by the concrete. The thickness of the cylindrical concrete shield is 2 m. In the vicinity of the core, the shield is 1 m heavy concrete (barite) 1 m ordinary concrete.

The main purpose of the reactor is to support education in nuclear engineering and physics; however, extensive research work is carried out as well. Neutron irradiation can be performed using 20 vertical irradiation channels (Figure 4), 5 horizontal beam tubes, two pneumatic rabbit systems and a large irradiation tunnel (Figures 5 and 6).

The reactor core is made up of 24 pieces of EK-10 type fuel assemblies, which altogether contain 369 fuel rods (Figures 6 and 7). The fuel is 10 %-enriched uranium dioxide in magnesium matrix. The pellets are filled into aluminum cladding at a length of 50 cm. The total mass of uranium in the core is approximately 29.5 kg. The horizontal reflector is made of graphite and water, while in vertical direction water is used as reflector. The highest thermal neutron flux in the reactor core is $2.7 \cdot 10^{12}$ n/cm^{2}s, measured in one of the vertical channels.

Five measuring channels are applied for reactivity control and power regulation. The detectors are ex-core ionization chambers, two of which operate in pulse mode in the startup range, two operate in current mode and one is used for power regulation. In all power ranges period and level protection signals can invoke automatic scram operations. The reactor is operated when required for a student laboratory exercise or a research experiment. Accordingly, operation at 100 kW power for many hours is quite rare; on the average, it occurs once a month.

The reactor is used, among others, in the following fields:

- activation analysis for radiochemistry and archeological research,
- analysis of environmental samples,
- determination of uranium content of rock samples,
- nuclear instrument development and testing,
- experiments in reactor physics and thermal hydraulics,
- development and testing of neutron tomographic methods for safeguards purposes,
- development of noise diagnostic methods, isotope production and investigation of radiation damage to instruments/equipment.

A very high degree of safety is ensured by the application of passive safety systems. The safety control rods are suspended on electromagnets and move in air-filled vertical tubes. In case of a shutdown signal, all four safety and control rods are dropped automatically into the reactor core and thus shut down the reactor immediately.

As a consequence, burnup is very low: only about 0.8 % of the ^{235}U has been used up and 3.4 g ^{239}Pu and 12.3 g fission products have accumulated. Therefore, there has been no need to replace any of the fuel assemblies since 1971.

The most important characteristics of the neutron field in the reactor are shown in Table 1.

Table 1: Neutron flux-densities and γ dose-rates at 100 kW power.

Irradiation position	$\Phi_{thermal}$ [cm^{-2}s^{-1}] (E < 0.5 eV)	Φ_{fast} [cm^{-2}s^{-1}] (E < 1 MeV)	D_γ [Gy/h]
D5 core position (Vertical channel)	$2.7 \cdot 10^{12} \pm 4\%$	$1.82 \cdot 10^{12} \pm 10\%$	
G5 core position (Vertical channel)	$2.5 \cdot 10^{12} \pm 4\%$	$5.54 \cdot 10^{11} \pm 10\%$	
D9 core position (Vertical channel)	$1.07 \cdot 10^{12} \pm 4\%$		
No. 4. horizontal channel	$6.1 \cdot 10^{6} \pm 15\%$	$3.06 \cdot 10^{6} \pm 35\%$	
No. 5. horizontal channel	$1.5 \cdot 10^{7} \pm 6\%$	$2.24 \cdot 10^{6} \pm 10\%$	$0.312 \pm 15\%$
Irradiation tunnel (empty, inner surface)	$5.54 \cdot 10^{10} \pm 6\%$	$3.99 \cdot 10^{9} \pm 6\%$	$3300 \pm 20\%$

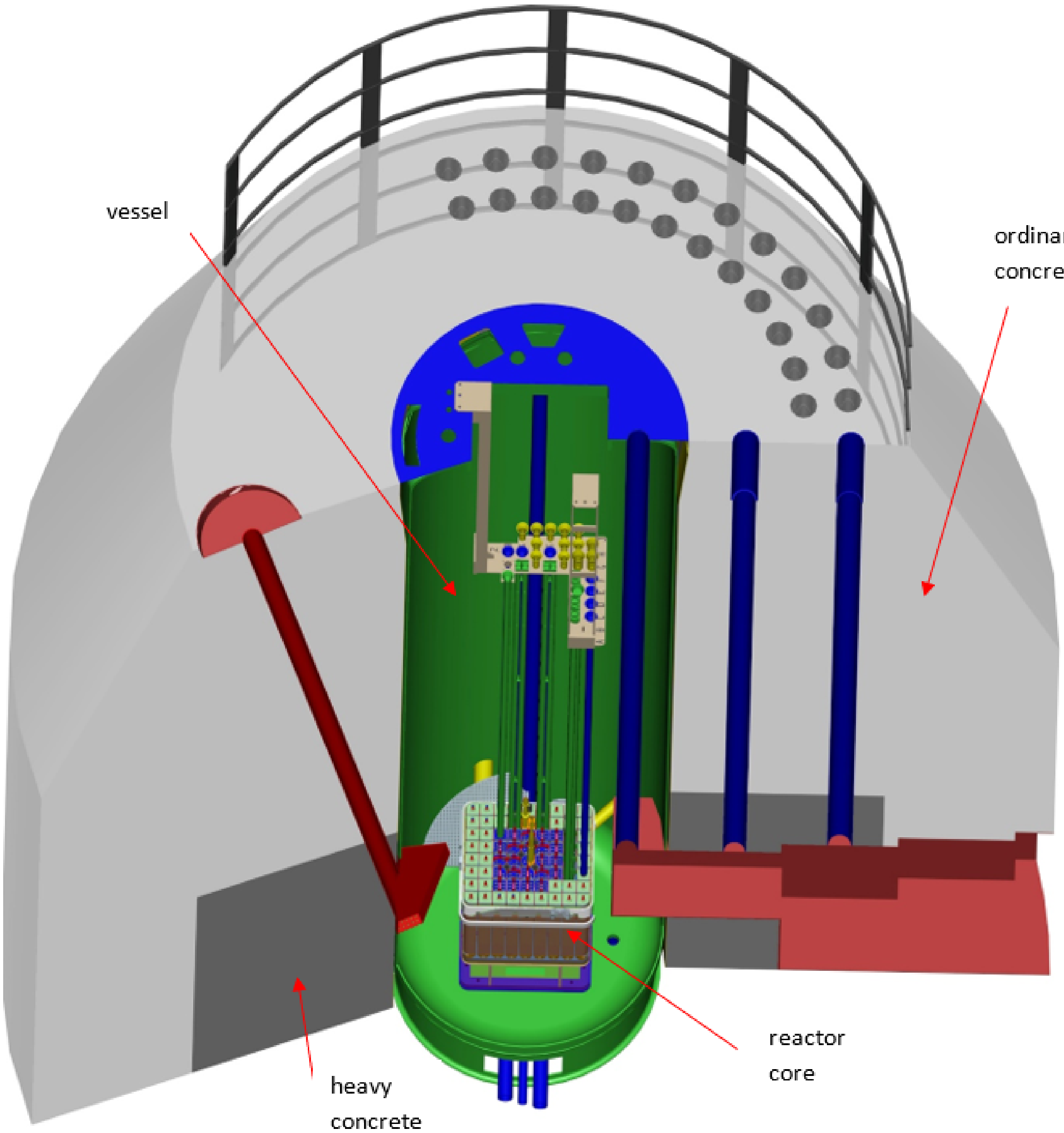

Figure 3: Overview of reactor block.

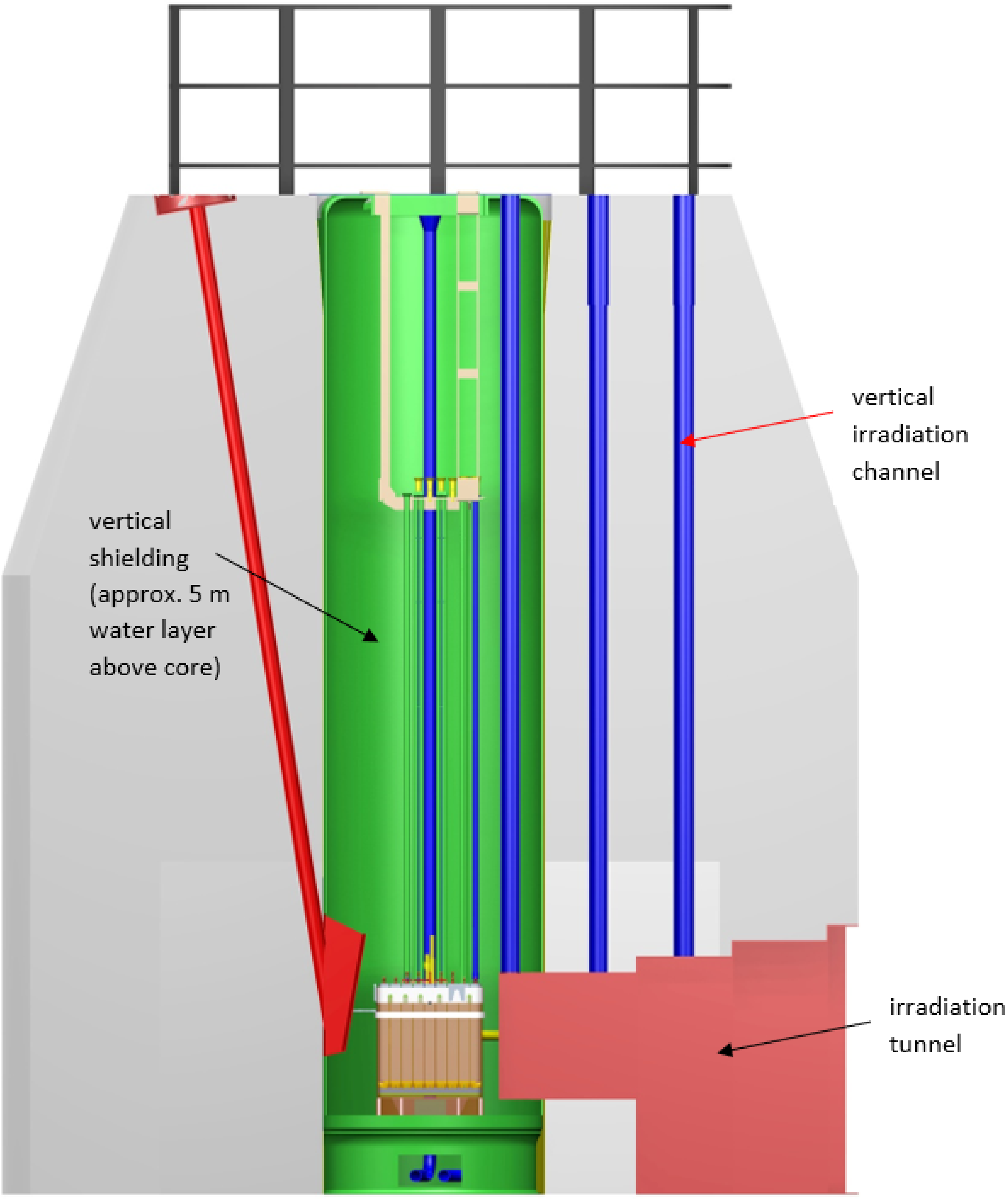

Figure 4: Vertical section of reactor block.

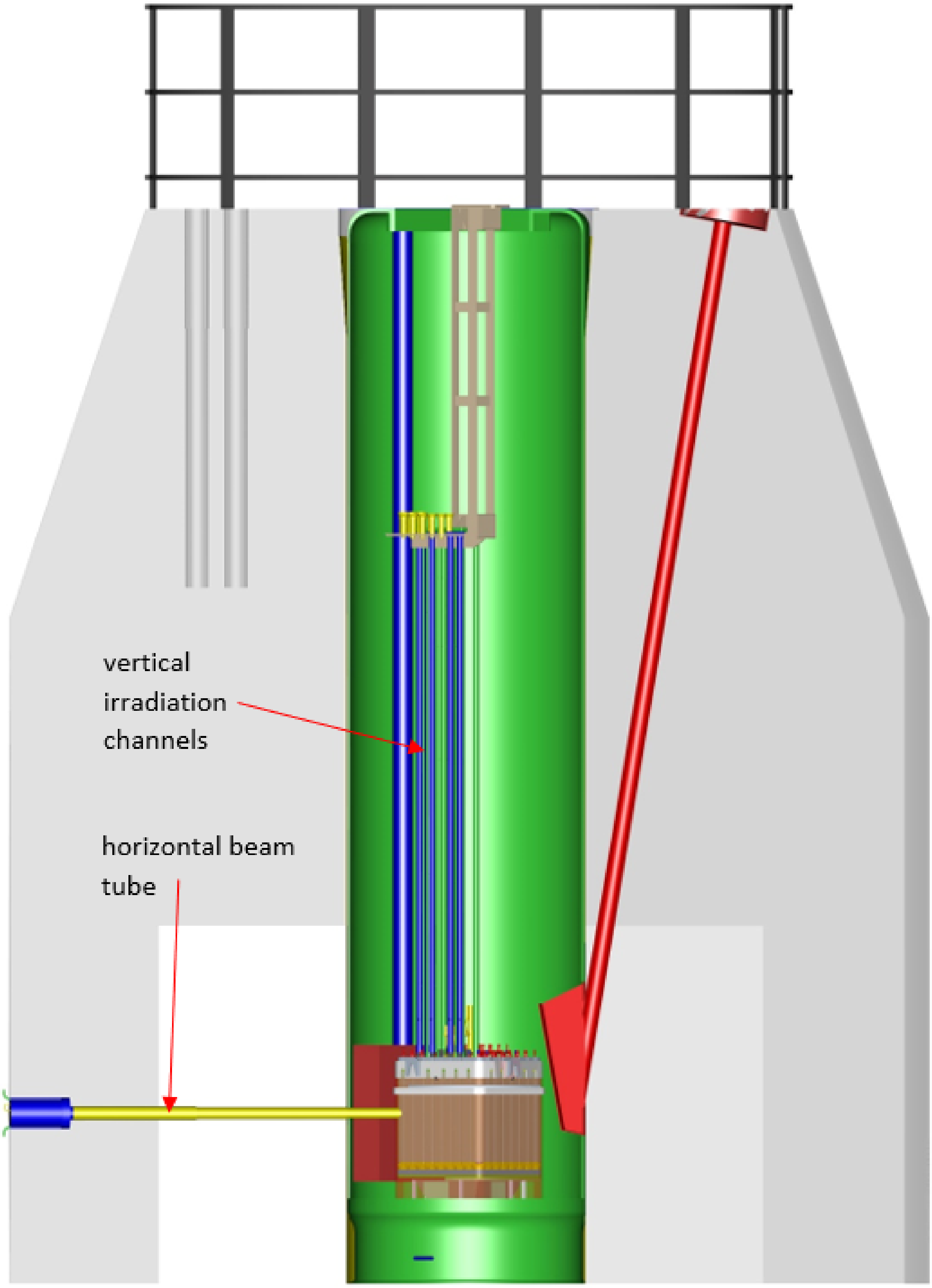

Figure 5: Vertical section of reactor block.

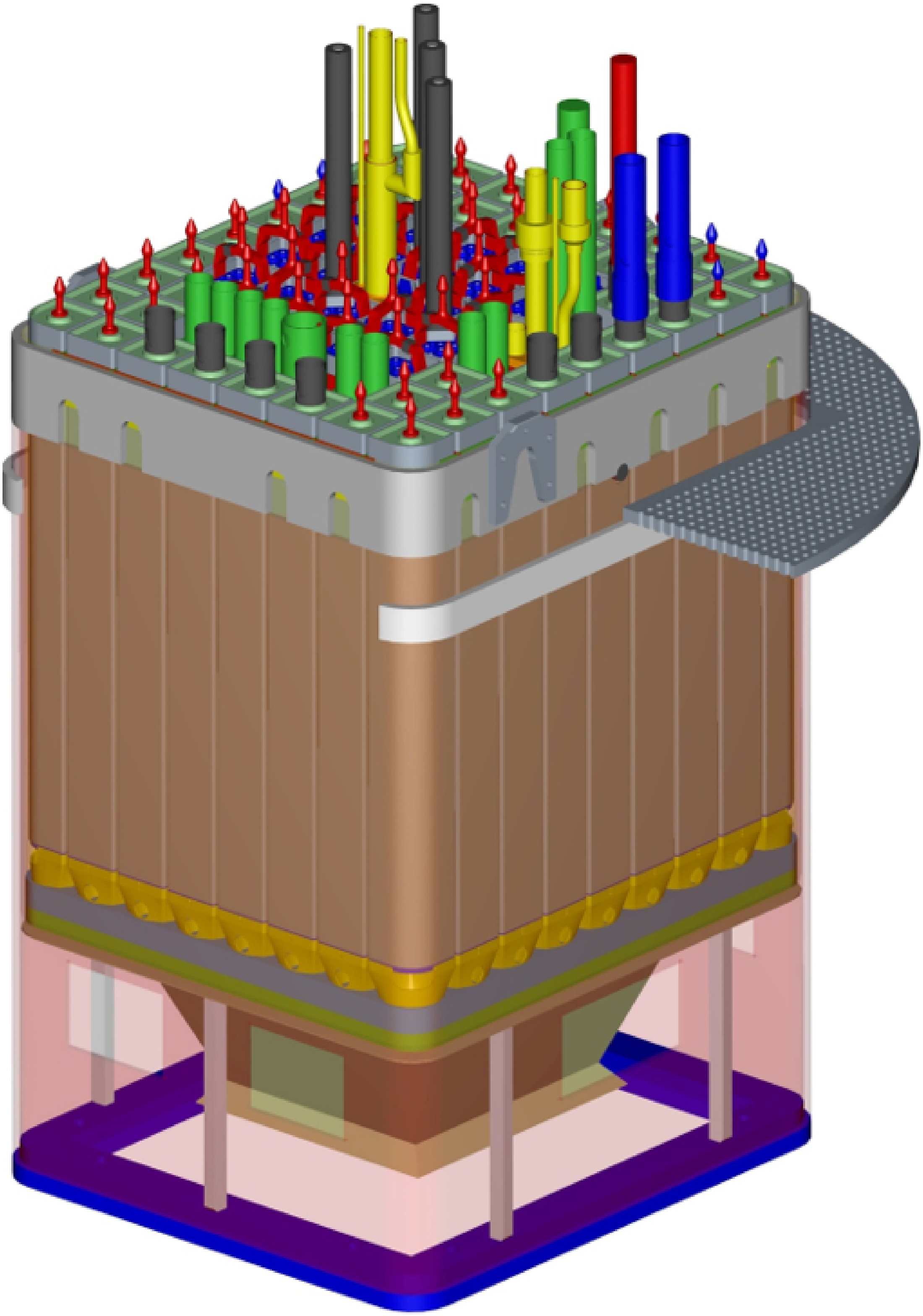

Figure 6: Overview of reactor core.

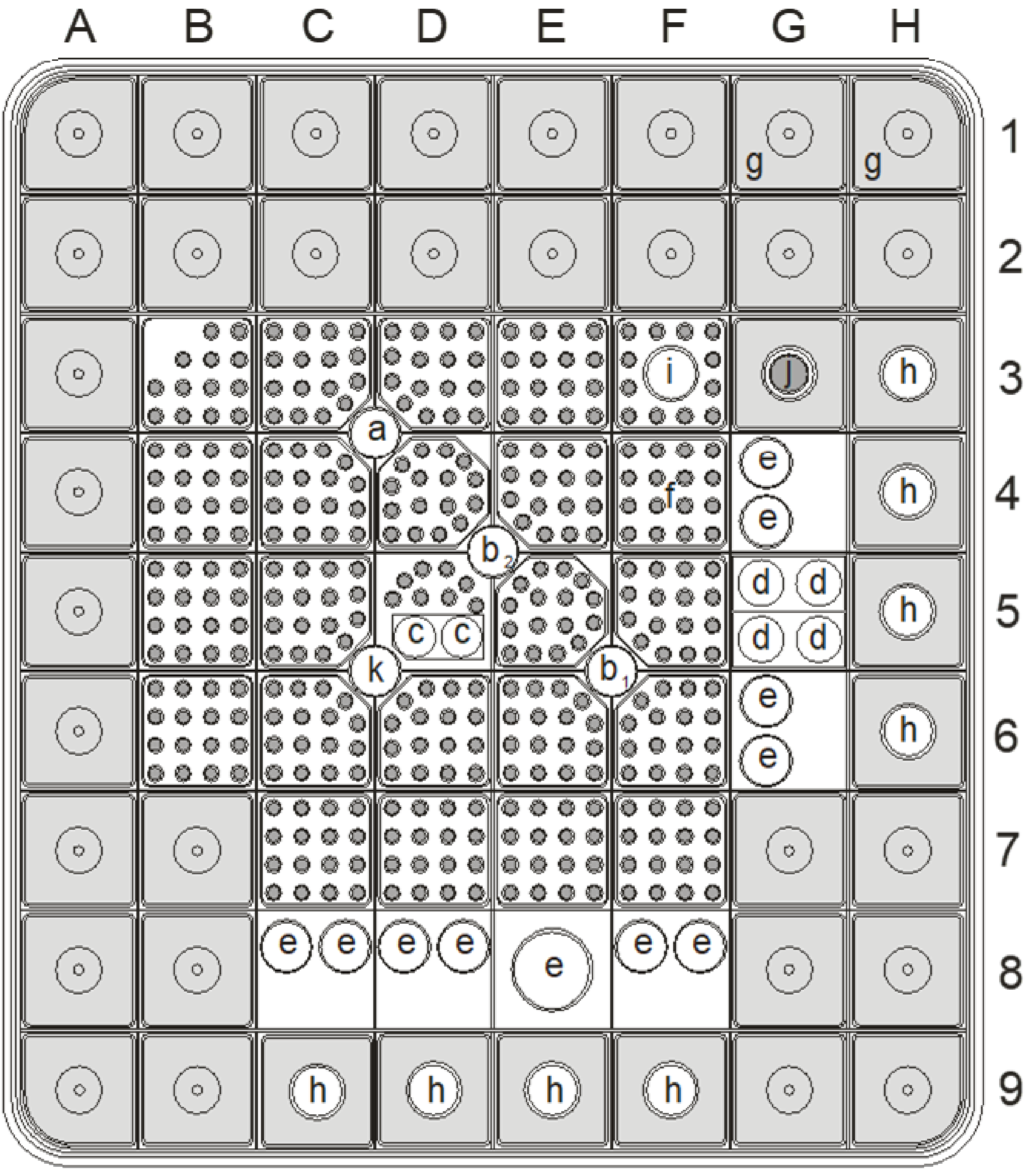

Figure 7: Horizontal section of reactor core (a – automatic control rod; b – safety rods; k – manual control rod; c, d – pneumatic rabbit system; e – vertical irradiation channels in the water reflector; h – vertical irradiation channels in the graphite reflector; i – vertical irradiation channels in a fuel assembly; j – startup neutron source; f – fuel assemblies).