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**Licensing process of a new fuel type element in Poland on an  
example of the experimental fuel element for samples  
irradiation in the fast neutron spectrum**

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**ABSTRACT**

Operating new type of nuclear fuel in the research reactor requires walking through the licensing process and obtaining the license from the national nuclear regulatory body. MARIA reactor currently have two types of fuel element in the routine element, but in the last months the third have obtained the license and will start operation in Q3 2022. The article reviews the licensing process, both from the perspective of the formal requirements, and measurements and calculations performer by the reactor's operational and engineering team. They include but are not limited to thermal-hydraulic, source term, reactivity, neutron spectrum calculation, and hydraulic and neutronic measurements. Recent completion of the fuel element licensing process means that the MARIA reactor's team is ready to repeat the process for the potential new fuel elements from new suppliers.

**1 Introduction**

The fuel is the key element connected to the research nuclear reactor operation. MARIA research reactor currently has the license to operate three types of fuel, all being LEU type in the shape of concentric tubes. Two of them: MC-5 and MR-6 are for the routine reactor operation, and third – MR-2 is designed for the irradiation within the fuel in the fast neutron spectrum.

To introduce the new type of fuel element, the modification of the license by the national regulatory body (PAA) is required. In Poland, the licensing process is task-oriented, meaning that the ultimate goal is to prove to the regulator that the modification in the reactor (i.e. new type of fuel element) is safe to operate. Usually, after the initial contact in the pre-licensing stage, during which it can be determined whether the regulator will require any special analyses, the safety report is developed and approved by the regulator in the iterative process. The whole process is briefly described in the next parts of the article. Additionally, MARIA research reactor details are provided for the technical clarity.

## 2 MARIA research reactor technical details.

MARIA is channels-in pool type research reactor. It operates since 1974, and since that date it went through several fuel conversions, from the initial uranium enrichment of 80% to the current LEU fuel <20%  $^{235}\text{U}$ . The newest fuel type – MR-2 is used in the core since the summer of 2022. Every fuel element is placed within individually-cooled fuel channel. All of the channels are immersed in the reactor pool. Reactor is cooled by light water, and moderated by beryllium and light water. Water flow through the individual fuel channel is within the range 25-30 m<sup>3</sup>/h and MARIA usually uses 20+ channels at the time. Cross section through the reactor and its installations can be seen in the figure 1. Figure 2 presents the cross section of the standard fuel element types.

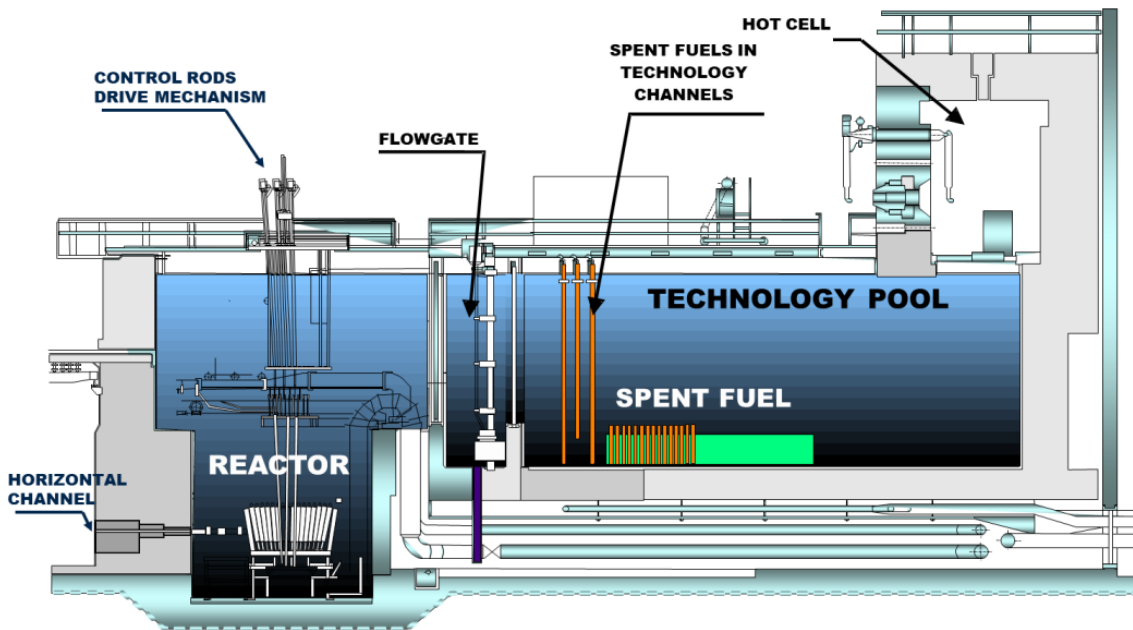


Figure 1: MARIA reactor cross section.

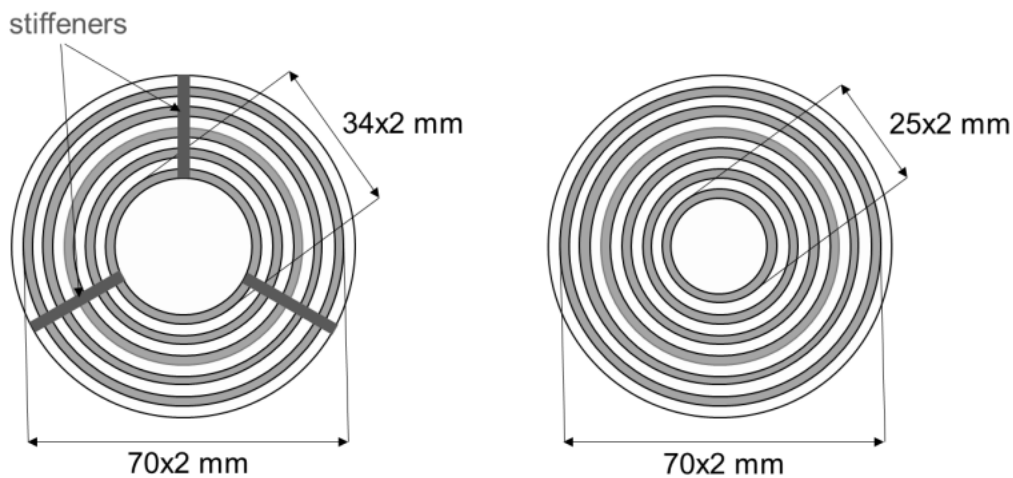


Figure 2: MC-5 (left) and MR-6 (right) fuel elements.

## 3 Pre-licensing and licensing process on an example of the newly-introduced MR-2 fuel element

As it has been mentioned before, the licensing process in Poland is task-oriented. As a result it has

been chosen to repeat the steps that has been taken during the period of the conversion to LEU fuel. That meant safety analyses gathered in the Safety Report Annex had to contain following analyses:

1. Thermal hydraulic simulations (both steady-state and transient)
2. Neutronic simulations
3. Reactivity simulations
4. Source term determination and atmospheric dispersion
5. Procedures connected to the fuel handling
6. Pressure drop test

As MR-2 was produced by the vendor, whose fuel was used in the reactor before, there was no need to perform vibrations measurement and perform mechanical calculations (e.g. by FEM). Additionally irradiation of two lead test assemblies was not required. However those steps will be needed if the new fuel were from the new vendor.

The preliminary version of the Safety Report Annex is presented to the internal safety commission (KBJ). Usually to make the licensing process smoother, its session is treated as the part of the pre-licensing process, and the representatives of the nuclear regulator are invited and they have the occasion to get acquainted with the Annex before its formal submission. KBJ is permitted to have comments to the annex. When the preliminary version of the annex is accepted, it is passed to the nuclear regulator.

Passing the draft version of the Annex starts the formal part of the licensing process. It has no determined schedule and is iterative. Usually there are several round of questions and answers connected with the changes to the analyses. For example their spectrum and physical conditions. The process ends when the regulator is convicted that the safety was proven. Figure 3 presents the time schedule connected with the licensing.

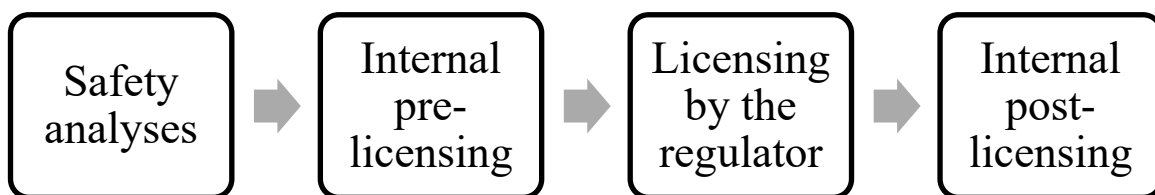


Figure 3: Licensing process

#### 4 Post-licensing fuel element examination

Post-licensing part of the process starts after the acceptance of the Annex to the Safety Report and modification of the Reactor Operation License by the nuclear regulator. Usually it contains following steps:

1. Irradiation of two lead test fuel assemblies (up to 60% burn-up) with online leaks monitoring
2. Visual examinations of the fuel element between the fuel cycles
3. Sipping tests

After their completion with the satisfactory results, the new fuel element type is considered ready for the routine operation in the MARIA reactor core.

For the MR-2 experimental type, those stages were partly omitted. It was irradiated in the reactor core in two dedicated fuel cycles to determine the fast reactor flux within its fuel tubes. Later this year it will be visually inspected and undergo sipping tests. After those stages the whole licensing process will be considered completed.

## **5 Summary**

The licensing process of the new fuel element type in Poland is quite straightforward. Its task-oriented procedure is friendly for the reactor operators. Three new fuel element types have been licensed in MARIA reactor in the years 2009-2022, together with additional four types of uranium LEU targets for Mo-99 production. As the operation of the MARIA reactor is planned to continue up to the year 2053, new fuel types, possibly with the higher neutronic parameters, will be needed in the future. The recent licensing of the MR-2 fuel element has proven that MARIA reactor team is ready for their introduction into the reactor operation.

## **6 Bibliography**

- [1] K. Pytel et al., MARIA Reactor Operational Safety Report, National Centre for Nuclear Research, Otwock-Świerk, 2014
- [2] M. Lipka et al., Annex 2019/1 to the MARIA Reactor Operational Safety Report, National Centre for Nuclear Research, Otwock-Świerk, 2019