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REPORT FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT

Operation of the High Flux Reactor in the period 2020-2023

{SWD(2025) 265 final}

OPERATION OF THE HIGH FLUX REACTOR IN THE 2020-2023 REPORTING PERIOD

On 29 June 2020, the Council adopted a four-year (2020-2023) supplementary research programme for the high flux reactor (HFR) (Council Decision 2020/960/Euratom) ([1]) to be implemented by the Joint Research Centre (JRC) on the operation of the HFR located in Petten, the Netherlands. Under Article 5 of the Council Decision, the Commission must keep the European Parliament, and the Council informed by producing a final report of the implementation of this Decision when the programme has ended. This report addresses this obligation.

The HFR has been in operation since 1961 and provides a variety of irradiation location possibilities (reactor core, reflector region and in the poolside).

The main objectives of the supplementary research programme are:

- to ensure the safe and reliable operation of the HFR in order to guarantee the availability of the neutron flux for experimental purposes,

- to allow an efficient use of the HFR by research institutes in a broad range of disciplines: (i) improvement of the safety of nuclear reactors, (ii) applications in the health sector, including the development of medical isotopes, (iii) nuclear fusion, (iv) fundamental research and training, and (v) waste management including the possibility to study the safety issues of nuclear fuels for reactor systems that are of interest to Europe.

The HFR is used for the commercial production of radioisotopes and acts as a training facility for doctoral and post-doctoral fellows, allowing them to perform research activities through national or European programmes.

1. SAFE OPERATION OF THE HFR

The European Atomic Energy Community (Euratom) is the owner of the HFR (for a lease of 99 years). The HFR is run by the Nuclear Research and Consultancy Group (NRG) which operates and maintains the plant and manages commercial activities around the reactor. It has an operating licence granted by the Dutch national regulator ANVS (Authority for Nuclear Safety and Radiation Protection). The HFR is subject to legally required 10-year periodic safety reviews under the same conditions as for nuclear plants, which are carried out by the NRG.

In the 2020-2023 reporting period, the HFR was operational above 90% of the scheduled operation time (which was set to be approximately 70% of a calendar year). In total, the HFR was operational for 991 days during 2020-2023.

([1]) OJ L211 of 3.7.2020, p. 14.

Regarding the safety operation of the reactor, in 2020, five notifications were sent to the regulator. Two of them related to higher collective exposure doses than expected during molybdenum (Mo-99) production and cell-dismantling activities.

In 2021, two notifications were sent to the regulator on temporary unavailability of the secondary-activity monitor and a longer-than-approved irradiation period in a production facility.

In 2022, three notifications were sent to the regulator, the first one on contamination in a pump cellar, the second on a temporary breach of reactor containment (during outage because of maintenance activities) and the last one on the inadequate performance of two activity monitors.

In 2023, only one notification was sent to the Dutch nuclear regulator on a leakage in the reactor pool liner. A safety assessment was drawn up and submitted to the Dutch regulator.

All events that occurred during 2020-2023 were classified as INES 0 (i.e. events without safety significance and/or below scale) in INES (international nuclear and radiological event scale).

In terms of radiation protection of workers during HFR operations from 2020 to 2023, the individual and collective exposure doses were kept within the expected and legal limits.

Maintenance activities comprise preventive, corrective and regular maintenance of all systems, structures and components. These were carried out with the aim of ensuring the HFR's safe and reliable operation. The main activities carried out during the maintenance period were the following:

(1) scheduled regular preventive and corrective maintenance,

(2) periodic leak testing of the containment building (as one of the licence requirements),

(3) in-service inspection of the safety-related parts of the primary system (reactor vessel, outlet reducers, bottom plug and primary piping in the primary pump building),

(4) cleaning of the secondary cooling system,

(5) revamp of the emergency power diesels,

(6) two-week training for the HFR operator staff.

2. RESEARCH AND ISOTOPE PRODUCTION

2.1. Research

The following scientific activities were carried out in 2020-2023:

- improving nuclear safety through online measurement of fuel creep: two experiments were performed during the period,

- nuclear fuel being crucial to all nuclear systems and essential to their performance and safety, a better understanding of the properties of the fuel and of the mechanisms underlying the changes under irradiation is key to developing more accurate and predictive codes for the simulation of fuel elements,

- research on molten salt reactor (MSR) technology: a molten salt reactor (MSR) is a generation IV fission reactor in which the primary nuclear reactor coolant and/or the fuel is a mixture of molten salt with a fissile material. Molten salt reactors have higher efficiency and less waste generation,

- the overall aim of the experimental molten salt programme is to gain experience with the handling, irradiation, post-irradiation research and waste treatment of molten salts,

- conducting materials irradiation experiments on graphite degradation (key to determining the remaining service life of advanced gas-cooled reactors),

- aluminium alloy samples of structural materials of the Jules Horowitz reactor (JHR) have been irradiated to provide input to the future surveillance programme of the JHR.

From 2024 onwards, Euratom stakeholders have continued to collaborate on developing irradiation facilities for fuel and materials as a new setting for experimental work at the HFR. Four new irradiation devices (experimental installations) are being set up to conduct research on molten salt reactors (two irradiation installations), a device for alloys and another for accelerated testing materials in capsules (as a series of joint experimental programme (JEEP) experiments operating within the Nuclear Energy Agency's framework for irradiation experiments (FIDES) second triennial).

2.2. Isotope production

Approximately 30 000 patients worldwide per day depend on medical radioisotopes produced in the HFR in Petten for diagnosis and therapy.

Molybdenum-99 is by far the most important of these isotopes. It plays a critical role in heart disease diagnosis and cancer diagnosis through bone and organ scans. In addition, new treatment methods are being developed, leading to an ever-increasing demand for new isotopes. Given the half-life of the isotopes produced and the high demand for related treatments, an efficient and just-in-time logistics infrastructure is essential.

The HFR is one of the largest molybdenum-99 producers in the world. It provides molybdenum-99 isotopes for 30 000 patient doses per day, which amounts to more

than 40 million patient doses in the 991 full-power days of operation in the 2020-2023 reporting period.

Other medicines also play an important role in the demand of isotopes. In addition to molybdenum-99 and lutetium-177, the HFR is a major supplier of terbium-161, yttrium-90, iridium-192 and holmium-166 for various types of medical indications.

The HFR is proactively producing medical isotopes and contributing to the development of new therapies and of the nuclear medicines market. In the 2020-2023 reporting period, new clinical trials with lutetium-177 were started or announced, and the HFR delivered more lutetium-177 to the market, allowing for more patient treatments.

In addition to the production of medical isotopes, NRG|PALLAS, the operator of the high flux reactor is also focusing on nuclear medical innovation. In the reporting period, great progress has been made in developing skills in the field of medical isotope processing and the required infrastructure. The FIELD-LAB was set up for this purpose. The FIELD-LAB is an important innovation facility that helps accelerate the development and launch of new nuclear medicines. With the help of this facility, medical isotopes produced by the HFR will be made available for clinical trials. This innovative infrastructure will further increase the positive impact of the HFR on the health sector.

3. FINANCIAL CONTRIBUTIONS TO IMPLEMENT THE PROGRAMME

During 2020-2023, Member States made the following financial contributions to implement the supplementary research programme:

- the Netherlands: EUR 26 654 000
- France: EUR 1 200 000

Note that these contributions cover the expenses related to the operation and decommissioning of the HFR. The Commission does not cover any operational deficits, including potential costs of maintenance or repair.

The annual contribution of the supplementary research programme to the decommissioning fund is EUR 800 000 per year. This amount is taken from the regular budget of the supplementary research programme. As of 31 December 2023, the total amount in the decommissioning fund was EUR 23 639 000.

In accordance with the mandate laid down by Council Regulation (Euratom) 2021/100, the JRC appointed an independent panel of experts to review the 2022 decommissioning plan for the high flux reactor at Petten. The objective was to assess the plan's completeness, feasibility and cost estimates, evaluate implementation scenarios and support strategic decisions on funding and potential liability transfer to the Dutch State. The review ([2]) concludes that the total decommissioning cost is

([2]) Final Report: Review of the HFR decommissioning plan, cost estimates and its implementation (JRC/IPR/2023/RP/1498 – Rev. C, February 2025).

estimated at approximately EUR 244 million. However, this remains the best possible estimate subject to a number of uncertainties, including waste volumes, scheduling risks and site end-state criteria, which could lead to higher final costs. Against this backdrop, the amount of approximately EUR 23.6 million currently set aside under the supplementary programme falls well short of covering the expected decommissioning liabilities (to be borne by Euratom).

Other expenditure incurred by the JRC during the 2020-2023 reporting period and paid from the supplementary research programme budget includes (i) direct staff costs (e.g. HFR supplementary research programme management) of EUR 281 000 (ii) support costs (e.g. legal advice) and utilities (e.g. electricity, water, heating) of EUR 2 585 000, and (iii) spent fuel management costs of EUR 5 719 000.

The staff working document enclosed presents in more detail the results of the HFR's operation in the 2020-2023 reporting period.