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**REPORT FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN
PARLIAMENT**

Operation of the High Flux Reactor in the years 2014-15

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On 13 November 2012, the Council adopted a four-year (2012-15) supplementary research programme for the HFR¹, to be implemented by the Joint Research Centre (JRC) on the operation of the high flux reactor (HFR) located in Petten, The Netherlands. Under Article 4 of this Council Decision, the Commission must keep the European Parliament and the Council informed by producing reporting on the implementation of the supplementary research programme. A mid-term report has already addressed the 2012-2013 period². and therefore this final report will address the remaining 2014-2015 period.

In operation since 1961, the HFR reactor 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: improvement of the safety of nuclear reactors, health including the development of medical isotopes, nuclear fusion, fundamental research and training, and waste management including the possibility to study the safety issues of nuclear fuels for reactor systems of interest to Europe.

The HFR is used for the commercial production of radio-isotopes and also 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 reactor is operated by the NRG (Nuclear Research and Consultancy Group) which operates and maintains the plant and manages the commercial activities around the reactor. It has an operating licence granted by the Dutch national regulator KFD (Kernfysische Dienst). As for nuclear power plants, the HFR is subject to legally required 10-year periodic safety reviews which are performed by the NRG.

The 2014-15 period was characterised by one safety-related event (second half of 2015) that affected the availability of the neutron flux.

After an unplanned shutdown period of about 4 months, the HFR returned to service in February 2014. The cycle pattern consisted of a scheduled number of 216 operation days, scheduled 4-day reactor stops and a longer shutdown period of 65 days in October and

¹ COUNCIL DECISION of 13 November 2012 on the adoption of the 2012-2015 High Flux Reactor supplementary research programme to be implemented by the Joint Research Centre for the European Atomic Energy Community, Council Decision 2012/709/Euratom.

² REPORT FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT Operation of the High Flux Reactor in the period 2012-2013, COM(2016)170

November 2014. This corresponds to an actual availability of almost 100% with reference to the original scheduled operation plan. Nominal power in this period has been 45 MW.

The HFR was scheduled to operate for 9 cycles in 2015, with 271 planned full power days but only 230 were realized. The main cause for the lost full power days was the cancellation of cycle 2015-08 in October 2015. This cycle was skipped because of a deviation in the control rod system performance. Inspection and analyses revealed a marginal play in one of the reactor control rods used to adjust the reactor power. While this play did not affect the functionality of the control rod nor reactor safety in any way, a new procedure for assembly, commissioning and maintenance/inspection of the control rods was developed preventively to avoid such effects in the future. This was then included in the safety case which was evaluated by the Reactor Safety Committee and by the Autoriteit Nucleaire Veiligheid en Stralingsbescherming (ANVS) - the Dutch nuclear regulator. The ANVS provided a formal statement of no objection to reactor restart. The HFR was safely restarted in December 2015. In close cooperation with rivet experts and after a technical visit to the SAFARI reactor in South Africa (of which the control rods have a similar design) it was also decided to also improve the structural design of the control rod. The new design will make use of different rivets to improve the safety margin. Next to that, also the control rod guide seats will be improved by making use of another bearing material. Implementation of these modifications will be implemented in between 2018 and 2019.

Nominal power in this period has been 45 MW.

During the reporting period (2014-2015), the annual 30 MW reactor training for the operators and the yearly flux measurements have been carried out as scheduled.

In 2014 and 2015, maintenance activities consisted of the preventive, corrective and breakdown maintenance of all systems, structures and components (SSC) of the HFR, as described in the annual and long-term maintenance plans. These activities were carried out to ensure the HFR's safe and reliable operation and to prevent inadvertent shutdowns caused by insufficient maintenance. The following activities were successfully completed:

- Scheduled regular preventive and corrective maintenance;
- Periodic leak testing of the containment building (0.02 MPa overpressure for 24h) as one of the license requirements;
- In-Service Inspection of the safety relevant parts of the primary system (reactor vessel, the outlet reducers, the bottom plug and primary piping in the Primary Pump Building);
- Cleaning of the secondary cooling system;
- Revision of the emergency power diesels

2. Research and isotope production

2.1 Research

The following scientific activities were performed in the period 2014-15 (many were a continuation from the 2012-13 period):

- nuclear fuel irradiation experiments investigating the reduction of the radiotoxicity of nuclear waste; minor actinide transmutation technological issues (i.e. fission products retention capabilities, dust-free process, helium swelling);
- nuclear fuel (e.g. for High Temperature Reactors and Molten Salt Reactors) and graphite qualification for high-temperature reactors (;
- experiments investigating the nuclear reactor's structural material degradation under irradiation (graphites, model steels, welds, etc.);
- fusion reactor technology used in the irradiation and post-irradiation examination of material planned to be used in ITER's (International Thermonuclear Experimental Reactor) shielding blanket;
- standardisation of materials (e.g. neutron diffraction method for residual stress measurement in thick bi-metallic welds; residual stress measurements).

2.2 Isotope production

Worldwide, approximately 25.000 patients per day depend on medical radio-isotopes produced in the HFR in Petten for diagnosis and therapy.

NRG delivers these medical isotopes to mainly radio-pharmaceutical companies. Molybdenum-99 is by far the most important of these isotopes. It is a precursor of Technetium-99m which represents the most widely used medical isotope for imaging, accounting for 80% of all nuclear diagnostic procedures. It performs a critical role in the diagnosis of heart disease, and is also used in cancer diagnosis through bone and organ scans. In addition, new treatment methods are being developed thus leading to ever increasing demand for (new) isotopes. Given the half-life of the produced isotopes and the high demand for treatment, a well-oiled just-in-time logistic infrastructure is essential.

The Dutch expertise from NRG, URENCO (a nuclear fuel company operating several uranium enrichment plants) and TU Delft (Technical University of Delft) in the area of medical radioisotopes has been recently bundled into the association "Dutch Isotope Valley" (DIVA) where knowledge, skills, capacity and alternative production methods for (medical) isotopes have attained sufficient weight to serve the world market. Considering that the NRU reactor at Chalk River, Canada will stop routine production of Mo-99 and is planned to be shut down in 2018 and that Canada will concentrate on domestic demand as opposed to export, this represents an excellent opportunity for DIVA to fill the production gap.

In order to carry out the asset integrity program which is a prerequisite to run the HFR and its ancillary installations until 2024, the Dutch government has granted NRG a loan (through its parent company ECN). In parallel, NRG has successfully increased prices for its entire service package and these were accepted by all customers. In particular, NRG's top 6 isotope customers have expressed their confidence in NRG through signing long-term supply agreements. This was a successful step into the direction of financial robustness and viability.

The HFR restarted its operation on 14 February 2014 and has performed its production schedule as planned during the rest of that year. The HFR was thus back on the international scene as one of the major producers of medical isotopes worldwide. In 2015, the HFR missed one production cycle in October but could be restarted in December 2015.

3. Financial contributions to the programme's implementation

In 2014-15, the following financial contributions were received from Member States for the implementation of the supplementary programme:

- Belgium: EUR 300 000 (2014) + EUR 300 000 (2015)
- France: EUR 300 000 (2014) + EUR 300 000 (2015)
- The Netherlands: EUR 7 250 000 (2014) + EUR 7 250 000 (2015),

for a total of EUR 15 700 000. These contributions cover the expenses specified under Annex II of Council Decision 2012/709/Euratom. The European Commission does not cover any operational deficits, including potential costs of maintenance or repair. Financing for the decommissioning fund and other expenditure linked to the Commission's management of the supplementary research programme originates from this amount.

Since 2004, due to a re-evaluation of decommissioning costs, the annual contribution of the supplementary programme to the decommissioning fund increased from EUR 400 000/year to EUR 800 000/year. This amount is taken from (a) the regular budget of the supplementary research programme, and (b) the interest earned on the bank account of the decommissioning fund of the supplementary research programme. For example, in 2014 the estimated amount of interest generated by the decommissioning fund was EUR 145 000. Therefore, only EUR 655 000 was added from the regular supplementary research programme budget to reach the EUR 800 000/year. The total amount in the decommissioning fund is EUR 17 239 000. This fund will contribute to the future decommissioning costs of the HFR (to be borne by Euratom), estimated at EUR 72 600 000 in the most recent decommissioning study available³.

Other expenditure incurred by the JRC during the reporting period and paid directly from the supplementary research programme budget includes:

- direct staff costs (e.g. HFR supplementary research program management): EUR 257 000
- HFR support costs (e.g. legal advice): EUR 166 000
- utilities (e.g. electricity, water, heating): EUR 1040 000
- spent fuel management costs: EUR 2 450 000

An accompanying staff working document presents the technical results of the HFR's operation in 2014-15 in more detail.

³ Communication from the Commission to the Council and the European Parliament on Decommissioning of Nuclear Installations and Management of Radioactive Waste: Management of Nuclear Liabilities arising out of the Activities of the Joint Research Centre (JRC) carried out under the Euratom Treaty — COM(2013) 734 final.