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CURRENT ACTIVITIES AT THE FiR 1 TRIGA REACTOR

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Abstract

The FiR 1 –reactor, a 250 kW Triga reactor, has been in operation since 1962. The main purpose to run the reactor is now the Boron Neutron Capture Therapy (BNCT). The epithermal neutrons needed for the irradiation of brain tumor patients are produced from the fast fission neutrons by a moderator block consisting of Al+AlF_3 (FLUENTAL™), which showed to be the optimum material for this purpose. Twenty-one patients have been treated since May 1999, when the license for patient treatment was granted to the responsible BNCT treatment organization. The treatment organization has a close connection to the Helsinki University Central Hospital. The BNCT work dominates the current utilization of the reactor: three days per week for BNCT purposes and only two days per week for other purposes such as the neutron activation analysis and isotope production.

In the near future the back end solutions of the spent fuel management will have a very important role in our activities. The Finnish Parliament ratified in May 2001 the Decision in Principle on the final disposal facility for spent fuel in Olkiluoto, on the western coast of Finland. There is a special condition in our operating license. We have now about two years' time to achieve a binding agreement between VTT and the Nuclear Power Plant Companies about the possibility to use the final disposal facility of the Nuclear Power Plants for our spent fuel. If this will not happen, we have to make the agreement with the USDOE with the well-known time limits.

At the moment it seems to be reasonable to prepare for both spent fuel management possibilities: the domestic final disposal and the return to the USA offered by USDOE. Because the cost estimates of the both possibilities are on the same order of magnitude, the future of the reactor itself will determine, which of the spent fuel policies will be obeyed. In a couple of years' time it will be seen, if the funding of the reactor and the incomes from the BNC treatments will cover the costs. If the BNCT and other irradiations develop satisfactorily, the reactor can be kept in operation beyond the year 2006 and the domestic final disposal will be implemented. If, however, there is continuously lack of money, there is no reason to continue the operation of the reactor and the choice of the USDOE alternative is natural.

1. Introduction

The FiR 1 –reactor, a 250 kW Triga reactor, has been in operation since 1962. The main purpose to run the reactor is now the Boron Neutron Capture Therapy (BNCT). The epithermal neutrons (1 eV – 10 keV) needed for the irradiation of brain tumor patients are produced from the fast fission neutrons by a moderator block consisting of $Al+AlF_3$ (FLUENTAL™) developed and produced by VTT. The material gives excellent beam values both in intensity and quality and enables the use of a small research reactor as a neutron source for BNCT purposes. Twenty-one patients have been treated since May 1999, when the license for patient treatment was granted to the responsible BNCT treatment organization, which has a close connection to the Helsinki University Central Hospital. The BNCT work dominates the current utilization of the reactor: three or four days per week for BNCT purposes and only one or two days per week for other purposes such as the neutron activation analysis and isotope production. Figure 1 describes the general layout of the BNCT facility at the FiR 1 –reactor. The facility gives a high epithermal neutron field, 1.1×10^9 n/cm^{2}s with a very low fast neutron and gamma component.

In the near future the back end solutions of the spent fuel management will have a very important role in our activities. There is a special condition in our operating license. We have now about three years' time to achieve a binding agreement between VTT and the domestic Nuclear Power Plant Companies about the possibility to use the final disposal facility of the Nuclear Power Plants for our spent fuel. If this will not happen, we have to make the agreement with the USDOE with the well-known time limits.

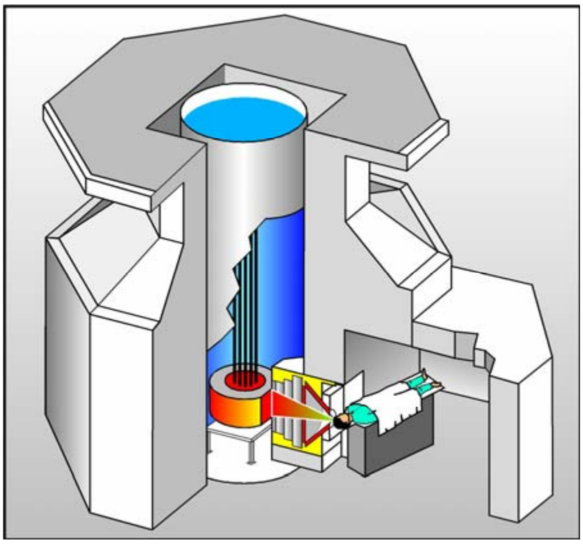

Figure 1. BNCT Facility at the FiR 1 –reactor

2. Utilization of the reactor

The current operation of the reactor means that three or four days per week are reserved for the BNCT-project and the rest of the days for other purposes. The BNCT-project needs reactor time for the BNCT measurements and calibrations and naturally for patient treatments, which, however, have taken place only few times per year so far. Although the frequency of the patient treatments has been rather low, nearly whole the responsibility to find funding for the reactor has been changed this year on the BNCT project.

Besides the BNCT-project, there is still time, one or two days per week, for isotope production and neutron activation analysis. The amount of neutron activation analyses has decreased clearly during the last four or five years, only some Cl- and In-analyses will be carried out. The volume of the neutron activation analysis task is so small that it has no business value any more for the reactor.

On the other hand the production of short-lived radioactive isotopes has its role on the incomes of the reactor. It gives nearly 10 % of the funding needed to run the reactor. The main isotopes produced in the reactor are ^{24}Na, ^{82}Br and ^{140}La and they are used in tracer studies in industry. Typical problems are flow meter calibrations, which are solved with tracer method. Normally KBr is used as tracer material when calibrating water flow meters and CH_3CH_2 Br in case of a gas flow meter. We only produce the isotopes and a separate company carries out the measurements.

3. Spent fuel management

In Finland also the research reactor must have a nuclear waste management plan, which contains among others a part for spent fuel management. The plan describes the methods, the schedule and the cost estimate of whole the spent fuel management procedure starting from the removal of the fuel from the reactor core and ending to the final disposal. The plan has been based on the assumption that the final disposal site will be somewhere in Finland. The Finnish Parliament ratified in May 2001 the decision in principle on the final disposal facility to be situated in Olkiluoto, on the western coast of Finland, for the spent fuel of the nuclear power plants. Olkiluoto is also one of the two nuclear power plant sites in Finland. The final disposal facility is supposed to be in operation in 2020.

There is a special condition in the current operation license of our reactor. We have to achieve a binding agreement between our Research Centre and the domestic Nuclear Power Plant Companies about the possibility to use the joint final disposal facility of the Nuclear Power Plants for our spent fuel, if we want to continue the reactor operation beyond the year 2006. We have had already for twelve years an agreement in principle with one of the Nuclear Power Companies about the final disposal matter, but it does not satisfy the requirements any more. If an acceptable agreement will not be accomplished in about three years' time, we have to use the USDOE alternative with the well-known time limits. The Ministry of Trade and Industry has the responsibility to decide, if the agreement is acceptable or not. Before we can start the real negotiations about the final disposal of our spent fuel with the Nuclear Power Companies, we have to prepare a safety study about the behaviour of the Triga fuel in the final disposal surroundings.

The operation license of our reactor will expire in 2011. It is very probable that there will be certain waiting time from the shut down of the reactor to the opening of the final disposal facility. Therefore there have to be a sufficient interim storage for the spent fuel before the transportation to the final disposal facility. After enlargement work of our spent fuel storage in 1997 we have sufficiently storage capacity for the fuel in the reactor building. In addition to the domestic final disposal solution there is still the USDOE alternative available until 2006.

In order to start the negotiations with the Nuclear Power Companies or their representative Posiva we have to prepare a safety study about the long-term behaviour of the Triga fuel in the final disposal surroundings. The Triga fuel elements will be loaded in containers, which have the same outer dimensions as the nuclear power plant fuel assemblies. We need from 3 to 5 such containers for all the Triga fuel elements. The containers can easily be loaded into the heavy copper canisters, which have 12 positions to be loaded. For the criticality reason the Triga containers will be situated in the outer zone of the canister and the inner zone will be left empty. In practice the empty positions will be loaded with dummy assemblies made of cast iron. It can be shown that the system is critical safe. This is important, because if the criticality safety would demand the fuel to be divided to two or more canisters, the expenses also would be about twice or more compared to the one canister alternative.

4. Decisions in the near future

If we want to utilize the USDOE policy and return our fuel back to USA, it means in practice, for economical reasons, that the whole inventory of the irradiated fuel should be sent to USA at the same time. Thus the return of the fuel back to USA means in other words the shutting down of the reactor. In our case the important question will be: are we willing to shut down the reactor within the time limits declared by the USDOE?

The BNCT work is today the main purpose to run the reactor. The amount of BNCT irradiations is still rather low: twenty-one irradiations during three years. At the moment we assume that we are getting funding for the reactor and the BNCT for the next two or three years. During that time we together with the treatment organization have the opportunity to show that the BNCT irradiations will be needed also in the future and that the annual number of patients will be satisfactory to run the reactor. If the turnover of the BNCT and other irradiations will be satisfactory and the positive trend seems to continue, there is no reason to use the USDOE alternative. Instead it is reasonable to continue the reactor operation beyond the year 2006, which means inevitable also the choosing of the domestic alternative for the treatment of the spent fuel. If, however, the frequency of the treatments is not growing up to a acceptable level, the funding of the reactor will be stopped after the said period, which leads inevitably to the permanent shut down of the reactor. In that case the USDOE alternative seems to be the right one.

5. Conclusions

We have now ahead of us a restricted period of time, during which we have the possibility to show that the BNCT method works successfully and that the annual amount of patients is satisfactory. After about two years, in 2004 we are in the situation, when we have to decide in every case, if the reactor will continue the operation or will it be shut down. As the criterion there will be the possible success of the BNCT. After the decision of the reactor operation the choosing between the USDOE and the domestic back end solution will be rather easy, because the expenses of both of the spent fuel management alternatives seem to be of the same magnitude.