SPENT FUEL MANAGEMENT – TWO ALTERNATIVES AT THE FiR 1 REACTOR

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ABSTRACT

The FiR 1 –reactor, a 250 kW Triga reactor, has been in operation since 1962. The reactor with its subsystems has experienced a large renovation work in 1996 - 97. The main purpose of the upgrading was to install the new Boron Neutron Capture Therapy (BNCT) irradiation facility [1]. The BNCT work dominates the current utilisation of the reactor: four days per week for BNCT purposes and only one day per week for neutron activation analysis and isotope production.

The Council of State (government) granted for the reactor a new operating license for twelve years starting from the beginning of the year 2000. There is however a special condition in the new license. We have to achieve a binding agreement between our Research Centre 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 we want to continue the reactor operation beyond the year 2006.

In addition to the choosing of one of the spent fuel management alternatives the future of the reactor will also depend strongly on the development of the BNCT irradiations. If the number of patients per year increases fast enough and the irradiations of the patients will be economically justified, the operation of the reactor will continue independently of the closing of the USDOE alternative in 2006. Otherwise, if the number of patients will be low, the funding of the reactor will be probably stopped and the reactor will be shut down

1. Introduction

The Finnish FiR 1-reactor is a 250 kW Triga reactor operating since 1962. The reactor with its subsystems has experienced a large renovation work in 1996 - 97. The main purpose of the upgrading was to install the new Boron Neutron Capture Therapy (BNCT) irradiation facility [1]. The fast fission neutrons are slowed down to the epithermal energy range (1 eV - 10 keV) by a special composite moderator material consisting of Al+AlF_3+LiF (FLUENTAL™) developed and produced by VTT. This 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. The epithermal beam facility of the BNCT-irradiation station got its final form and the therapy area was surrounded with a heavy radiation shield made of steel and heavy concrete. The reactor was taken again into operation in November 1997. The license for patient treatment was granted in May 1999 to the responsible BNCT treatment organisation, which has a close connection to the Helsinki University Central Hospital. Soon after that, in May the first patient was irradiated at the FiR 1 BNCT facility. Now the BNCT work dominates the current utilisation of the reactor: four days per week have been reserved for BNCT purposes and only one day per week for neutron activation analysis and isotope production. Figure 1 describes the general layout of the BNCT beam facility at the FiR 1 reactor. This arrangement gives a high epithermal neutron field, 1.1 x 10^9 n/cm^2s with a very low fast neutron and gamma component.

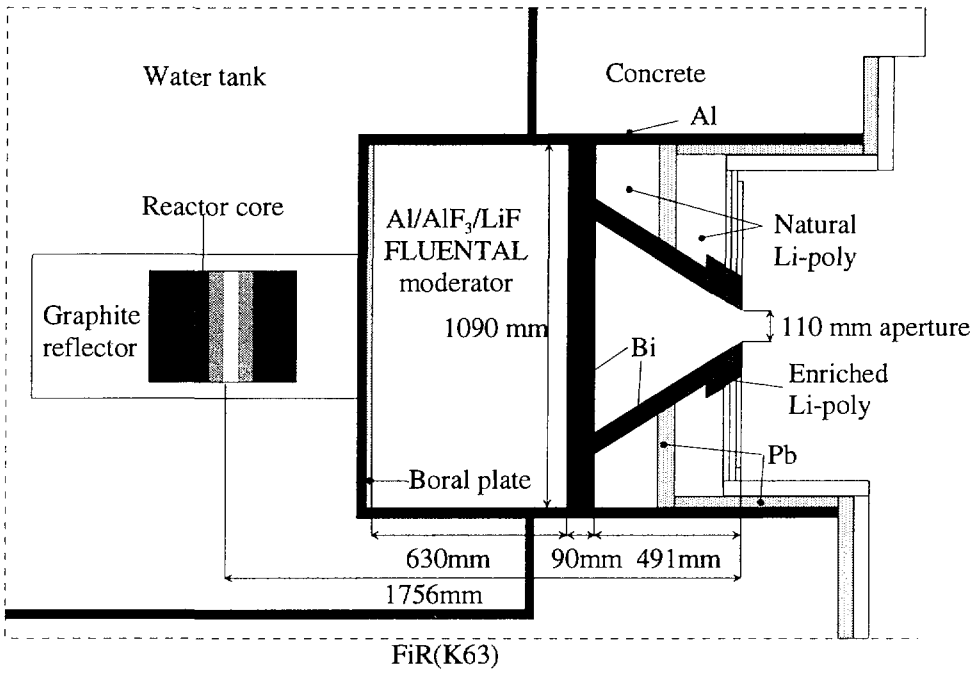

Fig 1. FiR 1 epithermal neutron beam facility

2. Current situation

The Council of State (government) granted for the reactor a new operating license for twelve years starting at the beginning of the year 2000. There is however a special condition in the new license. 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 four years' time, we have to use the USDOE alternative with the well-known time limits. The Ministry of Trade and Industry has the duty 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. We need also a description how our spent fuel will be handled at the final disposal facility. We assume that these reports will be ready this year and after that the agreement should be ready in one or two years. If we can keep this time schedule, we can "freely" choose one of these two spent fuel management alternatives. This will happen in 2004 at latest. If we choose the USDOE alternative, it means the shut down of the reactor clearly before the year 2006. The BNCT facility is completely ready for the treatment of the patients, but there are still too few patients annually to be irradiated. This means lack in funding the reactor operation. If there is not enough funding for the reactor, there is also no reason and no means to continue the operation.

3. Alternatives of back end solutions

USDOE's Program

According to the US Department of Energy's Foreign Research Reactor Spent Nuclear Fuel Acceptance Program the ultimate time limits are May 2006, when you have to stop burning the fuel in the reactor and May 2009, when the fuel has to be at its destination in the USA. In practice the arrangements needed to send the spent fuel back to USA have to be done much earlier. When the representatives of USDOE visited our reactor in 1999, we told them that our intention is to choose the back end solution of the fuel in 2004. Next year, in 2000, USDOE reminded us that our possible negotiations with USDOE about the return of the spent fuel should start already in 2004 or earlier.

Domestic alternative

The Council of State (government) outlined already in 1983 the time schedule for the final disposal of spent fuel of the nuclear power plants. Since that the Finnish Nuclear Power Companies have made research work aiming for the final disposal of the radwaste. Later, in 1995 they founded a separate company Posiva to develop the technology and carry out safety analysis and site investigations for implementing spent fuel final disposal. In 1999 Posiva submitted an application for a decision in principle for a final repository to be built at Olkiluoto, the site of two nuclear power units. At the end of the year 2000 the Finnish government approved the application and sent it to the parliament for ratification. After the ratification, if positive, separate licenses still will be needed for the construction of the facility, scheduled to start in 2010, and also for the operation, 10 years later. The government alone will decide, if these licenses are granted or not.

For the final repository the spent fuel will be encapsulated in airtight copper canisters and situated in the bedrock at a depth of 500 m. The safety of this deep underground repository is based on multiple natural and engineered barriers. Each canister contains 9-12 normal fuel assemblies from nuclear power plants. The present concept for Triga fuel elements is that the elements will be loaded in containers, which have the same outer dimensions as the nuclear power plant fuel assemblies. This ensures that the Triga fuel will be easily handled in the final disposal facility and also loaded in the heavy copper canisters.

4. Decisions in the near future

As was mentioned earlier the BNCT work is today the main purpose to run the reactor. The amount of BNCT irradiations is still rather low: twelve irradiations during the first eighteen months. If the frequency of the treatments is not growing up soon, the funding of the reactor will be stopped, which leads inevitably to the permanent shut down of the reactor. In that case the USDOE alternative seems to be the right one. The economic situation of the reactor will be the basic factor when we have to decide about the future of the reactor. The economic situation will be analysed during the next two or three years at latest. 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.

5. Conclusions

The choosing between the USDOE and the domestic back end solution will be based on the economic situation and the economic forecasts of the reactor and the BNCT irradiations, not the economics of the spent fuel management. At the moment the expenses of both of the spent fuel management alternatives seem to be of the same magnitude. The time of the decision will be very soon, in 2003 – 2004 at latest.

References

[1] Iiro Auterinen, Carita Aschan, Pekka Hiismäki, Mika Kortesniemi, Antti Kosunen, Petri Kotiluoto, Juha Laminen, Rolf J. Rosenberg, Seppo Salmenhaara, Sauli Savolainen, Tiina Seppälä, Tom Serén, Vesa Tanner, Matti Toivonen and Petteri Välimäki: Metamorphosis of a 35 Years Old TRIGA Reactor into a Modern BNCT Facility. Proc. of the Eighth International Symposium on Neutron Capture Therapy for Cancer, La Jolla, California, USA, 13-18 Sept. 1998