FRM-II: STATUS OF CONSTRUCTION, LICENSING AND FUEL TESTS

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1. Introduction

The research reactor FRM-II of the Technische Universität München is now ready for the nuclear start-up, but still waiting for the operational license.

The high-flux neutron-source FRM-II (8×10^{14} n/(s cm^2)) is a unique tool for

- solid state physics and materials research by neutron scattering, positron annihilation experiments and activation analysis
- fundamental physics
- isotope production
- silicon doping
- cancer therapy by irradiation with fission neutrons
- tomography with fast and thermal neutrons

Reactor built in facilities as

- a hot source
- a cold source
- an uranium loaded converter plate producing an intense beam of fission neutrons

allow to expand the range of usable neutron energies far beyond the thermal spectrum. In addition, a source providing an intense beam of fission products is planned to be constructed by the Ludwig-Maximilians-Universität München and a source of ultra cold neutrons is planned by the Physics Department of the Technische Universität München. The reactor is already prepared for both of these facilities.

Tangential beam tubes beginning in the flux peak of the D_2O-moderator and equipped with large sized apertures will supply the experiments with the highest neutron flux possible. The available areas around the reactor block and in the neutron guide hall are optimally used by neutron guides coated with Nickel-58 or multilayers. For background reduction the biological shieldings are made of heavy concrete with the highest densities possible (4.5 to 6 g/cm^3).

For these reasons the FRM-II is a highly optimized neutron source with the highest signal to noise ratio for neutron beam experiments worldwide. An important basis for the high performance of the neutron-source is the compact core with only 17 liters of active volume using highly enriched uranium.

The thermal power of the source has been limited to 20 MW for reasons of safety and costs. The FRM-II operates within the well established safety margins of the high flux reactor in Grenoble. Furthermore, due to the low power and unique construction features (safety with respect to impacts due to earthquakes and airplane crashes) the FRM-II fulfills the demands on nuclear power stations of paragraph 7, point 2a of the German Atomic Law concerning the limitation of necessities of severe accident control measures (no evacuation of the population must be taken into consideration).

2. Status of the licensing procedure

In the Federal Republic of Germany the regional state governments are responsible for the licensing procedures of nuclear reactors, however, the state administration jurisdiction depends on the instructions of the federal authority, the Federal Ministry of Environmental Protection and Reactor Safety (BMU).
Appropriate licensing authority in Bavaria is the Bavarian State Ministry of State Development and Environmental Questions (Bay. StMLU). In 1993 the Technische Universität München applied for the licenses to construct and operate the FRM-II. This application was divided into three partial licenses:

- construction of the reactor building with preliminary positive general assessment
- construction of the additional buildings and the electrical and mechanical installations
- introduction of the fuel element and nuclear operation of the research reactor.

The 1st and the 2nd partial licenses were granted in 1996 and 1997, respectively. At court it was sued against these licenses without any success. As a result of the court decisions the construction licenses are legally binding in all aspects.
In May 1999 the TUM applied for the operational license which was expected and needed in September 2000.
In August 2000 the state authority presented the draft operational license to the federal authority, however, the final decision is still pending.
As ordered by the BMU the new Reactor Safety Commission (RSK) and the Radiation Protection Commission (SSK) – the highest nuclear experts bodies in Germany - examine in detail all aspects concerning the fuel elements and the nuclear operation and such topics of the construction licenses which could be influenced by a change of the so-called "current status of science and technology" (paragraph 7 of the German Atomic Law).

3. Status of the plant erection

6.5 years after commissioning of the Siemens AG the erection of the reactor is completed. Included in the work finished is the "cold" start up procedure of the reactor systems. Now the reactor is ready for the nuclear start up.

The following highlights describe the development of the project during the last 4.5 years:

Turning the first sod	Aug 96
Installation of the pool liner	June 97
Completion of the pool structure with inner liner	June 98
Construction topping out ceremony	Oct 98
Moderator tank ready for installation	Oct 99
Installation of components in the pool	Aug 00
Overall plant view	Jan 01

Some of the above mentioned items are shown in the pictures at the end of this paper.

4. Status of fuel tests

As reported at last year's RRFM Meeting the TUM irradiated a test-plate containing fuel with 1.5 gU/cm^3 at the SILOE-reactor of the CEA-Grenoble. The results of this test and of the post irradiation examinations (PIE) that followed afterwards were in very good agreement with the values given in the literature and the predictions for the FRM-II derived out of them.

In addition to these tests and PIE the TUM started the irradiation of two more plates in the OSIRIS-reactor of the CEA-Saclay. One plate contains fuel with an uranium density of 3.0 gU/cm^3 ("homogeneous plate"), the other one contains fuel with two uranium densities, 1.5 gU/cm^3 and 3.0 gU/cm^3 ("mixed plate"). The results of the irradiation experiment performed with the homogeneous plate are given in figure 1. The results of the measurements on the mixed plate can be seen in figure 2. As one can see from figure 1 the increase of the thickness of the homogeneous plate is a uniform and approximately linear function of the fission density in the fuel-particles; this indicates that the fuel swelling is stable and that there is no indication of breakaway-swelling. In addition, the value for the increase of the thickness is within the predicted range. In figure 2 one can clearly see the difference between the swelling in the 1.5 gU/cm^3– and the 3.0 gU/cm^3–zone and it can be stated that the fuel swelling behavior is as predicted also in the plate with fuel grading.

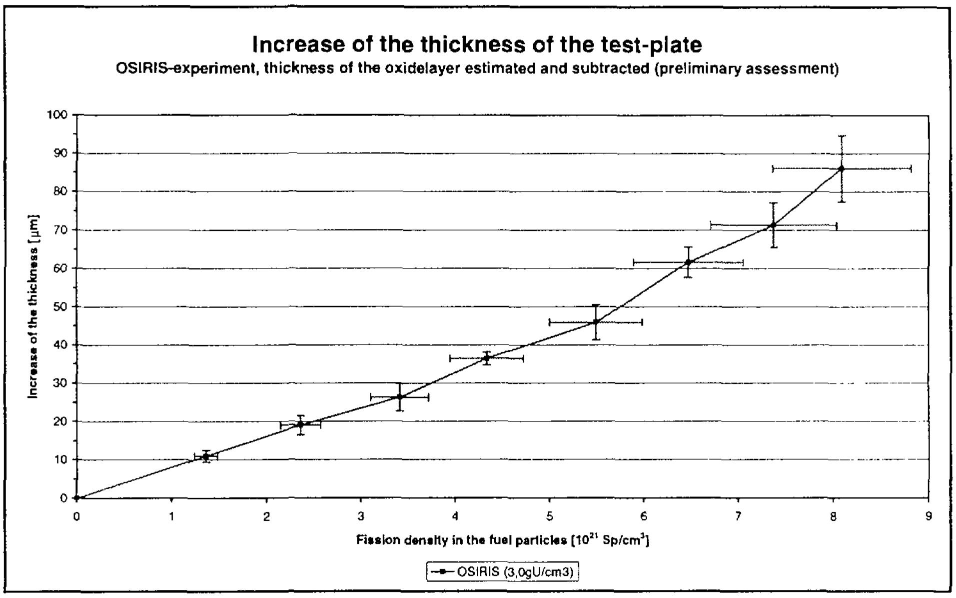

Figure 1: Increase of the thickness of the test-plate with an uranium density of 3.0 gU/cm^3 as a function of the fission density in the fuel-particles. The thickness of the oxidelayer has been estimated and subtracted.

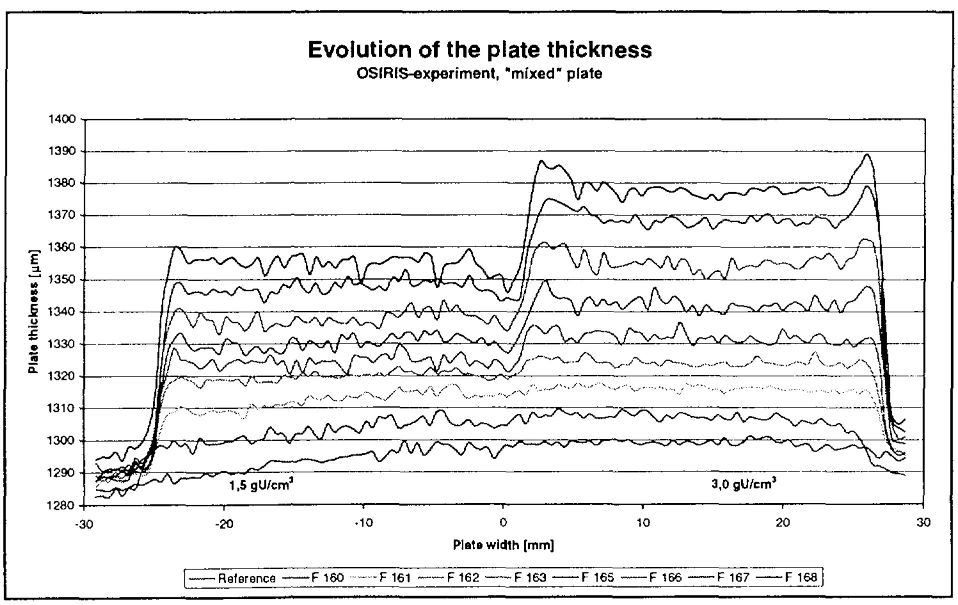

Figure 2: Measurements of the thickness of the mixed plate in transversal direction, i. e. perpendicular to the border between the areas containing fuel with an uranium density of 1.5 gU/cm^3 and 3.0 gU/cm^3, respectively, available to date.

Figure 3: Turning the first sod.

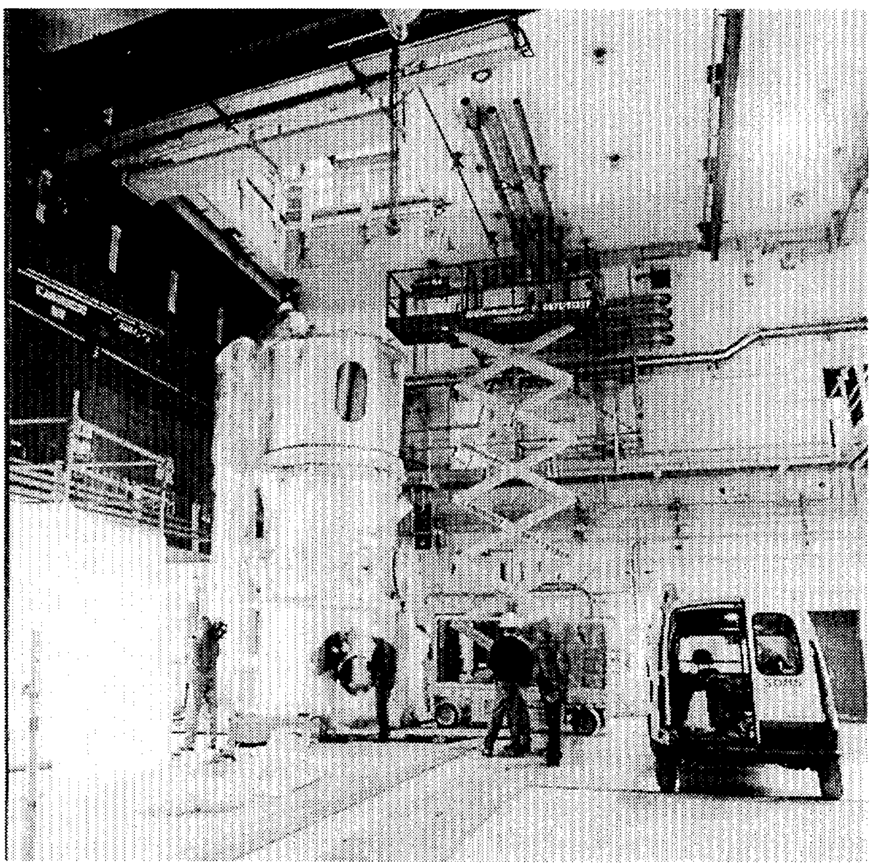

Figure 4: Moderator tank as arrived in the experimental hall of the FRM-II, ready for installation in the reactor pool.

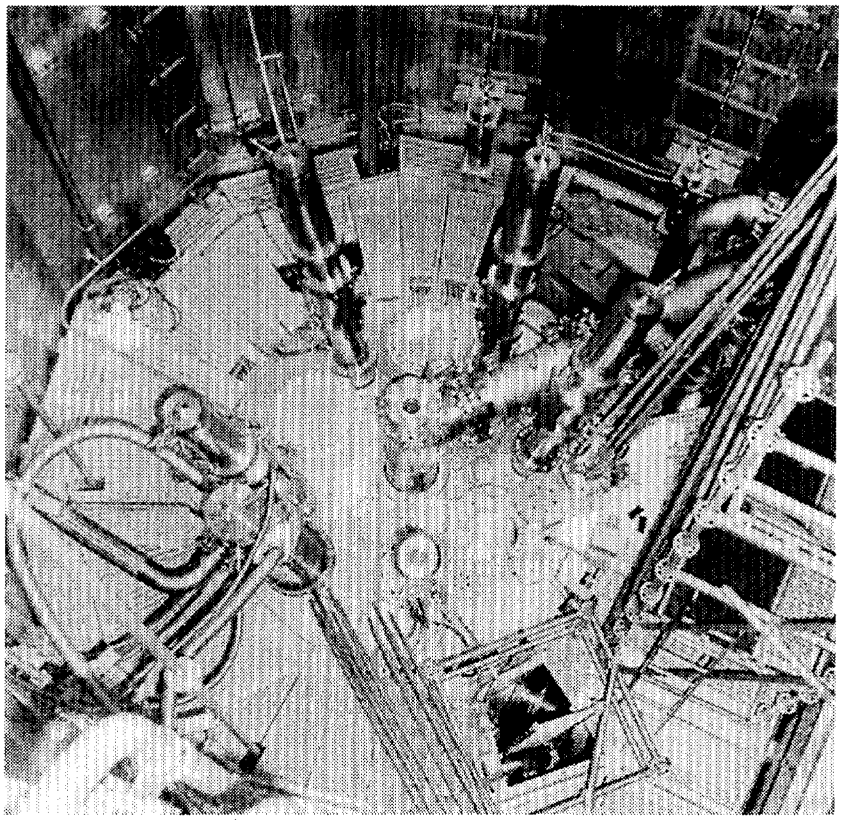

Figure 5: View of the reactor pool of the FRM-II.

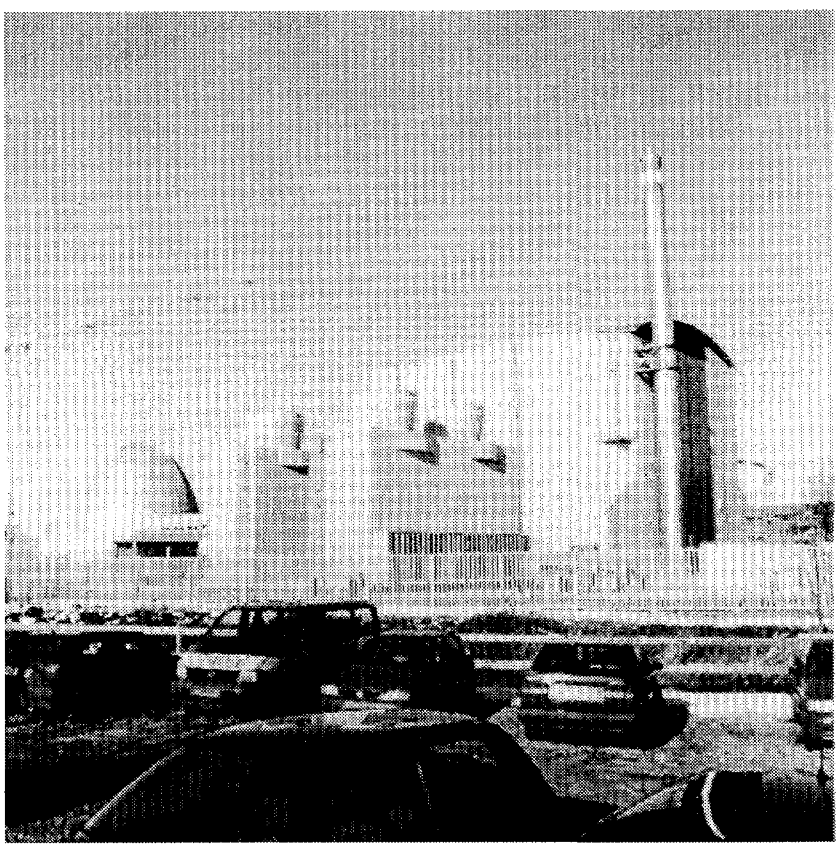

Figure 6: Overall plant view with the air coolers in front and the old FRM on the left.