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Status of the FRM-II Project at Garching

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Abstract:

The FRM-II is a new research reactor at Garching near Munich with a maximal power of 20 MW. Because of its single element compact core it will provide a max. thermal flux of $8 \cdot 10^{14}$ $cm^{-2}sec^{-1}$ outside of the core. It is presently under construction.
All buildings are almost completely erected, the installation of the technical components is in progress and the non nuclear operation for testing has started. In accordance with the time schedule the nuclear commissioning will begin in January, 2001.

The first partial licence for the concept of the whole plant and the erection of the reactor building was obtained in April, 1996 and the second partial licence for the erection of the complete facility was given in October, 1997. The third permit for the nuclear commissioning and operation is expected for fall 2000. The new German government is presently discussing which consequences a conversion of the FRM-II to reduced or low enrichment would have. From scientific, technical and economic reasons there is no doubt, however, that the FRM-II should best go into operation with highly enriched fuel as planned.

Thus, the Technical University of Munich (TUM) as the overall manager and Siemens AG (KWU) being the general supplier are confident that this high flux neutron source will soon be available for the benefit of the national and international scientific community.

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1. Introduction

For progress in the scientific fields of solid-state physics, chemistry, biophysics, molecular biology, material sciences and medicine the more than 40 years old research reactor FRM of the Technical University must be replaced by the new FRM-II being erected since August, 1996. The thermal neutron flux density will be 50 times higher, whereas thermal nuclear power will only be 5 times higher.

Siemens was nominated the general contractor to design, build and commission the FRM-II reactor facility whereas TUM remained responsible for the experimental installations and the operator´s requirements.

The characteristic data of the facility are given in Tab. 1.

Reactor type	compact reactor core, light water cooled, in the center of a moderator tank of 2.5 m ∅ filled with heavy water
Power	20 MW, thermal
Core	one cylindrical fuel element (d_j=118 mm ∅, d_o=243 mm ∅, 700 mm high) 113 involutely, bent fuel plates, cycle time about 52 days, 5 cycles per year.
Coolant	primary: light water from the pool with 1000m³/h at 37 / 52°C secondary: closed system of light water tertiary: transfer of the heat to the atmosphere by evaporation
Pool	ca. 700 m³ demineralized water, gate for separating the reactor and the storage pool
Shielding	lateral: 2.5 m water and 1.5 m heavy concrete vertical: about 10 m water
Beam tubes	10 horizontal, 1 vertical, 2 oblique
Neutron flux	max. $\approx 8 \cdot 10^{14}$ $cm^{-2}s^{-1}$ thermal, unperturbed

Tab. 1: Characteristic data

This paper shows some basic information and the progress on the site in Garching near Munich since May, 1998 (IGORR 6).

2. Design Concept

The basic safety principle of the design is the 3-barrier concept and the securing of the maintaining of these barriers (fuel and cladding, pool water, confinement). Thus the radioactive fission products are kept back so that inadmissible radiation exposure in operation and after accidents can be avoided at every time.

2.1 Engineered Design Features

In addition to inherent and passive safety characteristics as reactivity decrease e.g. after leakages of heavy water from the moderator tank or of light water from the core many constructive features make sure that only a low level of radiation exposure will occur in design basis accidents. These features are:

- big volume of pool water as a heat sink
- integrity of the pool with the primary cooling system
- shutdown systems
- shutdown cooling systems
- confinement
- reactor protection system
- auxiliary safety-related systems

2.2 Building Concept

The whole reactor plant consists of the following buildings:

- UJA reactor building (40 m x 40 m, 30 m high)
- UBA entrance building
- UYH neutron guide hall (60 m x 25 m)
- UJB basement of neutron guide hall
- UTA building for auxiliary systems
- UKA stack
- URA tertiary circuit air cooler
- UGX fresh water storage
- UCX emergency control room
- UBZ/URZ underground supplying ducts

The arrangement of these buildings is shown in fig. 1. The reactor and the surrounding buildings contain the systems as listed in chapt. 2.1 to withstand a “safe shutdown earthquake” that means these systems are able to fulfil their safety functions during and after an earthquake. Additionally the reactor building is protected against the effects of an airplane crash. Therefore the outer walls and the roof are made out of 1.8 m thick reinforced concrete. The pool water always covers the fuel element in any post-accident phase because the integrity of the reactor pool is secured in consequence of its mechanical isolation from the outer building structure.

Fig. 2 shows a vertical cross section of the reactor building. The separation of the experimental hall and the reactor hall at a height of 11.7 m can be recognized.

In fig. 3 a schematic picture of the reactor and the storage pool is shown. The fuel element is located in the middle of the moderator tank. The two fast shut down systems and the primary cooling system can be identified, too.

3. Licensing Procedure

In April, 1996, TUM and Siemens got the first partial licence covering the general safety concept acceptance, site development and the erection of the reactor building. Immediately afterwards the site was established and the construction was started in August, 1996.

The second partial licence was obtained in October, 1997. So it was permitted to erect all other buildings and to install and to commission the whole technical equipment.

The third nuclear licensing step covering the nuclear operation is expected for fall 2000. The German government which changed from the conservative to the social democratic and green parties in fall of last year is presently discussing which consequences a conversion of the FRM-II would have to reduce the uranium enrichment from high to low. Table 2 shows an extract of the government report out of June, 1999 for the different fuel versions.

	FRM-II	2b [1)]	3a [2)]	3b [2)]
fuel	U_3Si_2	U_3Si	U-6Mo-Al	U-6Mo-Al
enrichment U-255 [%]	93	19.75	19.75	50
fuel density [gU/cm³]	1.5 / 3.0	5.8	7 - 8	4.0 / 8.0
diameter [cm] outside/inside	24.3 / 11.8	28.6 / 14.4	27.9 / 14.4	24.3 / 11.8
length fuel zone [cm]	70	80	80	70
thermal power [MW]	20	20	20	20
decrease of thermal neutron flux [%] of FRM-II	0	21[3)]	21[3)]	7

[1)] immediate conversion with change to version 3a later
[2)] change later after beginning with fuel of FRM-II as planned
[3)] as calculated by TUM this value amounts to about 25 %

Tab. 2: Different inspected fuel versions for FRM-II

The German federal government plans to decide towards the end of this year how to proceed. But from scientific, technical and economic reasons there is no doubt that the FRM-II should best start with highly enriched fuel as planned.

4. Time schedule

The following table 3 gives an overview about the key project data from the beginning in 1980 till to the future (extract see fig. 4).

1980 – 1984	Proposals of the compact core concept
1984 – 1987	Feasibility study
1987 – 1988	Design study
1988 – 1992	Safety analysis and elaboration of safety analysis report
1989	First recommendation and preliminary classification of the project by the Federal Scientific Council
02/93	Application for license (first partial licence)
11/93 – 12/93	Presentation of the safety analysis report to the public
05/94	Second recommendation and enhancement of classification by the Federal Scientific Council, first public hearing
09/94	Turnkey contract with Siemens for design and construction of the FRM-II
12/94	Budget decisions by the parliament of the state of Bavaria
05/95	Final recommendation by the Federal Scientific Council
07/95	Presentation of the environmental impact statement to the public

10/95 04/96 08/96 01/97 10/97	Second public hearing in connection with the environ-mental impact evaluation First partial licence for the entire concept and for the erection of reactor building Groundbreaking ceremony Laying of the foundation stone Second partial licence for the erection of all auxiliary buildings and the entire installations necessary to perform successfully the cold commissioning	IGORR 6
08/98 since 08/98 01/99	Topping-out ceremony Installation of technical equipment, erection of other buildings (cont.) Third public hearing in connection with the permission for operational water	} see chapt. 5 IGORR7
11/99 02/00 – 12/00 fall/00 01/01 – 10/01	Erection of all buildings completed Cold commissioning phase Third partial licence for hot commissioning expected Hot commissioning phase (assumption: start with HEU, see chapt. 3)	

Tab. 3: Key project data

5. Progress on Site

The following pictures show the progress on the site in Garching near Munich since the IGORR 6-meeting in April/May, 1998.

Fig. 5 98-08-24 Topping-out ceremony

Fig. 6 99-02-23 Experimental hall with reactor pool

Fig. 7 99-04-29 Leakage test of reactor / storage pool

Fig. 8 99-05-25 Total view of site

Fig. 9 99-06-30 Reactor hall: reactor / storage pool with hot cell

Fig. 10 99-08-12 Moderator tank during manufacture

Fig. 11 99-08-31 Total view of site

6. Conclusion

The new German high-flux research reactor of the Technical University of Munich – planned, erected and to be commissioned by Siemens – will soon be available for the benefit of the national and international scientific community. Under the condition that the third partial licence will be obtained as proposed the project progress will remain on schedule with regard to budget and time as planned.