

## A CENTRAL EUROPEAN TRAINING COURSE ON REACTOR PHYSICS AND KINETICS-THE “EUGENE WIGNER COURSE” – ORGANISERS VIEW

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Abstract: Initiated by the 5th Framework Program of the European Commission, the European Nuclear Engineering Network (ENEN) is preparing the future European Nuclear Education schemes, degrees and requirements. To fully utilize the benefits of international co-operation and to promote the knowledge of students in nuclear engineering a 2.5 weeks course has been held, both in spring 2003 and 2004. The main emphasis of the course is to perform reactor physics and kinetics experiments on three different research- and training reactors in three different locations (Vienna, Prague, Budapest). The experimental work is preceded by theoretical lectures aiming to prepare the students for the experiments (Bratislava). The students' work will be evaluated, and upon success the students will get a certificate. The finally accepted credit (ECTS) value will be determined by the students' home university. The ENEN-recommended value is between 6 and 8 ECTS. The more detailed description of the course will be given in the full paper.

### 1. Introduction

As a result of the ENEN project and as a demonstration of international cooperation in the field of nuclear education the participating institutions decided in early 2003 to carry out a common demonstration course on reactor physics and kinetics at three different research- and training reactors in three different locations (Vienna, Prague, Budapest). The experimental work is preceded by theoretical lectures aiming to prepare the students for the experiments (Bratislava). These courses are an upgraded result of a long-standing similar cooperation between the above-mentioned four institutions. The participation was open to students of any European university, however, basic knowledge of reactor physics theory is requested, and this knowledge has to be attested by a professor of the student's home university. The number of participants should be limited to 20. The application is subject of a selection procedure, and may be refused, if the course is already fully booked or if the selection committee decides so, due to any reason. The quality control and accreditation of ENEN assures that the acquired knowledge of the participants will fulfill the requirements of the European Nuclear Education and fits in the European ECTS system.

### 2. The course content

As four different institutions were involved attention has been given to the fact that there is no overlapping between the course content in the different locations. As the three involved reactors differ strongly in their technical design and in their special features the students received an excellent technical overview during the educational program. The following table 1 gives a summary of the technical specifications of the three involved research reactors.

Table 1: Technical specifications of the research reactors used for the "Eugene Wigner Course"

	Czech Technical University in Prague	Budapest University of Technology and Economics	Vienna University of Technology Atominstitut
reactor type	pool type	Pool type	TRIGA Mark II
reactor power	1 kW	100 kW	250 kW/250 MW pulse
type of fuel elements	IRT-3M type, UO <sub>2</sub> -Al square shape tube	EK-100 type, 16 UO <sub>2</sub> fuel rods form a rectangular assembly	solid rod U-Zr-H
enrichment	36%	10%	19,8 %
number	14-16	24 assemblies	81
irradiation facilities	2 horizontal channels 7 vertical channels 1 reflector irradiation facilities	5 horizontal channels 12 Vertical channels 1 large irradiation tunnel.	4 beam tubes, 1 thermal column 2 neutron radiography facility several in-core irradiation facilities

For each reactor station a training and exercise program was established which was compacted in such a way that the students would perform around 5 - 6 experiments in 2,5 days including theoretical introduction and preparing of a protocol. In the following table 2 an overview of the exercises is summarized.

Table 2: Type of exercises at the three reactor stations:

	Czech Technical University Prague	Budapest University of Technology and Economics	Vienna University of Technology Atominstitut
Exercise 1	Properties of neutron detectors for nuclear reactor control	Neutron activation analysis	Thermal neutron flux measurement
Exercise 2	Measurements of reactivity by various methods (source jerk, rod drop, Greenspan)	Measurement of delayed neutron parameters and determination of uranium concentration	Influence of void coefficient on reactor power
Exercise 3	Calibration of control rods	Exercise on reactor operation and control	Critical experiment
Exercise 4	Study of nuclear reactor dynamics	Determination of the diffusion length of thermal neutrons in graphite	Determination of the neutron absorption cross section according to the danger coefficient method
Exercise 5	Start-up and operation of the VR-1 reactor	Measurement of the reactivity importance of neutron absorbers	Reactivity values of fuel elements in different core positions
Exercise	Digital control systems of		Reactor power

6	research reactors		calibration and temperature coefficient of reactivity
Exercise 7			Demonstration of a prompt critical power excursion to 250 MW

### 3. Course logistics

As the participating students came both from EU and non-EU countries travel logistics required a good fraction of the organizational work. All students first traveled to Bratislava where they were divided into four groups, attention was given to mix the nationalities in order to increase the international aspect of the course. An additional problem was also to plan accommodation for female and male participants. All participants were accommodated either in university guest houses or in reasonable hotels (single or double as available) with breakfast included which was covered by the course fee except for those participants who had its permanent residence in the host city. In addition all local transportation in the host cities and the train transfer between the host cities were included in the course fee.

The first days in Bratislava were devoted to a theoretical introduction into the course with subjects such as

- Survey of research reactors and associated systems
- Data evaluation techniques (related to the practical exercises)
- Radiation protection and dosimetry
- Detectors of radiation
- Instrumentation for nuclear measurements
- Nuclear measuring methods
- Nuclear Safety

The students received written handouts for all theoretical and practical courses, at the end of the theoretical part tests were performed and the results were evaluated. This evaluation together with the further evaluations at the three reactor stations were the basis for the final course evaluation of each participant.

After the theoretical course in Bratislava two groups travelled together by train to Budapest where two groups could be handled simultaneously, while one group transferred to Vienna and the other to Prague. The Vienna and Prague group were exchanged in the middle of the second week (travelling day). After the second week the groups from Vienna and Prague met in Budapest while the previous two Budapest group were distributed to Vienna and Prague again with one exchange in the middle of the week. Finally all groups and the instructors met for a common course evaluation and course wrap up in Vienna to exchange information. The Eugene Wigner Course in 2003 revealed some organisational short comings which were also mailed at a later stage to the organisers and were considered in 2004 course.

### 4. Financial aspects

The course was financially calculated to cover all expenses for accommodation and travel (except the initial travel to and from Bratislava) as well as for the administrative and organisational work and a reasonable amount for reactor availability time, the overall cost per participant is in the range of € 2000. However the applicant is requested to take care about his/her insurance and visa arrangements if necessary. It has also to be acknowledged that the two courses would not have been possible without the generous support of the IAEA and CENS. The final cost recovery calculation was not very easy because the available money comes from different sources (course participants, IAEA, private company) and the sponsor money was specifically allocated for a subgroup of participants such as non-EU countries at that time. Finally the overall available amount had to be divided among the host institutions

taking the mentioned restrictions into account. It has also to mentioned that the two weeks time invested by the instructors was not considered in the financial aspects.

Though the financial support from IAEA and from CENS is gratefully acknowledged some expenses had to be compensated from the institutes internal sources. The situation was extremely critical especially in 2004 when the course was accomplished only due to an extensive involvement of the organizing institutions which have covered a substantial share of running costs of the reactors from their own budgets. It should be emphasized that the “Eugene Wigner Course on Reactor Physics Experiments” is unique in a sense that it provides access to experimental nuclear facilities comprising practical exercises on research nuclear reactors as well as an excursion to an operating nuclear power plant in four European countries. As such, it strengthens the European dimension in nuclear education which is actually twofold:

1. The course takes place in four European capitals and it is supervised by experts from these countries and, at the same time

2. the participants are working in international groups which, as a rule, are not formed from students coming from the same country. So the trainees are experiencing working conditions in an international team in foreign institutions for the whole duration of the course. For these reasons the course is very attractive because it enables not only to acquire new knowledge and skills but also to share one’s experience with colleagues from other countries. On the other hand, particularities of this course which is jointly organized by four universities from four countries with direct involvement of nuclear experimental facilities makes it very demanding from the financial as well as organizational point of view. The feasibility of such a course was successfully demonstrated. Taking into consideration the now two years experience, the self-sustained financial model puts some constrains to the participation. To improve this situation as well as to enable lowering the participation fee an external support for e.g. running reactor costs would be of a great help. Dedicated grants from EU funds, leading industrial companies, WNU or other sources should be considered. Otherwise this useful activity would be real in threat in the years to come.

5. Course evaluation:

The 2003 Eugene Wigner Course was carried out between 28.4. to 16.5.2003 with 21 students from 10 countries

- Austria
- Belgium
- Czech Republic
- Finland
- Italy
- Sweden
- Slovak republic
- Slovenia
- Romania

and 2004 course between 26.4. to 15.5.2004 was attended by 17 students from 7 countries

- Austria
- Bulgaria
- Switzerland
- Czech Republic
- Sweden
- Slovak republic
- Slovenia

The 2004 course was slightly changed as a result of the feedback from the 2003 participants, especially the theoretical part in the first week was reduced and some overlap in the exercises between Vienna and Prague have been eliminated. The students interest and cooperation was excellent in both cases. At the final meeting a certificate was issued which serve as a basis for the ECTS acknowledgement at the home universities. Taking the duration and the contents into consideration 6 to 8 ECTS were recommended by the course organizers.

The future of the “Eugene Wigner Course” mainly depends on adequate funds available but it has been efficiently demonstrated that such a course has an important role to play in knowledge management and training in reactor physics and kinetics.