Transactions

2009

Vienna, Austria
22 -25 March 2009

IAEA
International Atomic Energy Agency

ATOMINSTITUT
TU WIEN

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ISBN 978-92-95064-07-2

These transactions contain all contributions submitted by 20 March 2009.

A MULTI-NATIONAL PRACTICAL TRAINING COURSE FOR NUCLEAR CANDIDATE COUNTRIES ORGANIZED BY EERRI

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ABSTRACT

An increasing number of Member States (MS) requests IAEA assistance to develop nuclear skills and resources in support of national nuclear power programmes under development. For countries with little or no existing nuclear infrastructure, human resources and skills must be developed to support planning, analysis, evaluation and other prerequisite activities for the decision making process. The Eastern European Research Reactor Initiative (EERRI) was approached by the IAEA to organize and implement a Group Fellowship Training Program on Research Reactors (GFTPRR) to satisfy the increasing demand for the aforementioned skill development. The GFTPRR will be offered to participants from MS who have expressed interest in this subject to the IAEA. The first training course is planned for spring 2009 with six participants organised by the Vienna University of Technology/Atominstitute, two Hungarian Nuclear Research Institutes and the Jozef Stefan Institute/Ljubljana, Slovenia. This paper presents the planning procedures, the detailed course content and logistics for the first model course.

1. Introduction

An increasing number of Member States (MS) are requesting IAEA assistance to develop nuclear skills and resources in support of national nuclear power programmes under development. Some of these MS are planning to construct a research reactor as a first step to develop nuclear competence and infrastructure. For countries with little or no existing nuclear infrastructure, human resources and skills must be developed to support planning, analysis, evaluation and other prerequisite activities involved in the related decision making process and subsequent projects. The Eastern European Research Reactor Initiative (EERRI) was approached by the IAEA to organize and implement a Group Fellowship Training Program on Research Reactors (GFTPRR) to satisfy the increasing demand for the aforementioned skill development. The GFTPRR will be offered to participants from MS who have expressed interest in this subject to the IAEA.

The program is being organized in collaboration with the Vienna University of Technology/Atominstitute (VUT/ATI). The first iteration will involve VUT/ATI, two Hungarian

Nuclear Research Institutes, and some staff members from the Jozef Stefan Institute's/Ljubljana (IJS), Slovenia. The duration of the training program is estimated between 4 to 6 weeks and will cover about 30 topics ranging from theoretical lectures to practical experiments at the TRIGA reactor Vienna and at the training reactor of the Budapest Technical University grouped into three main areas:

- Organisational Matters
- Research Reactor Operation and Maintenance
- Radiation Protection

The first training course is planned for spring 2009 with six participants. This paper presents the planning procedures, the detailed course content and logistics for the first model course.

2. Involved Institutions

2.1 Vienna University of Technology/Atominstitute (VUT/ATI), Austria

The Atominstitute being the closest nuclear facility to the IAEA has long-term experience in organising national and international training courses. The course contents origins from the regular students curriculum at the Vienna University of Technology (VUT). The courses are part of the eligible course during the Masters Program in the Technical Physics Curriculum. There are three practical courses offered by the Atominstitute which are

- Practical Exercises in Reactor Physics and Kinetics
- Practical exercises in Reactor Instrumentation and Control
- Practical Exercises in radiation protection

Each of these exercises are composed of about 10 topics where the students have to work directly at the reactor in groups of maximum eight students according to the provide programme. Each exercise is introduced by theoretical part and followed by the practical experiment. As the TRIGA reactor is designed primarily for education and training the students also have the possibility to start-up the TRIGA reactor on their own towards the end of the course. Out of these totally 30 exercises any combination of exercises are possible according to the interest for the group. In addition a number of course are available covering all legal and technical aspects of research reactor planning an d operation. During the past 5 years the request for training courses have increased from about 10% to almost 50% which poses a limit to the course staff but also to the reactor availability.

2.2 KFKI Budapest, Hungary

The KFKI Atomic Energy Research Institute (AEKI) has been operating a research reactor, namely: Budapest Research Reactor (BRR) since 1959. Since its initial criticality, the BRR has been utilized as a neutron source for research and various industrial and health care applications, as well as education and training purposes in the nuclear field. The reactor contribution in the training course is aimed to the practical subjects. Thus, on the basis of the operational and utilization experiences the subjects of the training courses are:

Research Reactor operation and utilization matters
Water chemistry in general and in practice at BRR
Emergency procedures
QA issues at a research reactor and practical approaches of nuclear project planning and implementation

The listed subjects are divided in theoretical topics and on site training where the students can see how the operating matters are managed in the everyday practice. The students have

an opportunity to take an insight into the regulatory environment from the viewpoint of operators as well as from the specific research reactor management practice (the operation and utilization meters are separated) applied at BRR.

2.3 Budapest University of Technology, Hungary

The training reactor of the Budapest University of Technology and Economics is a pool type reactor located at the university campus. The facility was designed and built between 1961 and 1971, by Hungarian nuclear and technical experts. It first went critical on May 22, 1971. The maximum power was originally 10 kW. After upgrading, which involved modifications of the control system and insertion of one more fuel assembly into the core, the maximum licensed power was increased to 100 kW in 1980. The reactor still operates with the original LEU fuel assemblies. The reactor building houses reactor physical, radiation protection, and radiochemical laboratories, and a small hot cell too.

The main purpose of the reactor is to support education in nuclear engineering and physics for Hungarian graduate students, but international training courses (e.g. „Eugene Wigner Course for Reactor Physics Experiments") are organized and IAEA fellows are hosted too.
The reactor is used, among others, in the following fields: experiments in reactor physics and thermal-hydraulics, activation analysis for radiochemistry and archaeological research, analysis of environmental samples, determination of uranium content of rock samples, nuclear instrumentation development and testing, development and testing of tomographic methods for safeguards purposes, and investigation of radiation damage to instruments/equipment. The subjects in the training course will be the following:

- Thermal hydraulics
- Radiation protection and waste management
- Site requirements
- Public information

2.4 Jozef Stefan Institute, Ljubljana, Slovenia

Jozef Stefan Institute (JSI) has been operating a 250 kW TRIGA type research reactor since 1966. In 1991 it was reconstructed and equipped for pulse operation. The reactor has been used for neutron activation analysis, irradiation of various samples (semiconducting detectors, fusion reactor materials, etc.), neutron radiography, training (Slovenian nuclear power plant (NPP) reactor operators, students of University of Ljubljana, IAEA trainees from developing countries, etc.) and for testing and development of various computer codes. The reactor physics division at JSI has long-term experience in usage and development of various computer codes for reactor core calculations. Among others they have developed a program package for reactor calculation of TRIGA Mark II research reactor cores, TRIGLAV-W (http://www.rcp.ijs.si/triglav/), which will be explained and demonstrated during the course. Lately they have been working extensively also on validation and verification of modern Monte Carlo computer codes, such as MCNP, which will be presented at the course. Since the 1980's the group has been using the WIMS-D computer code together with other home-developed codes for performing core design of the NPP Krško in Slovenia. The WIMS-D will also be presented at the course. The computer codes mentioned above are one of the most commonly used codes for performing the reactor calculations world-wide. The trainees will become familiar with the WIMS-D, TRIGLAV-W and MCNP computer packages and will learn how to calculate various research reactor physics parameters and models that lie behind the calculations. They will also learn the basics of burn-up calculations and core optimization. The lectures will be followed by computer exercises and practical case studies.

3. Research Reactor Situation Worldwide

According to the latest IAEA information totally 768 research reactors have been built world wide, from these 170 have decommissioned, 248 are in various shut down states and 250 are operational and one is under construction. A number of countries exist who have not been involved in any nuclear activities but they realize that nuclear power could be an option for the future. Although in these countries highly trained technical staff is available in other fields such as oil or chemical industry there is however a lack of nuclear experience. The normal first step to nuclear is the planning of a research reactor as this was the usual way in the late 50ies and early 60ties for industrialized countries to gain nuclear experience and to step further into nuclear power. This is the reason why it was decided to offer a training course covering all aspects of the pathway to nuclear.

4. EERRI Training Course Background Information

The Research Reactor Group of the Nuclear Fuel Cycle and Waste Technology Division, organises a Group Fellowship Training programme to assist Member States that consider building a Research Reactor as a first step to develop nuclear competence and infrastructure in the Country. The training programme has been elaborated with the purpose to assist such Member States in the pursuit of these ambitious endeavours. It will help develop the necessary skills and background to carry out activities related to planning, evaluating, development, construction, commissioning, operation and maintenance of research reactors.

The programme has been organised within the framework of the "Eastern European Research Reactor Initiative (EERRI)". In its inaugural edition in spring 2009, the programme will involve the participation of 4 institutions that operate research reactors, the Atominstitute of the Vienna University of Technology (Vienna-Austria), the Jozef Stefan Institute (Ljubljana - Slovenia), the KFKI Atomic Energy Research Institute and the Budapest University of Technology and Economics, the last two from Budapest, Hungary.

The programme is aimed at young, technical professionals who have no nuclear experience. Candidates should have technical degrees in engineering or science and may eventually be responsible for research reactor activities in countries that have no experience with such facilities. Participants may also include technical professionals seeking hands-on nuclear rector facility experience and familiarisation to support the development of a nuclear power programme. Due to limited infrastructure for practical/experimental activities, for each edition the programme at most 8 students may be accommodated. If the programme is successful it may be repeated in Fall 2009 depending on the outcome of this first programme and ongoing interest from IAEA Member States.

- Administrative and organisational topics such as regulatory requirements, site requirements nuclear project planning and implementation/control, decommissioning planning and implementation
- Reactor related topics such as reactor physics, I&C Systems, thermo-hydraulics, maintenance and inspection programs
- Radiation monitoring such as radiation protection, personnel and environmental monitoring
- Practical courses such as Practical courses on reactor physics and kinetics, on I&C systems, in radiation protection and dosimetry and on fuel management

The overall time of this course is scheduled for five weeks where the participants start in Vienna due to the location of the IAEA and the Atominstitute. The first three weeks will take place mainly at the Atominstitute with some presentations also at the IAEA. To reduce travel expenses the lecturers from the Institute Josef Stefan/Slovenia will come to the Atominstitute and present their contribution in Vienna. After these three weeks the participants will move to Budapest by train for one week of training at the KFKI and one week at the TU Budapest. The termination of this course is planned again in Vienna together with the IAEA. When planning the course other institutes (i.e. Rez/Czech Republic,

TU Prague, Swierk/Poland, Pitesti/Romania) indicated also their interest to contribute however to save travel costs the present schedule was selected for the initial course . It is however easily possible in future to offer this course also in cooperation with the above mentioned institutes. The proposed course schedule is shown below:

Education and training subjects	TU Vienna	NRI Rez	TU Prague	BRR Budapest	TU Budapest	TRIGA Ljubljana	MARIA Swierk	TRIGA Pitesti
Regulatory requirements			Yes		Yes			Yes
Code of Conduct		Yes					Yes	Yes
RR Management		Yes	Yes	Yes			Yes	Yes
Staffing requirements		Yes	Yes					Yes
Site requirements					Yes			
Waste management					Yes			Yes
Public information				Yes	Yes			Yes
Physical security			Yes					Yes
Emergency procedures		Yes	Yes	Yes	Yes		Yes	Yes
Nuclear project planning and implementation/control				Yes				
Decommissioning planning and implementation		Yes			Yes		Yes	Yes
RR Overview	Yes		Yes	Yes	Yes		Yes	Yes
RR Utilization	Yes	Yes	Yes	Yes			Yes	Yes
Introduction to atomic and nuclear physics	Yes		Yes		Yes			Yes
Reactor physics	Yes		Yes		Yes	Yes	Yes	Yes
I&C Systems	Yes		Yes					Yes
Thermohydraulics					Yes		Yes	Yes
Maintenance and inspection programmes	Yes	Yes	Yes	Yes			Yes	Yes
Fuel management		Yes	Yes	Yes		Yes	Yes	Yes
Fuel Cycle		Yes		Yes	Yes	Yes	Yes	Yes
Water chemistry		Yes		Yes				
Radiation protection	Yes	Yes	Yes	Yes	Yes			Yes
Personnel monitoring	Yes	Yes	Yes	Yes	Yes			Yes
Environmental monitoring	Yes	Yes		Yes	Yes		Yes	Yes
Practical course on reactor physics and kinetics	Yes		Yes		Yes		Yes	Yes
Practical course on I&C systems	Yes		Yes					Yes
Practical course in radiation protection and dosimetry	Yes		Yes	Yes	Yes		Yes	Yes
Practical course on fuel management		Yes	Yes	Yes		Yes	Yes	Yes

Day	Morning 9-12h, 20 min Coffee	Afternoon 13-16h Break as required	Location
WEEK 19			
4. May	Administrative Procedures Visit to the TRIGA facility	Research Reactor Overview	ATI
5. May	RR utilization	RR vs Nuclear Power Plants	ATI
6. May	Regulatory requirements	RR Staffing	ATI
7. May	Strategic planning for RR	Code of Conduct for RR	ATI
8. May	Introduction to Radiation Protection and instrument demonstration	Test and discussion on week no 1	ATI
WEEKEND	VIENNA		
WEEK 20			
11. May	Reactor Physics 1	Determination of the thermal neutron flux density in the TRIGA reactor	ATI
12. May	Reactor Physics 2	Power calibration and temperature coefficient	ATI
13. May	Critical experiment	Calibration of control rods, etermination of reactivity worth and excess reactivity	ATI
14. May	RR I&C systems	Demonstration of I&C Detectors	ATI
15. May	Demonstration of fuel handling and fuel transfer	Test and discussion on week no 2	ATI
WEEKEND	VIENNA		
WEEK 21	Preparation of Safety Analysis Report (SAR)	Safety assessment for RR	ATI or IAEA

18. May	Training of operating personnel	Special applications of RR (BNCT, Silicon doping, isotope production etc)	ATI or IAEA
19. May	RR maintenance and in-service inspections	RR Decommissioning	ATI or IAEA
20. May	NPP-PWR overview	NPP-BWR overview	ATI or IAEA
21. May	Public Information	Physical security	IAEA
22. May	Demonstration of prompt criticality	Test and discussion on week no 3	ATI
WEEKEND	VIENNA		
WEEK 22			
25. May	Introduction to reactor calculations	Introduction to computer codes WIMS (demonstration and computer exercises)	IJS at ATI or IAEA
26. May	RR reactor physics parameters and models	Introduction to computer codes - TRIGLAV (demonstration and computer exercises)	IJS at ATI or IAEA
27. May	Calculation of RR safety parameters	Introduction to computer codes MCNP (demonstration and computer exercises)	IJS at ATI or IAEA
28. May	Burn-up calculations and core optimization	Questions and problems from the participants (discussion and computer exercises)	IJS at ATI or IAEA
29. May	Questions and problems from the participants (discussion and computer exercises)	Questions and problems from the participants (discussion and computer exercises) Test and discussion on week 4	IJS at ATI or IAEA
WEEKEND	TRANSFER FROM VIENNA TO BUDAPEST		
WEEK 23			
1. June	The BRR (VVR-10 MW) reactor as a tank type RR reactor	Reactor systems - site visit BRR's utilization	KFKI Budapest
2. June	RR management (operation and utilisation issues)	Emergency procedures	KFKI Budapest
3. June	Water chemistry in general and in practice at BRR	Personal monitoring Environmental monitoring	KFKI Budapest
4. June	Quality assurance in practice at a research reactor	Nuclear project planning and implementation	KFKI Budapest
5.June	Site visit.	Site requirements, Public information Test and discussion on week 5	TU Budapest
WEEKEND	BUDAPEST		
WEEK 24			
8.June	Thermal hydraulics	Thermal hydraulics	TU Budapest
9.June	Waste management	Radiation protection	TU Budapest
10.June	Practical course in radiation protection and dosimetry	Practical course in radiation protection and dosimetry Test and discussion on week 6	TU Budapest
11.June	TRANSFER FROM BUDAPEST TO VIENNA		
12.June	FINAL COURSE DISCUSSION		IAEA

5. Conclusions

It has been demonstrated that among the various research reactors in Central and Eastern Europe a very positive and beneficial co-operation is possible which can be offered to nuclear candidate countries. In addition part of these courses could also be used for training or retraining of junior and/or senior research reactor operators as the various course modules can be extracted from the above mentioned course can be and recombined in a customized manner.