OPERATION EXPERIENCE WITH THE TRIGA REACTOR WIEN

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1. Introduction

The TRIGA Mark-II reactor Wien is now in operation for more than 46 years. The average operation time is about 230 days per year with 70% of this time at nominal power of 250 kW. The remaining 30% operation time is used for students' training courses at low power level. Pulse operation is rather infrequent with about 5 to 10 pulses per year.

The utilization of this facility is excellent, especially the number of practical training courses has increased strongly. These courses are offered regularly to students from the University of Manchester, to reactor staff from the NPP Bohunice and Mochovce and to reactor staff from the research reactor in Mol.

All experimental facilities are intensively used, therefore, neither from a technical nor from an economical and utilization viewpoint a need for decommissioning is necessary and it is intended to operate the reactor as long as possible into the next decade. The on-going US fuel return program has been discussed with the Regulatory Body and the authority's viewpoint at present is to continue reactor operation to the latest possible moment determined by the US fuel return program.

2. TRIGA reactor technical related work

2.1 Instrumentation

As reported at previous TRIGA conferences the instrumentation of the TRIGA reactor Wien was renewed in 1992, employing the digital console developed by General Atomics. Experience with this instrumentation has been reported at various conferences. Since the installation of new DAC and CSC computers in April 2000 the reactor instrumentation is working without major problems. In the past the two monitors have been replaced by flat screens and some Action Paks failed by ageing, it seems to be more and more difficult to get adequate spare parts as most of the I&C components are from the late 80'ies and the new components sometimes do not fit into the old sockets. Otherwise the I&C system is working satisfactory and the unavailability due to I&C problems is low.

2.2 Fuel Elements

There has been a significant change in the core compositions since a few weeks ago. For many years the core is a complete mixture of a 46 years old Al-clad TRIGA fuel, of several 40 year old SST fuel elements and of 9 FLIP elements (70% enriched) being 34 years in the reactor core. For many years the FLIP elements were occupied the C-ring of the core. After extensive core calculations and in view of increasing the excess reactivity six FLIP elements were placed in the B-ring /Tab.1,2, Fig1,2/. This increase the reactivity of the core by about 40 cents, however it reduced the thermal flux in the centre.

Until now only 8 fuel elements (all Al-clad) have been permanently removed from operation and are stored in a dry fuel storage pit. Further 9 SST elements, 2 of them instrumented, are on stock stored in the fresh fuel storage.

The fuel elements are controlled for their elongation and/or bowing every two years and until now 4 elements had to be removed permanently for excess elongation or bowing and 4 for fission product release. Taking the past and present reactor operation schedule into account, the reactor could operate another 15 to 20 years without purchasing further fuel.

2.3 Cooling Circuits

The primary, secondary and purification circuit have been modified in 1985 and since that time are operational without any modifications. Only maintenance work is carried out regularly, (i.e. replacing ion exchange resin, filters etc). Since the last cleaning of the heat exchanger in September 1997 no further problems with the heat exchange capacity was observed, however to prevent the transfer of sub-micron particles into the pool a 0,2μm filter is placed right after the ion exchange resin container, the resin is replaced every two years.

2.4 Ventilation System

The ventilation system is in an excellent technical state and operates without major problems. The off-gas is monitored for noble gases by a set of NaI detectors looking on a glass fiber filter and for halogens by active charcoal in a bye-pass. In addition an aerosol monitor collects continuously air samples from above the pool water surface 24 hours a day with two alarm levels.

2.5 Area Monitoring System

This system is rather overdesigned for such a small facility, it has been installed a few years ago and is basically composed of 19 dose rate meters type FH40G instruments by Thermo Eberline. These instruments have the advantage that they contain an internal proportional counter but also external detectors such a NaI scintillators can be connected.

- 13 dose rate meters distributed in the reactor hall and basement
- 2 dose rate meters with external scintillation detectors installed in the primary and secondary cooling system
- 3 dose rate meters with external scintillation detectors used as aerosol monitors, one above the pool, two in the off-gas channels
- 1 dose rate meters with an external neutron monitor in the reactor control room.
- 1 dose rate meters with an external scintillation detector at the gate entrance

All data are scanned continuously and an alarm is triggered and documented when any of the detectors exceed a preset pre-alarm or main-alarm level. Further this system is connected to an uninterrupted power supply system (UPS) to operate even during power supply failure.

2.6 Re-inspection and Maintenance Program

All components and systems are re-inspected following an elaborate re-inspection program. This consumes about 4 man-days per month. Once a year all the reactor systems are inspected in presence of an expert nominated by the regulatory body and his expertise is the basis for the annual renewal of the operation license valid again for the coming year. This annual inspection requires approximately 1 man-month (four persons for two weeks). Especially the 6,5 m underwater endoscope proved very helpful in inspecting core internals. This endoscope was applied successfully at inspections in other research reactors such as Pavia, Rome, Kinshasa, Imperial College/UK and Rabat/Morocco.

One major task during the last year was the removal of a fast pneumatic transfer system from the piercing beam tube A and a collimator removal from a radial beam tube D. Before this task parts of the fuel elements had been removed to reduce the radiation level during inspection. Both beam tubes have been inspected visually for corrosion and the results were documented electronically.

3. TRIGA reactor research related work

3.1 Concrete activity of the Vienna TRIGA shield

A project involving two PhD and several student project works is the determination of the activation of the concrete shield of the TRIGA Vienna in view of future dismantling. Although several TRIGA reactors have been decommissioned in Europe (i.e.Heidelberg, Hannover) and some experience exists, for every TRIGA owner it is of interest what will be the activity and the mass of activated concrete when the specific reactor will be decommissioned. Therefore concrete core samples have been taken from the outside of Vienna TRIGA reactor and activated to determine the trace elements and the major long-lived activation products. Ba-133 and Eu-152 are the main contributors with half-lives around 10 years /2-6/. A major task was the determination of the neutron diffusion length in the specific concrete. Experiments were carried out in the thermal column of the TRIGA reactor. Using the obtained value and a MCNP model of the shield structure allows the determination of the activity distribution. A major problem is the concrete penetrations such as beam tubes. The activity around these cavities depends very much on the scattering effect of the collimator installation.

3.2 Minimizing radiation exposure of staff during TRIGA dismantling

With the results of the concrete activity distribution it is also possible to establish a model to minimize the radiation exposure of staff during the shield dismantling. Experience was also drawn from the well documented dismantling of the 10 MW ASTRA reactor between 1999 to 2005. it was shown that a typical TRIGA shield dismantling should be performed from outside to inside instead the shield instead of top down due to the self shielding of the inner activated concrete layers when working form outside. /3/

3.3 Reactor core calculations

In autumn 2006 work on a MCNP model for the TRIGA Vienna started implemented into one Diploma work and one PhD work /1/. At the moment it incorporates a detailed core geometry including the different fuel element types, regulating rods, source and in core pneumatic transfer systems. Because of insufficient burn up and temperature data only fresh, cold cores can be modelled. Originally it should predict possible neutron flux density and reactivity changes after the removal of the nine 70% enriched FLIP elements from the core due to the US spent fuel return program's focus on conversion of research reactors to LEU fuel. After the extension of the US HEU fuel return programme the focus shifted to improve the fuel utilization of the inserted fuel rods.

In order to increase the excess reactivity 6 of the 8 FLIP fuel elements in the C-ring were exchanged with the standard SS elements in B-ring. As seen in the following table the simulations predicted a 0.65$ increase in reactivity coupled with a slightly higher hot channel factor. Additionally a 9% reduction in thermal flux at centre of the core was expected /2/.

Core configuration	1962	2007	FLIP in B-ring	2007 without HEU
Number of type 102 elements	62	54	54	54
Number of type 104 elements	0	19	19	28
Number of FLIP elements	0	9	9	0
k_{eff}	1.015	1.055	1.060	1.037
Hot rod factor	1.60	2.11	2.17	1.72
Position of hottest element	B2	C7	B2	B2
Type of hottest element	102	FLIP	FLIP	104

Tab 1: k_{eff} and hot rod factor for various core configurations (MCNP results)

Experimentally the FLIP exchange increases excess reactivity by 0.4$ and stronger thermal flux reduction (18%) in the core centre. The most likely reason for the differences between simulation and experiment is because the fuel burn up is neglected in the simulation. Currently a PhD student is involved in solving this problem.

Total Excess Reactivity [$]	FLIP in C-ring	FLIP in B-ring
10 W	1.79	2.16
100 W	1.74	2.12
1 kW	1.72	2.10
10 kW	1.61	2.02
100 kW	1.13	1.53
250 KW	0.44	0.83

Tab 2: Excess reactivity (experimental)

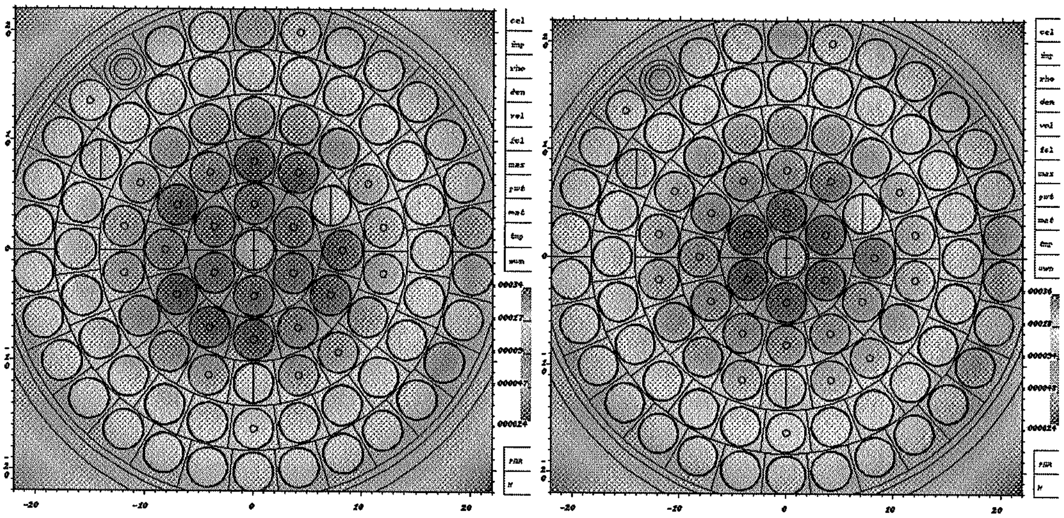

Fig.1: Neutron Flux E>0.2 MeV: FLIP in C ring left, FLIP in B-Ring right

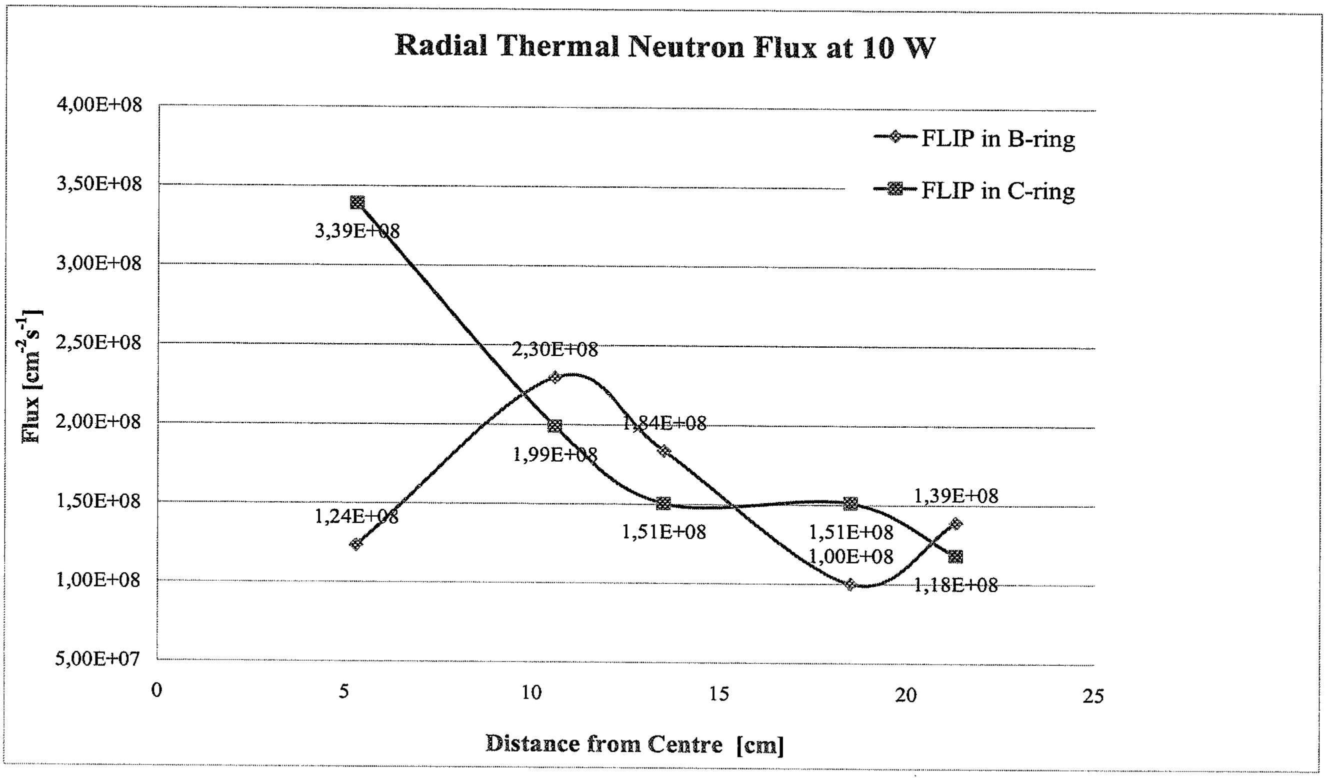

Fig.2: Thermal radial neutron flux distribution before and after changing core configuration

4. Summary and Outlook

The TRIGA reactor Vienna is well utilized and in an excellent technical state. Especially during the last few years the demand of the TRIGA reactor Vienna increased strongly as a training reactor for different target groups such as foreign research reactor operators, NPP operators, IAEA staff and students from within the EC. This places a heavy load on the TRIGA reactor staff as all these courses a carried out with only four members of the reactor group in addition to the routine operation, maintenance and repair work. As the closed research reactor to the IAEA the TRIGA reactor acts as a model show case for a well utilized low power reactor facility. In addition about 2-3 IAEA fellows are also hosted within the reactor group to be trained on various issues of research reactor operation or utilization. There are no technical or economical reasons to consider shut-down. However the future of the TRIGA Vienna will be decided by politicians and not by the technical staff.

5. References

/1/, T. Stummer, R. Khan, H. Böck, M.Villa,: "Monte Carlo Core Calculation For A Mixed Triga HEU/LEU Core" Research Reactor Fuel Management 2008 Conference 2-5.March 2008 Hamburg

/2/ S.Merz: „Neutronenflussmessungen an verschiedenen Bestrahlungspositionen des TRIGA-Reaktors bei unterschiedlichen Kernkonfigurationen AIAU 28312 Juli 2008

/3/ M.Lesar: "Minimizing Radiation Exposure for the Reactor Staff During the Dismantling of a TRIGA Research Reactor" Kerntechnik 71 (2006), May-June, p 321

/4/ M.Djuricic: "Determination of the mass of activated concrete at the TRIGA Reactor Vienna " PhD in progress, TU Vienna, June 2008

/5/ R.Khan: "MCNP Modelling of the TRIGA core including individual fuel burn-.up dtata" PhD in progress, TU Vienna June 2008

/6/ B. Siebenhofer: "Diffusionslängenmessung thermischer Neutronen in Schwerbeton" AIAU 27315Dezember 2007