1.13 PRR1 REHABILITATION AND THE CURRENT AND FUTURE NEUTRON BEAM UTILIZATION PROGRAM

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ABSTRACT

The PRR1 research reactor is the center for nuclear science R & D in the Philippines. It is located in Metro Manila inside the campus of the University of the Philippines. It is a General Electric designed reactor and was commissioned in 1963 with a rated thermal power of 1 MW. It was operated for 20 years enabling the Institute to pursue activities in radioisotope production, neutron scattering, activation analyses and other R& D activities requiring neutron beam. In 1984 it was converted to a 3 MW TRIGA Type reactor. Conversion was completed and test run was successfully accomplished in 1988(1). In the same year the reactor was shut down due to a leak in the aluminum liner of the reactor pool. During the repair deterioration of the other parts of the reactor was discovered that could affect the safety of its operation. A rehabilitation program is made that include the reactor core box and all the other peripherals that could affect its safety operation and to address present regulatory concerns (2). Modification of the core box and its position in the pool opens opportunities and possibilities to suit specific neutron beam application for the users. Plans for this will be presented as well as the strategy of the Institute to satisfy the current need for reactor based facility to enhanced implementation of the Country's S & T Program.

INTRODUCTION:

Fig. 1 and Fig. 2 shows the reactor building and the Cut-away view of reactor pool respectively. The pool walls are penetrated by a thermal column, 6 beam tubes and a gamma irradiation window. The Double Axis Neutron Spectrometer and a Beryllium Filter Neutron Diffractometer were installed in Beam tube BX-6 and BX-4 respectively before they were dismantled to give way for the repair. Neutron scattering researches and the IPA Project(India-Philippines-IAEA) 5 year cooperative program revolve around these two facilities (3,4,5,6,7). The pool has 3 sections: a circular high power section about 2.6m in diameter where the thermal column and beam tubes are located and were connections to a forced cooling system are available; a rectangular low-power section about 2.4m X2.6m, in which a gamma irradiation window is located; and a rectangular intermediate section about 1.6 X2.6 m used for storage of tools and irradiated fuel.

The present core of the PRR-1 contains 115 TRIGA fuel rods in 30 shrouded assemblies, each containing a 2 X 2 cluster as shown in Fig.3 in the original core box. The fuel assemblies are arranged in a 5 x 6 array at center to center spacing of 77.7mm, the same as the original core, which also had 30 fuel assemblies (but plate-type). The grid plate actually is a 7 x 9 array; graphite reflector assemblies, irradiation baskets, and instrumentation detectors occupy other positions. The core requires forced cooling to operate in the megawatt range. The primary cooling circuit includes a 56KW pump, a heat exchanger, and a N-16 decay tank, all installed in an underground equipment room off the floor of the reactor building. In reality all the components of the reactor were still the same since its original construction in 1964 except for some instrumentation in the control room which were up-graded in the early 80's and the TRIGA fuel rods which are relatively new.

THE REHABILITATION PROGRAM*

1. Replacement of the core container with a new core tank fixed in place on the floor of the pool on the pool's high power section. The new core will solve several safety problems simultaneously:
   a. The lack of protection against the loss of pool water accident
   b. High pressure drop in the coolant channels
   c. Lack of inspectability
   d. Uncertain earthquake resistance of the core support

   It will also solve some operational problems such as the too few high flux irradiation facilities and difficult manual access to the core because of the obstructing bridge and suspension frames.

Fig. 4 and Fig.5 shows the new core tank and the three views of the new grid plate with fuel and reflector assemblies and control blades installed. This new tank and grid plate will have 30 additional irradiation positions in the reflector area.

2. A new N-16 tank will be built inside the reactor pool to replace the old N-16 tank
3. A new fixed bridge, with a guard against a drop of the building crane will be built
4. The old thermal column will be removed. This could be used to add new facilities to the reactor such as a new beam tube, a neutron radiography facility or a horizontal pneumatic tube system. Use of this is under consideration.

THE REACTOR UTILIZATION PROGRAM

The planned utilization program is based on the role played by Philippine Atomic Research Center (under the Philippine Atomic Energy Commission) and the Philippine Research Institute in promoting and harnessing the applications of neutrons in various fields. One of the priority area in the national S & T Program is on Materials R & D. PNRI is just one of the research institutes in the country engaged in materials R & D. The National Institute of Physics and the Materials Science Group of the University of the Philippines and the Industrial and Technology Development Institute another research institute of the Department of Science and

* based on the paper of L.S. Leopando, Reference 2.

Technology are the most active in this field. However, only the researchers from PNRI had used nuclear techniques as a tool for studies of materials. In the past and up to the present local researchers recognized the power of neutron scattering in studying the static and dynamic properties of materials. Historically, it is first project approved for implementation by the Physics Group. This paved the way for the training and development of experience in the following:

1. Powder and single crystal structure studies
2. Magnetic structures, magnetic ordering, sublattice magnetization, magnetic transition
3. Instrumentation and neutron spectrometric techniques

It has also spin-off the setting-up of an x-ray diffractometer, Moessbauer effect spectrometer, angular correlation(positron annihilation spectrometer), NMR-EPR spectrometer and other facilities to complement and enhance researches using the two neutron spectrometers for condensed matter physics studies. The recent addition to the facilities is a Total Reflection X-ray Fluorescence Spectrometer.

A recent report by the Reactor Operations Unit, the group responsible for the rehabilitation of the PRR-1 estimated that the funding necessary to completely rehabilitate the reactor would be about 8 to 10 MUS$ or about 400 to 800 million pesos excluding laboratories. This amount is very large and could not be financed from the PNRI regular annual budget alone. The users group is optimistic that this financial constraint as well as the other concerns will be addressed. The facilities identified that should be included in the "new reactor" are:

1. Neutron scattering facility, a diffractometer and small angle neutron system(For structural analyses, magnetic studies and physical properties/characterization of materials)
2. Irradiation facility for performing NAA and PGNAA.
3. Irradiation facility for performing delayed neutron activation analysis.
4. Irradiation facility for radioisotope production used in the following research
   a. Isotopes for industrial applications ^{82}Br, ^{140}La, ^{24}Na, ^{147}Au, etc.
   b. Isotopes for pharmaceutical and biomedical applications, ^{99m}Tc, ^{32}P, ^{131}I
   c. Tracers for soils and plant nutrition ^{32}P, ^{65}Zn and ^{54}Mn
   d. Moessbauer sources(elements in the lanthanide series produced by n-γ reaction) and positron sources(^{64}Cu, ^{65}Zn, ^{80}Br, etc) for condensed matter physics researches
5. Irradiation rig for neutron radiation effects in various types of materials
6. Neutron Radiography
7. Facilities for Neutron dosimetry, The SSDL(secondary Standards Laboratory) needs neutron energies from thermal to fast to establish the appropriate parameters to relate radiation field quantities to relevant dose quantities. Radiation Protection Services needs the reactor to provide for training of personnel in conducting radiation measurements of neutron fields and monitoring of neutron exposures of personnel
9. Facility for Biomedical studies on effect of neutron radiation

CURRENT STATUS OF NEUTRON BEAM RESEARCHES

With the extended shut down of the reactor, techniques that were originally envisioned to be supportive and complimentary to neutron scattering became the major techniques for materials characterization: X-ray crystallography, Moessbauer effect total reflection XRF and others available locally from other research groups both at PNRI and the from the University. Efforts to keep the capability and interest in reactor utilization researches are done by continuously sending researchers to laboratories abroad whenever there is an opportunity. A junior staff had a long-term fellowship on SANS, 2 Professors from the university attended workshop on the utilization of neutron scattering for materials characterization. A research collaboration on structural analysis using HRPD with the Group in Serpong, Indonesia was initiated using the RSG-GAS Reactor(8) under the ICNCA. It is anticipated that under this FNCA similar schemes could be arranged with other Countries. A proposal for this will be presented in another paper. Some staff was also trained on neutron radiography. Proposed neutron radiography facility(9) at PRR1 was made and could be implemented when the reactor is ready. Neutron activation analyses of geological samples and air filters were conducted in different laboratories outside the country made possible through IAEA fellowships.

The on-going IAEA/RCA Program on Sharing of Research Reactor Resources is also being tapped to answer the need for neutron scattering facilities while the local facility is not yet available.

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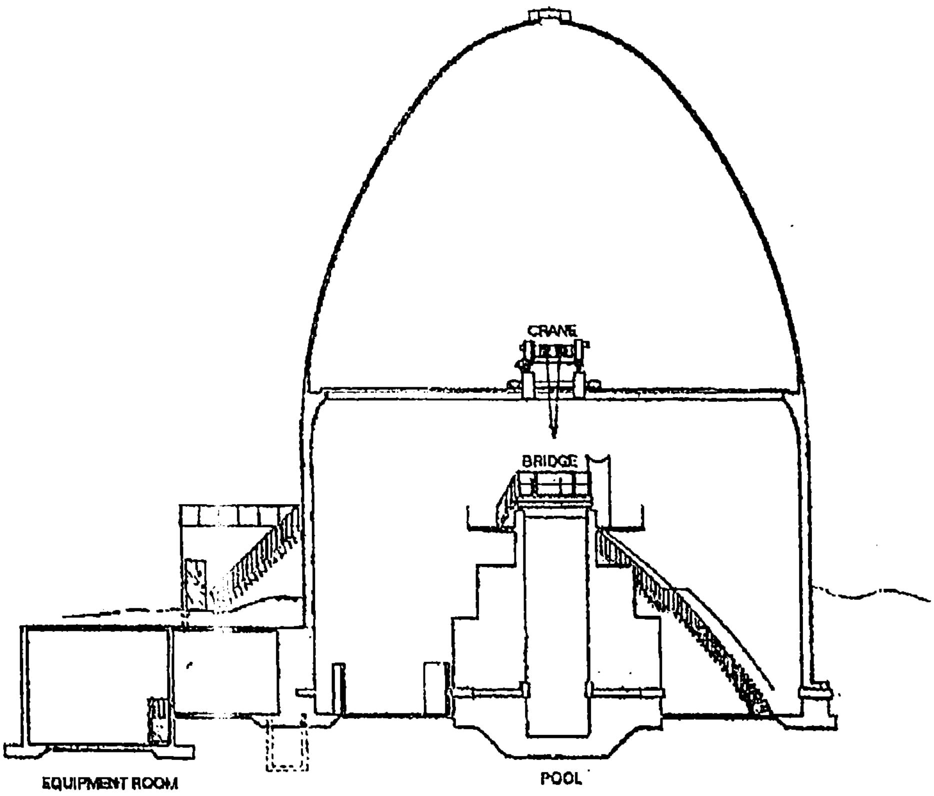

Figure 1. Transverse section of the reactor building.

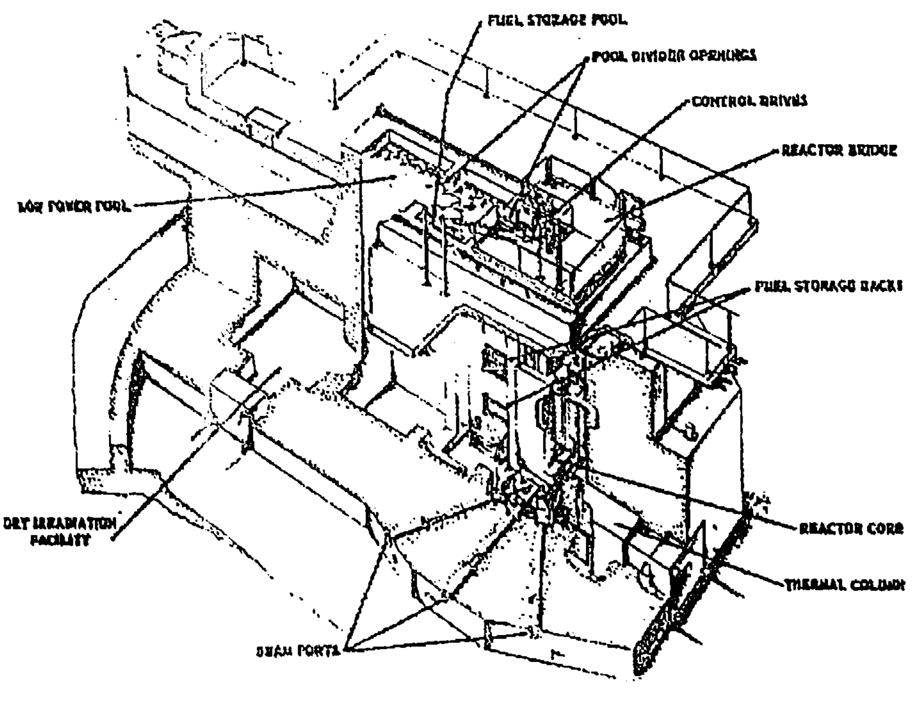

Figure 2. Cut-away view of the reactor pool.

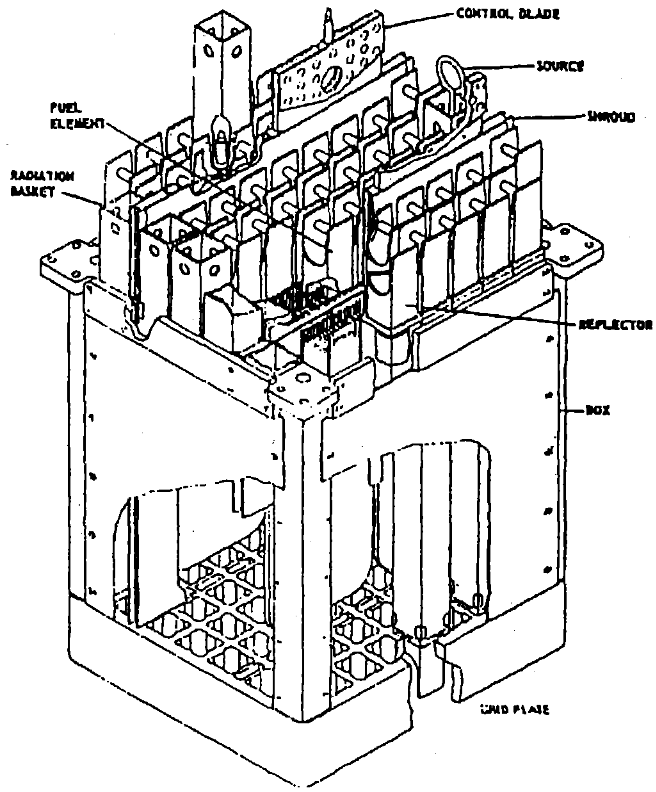

Figure 3a. Cut-away view of the core box that is attached to the bottom end of the suspension frame. The contents of the core box shown in this drawing are actually decommissioned GE core elements, except for the control blades and irradiation baskets that are also used in the current TRIGA core.

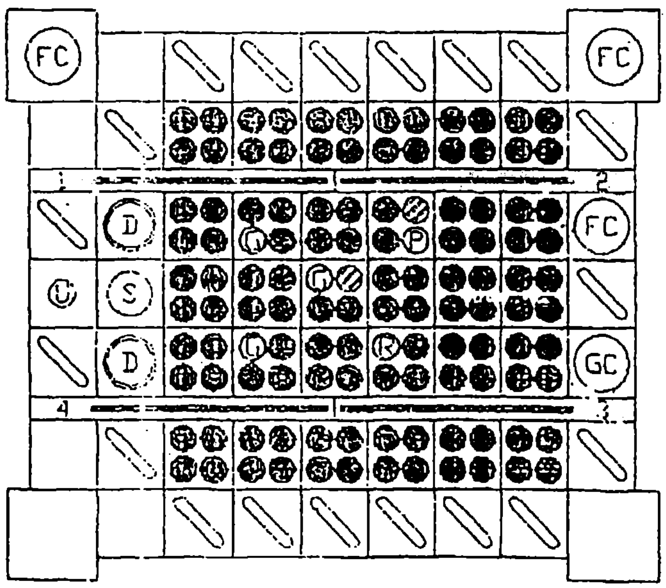

Figure 3b. The TRIGA core layout. The old GE core was similar, but used plate fuel assemblies instead of the 2x2 TRIGA rod clusters shown.

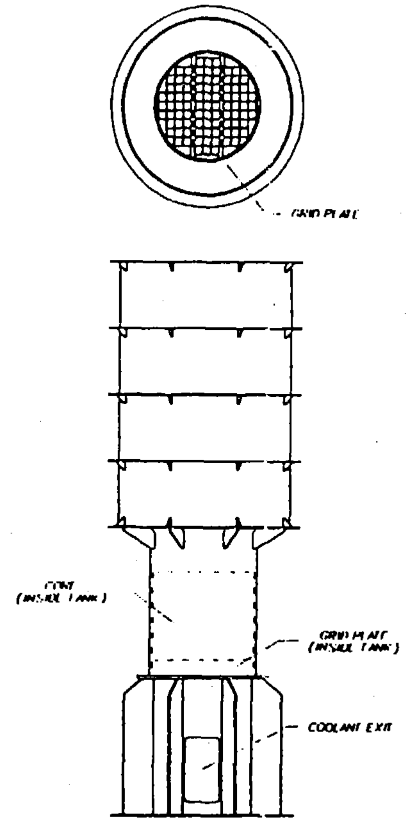

Figure 4. The New core tank

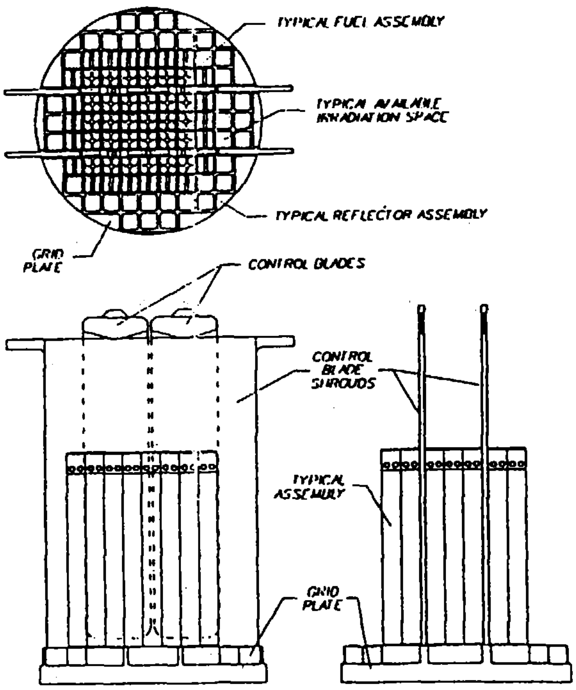

Figure 5. Three views of the new grid plate with fuel and reflector assemblies and control blade