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Current Status of Nuclear Research Reactor Management and Utilization Program in Thailand

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ABSTRACT

The TRR1/M1 is the first research reactor and has been in operational for more than 20 years. During the three decades of research reactor operation in Thailand the utilization of research reactor have been broadened in different fields such as agriculture, medicine and industry. Limitation on utilization of the existing reactor in various fields has led to establishing of a new nuclear research center, Ongkharak Nuclear Research Center (ONRC). The ONRC comprises three major facilities, namely Reactor Island, Isotope Production Facility and Waste Processing and Storage Facility. The reactor itself is a 10 MW TRIGA-type fuels, moderated and cooled by light water with beryllium and heavy water as the reflectors. It is a multi-purpose reactor consisting of different facilities inside and around the core for radioisotope production, medical and industrial uses; and for beam experiments such as High Resolution Powder Diffractometry (HRPD), Neutron Radiography (NR), Prompt Gamma Neutron Activation Analysis (PGNAA), and Boron Neutron Capture Therapy (BNCT). The center is expected to be operational by year 2001.

1. INTRODUCTION

The Thai Research Reactor 1 Modification 1. (TRR 1/M1) is a TRIGA mark III reactor having been operational since 1977. It is an LEU-fuel core replacing the previous HEU-fuel core and has extended utilization of research reactor in Thailand since 1962. It is operated by the office of Atomic Energy for Peace (OAEP). Utilization and research activities of the research reactor is gradually broadened. During the last two decades the need of radioisotopes for medical use has been increasing rapidly, but the domestic supply was rather limited. Other research activities using the existing reactor is also limited due to the power capacity and the old design of experimental facilities. There was pressing need for extended research utilization beyond the present capacity.

In late 1989, a new nuclear research center was first introduced and later became the Ongkharak Nuclear Research Center (ONRC) project. This project comprises three main facilities namely Reactor Island, Isotope Production facility and Waste Processing and Storage facility. There are associated office building, laboratories and residential quarters for researchers. There are extensive irradiation facilities and beam experiment facilities to accommodate various needs of scientists of the next century.

2. CURRENT ACTIVITIES

The existing reactor, TRR1/M1is being used mainly for neutron activation analysis of various samples and for radioisotope production. The normal operation of the reactor is about 65 MWD per year or 40 hours a week at nominal power level of 1.2 MW. It is also used occasionally for colonization of topaz and neutron radiography. Facilities for other nuclear physics experiments are very much limited. It is, therefore, hopeful to have a more extensive utilization program of the new center.

3. ONRC PROJECT ACTIVITIES

The project is divided into 2 parts, turnkey and non-turnkey parts. While non-turnkey is construction of office building and laboratories, the turnkey part is the core of the center comprising a research reactor facility, a radioisotope production facility and a central waste processing and storage facility; and they will be designed and constructed by General Atomics company of the United States. Under the contract, the 10 MW. TRIGA Reactor and its facility is to be supplied by Triga International, the radioisotope production facility (IPF) is to be supplied by Australian Nuclear Science and Technology Organization (ANSTO), and the central Waste Processing and Storage Facility (WPSF) is to be supplied by Hitachi of Japan. The project has the following feature.

3.1 Siting

The Ongkharak Nuclear Research Center (ONRC) located at Ongkharak District, NakhonNayok Province, about 60 km. northeast of Bangkok. The project area is about 500,000 m^2 (or approximately 126 acres) and comprises a research complex (or technical area) and a supporting area consisting of site access and landscaping, a visitor's center, general utility systems, and residential area and recreational parks.

3.2 Reactor Building & structure

The Reactor Building is approximately 25-m wide and 57-m long and consists of the Reactor Hall in the center and two wings. The Reactor Hall houses the reactor. The Reactor Hall has a clear space that is about 23-m wide by 23-m long and 26-m high. The west wing contains the offices, the control room, dark room, waiting room, and fresh fuel storage. The east wing contains the remainder of the reactor auxiliary equipment.

The centerpiece of the Reactor Island is a multipurpose, pool-type TRIGA reactor having a steady-state thermal power output rating of 10 MW. The reactor uses low-enriched uranium (LEU) fuel having a U-235 enrichment of about 19.7 wt. %, is cooled and moderated by light water, and reflected by heavy water (D_2O) and beryllium.

The arrangement of the reactor and auxiliary pools, transfer canal, and isotope transfer hot cell allows irradiated targets to be transferred entirely underwater from their irradiation locations in the reactor to the isotope transfer hot cell. The targets are then pneumatically transferred from the hot cell to the IPF via a tube connecting the Reactor Building and adjacent IPF.

3.3 Core Components

The reactor core configuration, the active core consists of 29 standard fuel- rod clusters, a modified fuel-rod cluster serving as a fast-neutron irradiation facility, 4 control rods, and an in-core Ir-192 production facility, all of which are arranged in an approximately square array. The active core is reflected on two sides by twenty-seven beryllium reflector blocks and on the other two sides by a D_2O reflector blanket. Twenty-three of the beryllium reflector blocks have a central hole to accommodate irradiation experiments; the other four are solid beryllium. A position for an equipment rig for conducting irradiation damage experiments is also located in the reflector area. There are three rapid pneumatic transfer (i.e., "rabbit") systems for transfer of very short-lived radioisotopes from the reactor core to receiving stations located in the Counting Room in the west wing

The 63 core components are installed in a square grid plate having 81 grid positions in a 9 by array. The 18 remaining grid positions filled with solid aluminum blocks to displace water in this area. There are four vertical irradiation sites situated in the D_2O reflector tank. Three are for neutron transmutation silicon doping; the fourth is a spare irradiation facility available for currently undefined use. (fig 4.1)

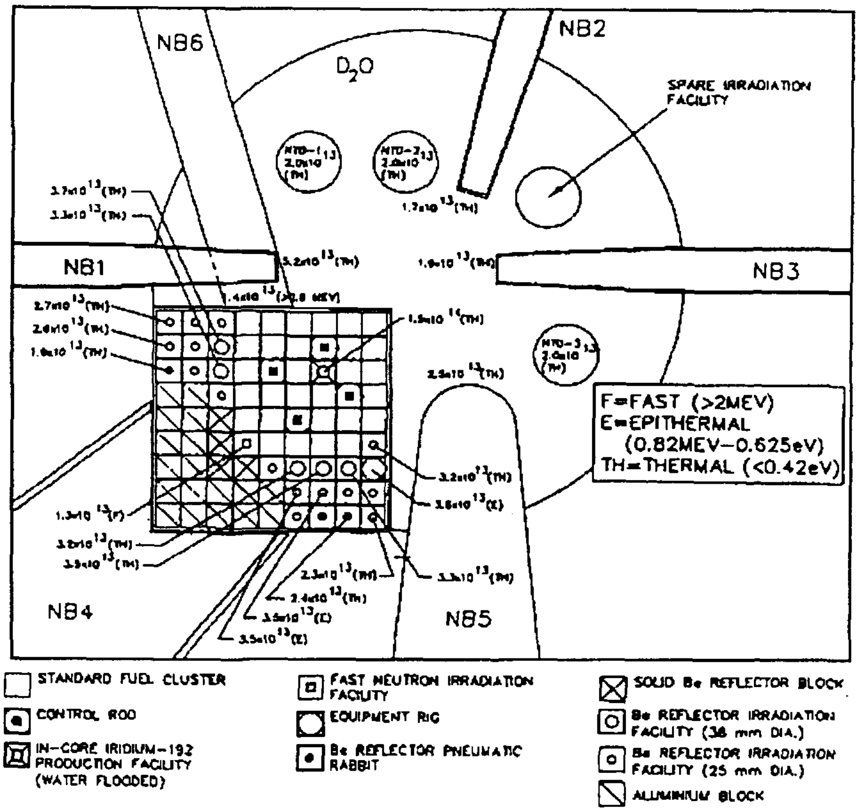

Fig. 4.1 ONRC Reactor Core Configuration & Typical Neutron Fluxes

3.4 Cooling System

The Primary Coolant System removes the heat generated in the core by forced convection cooling during normal reactor operation, or by natural convection cooling with reactor pool water when the reactor and primary coolant pumps are shut down. An important feature is that core decay heat removal passively and safely changes from forced convection to natural convection with reactor pool water if forced convection cooling is terminated (causing the reactor to scram).

The Primary Coolant System consists of the primary cooling loop, two primary coolant pumps, valves, a heat exchanger, and a delay tank with sufficient capacity for N-16 decay. One pump circulates the coolant water through the system. A second pump of equal capacity is available as a backup in case the first pump fails or needs to be shut down for maintenance.

3.5 Emergency Core Cooling System

The reactor design includes an Emergency Core Cooling System (ECCS) designed to ensure that the core remains covered with a sufficient volume of water to maintain adequate core decay heat removal in the event of a loss-of-coolant accident (LOCA). The ECCS delivers water from the primary coolant system delay tank to the reactor structure via the primary coolant outlet pipe as needed to replace the water lost to evaporation. The water is delivered by two parallel-connected, battery-powered pumps, either of which operating by itself has sufficient capacity to deliver the required flow. The ECCS is triggered by a signal from the reactor pool low-low water level SCRAM circuit.

3.6 Instrumentation & Control

The Reactor Instrumentation and Control (I&C) system includes instrumentation for monitoring reactor parameters during normal and abnormal operation. It also manages all control rod movements taking into account the choice of operating mode and interlocks. The Reactor I&C system is a computer-based system, but includes dedicated hardwired displays and controls so that safe operation can continue should the computer become unavailable.

3.7 Reactor Protection System

The Reactor Protection System (RPS) initiates a reactor scram in response to abnormal operating conditions (e.g., high reactor power, high fuel temperature, low coolant flow, coolant flow imbalance, or reactor pool low-low water level) by interrupting the current to the magnets that connect the control rods to the control rod drives. This results in immediate insertion of the rods by gravity.

3.8 Ventilation System

The Reactor Island Ventilation and Air Conditioning (VAC) System provides a suitable work environment for personnel and controls the release of radioactive effluents to the environment. The capacity of the system is based on providing a minimum of two air exchanges per hour. The ventilation zones and air distribution patterns are arranged so that leakage of air from one zone to another will be from clean areas to areas of potentially greater radioactive contamination. A negative pressure of at least 20 Pa is maintained in the Reactor Hall.

The release of any radioactive materials to the environment is limited by confinement in the Reactor Hall. The Reactor Hall has two redundant ventilation systems - the normal ventilation system, and a purge system that exhausts air from the upper part of the Reactor Hall and from directly over the reactor pool to the ventilation stack through an air cleanup unit including a charcoal absorbed. The normal ventilation system will shut down in the event of any accident involving a substantial release of radioactive material .

4. UTILIZATION PLAN & EXPERIMENTAL FACILITIES

4.1 Utilization Plan

The 10 MW. TRIGA multipurpose reactor is dedicated for the R&D in the field of nuclear science and engineering and production of radioisotopes for domestic supply. The main utilization are following:

(a) To conduct beam experiments: high resolution powder diffractometry (HRPD), small angle neutron scattering (SANS), neutron radiography, and prompt gamma neutron activation analysis (PGNAA);
(b)To perform medical therapy of patients through the boron neutron capture therapy (BNCT) technique;
(c) To produce radioisotopes for medical, industrial, and agricultural uses;
(d) To perform neutron transmutation silicon doping (NTD);
(e) To conduct applied research and technology development in the nuclear field;
(f) To provide general training to master the fundamental principles of the reactor and its operation; and
(g) To provide training in reactor physics (neutron physics, thermal hydraulics, reactor experiments, etc.).

4.2 Experimental Facilities

There are different kinds of experimental facilities using in the 10 MW. ONRC TRIGA reactor. These facilities include 6 neutron beam tubes, 2 in-core irradiation facilities, 19 out-of-core irradiation facilities, 3 pneumatic transfer system ("rabbit" systems) for neutron activation analysis, 4 neutron transmutation silicon doping facilities located in the D_2O reflector, and 75-mm diameter edge-of-core fast neutron irradiation facility (75-mm diameter).

(a) Neutron Beamports

The reactor has six neutron beam tubes. The general layout of the beam tubes is shown in Fig. 4.1

NB1 is a tangential beam tube that is designed to service a high-resolution powder diffractometer (HRPD). The core end of the port is narrowed to 100 mm in width (but with the full 150-mm height) to minimize the depression of the otherwise high neutron flux in the D_2O.

NB2 is a tangential beam tube for neutron radiography (NR). The port at the core end is reduced to 100-mm diameter to minimize the flux depression in the D_2O reflector and to accommodate the requirements of the NR collimator.

NB3 is a tangential beam tube for prompt gamma-neutron activation analysis (PGNAA). The core end of the port is tapered to a 100-mm diameter to maximize the thermal neutron current with the least depression of the unperturbed high flux.

NB4 is a radial beam port assembly reserved for boron neutron capture therapy (BNCT). To obtain the high intensity of epithermal neutrons (1-10 keV) required for current BNCT technology.

NB5 is a tangential beam tube intended to supply neutrons for a future Guide Hall. To this end, a large diameter port is inserted to accommodate a future.

NB6 is a radial beam tube reserved for future use. This beam tube has a 150-mm diameter section starting at the surface of the bare core. The diameter is stepped up to 200 mm, and then to 250 mm at the outer end of the beam tube.

(b) In-Core Irradiation Facilities

Two in-core irradiation facilities are planned for the ONRC TRIGA reactor; namely, a centrally located iridium (Ir-192) production facility; and a fast neutron sulfur/P-32 facility (see Fig.4-1)

(c) Out-of-Core Irradiation Facilities

The larger number of out-of-core irradiation sites located in the beryllium reflector blocks (15 blocks with 25-mm holes and S blocks with 38-mm holes) will normally be filled with an aluminum bar or a target assembly. Initially, a limited number (perhaps 6 to 8) will be used for isotope production.

(d) Pneumatic Transfer System

The experimental facilities include three pneumatic ("rabbit") transfer systems (PN 1, PN 2, and PN 3) for the production of very short-lived radioisotopes. All three systems have receiving stations located in the counting room, approximately 20.5 m from the reactor core, and each has a removable cadmium shield located at the irradiation position.

(e) Neutron Transmutation Doping Facilities

The D20 reflector tank has been designed to provide an extended vertical height of the reflector in order to minimize the variation in axial flux at the location of the NTD facilities. Three vertical ports having an internal diameter of 203 mm penetrate completely through the D20 reflector.

5. OPERATION & MANAGEMENT

As previously mentioned, the 10 MW. ONRC TRIGA reactor will serve the R&D program substituted the existing TRR1/M1. It has the operation capacity 3-weeks continuous operation cycles and 10 cycles per year. The operating staff will be 5 rotating shifts (3 per shift), 5 shifts for cooling system(2 per shift) including maintenance and health physicists personnel. The minimum number of operation staff is expected to be 36 persons including senior operations and supervisors.

6. CONCLUSION

The Ongkharak Nuclear Research Center is expected to be operational by year 2001. It is to be the most modern nuclear research and development center in South-East Asia. The future utilization program for Thai researchers will be much broadened and in depth than the current program. More qualified researchers will be mobilized and developed for long-term goal. It is also foreseen to incorporate part of the utilization program into international and regional cooperation in the future.

7. REFERENCES

7.1 Ongkharak Nuclear Research Center Project, September 1995.

7.2 ONRC Preliminary Safety Analysis Report for the 10 MW. ONRC TRIGA Reactor, June 1998.