Sustaining the Operability and Safety of Malaysian Research Reactor to support national nuclear research and education

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Abstract. PUSPATI TRIGA Reactor (RTP) has been in operation since June 28th 1982 with a good track record of safety and operability. As a part of tools for propel national economic development, RTP experienced multi-disciplinary operation request from all over the country to fulfil the need of new technology or technique in the areas of medical, agriculture, oil and gas, materials, environment as well as education. Even at the age of more than 30 years, RTP has to maintain it integrity to cater the operational demands from the academic institutions and industry players.

Keywords: Operability, Safety, RTP

1. Introduction
The only one nuclear research reactor in Malaysia, PUSPATI TRIGA Reactor (RTP) first came into operation in 1982. It reached the first criticality on 28 June 1982 at nominal power of 1000 kW. The reactor uses 19.9% enriched uranium zirconium hydride as fuel. The reactor core sits at the bottom of a 6.5m aluminum tank and has 127 locations for positioning fuel elements, control elements and irradiation facilities.

RTP offers neutron and gamma radiation and sample activation for conducting research as well as education and training of staff and students from varies agencies. Since 2015, RTP has been chosen to conduct an experiment on reactor operation for 3 local universities namely Universiti Teknologi Malaysia, Universiti Kebangsaan Malaysia and Universiti Tenaga Nasional and 1 overseas Sudan University of Science and Technology (SUST). In addition, the reactor receives about 3000 visitors annually and is part of the public awareness programme carried out by the Malaysian Nuclear Agency. As far as the education and training is concern the operation, maintenance and inspection program, and the upgrading projects are the central importance in order to ensure that RTP is safe and available to be operated at any time.

2. Operation & Maintenance
The RTP accumulative operation time and energy release from 1982 are 27,003hrs and 17,831MWhr respectively. The average annual operating hours is about 600 hours. The reactor is normally operated on a daily basis of 6-hours and mainly for the above-mentioned purposes. Figure 1 shows the RTP operational data from 1982 until 2017.

The objective of maintenance and inspection is to ensure that the structural, systems and components of the reactor is in accordance with the design intents and requirements. The RTP
maintenance program is carried out on periodic basis where maintenance and inspection is done on annual and semi-annual basis where the period for annual maintenance is usually 4 weeks and semi-annual maintenance is 2 weeks.

![Operational Data of PUSPMA TRIGA Reactor](image1)

**Figure 1.** RTP Operational Data from 1982-2017

Figure 2 shows the RTP maintenance from 2004 until 2017. The unscheduled shutdown was the longest period in 2008. It was caused by the discovery of the control rod problem during annual maintenance and a long time was required to solve the problem. Besides, the unscheduled shutdown was also caused due to the ageing of the reactor instrumentation and control system where the reactor console at that time was still based on analog signal and very prone to external interference and signal disturbance.

![RTP Maintenance](image2)

**Figure 2.** RTP Maintenance from 2004 - 2017

As the RTP becomes older, the growing need for information relating to the components and structures condition becomes greater. Maintenance program that include an inspection of RTP
components and structures has been carried out as a monitoring process in order to extend the useful life and reliability of the components and structures for the safe operation of RTP. Since year 2007, regular inspection have been provided trending of the operational data that has allowed a predictability of the condition extending into the future and has demonstrated the benefits of maintenance and inspection to ensure the components, structures integrity and continued safe operation of the reactor.

Due to the input of the RTP maintenance and inspection program, the upgrading projects plan was drawn to enhance a longer term of safe operation of RTP.

3. RTP Upgrading/Refurbishment Projects

After more than 30 years of operation, the RTP systems, structures and components (SSCs) experienced ageing problems and obsolescence of components and parts. Several refurbishment and upgrading projects have been carried out over the years. The upgrading projects at RTP are summarized in Figure 3 below where it will be described briefly in the next section.

![Figure 3. RTP Upgrading Projects](image)

3.1 Primary Cooling System

The upgrading of the primary cooling system in 2010 saw the replacement of the tube and shell type heat exchanger with a higher capacity of plate type heat exchanger. This project was implemented to meet the possible future RTP power needs where the cooling system capability of heat removal for a 3MW thermal power. In this project, new features such as capability for remote switching from the control room and the ability to monitor the water temperature, flow rate, pH and conductivity via the SCADA control and monitoring system were added. This project was successfully completed in accordance with the design, safety and regulatory requirements.

Figure 4 shows the some of the activities done during the construction and installation of the new RTP primary cooling system.
3.2 Reactor Digital Instrumentation and Control System (ReDICS)

Most of the RTP unscheduled shutdowns as shown in Figure 2 are due to the ageing of the reactor instrumentation and control system. The analogue control console was facing ageing and obsolescence problems as it frequently failed and spare parts could not be purchased as some components used in the analogue console were manufactured in the early 1980’s.

Therefore, in order to mitigate the aging factor of the reactor and to prevent the worsening of the aging problem, RTP console was upgraded from analog to digital system. The Reactor Digital Instrumentation and Control System (ReDICS) project was performed together with Korea Atomic Energy Research Institute (KAERI) including the technical part from the design stage until commissioning as well as the technology transfer program. The process of tender for the new console was started in 2012 and ReDICS was commissioned in 2014. Figure 5 shows both the analogue control console and ReDICS respectively.

**Figure 4.** The construction and installation of the new RTP Primary Cooling System

(a) Lifting the Shell and Tube Heat Exchanger  
(b) Removing Shell and Tube Exchanger  
(c) Primary Pumps connected to Heat Exchanger  
(d) SCADA Display at Control Room
3.3 Electrical System Re-wiring

As for the re-wiring electrical system, Figure 6 shows the rational of re-wiring of the electrical system where the condition of the electrical Distribution Board (DB) including the electrical wiring, equipment and accessories are based on old design. All DB at the RTP building used Moulded Case Circuit Breaker (MCCB) as the main circuit breaker and do not have Residual Current Breaker (RCCB) which only RCCB can detect the current leakage whilst other circuit breaker only can detect the fault from over current and short circuit.

The main scope of this project was to supply and installation of new DB and re-wiring lighting circuits and sockets. This project started in July 2015 and completed in November 2015.

3.4 Active Ventilation System Upgrading

Since the active ventilation system is operated full every day, there is some damage and the lack of ability on the system has affected the RTP operation. The previous system was designed and installed
in 1992 have been operating at an optimal level in terms of operating costs, electricity consumption and achieve the desired temperature to control the reactor. The scopes of the projects are as follows

i- Achieving negative pressure in the reactor hall
ii- Replacing the heat recovery wheel or energy wheel
iii- Installing of SCADA system
iv- Changing the stack monitor tower

Figure 7 shows the active ventilation project pictures and this project was completed in October 2015

![Existing Stack monitor](image1.jpg) ![Installing new pumps and fans](image2.jpg)

**Figure 7. RTP Active Ventilation Project**

3.5 Monitoring and Support Systems

Besides in-core irradiation facilities, RTP is also equipped with 4 beam ports and one thermal column to accommodate neutron beam experiments. Currently, only 2 beam port (Small Angle neutron scattering (SANS) and Neutron Radiography (NuR)) have been utilised by local research team from local universities and internal researchers. Since 2008, there are significant increasing of researchers attracted to RTP which resulting the development of new neutron beam facilities. At the moment RTP has three major projects for the beam port which are:

i- Development of boron neutron capture at Thermal Column
ii- Development of Neutron Diffractometer at Beam Port #1
iii- Upgrading of Neutron Radiography at Beam Port #3

![Thermal Column project](image3.jpg) ![Neutron Diffractometer](image4.jpg) ![Neutron Radiography](image5.jpg)

**Figure 8. Beam Ports Development**
Considering above developments, RTP has enhanced its monitoring and surveillance system at the Reactor Hall where all the beam ports facilities are located and give ability to the Reactor Operators to supervise from the control room and SCRAM the reactor if any incident occur. CCTVs are installed at strategic location and the beam port shutter indicator is also installed in control room to ensuring the safety of researcher during the experiment.

Figure 9. Enhancements of Surveillance and Monitoring System

4. Conclusion
The RTP ageing may lead to an increase of failures and a decrease in the availability of the reactor. The maintenance, inspection and upgrading/refurbishment projects has been implemented to ensure a continuous safe operation of RTP and also could result the utilization of RTP for research and development to propel national economic growth.

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