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PUSPATI TRIGA REACTOR (RTP) RADIATION MONITORING PROGRAM

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ABSTRACT

Radiation Monitoring System aims to limit the exposure dose to personnel to the lowest level referring to the concept of ALARA (As Low As Reasonably Achievable). Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010 is useful to control employee and public radiation protection program and guideline. This paper discussed the methodology and implementation of the radiation protection program at PUSPATI TRIGA Reactor (RTP) which is implemented in Nuklear Malaysia, Complex Bangi.

Keywords: Exposure dose, monitoring, PUSPATI TRIGA Reactor (RTP), radiation protection, safety

INTRODUCTION

The safety of the reactor can be assured through the continuous and vigilant monitoring of its operational parameters. Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010 require monitoring to be carried out on all personnel who work in controlled areas (and selectively in supervised areas) as well as visitors. Occupational exposure can be delivered to personnel either by sources outside the body in the form of external radiation or by intake of radioactive contaminants. The purpose of the monitoring is to keep a constant surveillance over the working environment and to detect the quantity and extent of contamination. All instruments shall be calibrated periodically in terms of the appropriate quantities used in radiation protection. The monitoring covers both radiation and contamination and consists of Personnel, Workplace and Environment. The reactor building is categorized into Controlled, Supervised and Clean areas. Hence, the radiation monitoring program is specific for each category.

MATERIALS AND METHODS

Personnel Monitoring

At the PUSPATI TRIGA Reactor (RTP), Thermoluminescent Dosimetry (TLD) badge and ring are worn by all personnel and Pen Dosimeter are worn by visitors and contractor workers to measure the radiation dose received while working with radiation sources or working in classified areas or visiting. TLD badges and rings are anaylsed at the Secondary Standard Dosimetry Laboratory Group every month to measure dose received and for calibration. Unlike TLD's, doses received by pen dosimeter user can be identified immediately due to the direct reading feature. The annual dose limit for different individuals is tabulated in Table 1.

Table 1: Difference categories of Annual Dose Limit (ADL)

Categories	Radiation Worker (mSv)	Pregnant Worker (mSv)	Members of the Public (mSv)	Trainees in Radiation Area (mSv)
Dose limits	20	1	1	6

Workplace Monitoring

Area Radiation Monitor (ARM)

The instrument used for measuring radiation levels in the RTP area known as Area Radiation Monitor (ARM). It can also be described as a precaution device since it will give an alarm or notification that reactor shutdown is necessary when the surrounding area radiation level goes beyond safety setting limits as shown in Table 2. To ensure radiation in the reactor building is monitored, ARM's are installed in five strategic locations in the reactor hall and other controlled area as shown in Figure 1. The testing and calibration of ARM system is done annually by the Secondary Standard Dosimetry Laboratory (SSDL), Nuklear Malaysia.

Table 2: ARM's alarm settings

Location	Pre-Alarm (µSv/hour)	Alarm (µSv/hour)
Reactor Beam Ports	5.0	10.0
Reactor Pool Top	5,000.0	10,000.0
Reactor Control Room	5.0	10.0
Pneumatic Room	5.0	10.0

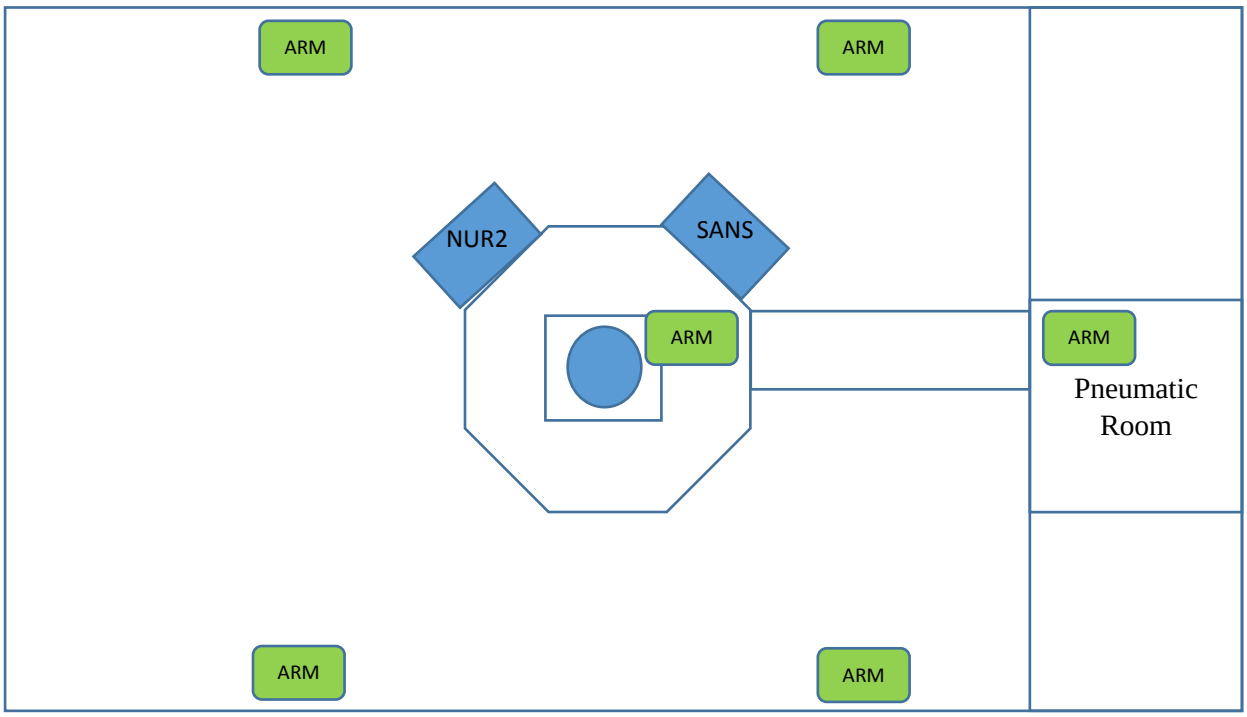

Figure 1: ARM's location at reactor hall

Stack Monitor

The possible radioactive released to the air includes noble gas, iodine and particulates. The Active Ventilation System (AVS) continuously controls and monitors airborne release resulting from the operation of the reactor. The radioactive gases and particulates will be treated through High Efficiency Particulate Arrestor (HEPA) system before being released to the atmosphere. The stack monitoring system will consist of AVS and HEPA will trigger if the noble gas exceeds 900,000 Bq/m^3. Meanwhile for iodine and particulates released from the reactor pool water and reactor facilities exceeds 5000 Bq/m^3. At this stage, the reactor can be manually shutdown and the emergency mode of the active ventilation system will be activated. The stack monitor is calibrated annually by the Radiation Safety and Health Division.

Reactor Tank Water Radioactivity

Water in the reactor tank has been routinely checked for radionuclides by gamma spectroscopy method. The presence of fission products would indicate that there has been a fuel element cladding integrity loss. The possible fission products that can leak out of a damaged fuel are:

Noble gases : Krypton (Krypton-85, Krypton-87, Krypton-88) and Xenon (Xenon-133, Xenon-135)
Halogens : Iodine (Iodine-131, Iodine-132, Iodine-133, Iodine-134) and Bromine
Alkali metal : Caesium (Caesium-134, Caesium-137,Caesium-138) and Rubidium
Alkaline earth : Strontium (Strontium-90, Strontium-91, Strontium-92) and Barium (Barium-140)
Noble metal : Ruthenium (Ruthenium-103), Rhodium, Palladium, Molybdenum (Molybdenum-99) and Technicium
Actinides : Uranium and Americium-241
Refractory : Zirconium (Zirconium-95, Zirconium-97) and Niobium

Environmental Monitoring

Environmental monitoring covering radioactivity of water, sediment, soil and flora as well as radiation levels have been done routinely. There are 8 sampling locations within the Selangor state border as shown in Figure 2. While 16 sampling locations within Nuklear Malaysia, Complex Bangi, as illustrated in Figure 3. Samples collected from these stations are tested for Radium-226, Radium-228 and Caesium-137.

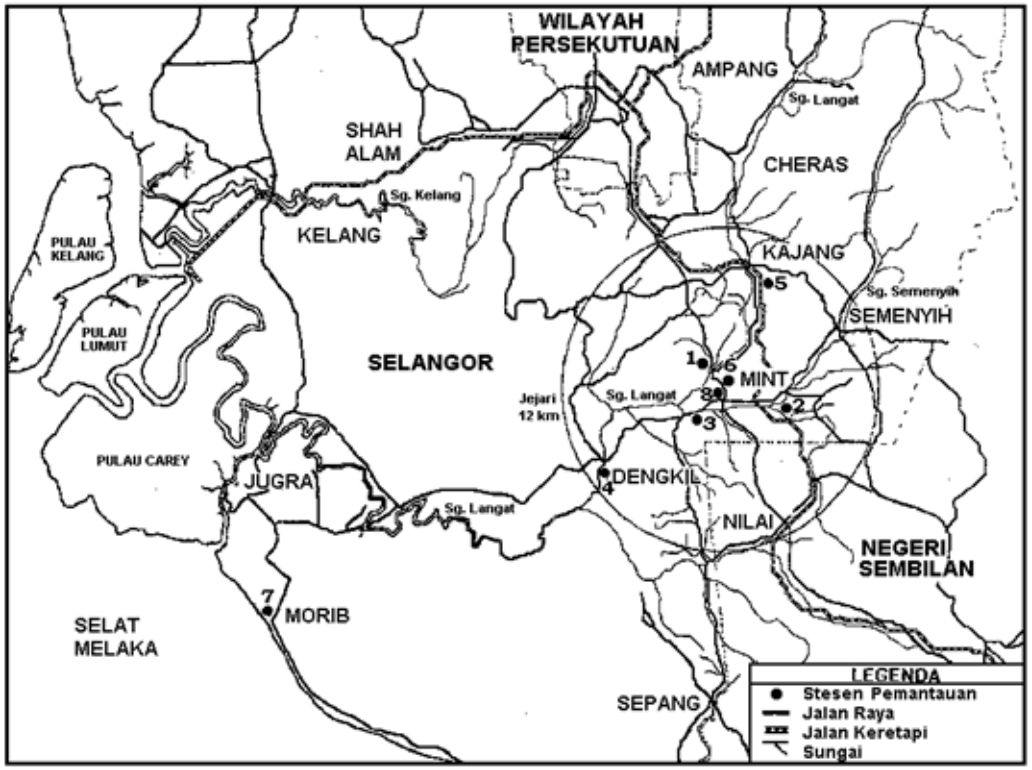

Figure 2: Monitoring station location surrounding Nuklear Malaysia.

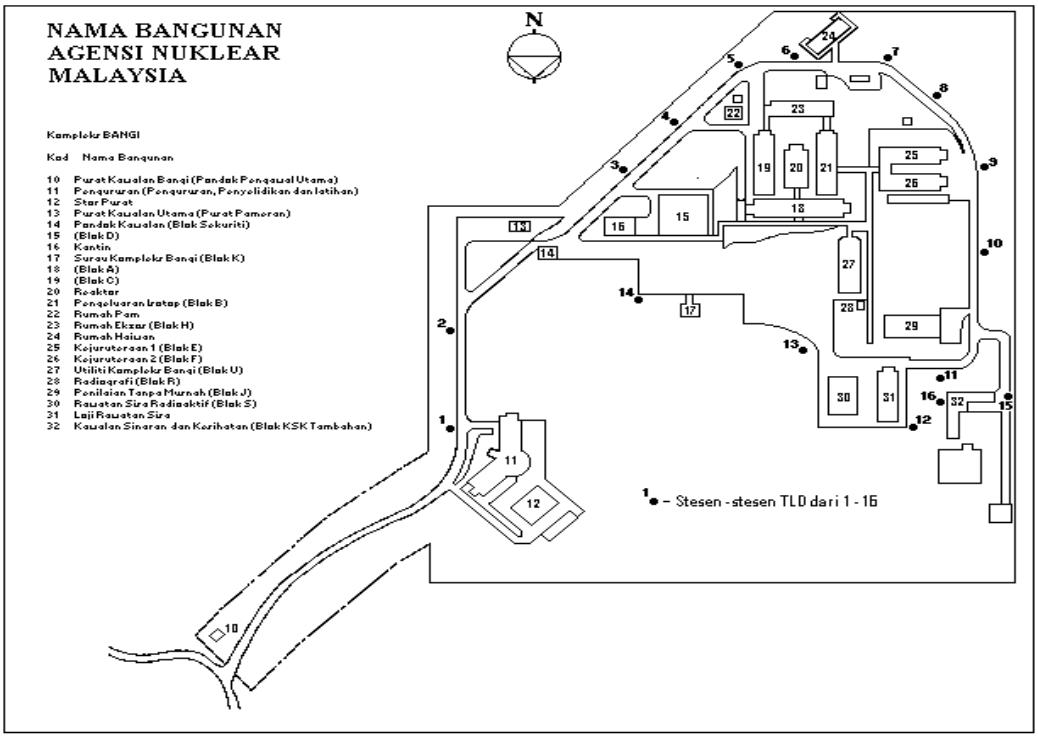

Figure 3: TLD radiation level measurement location at Nuklear Malaysia, Complex Bangi

RESULTS AND DISCUSSION

Personnel Monitoring

Collective data obtained since year 2006 monitoring instruments such as pen dosimeter, film badge, TLD and TLD ring, show working personnel and visitors to the reactor facilities received very low maximum dose of less than half compared to Annual Dose Limit (ADL) 20 mSv/year (Table 3).

Table 3: Dose exposure received by reactor personnel from year 2006 to 2015

Year	No. of Workers	Individual Dose (mSv/yr)					
		< 0.1	0.1 - 1.0	1.1 - 6.7	6.71 - 10	10.1 - 20	> 20
2006	19	0	18	1	0	0	0
2007	20	0	20	0	0	0	0
2008	26	7	19	0	0	0	0
2009	36	36	0	0	0	0	0
2010	42	41	1	0	0	0	0
2011	42	29	13	0	0	0	0
2012	41	33	8	0	0	0	0
2013	36	31	5	0	0	0	0
2014	35	34	1	0	0	0	0
2015	33	31	2	0	0	0	0

Workplace Monitoring

Area Radiation Monitoring (ARM)

The functionality of ARM always maintained according to maintenance program, periodic testing and calibration as well as inspection. There were few occasions that the ARM alarm was activated due to excessive detected radiation but at all-time personnel dose did not exceed limits.

Stack Monitor

Table 4 shows the radioactive effluent released to the environment during 2012 – 2014. During 2013, the reactor was only operated for a few months in order to install the new reactor console. This is reflected in the lower noble gas released in 2013. However, the iodine released in 2012 and 2013 is indicative of the reactor operation due to the malfunction of the iodine detector. The new liquid waste measuring meter was installed in mid-2012, hence the data in 2012 is a partial reading. All radioactive released are considered low therefore did not exceed allowable limits.

Table 4: Data of radioactive effluent released to the environmental in 2012 - 2014

Radioactive	2012	2013	2014
Noble gas released to the atmosphere	1.912 TBq	0.866 TBq	1.653 TBq
Iodine released to the atmosphere	80.06 MBq	30.07 MBq	24.81 MBq
Radioactive liquid waste released	12.16 m^3	24.84 m^3	20.32 m^3
Radioactive solid waste generated	0.05 m^3	0.07 m^3	0.24 m^3

Water Radioactivity

To date, there is no fission products have been detected in the reactor water and this assures that the fuel element cladding is still intact.

Environmental Monitoring

As can be seen in Figure 4, there is no significance change of Caesium-137 density in soil samples from 2003 to 2014. Figure 5 shows the radiation level measured at several locations within Nuklear Malaysia, Complex Bangi from 2003 to 2014 is 2.0 mSv/yr. The data and analyses show that activities carried out in RTP at Nuklear Malaysia does not contribute to the unacceptable increment of radioactive contamination and radiation levels of the environmental.

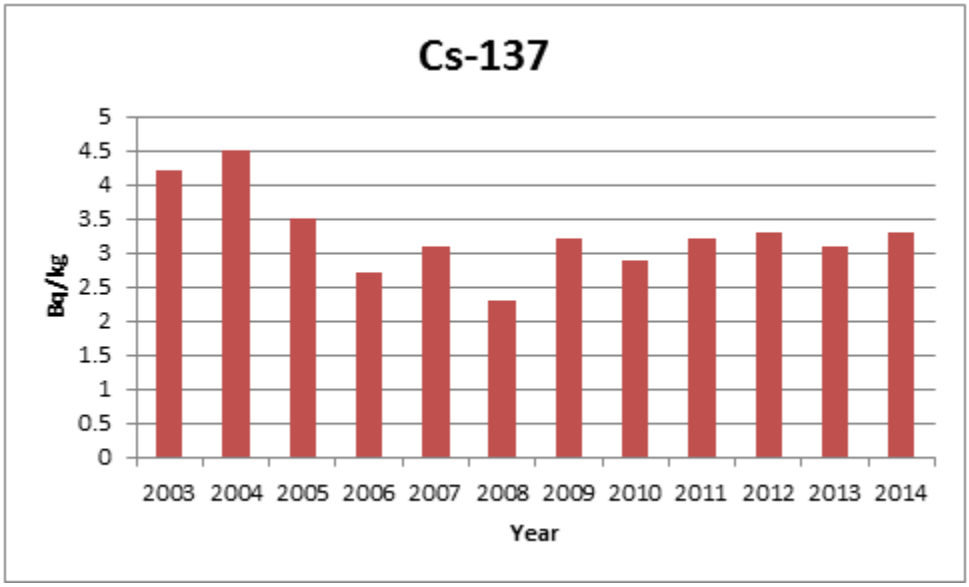

Figure 4: Cs-137 density changes inside soil sample

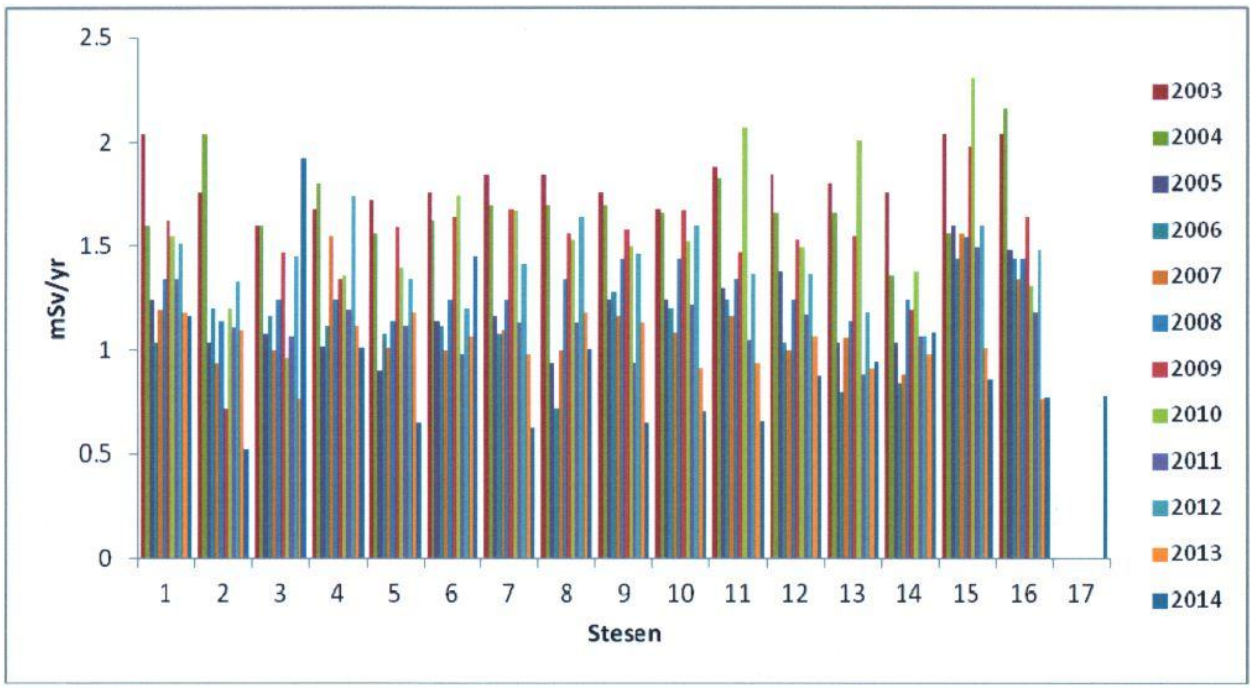

Figure 5: Radiation level changes outside of Complex Bangi

CONCLUSIONS

Continuous monitoring of operational safety parameters at the RTP is essential for assuring the safety of the reactor, personnel and environment. The safety of personnel and environmental are not compromised due to the operation of RTP. Analyses results shows that radiation dose and particulate releases measured at sampling location are did not exceed the allowable limits, therefore no significant contribution from the RTP operation.

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