EXPERIENCE ON MAINTENANCE OF THAI RESEARCH REACTOR "SMALL-POOL" SECTION

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ABSTRACT

The reactor pool of TRR-1/M1 has been used since 1962 when the reactor building was constructed. Periodic maintenance of the reactor pool has been conducted by cleaning the pool surface and re-painting with epoxy coating. The TRR-1/M1 pool basically consists of two sections referred as "large-section" and "small-section". The latest re-painting activity of the "large-section" pool was performed in 2006 but the "small-section" pool had not been re-painted for more than 10 years. Therefore, to assure that the "small-section" pool can maintain leak-proof condition, the re-painting of the "small-section" pool was performed in the early 2012. A project team was organized specially for this project and a detailed execution plan was developed. The project activities include removing foreign objects and highly activated materials from the pool section, cleaning, inspecting, re-painting the pool surface and testing for water leaks. Preparation of the repainting activities had begun 2 years in advance. During the time, the reactor core had been relocated to operate in the large-section pool away from the working area in order to minimize radioactivity. The challenge of this project was to handle 4 sets of highly radioactive bolts and nuts which support the weight of the "void tank" irradiation facility. These bolts and nuts were made from stainless steel and had been in the flux region since the installation of the "void tank" irradiation facility approximately 30 years ago. Dose rate measurement at the contacts of these bolts and nuts were found to be in the range of 10 – 20 R/hr. The strategy to minimize the dose rate of the workers to conduct the pool repainting in the area was to remove the bolts and nuts and replace with new ones before entering the area. Special tools were improvised in order to remove the bolts and nuts under water. During the execution of the project, close radiation monitoring was performed by the radiation protection team. The project was conducted successfully under the planned time period. Radiation exposure to the workers was minimized to much less than target exposure for the project.

1. Introduction

Thai Research Reactor-1/Modification 1 (TRR-1/M1) is currently the only Research Reactor in Thailand. Historically, Thailand has been operating the research reactor since its first criticality in 1962. The first core of the reactor was an MTR type and later the core was converted into a TRIGA type in 1977. However, the original reactor building and the reactor pool remains in use up to present. During long history of the reactor utilization, periodic maintenance of the reactor pool has been conducted by cleaning the pool surface and re-painting with epoxy coating. The TRR-1/M1 pool basically consists of two sections referred as "large-section" and "small-section". The latest re-painting activity of the "large-section" pool was performed in 2006 while the "small-section" pool was not re-coated for during the last 10 years. Therefore, to assure that the "small-section” pool can maintain leak-proof condition, the re-painting of the “small-section” pool was planned and executed in the early 2012. The execution of this project completed successfully and provided unique experience to the TRR-1/M1 staff. This paper summarizes the main activities, the challenges and the lessons learned during the execution of the project [1].

2. Planning for project execution

2.1 Brief Description of TRR-1/M1 Reactor Pool

The TRR-1/M1 pool is located in the center of the reactor building. Essentially, the pool is rectangular in shape and is divided into two sections by means of a removable watertight aluminum gate. The pool wall consists of 2 concrete layers of different densities; the inner layer made of conventional concrete and the outer layer made of high density concrete for biological shielding. The reactor core is hung by the reactor bridge which can be moved to either “small-section” or “large-section”. When the watertight gate is put in place, the section without the reactor core can be drained for in-pool maintenance. The reactor core is usually positioned in the small-section which is the main experimental area. There are a number of fixed irradiation facilities in this area. These include thermal column, void tank and neutron beam ports as shown in Fig 1. When the reactor core is positioned next these facilities for utilization of the facilities, the materials of these facilities are constantly irradiated which produces highly radioactive materials as a consequence. However, the material of these facilities is mainly high purity aluminum alloy which is not activated into long half-life radio-nuclides.

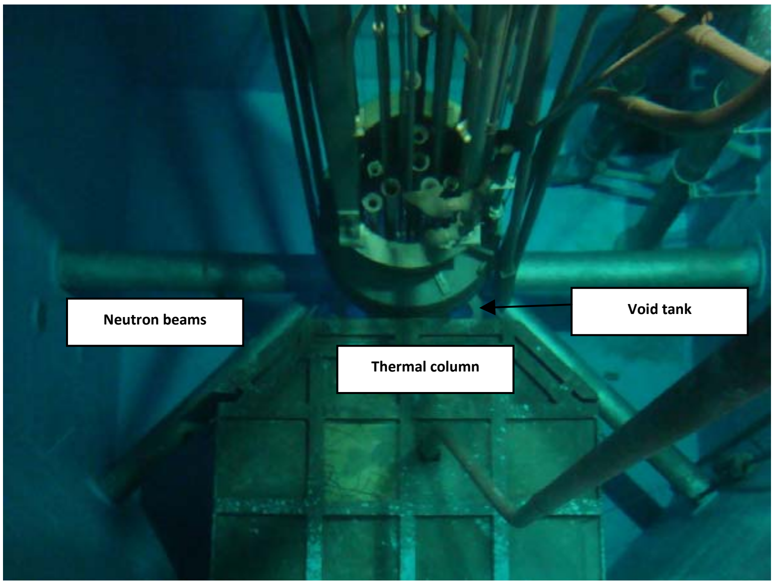

Fig 1. Irradiation facilities in the small-section area

2.2 Radiological Characteristics of the Small-section pool

In order to prepare for the maintenance, the reactor core was repositioned to operate in the large-section pool (away from the maintenance area) approximately 1.5 years prior to the maintenance activities. This period allowed for short half-life radio-nuclides to substantially decay. The radiological characteristic of the area was assessed by measuring the dose rate in-pool under water. The measurement used high-dose GM detector (measurement range up to 99 R/hr) connected to a long cable. Contact dose rates at various points in the area were measured as reported in Fig 2.

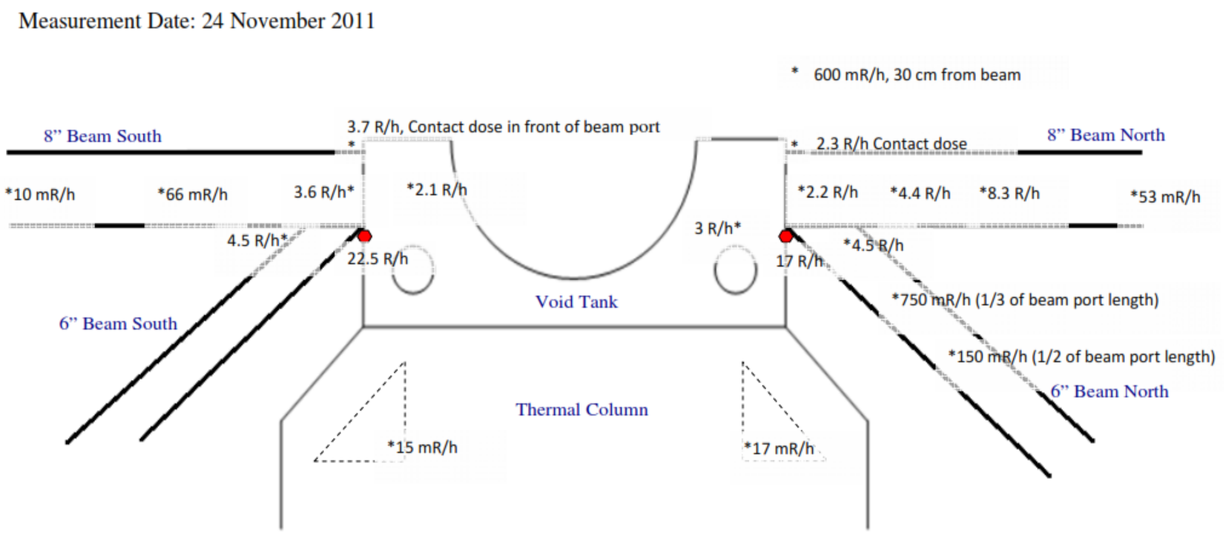

Fig 2. Radiation dose rate at various positions in the small-section area

From the radiation survey, three hot spots were identified. The first two areas were on the left and right side of the void tank. It was found then that the high dose rate was caused by 4 sets of bolts and nuts supporting the void tank. These bolts and nuts were made of stainless steel as supposed to aluminum alloy. However, it was also found that one of the washers was corroded suggesting that this particular washer was made of galvanized steel rather than stainless steel. The last hot spot was near the middle of the 8" north neutron beam. It was believed that there was also stainless steel acting as a structure inside the beam. Spectrum analysis of the radiation detected Co-60 as the main nuclide in these hot spots.

2.3 Execution Strategy

The strategy to execute the project was discussed at the inception of the planning. It was decided to remove the bolts and nuts and to replace with the new ones before entering the area in order to reduce the radiation dose rate. The removed hot items were to be placed into a shielded container and to be transferred to the large-section pool for temporary storage during the re-painting operation. Two methods to remove the bolts and nuts were discussed. The first was to remove them under water with special tool and the second was to drain the water completely and to remove them in air using normal tool. The first method had the advantages that the radiation dose rate in the working area would be much less but it needed to take longer time since it was much more difficult to conduct the work from far distance and special tools had to be prepared. The second method, on the other hand, would take much shorter time and no special tool had to be prepared but the radiation dose rate in the working area would be higher. It was finally decided that the execution strategy was to adopt the first method since the risks from unexpected situations could be better controlled and minimized.

2.4 Project Management

The planned activities of this project included removing foreign objects and highly activated materials from the small-section pool, cleaning, inspecting, re-painting the pool surface and testing for water leaks. This situation clearly presented radiological safety challenges. Moreover, industrial safety was another great concern and was extensively considered in the project planning as well. Also, the work was expected to produce some amount of radioactive wastes. Hence, a project team was organized to coordinate and handle these issues. The team was divided into operation group, radiation protection group, industrial safety group and planning and support group. Additional workers from outside the institute were contracted to perform the painting task. All personnel in the project received radiation protection refresher training and specific task training before the project execution.

3. Project Execution

The execution of the project was conducted into sequential steps as described in the following:

3.1 Area classification

In order to prevent spread of contamination, the working area was classified into three zones (i.e., Zone I, Zone II and Zone III). Zone I was the zone where contamination was highly possible. The area in this zone included in-pool and loading/unloading area. A high level of contamination control was enforced for this zone. Protective cloth and digital dosimeters were required to enter this zone. Contamination monitoring was conducted for all personnel and equipment in and out of this zone. Zone II was the buffered zone where contamination was possible but limited. This zone included the area surrounding the Zone I. Contamination control was also enforced in this area including periodic survey of the area, protective shoes and gloves and contamination check of personnel by a hands and shoes monitor. Lastly, Zone III was the clean zone where there was no expected contamination. Some degree of contamination control was conducted to ensure contamination –free area such as periodic survey of the area.

3.2 Draining pool water

The next step was to drain the pool water until the water level remained 1 meter above the void tank. This step was done in preparation for removing the activated bolts and nuts. The pool water was released in a step-wise manner to the retention pond of the radioactive waste treatment facility. Before each release step, water was sampled and measured for radio-nuclide concentration in the gamma spectroscopy laboratory. In addition, radiation dose survey was performed including periodic air sampling. Tab 1 presents the maximum radiation dose rate at each water level.

Tab 1: Results of radiation survey at each water level

Step	Water level (meter)	Maximum Measured dose rate (mR/hr)
Initial	7.8	0.1
1	6.8	0.1
2	5.5	0.1
3	4.0	0.1
4	2.8	1.0

Also at each step after the radiation survey was performed, the pool surface was cleaned using high pressure water gun. The cleaning workers were carried by a suspension platform supported by the reactor crane.

3.3 Reducing radiation

When the water level was approximately 1 meter above the void tank, the next step was to remove the activated bolts and nuts from the in-pool area. The water thickness of 1 meter was selected as the optimal point for compromising between the shielding efficiency and the difficulty in removing the items from far distance. A special tool set to disassemble the bolts and nuts from the void tank were prepared. The tool set was essentially pneumatic drill with extension to loosen the bolt while holding the nut, a dip net to catch falling objects and an extended tongs to remove the bolt. The task of removing each bolt and nut set took two workers. A new pin made of high purity aluminum alloy was prepared and used to replace the original bolt. All four sets of the bolts and nuts were successfully removed with minor difficulties. The other hot spot which was on the middle of the north beam was handled by covering with leaded sheet. A supporting structure covering the beam was prepared and the leaded sheet was placed on the structure in order to reduce radiation from the beam.

3.4 Coating

The recoating work was conducted after the major radiation sources were removed. The coating of the upper portion of the pool (i.e., above 3-meter area) was conducted first with water still covers the irradiation facility. By doing this, the exposure to the workers was minimized while the workers were coating the majority of the area. Three layers of epoxy paint including primer were coated in the project according to the paint company recommendation. When the coating of the upper portion of the pool was completed, the pool water was drained completely. A radiation survey into area was performed and the radiation dose rate map is shown in Fig 3.

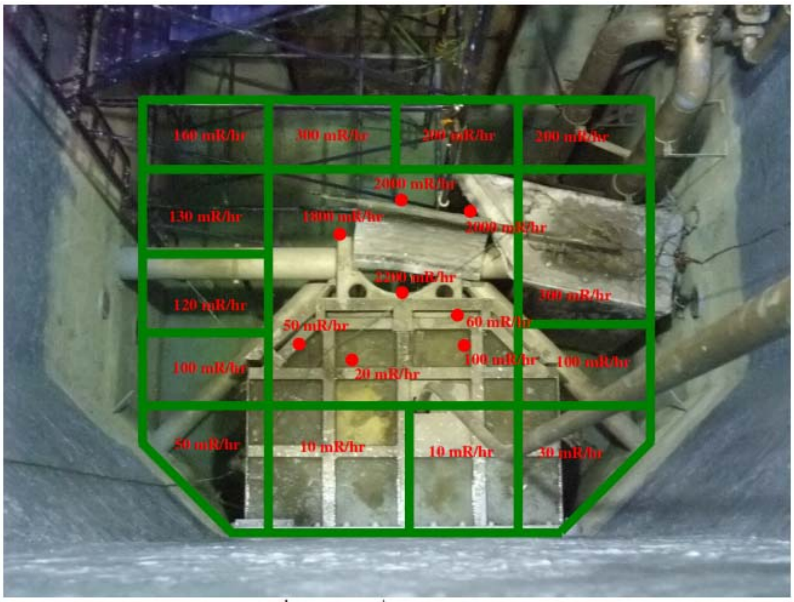

Fig 3. Radiation dose rate map of the reactor pool when completely drained

The radiation dose rate map showed that the area in the line of sight from the north beam had relatively higher dose rate than other area. Workers to perform the coating were advised to avoid or spend minimum time in the area. Strict radiation control such as time limit, equipping all workers with digital dosimeters for real-time monitoring, daily exposure record, contamination monitoring was enforced. The coating activities were finally completed according to the planned schedule. The exposure to all personnel in the project was found to much less than the target limit – the maximum exposure was 1.1 mSv and the collective dose for the whole project was 8.4 man-mSv.

3.5 Waste Management

During the course of the project, radioactive wastes were generated. Attempts were made to reduce the radioactive waste by segregating waste types. Essentially, the project produced approximately 11 bags of low level wastes mainly from protective cloth. The activated bolts and nuts were transferred to the waste management center for final storage.

4. Major lessons learned

The project team concluded major lessons learned after the completion of the project as the following:

- Thorough planning and practice in advance is critical to the success of the project.
- Engineering drawing of the facility is a critical document for project planning and execution and shall be well maintained.
- Practices and simulations shall be done as closely to the actual environment as possible.
- Using photographic images is an excellent way to communicate among members and outside workers.
- The ability to have visual image in real time is important to understand the problem on the field. This ability shall be considered in the planning.
- Reusing some of materials may reduce the amount of unnecessary radioactive wastes.

5. Conclusion

The maintenance of the TRR-1/M1 small-section pool was conducted in early 2012. The project planning was the critical key to the success. All unexpected incidents could be well controlled and the project could be conducted within the scheduled time period. Moreover, the radiation exposure to all personnel was much lower than target limit and there was no accident causing any injury during the project. Currently, the small-section pool is in use again and there is no leak found after the maintenance.

6. References

[1] TINT Internal Report, “Report on Small-Section Pool Maintenance Project (2012)”, 2012