Decommissioning Plan for Research Reactors in Indonesia

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ABSTRACT

Decommissioning is one of important stages in construction and operation of research reactors. In Indonesia there are three research reactors in operation, one of which has reached more than 40 years old since its first criticality. The reactor will probably be decommissioned in the next ten years. The three reactors are operated by the National Nuclear Energy Agency (BATAN) under control by the Nuclear Energy Regulatory Agency (BAPETEN). As bases for controlling the construction and operation of the reactors, there are several regulations available. However, the regulation specifically concerning decommissioning of the research reactors is still in developing.

INTRODUCTION

Currently, there are three research reactors operating in Indonesia. Those are Bandung Triga 2000 (2000 kW) at Bandung - West Java , Kartini Research Reactor (100 kW) at Yogyakarta – Central Java and Siwabessy Multipurpose Reactor (30 MW) at Serpong – Bnaten, West Java. These reactors are operated by the National Nuclear Energy Agency (BATAN). The age of the three research reactors varies from 19 to 42 years since the reactors reached their first criticality. Detailed data of the reactors are given below.

Regulatory control of the three reactors is conducted by the Nuclear Energy Regulatory Agency (BAPETEN). Controlling the reactors is carried out based on the Act No. 10/1997 on Nuclear Energy, Government Regulations and BAPETEN Chairman Decrees concerning the nuclear safety, security and safeguards. Nevertheless, BAPETEN still lack of the regulation, especially for controlling the decommissioning project. Therefore, in the near future BAPETEN has to prepare the regulations for decommissioning, particularly to anticipate the decommissioning of the oldest research reactors, which probably will be done in the next ten years.

OPERATING STATUS OF THE REACTORS

All the three reactors are in operation. However, they have different operating experiences, since they were built in different periods. Table 1 shows the data for the three reactors. As from Table 1, Bandung Triga 2000 reactor is the oldest among them.

Bandung Triga 2000 reactor has reached first criticality in year 1964, which means that the reactor has been operated about 42 years. Since its first criticality, the reactor has been modified several times. In the first time, the reactor was operated at a power of 250 kW. The reactor was then upgraded to 1000 kW power level in 1971, and to 2000 kW in 2000[2]. During the last upgrading project, some important components were replaced or modified. The old core with a circular configuration has been modified to be that with a hexagonal one. In addition, a new aluminum tank was placed as a liner inside the old one. This new liner is then becoming a reference for the period of reactor operability. Referring to the liner, the reactor is predicted to be operable until 2015, after which the reactor shall be decommissioned.

Recently, the reactor operation is limited by the Regulatory Body to about 1250 kW maximum, due to some safety problems relating to heat transfer in the core.

Table 1. Operating data of the research reactors in Indonesia

Reactor	**Bandung Triga 2000**	**Kartini Reactor**	**GA Siwabessy Reactor**
Power [kW]	2000	100	30,000
Type	Triga II	Triga II	MTR
Fuel	UZ_rH	UZ_rH	U_3Si_2-Al (plate)
First Critical	Year 1964	Year 1979	Year 1987
Operator	BATAN	BATAN	BATAN
Application	Research, training and isotope production	Research and training	Research, training and isotope production
Location	Bandung, West Java	Yogyakarta, Central Java	Serpong, Banten, West Java

DECOMMISSIONING PLAN FOR RESEARCH REACTORS

A. OBJECTIVES

The objectives of decommissioning activities for a nuclear reactor are to safely enclose the entire of reactor plant, to safely partial enclose the reactor plant and to completely disassemble all of the reactor plant. In reality, only one of those three decommissioning activities could be chosen depending upon many reasons, such as, uneconomical reactor operation, technical obsolescence, conclusion of research programs, safety considerations, change in government policy and other factors.

B. BASIC DESIGN

Basically, during the reactor design period, a nuclear reactor is designed based on at least some reasons namely, the reactor should be easily safely operated, maintained and decommissioned. The RSG-GAS was also designed based on the above principle. This principle was focused not only to mechanical point of view but also to fuel design, reactor pool, reactor core, instrumentation and control and electrical design. Indeed, most parts of the RSG-GAS plant would easily, safely handled once the commissioning activities to be taken place[1].

C. FACILITY DESIGN OF RSG-GAS

From facility design of view, the RSG-GAS core was designed based on design bases accident (DBA) one fuel element fails due some abnormal conditions. However, this accident could not possibly occur since the reactor was designed based on the defense-in-depth principle. Furthermore, design started from the structure of fuel element itself by applying matrix principle among uranium, silicate and Aluminum, hence this form avoiding the fission gas release while under circumstances take place. Furthermore, the beryllium reflector of the RSG-GAS core is easily dismantled once this would be partly decommissioned in the future.

As previously mentioned, taking out partly the reactor plant is one of the decommissioning activities. From mechanical point of view, the RSG-GAS pool as well as the core itself can be dismantled partly, and hence making easier to be decommissioned.

From handling point of view, the RSG-GAS building houses the crane with the capacity of 30 tons. By using this crane and the space available in the reactor building, the decommissioning of the reactor core plant would be easily handled out of the building through material access available in 0.00 m level of the reactor building. Indeed, once the policy of decommissioning of the reactor plant will be carried out, the reactor plants will be safely handled.

D. FACILITY OPERATION

The RSG-GAS building is in the area of Puspiptek in which the Serpong Nuclear Research Center is existed. In this area, BATAN (National Nuclear Energy Agency) operates not only RSG-GAS but also other facilities, such as, fuel element fabrication center, radioisotope production center, radioactive waste treatment center etc.

To enclose some reactor plants decommissioned, the decommissioned plant can be buried in the waste treatment center area since the center has facility to store medium and high active waste with the capacity of 200 m^3. The reactor building has also a big space available in the level of –9.50 m of reactor building and could be used for burial of the small-size decommissioned reactor plant. Principally, there are enough facilities in the Puspiptek area which can accommodate decommissioning activities, such as, the burial of the decommissioned reactor plant either completely or partly.

E. TYPES OF DECOMMISSIONING

Various procedures are conceivable for the decommissioning of the RSG-GAS. The selection of the procedure will essentially depend on the relevant boundary conditions at the time of decommissioning. Thereby the technical boundary conditions will be less important for decommissioning than the organizational and financial ones. It must then be clarified whether, or to what extent and for what purpose the existing facilities can or should be reused.

In principle, the decommissioning of the RSG-GAS will not bring about any basic technical or radiological problems. Furthermore, there is absolutely no need for it to be carried out within a short time. As a result, there will be sufficient time to check whether the buildings etc. can be reused.

Before starting the actual decommissioning work, the reactor is shut down according to plan. In accordance with the normal procedure during reactor operation, the fuel elements are withdrawn and conveyed to the normal waste disposal. New fuel elements, which have not been irradiated, are returned to the manufacturer. Similarly the experimentation facilities, the other mobile reactor internals (e.g. measuring chambers) and the radioactive operational waste are disassembled or removed and conveyed to waste disposal as in the case of normal operation. The primary water is purified and checked for activity as in the case of normal operation.

In principle, the three following models or a staggered combination of the same come into question for decommissioning.

E.1 Safe Enclosure of the Entire RSG-GAS Plant

After the reactor has been shut down and the above waste disposal measures have been implemented, technical measures are taken to ensure that re-commissioning of the reactor is impossible and that no further active measures are necessary for the cooling and/or shielding of any components or systems.

As regards the safe enclosure of the reactor plant, it is then enough to reliably prevent access to the Reactor Building and to verify by means of appropriate calculations and measurements that the radiological exposure outside the plant cannot exceed the permissible values. This decommissioning model is advantageous for implementing then measures given in previous subsection because the radioactivity decreases in accordance with the delay period. The disadvantage is that the plant cannot be used for other purposes and that costs arise for the continuous surveillance. The possibility of completely disassembling the plant will be given in section E.3.

E.2 Partial Enclosure of the RSG-GAS Plant

After the above waste disposal measures have been implemented, the systems and components to be disassembled are treated according to their radiological properties and are conveyed to waste disposal. After the decontamination of any possibly contaminated parts of buildings, systems or components to permissible radiation values, these can be taken down and removed or used for other purposes. The non-dismantled parts of the reactor plant are enclosed by means of appropriate shielding measures in such a way that the areas outside the enclosure do not require constant radiological surveillance. The possibility of completely disassembling the plant at a later date is given.

E.3 Complete Disassembly of the RSG-GAS Plant

This decommissioning model is the most complicated and expensive of the three. Thereby all materials, pieces of equipment and components are decontaminated or removed and an “unrestricted site release” is awarded. No further surveillance, inspection or testing is necessary from a radiological point of view. Without doubt, the unrestricted site release is to be considered as the most desirable conclusion to the decommissioning procedure. The execution of this complete disassembly does, however, lead to a higher radiation exposure of the personnel performing the decommissioning work and results in the largest quantities of radioactive waste, particularly when the complete disassembly is effected relatively quickly after the final shutdown. Consequently, this decommissioning model is certainly the most expensive version and should only be implemented after an appropriate decay period (model a) and/or b)). The fact that the complete disassembly of the RSG-GAS neither causes any fundamental technical nor radiological problems is demonstrated in the following:

The reactor components are loaded differently depending on the operation period of the reactor and the period of time after the final shutdown. The composition of the longer-lived activity inventories in the diverse irradiated components is dependent on the structural material, the operating period and the decay period. At the end of reactor operation, the following longer-lived activation products are to be expected as the main sources of activity from the different reactor components:

a) Beryllium reflector
   Tritium due to activation of the beryllium
b) Reactor pool with internals
   Activation of the iron and zinc fractions in AlMg3 (Mn-54, Fe-55, Zn-65) and contamination of the primary loop components including the heat exchanger
c) Inner layer of the biological shield (reactor block)
   Activation of the concrete and the iron reinforcement (Ca-41, Fe-55, Co-66, Ni-63, traces of Sm and Eu).

Realistic quantitative statements about the activity inventory must be made after decommissioning on the basis of the evaluation of detailed activity measuring programs. No waste, which can be termed highly radioactive, will occur during decommissioning of the RSG-GAS. In general, there will be slightly radioactive waste and relatively small quantities of medium active waste from the reactor area. Classification and conditioning of the radioactive waste are effected in accordance with the acceptance conditions of the competent waste treatment plant (WTP).

In this case, the following components will be the basic sources of activity due to activation and contamination:

a) Core restraint with core support plate
b) Beryllium reflector
c) Beam tubes
d) Structural material
e) Parts of the aluminum pool lining
f) Parts o the heavy concrete of the biological shield
g) Primary coolant circulating pumps
h) Heat exchanger
i) Pipes, valves and components of the primary water purification system
j) Tubes of the rabbit system and of the in-pile loop

All other facilities which are required for instrumentation, experimentation or repair purposes and which are thereby activated or contaminated are not taken into consideration, as they also occur during operation and are transported to waste disposal or intermediate storage respectively. The pool water, which also has to be subjected to waste treatment, is not considered in more detail here either, as certain quantities of radioactive waste water can also be conveyed to the waste treatment plant (WTP) during normal operation. This also applies to the auxiliary systems and their corresponding components (filters, ion exchanger resins etc.) which may possibly have been contaminated.

Only some of the components mentioned above, indeed only parts of them, achieve radiological importance due to activation. These are the iron and zinc fractions in the $AlMg_3$ in those parts of the core restraint and the core support plate near the core, the beryllium reflector as well as structural material and parts of the primary pipes which are in the area of high neutron flux densities.

The concrete of the biological shield and its reinforcement are only very slightly affected by an activation, as these parts which are shielded by the pool water are only exposed to a relatively low neutron flux density. The activation only affects a relatively thin layer of the concrete directly behind the pool lining of the operation pool on a level with the core and around the beam tube penetrations. The activity measuring programs to be performed in the event of decommissioning will provide detailed information on the components, these are conditioned in accordance with their activity and are transported to storage.

Depending on the degree of activation, the relevant components are dismantled using remote control and/or behind suitable shield, and are transported away in shielded and tight containers. If there is the possibility of the air in the halls being radioactively contaminated during this work, the personnel working in these areas is protected by appropriate respirators. As the ventilation systems also maintain a continuous under pressure in relation to the outside atmosphere in the relevant parts of the building during decommissioning work and as the retention facilities of the ventilation system are in operation, inadmissible radiological exposure of the environment can be excluded. All work connected with decommissioning is supervised by the radiation protection official.

Radioactive components can be subjected to decontamination if necessary in order to reduce the occurring quantities of radioactive parts. The volumes of the radioactive waste are considerably reduced by this decontamination. For example, the activity of the aluminum pool lining encountered during decommissioning is essentially caused by contamination of the surface, while only a very slight fraction is activated in the operating pool area on a level with the core. This also applies to the other pool internals. The pipes, valves, pumps and the heat exchangers of the primary cooling system can only be contaminated by radioactive deposits.

The methods required for effective decontamination are well known and correspond to those which are implemented in conjunction with maintenance and repair work during operation of the RSG-GAS reactor.

All radioactive waste occurring within the scope of decontamination plus the parts and components which can not be decontaminated are conditioned and conveyed to a storage position.

Finally those areas of buildings affected by the disassembly of contaminated facilities are decontaminated. Subsequently the buildings can also be used for conventional purposes or they can be demolished.

In conclusion, it can be stated that the complete disassembly of the entire reactor plant, which is the most complicated and expensive but, nevertheless, the most desirable decommissioning variation, will not pose any technical difficulties at all. Special radiation protection measures are only necessary in those areas which have been contaminated or activated in the course of the operating period. In principle, the applicable methods are well-known and do not differ from the normal radiation protection methods for handling radioactive materials.

F. REPORTINMG DOCUMENTS

Prior to carry out the decommissioning activities, there should be a report containing followings:

a. Introduction
b. Decommissioning Strategy
c. Project Management
d. Decommissioning Activities
e. Safety Assessment
f. Environmental Impact Assessment
g. Quality Assurance Program
h. Radiation Protection and Safety Program
i. Continued Surveillance and Maintenance
j. Final Radiation Survey Proposal
k. Outline of the Final Decommissioning Report
l. Future Decommissioning Activities

REGULATORY CONTROL

According to Act No. 31 Year 1964 on Atomic Energy, promotion and utilization, as well as controlling, of nuclear energy are performed by the National Nuclear Energy Agency (BATAN). Consequently, construction and operation of the reactors in Indonesia were conducted and also controlled by BATAN. However, in 1997 the Act No.31/1964 was amended and replaced by a new one, i.e. Act No. 10/1997 on Nuclear Energy, since then the function of control became independent of BATAN[3].

By the new law on nuclear energy, any activity of research and promotion of utilization of nuclear energy is conducted by BATAN. On the other hand, regulatory control of the nuclear energy utilization is under authority of the Nuclear Energy Regulatory Agency (BAPETEN).

BAPETEN is a national authority on nuclear regulation, which was established in 1998 under Presidential Decree No. 76/1998[4]. Based on the Act No. 10/1997 and the Presidential Decree No. 76/1998, BAPETEN performs regulatory control of the use of nuclear energy, including operation of the three research reactors. For technical aspects, BAPETEN has provided several safety provisions in the form of BAPETEN Chairman

Decrees (BDCs) and guidelines. Table 2 indicates the list of regulations relevant to the research reactor construction and operation.

Nevertheless, BAPETEN is still developing of the regulation, specifically for controlling the decommissioning activities. In the near future, therefore BAPETEN has to prepare the more detail and specific regulations for decommissioning, particularly to anticipate the decommissioning of the oldest research reactors (Bandung Triga 2000 reactor), which will probably be started in the next ten years.

Table 2. List of regulations relevant to construction and operation of the research reactors

Hirarchy of Regulation	No.	Number/Year of Issue	Topics
Act	1	Act No. 10/1997	Nuclear energy
Governmental Regulation	2	GR No. 63/2000	Safety and health against the utilization of radiation
	3	GR No. 26/2002	Transport safety of radioactive materials
	4	GR No. 27/2002	Radioactive waste management
Pres. Decree	-	-	-
BAPETEN Chairman Decree	5	BCD No. 01/1999	Safety provision on working against radiation
	6	BCD No. 02/1999	Radioactivity limitation in the environment
	7	BCD No. 03/1999	Safety provision on radioactive waste management
	8	BCD No. 04/1999	Safety provision on radioactive transport
	9	BCD No. 05/1999	Safety provision on design of research reactor
	10	BCD No. 07/1999	Quality assurance of nuclear installation
	11	BCD No. 10/1999	Safety provision on operation of research reactor
Guidelines	12	Guide No. 01-P/1999	Safety guide on site evaluation of nuclear reactor
	13	Guide No. 06-P/2000	Safety guide on preparation of safety analysis report for research reactor
	14	Guide No. 04-P/2003	Guide for training the research reactor operator and supervisor
	15	Guide No. 05-P/1999	Guide for emergency response planning

CONCLUDING REMARKS

Currently, there are three research reactors operating in Indonesia. These reactors are operated by BATAN under control by BAPETEN. One of the three reactors has reached about 42 years old since its first criticality. This reactor will probably be decommissioned in the next ten years. To control all reactors, BAPETEN has provided several numbers of regulations in the form of act, governmental regulation, presidential decree, BAPETEN Chairman decree and guidelines. However, the regulation specifically concerning decommissioning of the research reactors is still in developing.

REFERENCES

[1] PRSG, Multipurpose Reactor G.A. Siwabessy, Safety Analysis Report, Rev. 9

[2] CRDNT, Safety Analyses Report of the Bandung Triga 2000 Reactor, Rev. 2, 2001

[3] Act No. 10/1997 on Nuclear Energy.

[4] Presidential Decree No. 76/1998 on Establishment of Nuclear Energy Regulatory Agency.

[5] Governmental Regulation on Licensing of Nuclear Reactor (final draft).

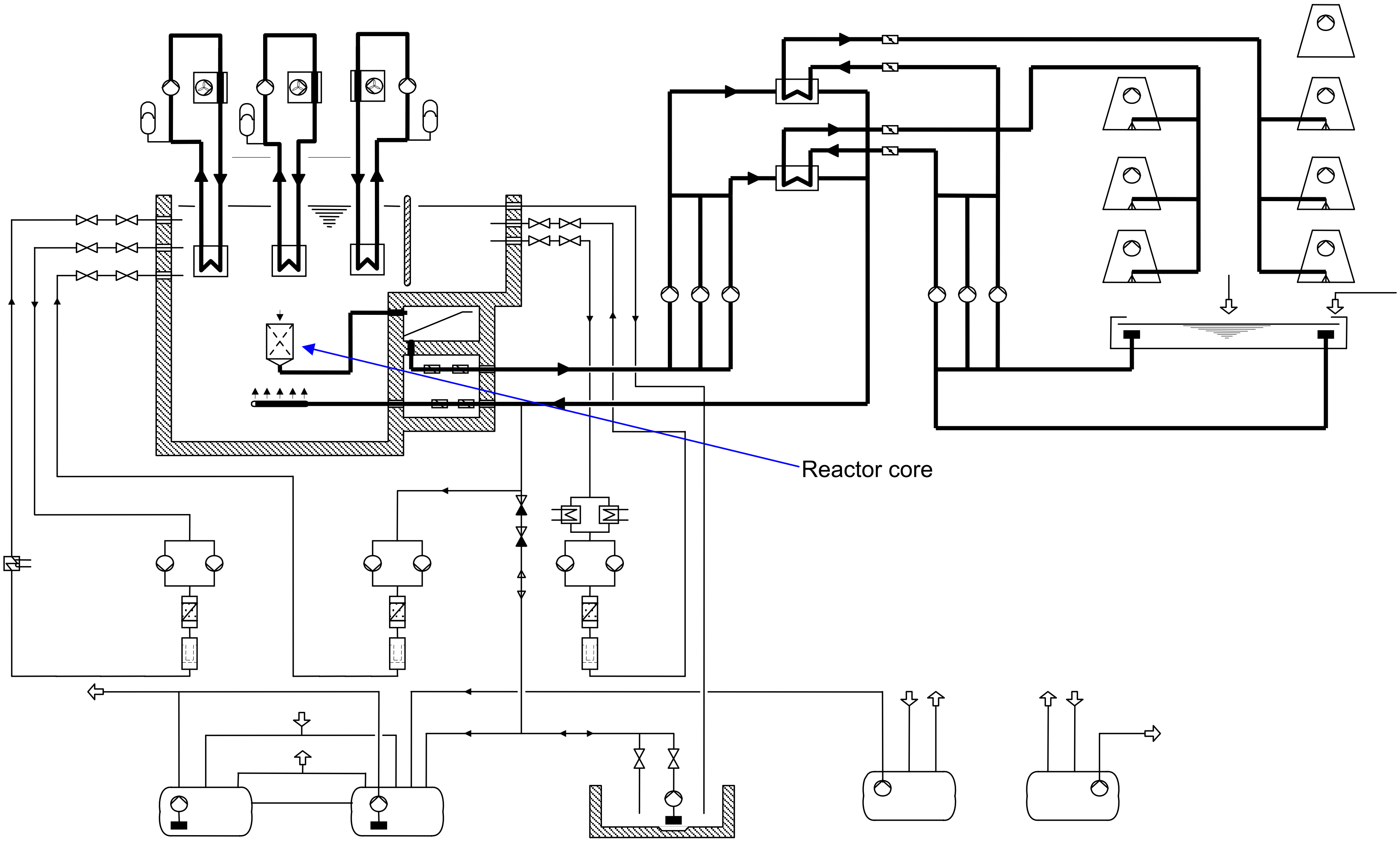

Fig. : Overview of the Main System of RSG-GAS

Format and Content of DECOMMISSIONING PLAN for Research Reactors in Indonesia (Under developing)

Based on IAEA Safety Reports Series No. 45

Chapter	CONTENTS
I.	Introduction
II.	Facility description
III.	Decommissioning strategy
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IX.	Safety assessment
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XV.	Final radiation survey