

# Lesson Learned from Regulatory Review and Assessment for Periodic Safety Review of 30 MW MTR Type Research Reactor in Indonesia

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**Abstract.** Lesson Learned from Regulatory Review and Assessment of Periodic Safety Review for 30 MW MTR Type Research Reactor in Indonesia. The first periodic safety review (PSR) for the Indonesian 30 MW MTR-type research reactor (RSG-GAS) completed meeting the mandatory requirements. RSG-GAS obtained an operating license from 1995 to 2020. During the operation of the reactor, BAPETEN and BATAN performed several inspections and examinations to ensure the safe condition of the installation. But those inspections performed partially, not related to each other, and have not reflected the entire comprehensive examination like periodic safety review (PSR). BATAN has submitted a collection of documents to BAPETEN includes the PSR document in the year 2017. The establishment and submission of PSR by BATAN as the operator and review and assessment performed by the BAPETEN as the regulatory body are the first events for both institutions. There has never been a real example or model procedure in the implementation of PSR before from both sides. The research of methodology uses a descriptive and comparative approach. The paper is a literature study of the formal process of PSR that compares regulatory review and assessment of PSR in several countries that regulate a research reactor, IAEA standards, and Indonesia regulation. The study concludes that PSR implementation in several regulating research reactor countries is varied. PSR regulations in Indonesia are sufficient. However, it needs updating specifically regarding the aging management program in GR 2 of 2014 and PSR formal procedure in the BCR or nuclear reactor licensing procedure. The results of PSR give benefits and lessons for the licensee and the regulatory body. BAPETEN gains benefits as follows: an input to update the regulation and procedures and develop databases for the licensing decision support system. Meanwhile, BATAN gains lessons as follows: to know actual plant safety, also to plan and to set work priorities for safety improvements.

**Keywords:** periodic safety review, regulatory review and assessment, research reactor

## INTRODUCTION

RSG-GAS was built in 1983, that the first criticality attained in 1987, after due approval of the regulatory body on the first core operation. RSG-GAS operates on 30 MW was achieved on the 6th core in 1992. RSG-GAS obtained an operating license from 1995 to 2020. RSG-GAS is a research reactor in which the utilization for the radioisotope production, material irradiation, material testing reactor, neutron activation analysis, neutron beam utilization, and education and training[1].

In the operation reactor, BAPETEN conducts routine inspections three times a year to monitor compliance with the license[2]. The licensee also performed an in-service inspection to identify the degradation of the structure, system, and component in aging management framework implementation, and stress tests after the Fukushima Daiichi accident. The purpose of the stress test is to examine the capability of installation in response to natural or external hazard in the site such as seismic and volcanic includes deterministic safety analysis with several scenarios such as loss of flow accident, loss of off-site power, and reactivity insertion accident due to inadvertent control rod withdrawal[3].

However, those inspections performed partially, not related to each other, and did not reflect a comprehensive examination such as periodic safety review (PSR). RSG-GAS has never been performing of PSR due to it is not mandatory according to the regulation.

Recently, PSR implementation is obligated. The PSR document included in the technical document requirement for operating license renewal based on Government Regulation (GR) No. 2 of 2014 on Licensing of the nuclear reactor and nuclear materials utilization [4]. In December 2017, BATAN submitted a collection of documents to BAPETEN includes the PSR document.

The establishment and submission of PSR documents by BATAN as the operator and review and assessment performed by the BAPETEN as the regulatory body are the first events for both institutions. There has never been a real example or model procedure in the implementation of PSR before from both sides.

This paper is a literature study of the formal process of PSR consisting of regulatory review and assessment of PSR in several countries that regulate a research reactor, IAEA standards, and Indonesia regulation. The availability and applicability of Indonesia PSR regulation such as GR and several Bapeten Chairman Regulations (BCR) are studied, also the benefit and feedback of the PSR implementation.

## Overview of PSR Regulation

### *International best practice*

Each country applied PSR provisions differently. Generally, the PSR applied in power reactors but in some countries also expect the PSR implementation in the research reactor. The following are the PSR practices in several countries in **TABLE 1**.

**TABLE 1.** The Implementation of Research Reactor PSR in Several Countries.

Country	USA	Australia	Netherlands	France	Germany	Slovenia	South Korea	India
Power	0.01 watt - 20 MW	> 10 MW	50 MW	N/A	20 MW	250 kW, pulsed 1 GWT	30 MW	100MWt
type of reactor	MTR & TRIGA	OPAL & HIFAR	HFR	N/A	N/A	TRIGA	MPR	N/A
Regulation of PSR and frequency	Not require	Every ten years (*)	(*)	mandatory	(*)	prerequisite of site of renewal operating license)	(*)	(*)
Reference of PSR	-	IAEA SSG-25 (**)	(**)	N/A	(**)	NSG 2.10 (previous of (**))	(**)	NSG 2.10 (previous of (**))
Scope of PSR	-	With a graded approach (***)	(***)	(***)	Full PSR (+ PSA)	(***)	(***) & Full PSR (+ PSA)	Full PSR (+ PSA)

Recently, the Nuclear Regulatory Commission of the United States (USNRC) regulates 31 operating research and test reactors. Most research and test reactors in the USA are at universities or colleges with range power in size from 0.01 watt to 20 megawatts-thermal (MW(t)). The technical document for license renewal is the full scope of FSAR to the facility with licensed power levels of 2 MW(t) or more. Meanwhile, the facilities with licensed power of less than 2 MW(t) perform a review that focuses on the most safety-significant aspects of the renewal application and considers past NRC reviews. Most significant to safety are radiation protection, waste management programs, financial requirements, reactor design and operation, accident analysis, and technical specifications [5].

In 2019 USNRC published new requirements in 10 CFR 50.71(e) for non-power and utilization facilities (NPUF) licensees to submit to the USNRC an updated FSAR and subsequent FSAR updates at intervals not to exceed five years. This change is motivated by the observation of license renewal applications for more than 20 licensees during the period 2006–2017. Some licensees did not adequately update their FSARs or did not properly maintain the supporting references. This event often led to delays in the license renewal reviews and significant resource expenditures to both licensees and the USNRC. According to NPUFs requirement, the information consists an evaluation of 1) a change made to the facility or a facility major modification, 2) a change in an SSC as part of major preventive or corrective maintenance (e.g., replacing an analog meter with a digital readout, replacing a safety-related pump with one that has increased flow); or 3) change in the facility, procedures, or experiments not previously described in the FSAR, should be considered in the FSAR.

The others information is evaluations regarding potential or actual aging of SSCs and any aging management actions taken, changes in the facility site environments, for instance: new industrial, transportation, military, or

residential facilities near the facility site or changes in the population potentially exposed to the facility releases), and changes significantly of design basis in the facility site environs related to natural phenomena, including geography, meteorology, geology, hydrology, and seismology[6]. However, there is no requirement for PSR in the USA research reactor regulation.

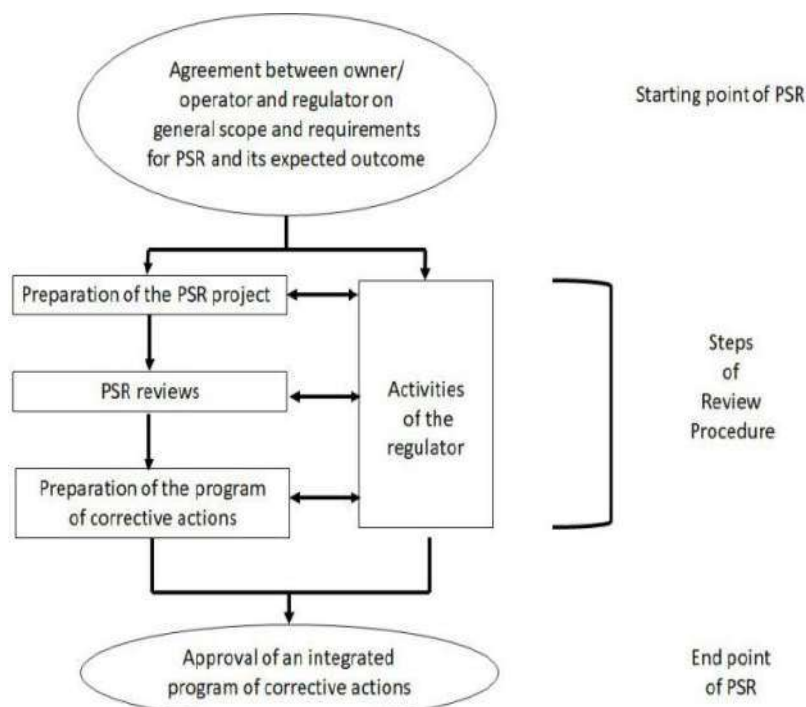
The PSR requirement practice in the USA is different from Australia, France, Netherlands, and Slovenia. In the four later countries, the PSR has become a mandatory requirement to be implemented every ten years. Moreover, in Slovenia, PSR has become an operating license renewal prerequisite. However, the adaptations and graded approaches of PSR apply due to specific features of research reactors in those countries [7-10].

Further, Germany, South Korea, and India employ PSR provisions with a more rigorous requirement. A research reactor in those countries has to perform a regular PSR every ten years with full-scope safety factors includes probabilistic safety analysis [11-13].

### IAEA Standard

The formal process of implementing PSR on power reactors is accomplished in four stages [14], as shown in **FIGURE 1**. The first stage is the preparation of the PSR project to establish a project team involving both the operating organization and the regulatory body. Then, the operator and regulatory body discussed the scope, level of detail, the timing of the review, and the codes and standards that will be employ. The summary of the discussion resulted in an agreement in the form of a PSR 'basis document'. The second stage is conducting the PSR. In this stage, the operating organization performs an agreed 'basis document' for the PSR. The review includes identifying positive or negative findings and a global assessment report (GAR) of the facility. These negative findings may lead to corrective actions or safety improvement proposals.

The third stage is performed by a regulatory body that reviews and assesses the PSR report prepared by the operating organization. The regulatory body then proposes corrective actions or safety improvements. Later, the regulatory body identifies any safety issues in each safety factor to makes categorization and prioritization of the safety improvements.



**FIGURE 1.** The overall process for a PSR of a nuclear power plant.

The last stage is the finalization of the integrated implementation plan. The integrated implementation plan has to contain corrective actions also reasonable and practicable safety improvements as needed, along with a schedule approved by the regulatory body.

## METHODOLOGY

The research methodology carried out using a descriptive and comparative approach. This paper describes the formal process of PSR comprise regulatory review and assessment of safety factors in several countries regulate research reactor, IAEA standard, and Indonesia regulation. For Indonesia regulation, GR No. 54 of 2012 on The safety and security of nuclear installation [15], and several Bapeten Chairman Regulation (BCR) are used to acquire information relating to the review and assessment of PSR documents. This paper will answer several research questions:

1. How does the implementation of PSR in other countries?
2. How the availability of regulation on PSR regulatory review and assessment of the research reactor in Indonesia?
3. What is the benefit and lessons gained from PSR review?

There are seven safety factors related to PSR document comprises of 1) plant design, 2) actual condition of important the structure, system, and component (SSCs) to safety, 3) qualification of important SSCs to safety, 4) aging, 5) safety performance and use of experience from other plants and research findings, 6) organization, management system, procedures, and emergency planning, and 7) environment radiological impact. Due to the broad scope of PSR, only safety factor numbers one to five that will be discussed in the paper because only those factors have quantitative data to be input and analyze using the computer database. However, the other two safety factors contain the program and standard operating procedure of the research reactor installation.

## RESULTS AND DISCUSSION

### Indonesia PSR Implementation

Recently PSR provision is specified in the GR No. 2 of 2014 and GR No. 54 of 2012 that is set more detail in BCR No. 2 of 2015 on Safety Verification and Assessment of Non-Power Reactor[16]. The licensee shall periodically conduct verification and assessment of safety at several stages of the nuclear installation license includes construction, commissioning, and operation stages. The scope covers are assessments of plant design, the actual condition of important a structure, system, and component (SSCs) to safety, qualification of important SSCs to safety, aging, the safety performance, use of experience from other plants and research findings, organization, and the management system, procedures, emergency planning, and radiological impact to the environment.

As a preparation of PSR, BAPETEN and BATAN held a focus group discussion in September 2016. Both parties agreed that the PSR basis document composed following the format and contents from BCR No. 2 of 2015 with consideration of the latest of the condition of reactor assuming and analyzing for 30 MW power. The data and analysis are collected and evaluated within ten years (2005-2015) in-line stated in BCR 2 of 2015. The data of PSR taken after the RSG-GAS license operation issued in 2005 [17]. The scope, level of detail, timing of the review, the regulation, codes, and standards to be used in the PSR agreed by both parties.

Based on the focus group discussion resulted in September 2016, PRSG-BATAN composed the PSR document which the scope and content referred to BCR No. 2 of 2015 that consists of ten sections as follow: an introduction, plant design, actual condition of the structure, system, and components, equipment qualification, aging management, safety performance and operating experience feedback, safety management, and emergency preparedness, and radiological impact on the environment, conclusion, recommendation and follow-up action.

Document of PSR submitted to BAPETEN by the end of 2017. The review of each safety factor includes identifying positive/strengths or negative/deviations findings. Negative findings may lead to proposals for corrective actions or safety improvements to be addressed in chapter ten of the PSR document.

The following are five of seven safety factors of the PSR document. The consideration of essential applicable input and output reviewed.

#### *Plant Design*

Review: RSG-GAS was designed and constructed with current standards and guides for a nuclear reactor at that time. The plant design requirements fulfillment stipulated in GR No. 54 of 2012 consist of general and specific requirements of the design. General design requirements consist of design for a) The reliability of the structure, system, and component; b) The simplicity for operation, inspection, maintenance, and testing; c) Nuclear emergency preparedness and response; d) The ease for decommissioning; e) Radiation protection; f) Human factor, and; g) minimize aging.

Nuclear reactor specific design requirements consist of design for a) reactor core; b) heat removal system; c) shutdown system; d) reactor protection system; e) technical safety feature; f) containment system; g) instrumentation and control system; h) handling and storage of nuclear fuel system; i) radioactive waste system; j) auxiliary system.

All the content from general and specific design compared with the article clause in BCR No. 1 of 2011 on the provision of design safety for a research reactor[18]. Each requirement of this BCR has been examined and observed to fulfill the implementation in GA Siwabessy reactor. There are no changes in design installation since RSG GAS obtained the last operating license. The modification program of reactor fuel type from Uranium-Oxide to Uranium-Silicide has been updated and stated in the previous SAR.

From 2014 through 2016, BATAN performed site characteristic evaluation in the Serpong area by concerning RDE development. The results of Peak Ground Acceleration (PGA) is 0.57g for 10.000 years recurrence [19]. This PGA will affect the adjustment of the reactor building and structure. As a result of the assessment, PRSG-BATAN will organize a seismic assessment team to perform analysis reliability of the building and the structure, also reactor core design. Additionally, based on their result/assessment, PRSG-BATAN will develop a work program and including an engineered solution if it is needed. Another specific design required special highlighted is the design of beam tube utilization and modification.

Conclusion: From all assessment results above, it concludes that all general and specific design safety requirements can fulfill, and the adequacy of the design still meets the applicable standard. The building and structure design include the reactor core, as well as the utilization and modification design required further analysis include an engineered solution.

#### *The Actual Condition of Important SSCs to Safety*

Review: The purpose of these safety factor study is to decide the actual condition of important SSCs to safety and to estimate whether they are capable and sufficient to meet design requirements, at least until the next PSR. The study also should check that the condition of important SSCs to safety documented accurately includes the continuous maintenance, surveillance, and in-service inspection program.

The review of the present condition of important SSCs to the safety of the research reactor also represents an examination of the following aspects for each SSC that is existing or anticipated aging processes, and operational limits and conditions.

The scope of SSCs is limited to important SSCs to safety, namely the systems of buildings and structures, reactor core, matrix and fuel assembly, reactivity control including control rod, primary loop, emergency cooling, ventilation, reactor protection, safety-related of control and instrumentation, electrical power supply, handling and storage of nuclear fuel, radiation protection, and fire protection.

To determine the actual physical condition of SSCs, the reviewer examines operation reports consist of records of maintenance covers calibration, surveillance, and functional test, and inspection report. The reviewer finds a discrepancy between the measurement and calculation of control rods reactivity. Due to this discrepancy, PRSG-BATAN is committed to adjusting core management calculations using a more reliable computer code. The assessment result also estimates that the reactor protection system considered replacement within the next 5-10 years.

Conclusion: The review concludes that the plant systems, structures, and components are functioning as expected. The core management aspect requires further investigation and engineered solutions.

#### *Qualification of Important SSCs to Safety*

Review: The purposes of the qualification important SSCs to safety review is to decide whether equipment to safety has been accurately qualified (including for environmental conditions) and whether qualification maintained through a sufficient program of maintenance, inspection, and testing that assures the performance of safety functions until at least the next PSR.

The review should also organize the requirements for performing safety functions while subject to the environmental circumstances that could remain in normal conditions and predicted accident conditions. These should include seismic, vibration, temperature, pressure, irradiation, corrosive atmosphere, and humidity conditions.

To determine the equipment qualification of SSCs, the reviewer examines operation reports consist of maintenance records, calibration, surveillance, and functional test, inspection report, and the measured value on the equipment (system and component). Then the reviewer will compare this measured value with the standard design value of a system and component-specific.

Conclusion: The review concludes that these systems and components to safety performed as expected.

## *Aging Management*

**Review:** The most significant safety factor for operation installation is the management of aging. The goal of the aging management review to determine whether the aspects of aging influence important SSCs to safety maintained adequately. Additionally, another purpose of this review is to decide whether effective management of the aging program is suitable so that all required safety functions will perform for the plant design lifetime or long-term operation.

In this aspect, the reviewer examines 1) the list from all important SSCs and critical of SSCs, specifically with SSCs fulfill three criteria: important SSCs to safety, not redundant, and not easy to repair/replace[20]. For instance, the reactor tank, structure building of the reactor, heat exchange, and the primary coolant pipe of the system; 2) the aging mechanism for SSCs, 3) its impact on safety function, and 4) the results of the in-service inspection. Evaluation of the aging degradation performed by comparing the condition of critical SSCs with report data from in-service inspection, surveillance, functional test, operation report, and performance indicators.

However, there is one component part of the critical SSC that cannot be observed due to the unavailability tools needed at PRSG-BATAN. For that reason, PRSG-BATAN commits to complete all assessment of critical SSCs and address it in an integrated implementation plan for safety improvements. Moreover, BAPETEN applies another data to justify that although these critical SSCs are unable to be assessed within this period, however, there is no abnormality data operation report during 2005-2015 related to this component.

The assessment result also showed that due to long-term exposure of radiation, temperature, humidity, and other environments, an aging process could happen in the component of the electric cable. Therefore, the management of the G.A. Siwabessy reactor should give attention to update the aging management program and maintenance program in the next reactor operation activity because of surveillance and maintenance of the electrical cable not included in the maintenance repair manual of RSG-GAS.

**Conclusion:** The review concludes that an update of the aging management program and maintenance program needs to apply in the next operation. The assessment of one critical of SSCs will be address in an integrated implementation or safety improvement plan.

## *The Operating Experience Feedback and Safety Performance*

**Review:** The safety performance review aims to recognize any need for safety improvements based on the reactor safety performance indicators and records of the experience operation, the plant-related event evaluations, and root causes. The reviewer evaluates safety performance using the operation installation report data during the period 2005-2015 contains the safety-related events, and records of the safety systems unavailability, the doses of radiation, and the radioactive waste production and radioactive effluent discharge. The unavailability system is the availability of the safety system cannot function when needed.

Data operation of the reactor from core 52 to 89 showed that generally, the RSG-GAS protection system functioned properly. However, there was one event during low power reactor operation where the trip from normally power supply did not operate. There was also know where the control rod automatically falls event caused the reactor scrambled frequently. However, the evaluations of these events have been resolved. As a result, since the core of 93 in 2017, the RSG-GAS system starts in a normal condition.

Regarding radiation protection, PRSG-BATAN monitored gamma and neutron radiation exposure in a normal operating cycle. The radiation doses from core 52 to 89 in the working area of the RSG-GAS reactor generally showed a value below ten  $\mu\text{Sv}/\text{hour}$ . The radiation dose exposure assessment of the reactor at the 8th and the zero levels operates in 15 MW showed a dose rate that is slightly above the dose limit value (NBD)/hour. This event is due to the presence of other radiation sources besides the reactor core, including a delay tank and a temporary storage area for radioactive materials at the 8th level of the reactor. However, the radiation protection implementation and the safety program document worked well, proved by the results of monitoring the receipt of the maximum personal dose for radiation workers is relatively far below the NBD determined in the regulation.

The second aspect of this chapter is the operating experience feedback of safety factor review. This factor purposes to assess if there is adequately relevant experience feedback from other research reactors and research findings, and to identify a good practice, lessons learned, and take advantage of improved knowledge derived from those researches. PRSG-BATAN highlighted several important events as feedback for future reactor operation such as 1) fission product of molybdenum (FPM) irradiation failure; and 2) some operating experiences, such as a) black spot on reactor fuel element; b) primary water conductivity raised; c) FPM leak event; d) fuel placement error events in reactor core; e) primary pump clutch broke; f) beam tube event, and g) unplanned shutdown event due to unbalanced loading of JKT03 detector.

**Conclusion:** The review concluded that the safety system was functioning as expected, the event of the unavailability system was followed up and resolved, and the radiation dose below the dose limit value. PRSG-BATAN management is also very well aware of operating experience reviews.

## *GAR and Integrated Implementation Plan for Safety Improvements.*

The next step activity after review completed in each aspect above has performed an analysis of the interfaces between the various safety factors with considering all the findings from each safety factor review and what safety improvements. The advance analysis or follow up action addressed in GAR also in an integrated implementation plan of proposed safety improvements linking safety significance and prioritization. The global assessment of all safety factors of the G.A. Siwabessy reactor had formulated into fourteen actions in the integrated implementation plan along with the year to resolve. The integrated implementation plan and summary report submitted and approved by BAPETEN at the end of 2019.

### **Lesson Learned from the RSG-GAS PSR Document Review and Assessment**

The RSG-GAS PSR documents review and assessment carried out using GR No. 54 of 2012 and several BCRs. The format, content, and scope of the PSR reviewed using BCR No. 2 of 2015. In this BCR, the formal procedure to perform a PSR is not stated, specifically in the preparation of the PSR project. This step important because it will produce guidance for both parties in the form of a PSR 'basis document' concerning the scope, level of detail, the timing of the review, and the codes and standards that will be employ. However, BAPETEN already performed this stage and declared in the preparation of the PSR process above by adapting the IAEA standard procedure and similar methods in other implementing PSR research reactor countries [7,12-14].

The PSR basis document is a necessary tool that directs the process of the PSR. It assures that the licensee and the regulatory body have equal expectations for the PSR's scope, methodology, and results. The PSR basis document covers some imperatives components such as 1) description of a current licensing basis, including exclusions and tolerable deviations, 2) description of the proposed operating plan of the facility, 3) the description of the PSR scope, 4) information on the methodology for the performance of the PSR, including the period for which the PSR is valid, 5) information about applicable regulations, codes, and standards, 6) the methodology for the identification, dispositioning, and tracking of gaps, 7. the method for the GAR, and PSR administration.

Considering the importance of this process before performing PSR review and assessment, therefore the process of producing guidance for both parties in the form of a PSR 'basis document' can be taken as a lesson learned and a significant issue to be a consideration in revising the BCR No. 2 of 2015 or in the nuclear licensing procedures.

In conducting the plant design review, the fulfillment of general and specific nuclear reactor design requirements carried out using BCR No. 1 of 2011. The reviewer compares all compliance of the article required in this BCR with information facility data declared in the last FSAR. In general, this BCR is sufficient to review the current conditions of general and specific design installation described in the review of the plant design above. Additionally, regarding the design of buildings and structures of the reactor, the reviewers also take into account the acceptance criteria stated in the BCR related to site evaluation of nuclear installation.

The actual condition of important SSCs to safety is reviewed by analyzing several data of inspection, maintenance, calibration, surveillance, functional tests, and operation reports for ten years. These data are interrelated to each other of the safety factors and able to give the necessary complement information. For instance, in reviewing plant design safety factors, such data can analyze whether SSCs are reliable and easy to operate, inspect, maintain, and test. In advance, this information and data include reactor parameter operation data collected can predict plant performance like availability factor, capacity factor, number of reactor trips, and unplanned shutdowns. Those data will be review in the safety performance of the safety factor.

The data collected in the PSR during 2005-2015 used as a temporary database system of operating installation data that describes the behavior of system and component operation, such as pressure, temperature, flow rate, conductivity, level of height, or humidity for important SSCs to safety. The databases associated with the event, deficiencies, anomalies, and deviation gathered to assist an essential view and analysis of operating experience from the failures of system or components, and maintenance deviation reports, which can transform into a database trending system representation. These systems will supply transparent data presentation that eases the diagnosis of monitored performance, and identify patterns, abnormal trends, recurrences, also quick plant management overview and action focus.

This trend analysis can provide information as an input on the aging safety factor review. For example, when the primary coolant pressure and temperature of the reactor are identified continuously outside the normal operating limits, the reviewer/inspector can rapidly recognize the possibility of degradation performance in those systems or components. Therefore, in the future, it is expected that BAPETEN creates a permanent database or integrating the inspection, maintenance, calibration, surveillance, functional tests, and operation reports data into Bapeten Licensing System and Inspection, as a useful additional tool to support BAPETEN supervision, to monitor reactor operation performance, as well as the licensing decision support system.

The second goal of the aging safety factor review is to know whether an effective management program of aging is suitable so that all required safety functions will be performing for the plant design lifetime or long-term operation. At the same time, additionally to PSR documents, the licensee also submits an aging study report in the operating license renewal that reflects the management implementation report of aging based on a predetermined program. The management program's effectiveness of the aging was decided by similitude the results of the aging management implementation as written in the study report with the management program composed by the licensee by referring to BCR No. 8 of 2008 on the Safety provision of non-power reactor aging management.

However, based on GR No. 2 of 2014, the aging management program is not included in the document for an operating license and is not approved by BAPETEN. Therefore, activities proposed in management programs that cover some process such as screening of SSCs, identification, and understanding of aging degradation mechanisms, determine critical of SSCs, and record of aging management data is potentially inappropriate due to the error of methodology with BCR No. 8 of 2008. As a result, the aging study report is potentially not accepted by the regulatory body. IAEA Specific Safety Requirement No. 3 shows that research reactor operating facility shall assure that the management program of aging performed effectively to maintain the aging of important SSCs to safety so that safety functions of SSCs are accomplished over the whole operating lifetime of the installation [21] as well in the IAEA SSG No. 12 [22]. This document declares that the operational program of licensee should have in place before and during operation. Such a program may be subject to approval by the regulatory body as appropriate is the management of aging. Therefore, as a lesson learned from the PSR review and assessment in the aging management aspect, BAPETEN should add an 'aging management program' in the revision of GR No. 2 of 2014 and should move the detailed requirements concerning the "aging management program" into a relevant BCRs.

## CONCLUSION

PSR implementation in several regulating research reactor countries is varied. PSR regulations in Indonesia are sufficient. However, it needs updating specifically regarding the aging management program in GR No. 2 of 2014 and PSR formal procedure in the BCR or nuclear reactor licensing procedure. The results of PSR give benefits and lessons for the licensee and the regulatory body. BAPETEN gains benefits as follows: an input to update the regulation and procedures and develop databases for the licensing decision support system. Meanwhile, BATAN gains lessons as follows: to know actual plant safety, also to plan and to set work priorities for safety improvements.

## REFERENCES

- [1] Badan Tenaga Nuklir Nasional, Chapter I Introduction in *Safety Analysis Report of GA Siwabessy Reactor Rev. 11*, Jakarta, 2019.
- [2] Badan Pengawas Tenaga Nuklir, Bapeten Chairman Regulations Number 1 of 2017 on Inspection in Utilization of Nuclear Power Oversight, Jakarta, 2017.
- [3] A. Khakim and Geni Rina, "Safety Reevaluation of Indonesian MTR-Type Research Reactor," Paper presented at the 18<sup>th</sup> IAEA IGORR Conference, 4-8 Dec 2017, Sydney.
- [4] Government of Republic of Indonesia, Government Regulation No. 2 of 2014 on Licensing of Nuclear Reactor and Utilization of Nuclear Materials, Jakarta, 2014.
- [5] Nuclear Regulatory Commission of United States, Interim Staff Guidance on the Streamlined Review Process for License Renewal for Research Reactors, United States, 2009.
- [6] Nuclear Regulatory Commission of United States, Reg Guide 2.7 Preparation of Updated Final Safety Analysis Reports for Non-Power Production or Utilization Facilities, United States, 2019.
- [7] Australian Radiation Protection and Nuclear Safety Agency, Regulatory Guide for Periodic Safety and Security Review of Facilities v.2.0, NSW, 2019.
- [8] International Atomic Energy Agency, Report of the Integrated Safety Assessment of Research Reactors (INSARR) Mission to the High Flux Reactor (HFR), Petten, 2016.
- [9] J. Couturier, D. Rive. "Periodic Safety Review Management for French Research Reactors, Technical Support Organization Approach, Institut de Radioprotection et de Sûreté Nucléaire, Fontenay-aux-Roses, [https://www-pub.iaea.org/MTCD/Publications/PDF/P1360\\_ICRR\\_2007\\_CD/Papers/J.%20Couturier.pdf](https://www-pub.iaea.org/MTCD/Publications/PDF/P1360_ICRR_2007_CD/Papers/J.%20Couturier.pdf), accessed on 12 Sep 2020.

- [10] T. Nemeč, “Experience with Safety Reviews of Slovenian Research Reactor by PSR and IAEA INSARR Missions and the Stress Tests for the Krško NPP,” Presented at 18<sup>th</sup> IAEA IGORR Conference, 4-8 Dec 2017, Sydney.
- [11] H. Gerstenberg et al, “First Periodic Safety Review of the FRM II After 10 Years of Routine Operation,” Technical University of Munich, ZWE FRM II, 85748 Garching – Germany,” Paper presented at 18<sup>th</sup> IAEA IGORR Conference, 4-8 Dec 2017, Sydney.
- [12] Jin-Won Shin, Seung-Gyu Do, Jae-Sam Han, and Choong Sung Lee, “Status of a Periodic Safety Review of HANARO,” Paper presented at 18<sup>th</sup> IAEA IGORR Conference, 4-8 Dec 2017, Sydney.
- [13] Bhuse P. P, “Safety Enhancement of Dhruva Reactor through Periodic Safety Review,” Paper presented at 18<sup>th</sup> IAEA IGORR Conference, 4-8 Dec 2017, Sydney.
- [14] International Atomic Energy Agency, Specific Safety Guide No. SSG-25, “Periodic Safety Review for Nuclear Power Plants,” Vienna, 2013.
- [15] Government of Republic of Indonesia, Government Regulation Number 54 of 2012 on The Safety and Security of Nuclear Installation, Jakarta, 2012.
- [16] Badan Pengawas Tenaga Nuklir, Bapeten Chairman Regulation Number 2 of 2015 on Safety Verification and Assessment of Non-Power Reactor, Jakarta, 2015.
- [17] Badan Tenaga Nuklir Nasional, *Document of Periodic Safety Review for GA Siwabessy Reactor 2005-2015* (Document Number: 002.002/RN 00 03/RSG 4.2), Jakarta, 2019.
- [18] Badan Pengawas Tenaga Nuklir, Bapeten Chairman Regulation Number 1 of 2011 on Safety Design of Non-Power Reactor, Jakarta, 2011.
- [19] Badan Tenaga Nuklir Nasional, *Document of Site Evaluation Report for BATAN Experimental Power Reactor* (seismic aspect) (Document Number: LET-RDE.01/RN 01/SN Revision 4), Jakarta, 2016.
- [20] Badan Pengawas Tenaga Nuklir, Bapeten Chairman Regulation Number 8 of 2008 on Safety Provision of Non-Power Reactor Aging Management, Jakarta, 2008.
- [21] International Atomic Energy Agency, Specific Safety Requirements No. 3, “Safety of Research Reactors,” Vienna, 2016.
- [22] International Atomic Energy Agency, Specific Safety Guide No. SSG-12, “Licensing Process for Nuclear Installations,” Vienna, 2010.