Overview of the Application of the Specific Safety Requirements to BATAN Research Reactors

Iman Kuntoro*1, Sriyono1, M. Subekti1, G.R. Sunaryo1, Agus Rokhim2, Taxwim3, Jaja Sukmana4

1) Center for Nuclear Reactor Technology and Safety, BATAN, Serpong, Tangerang Selatan 15310 Indonesia
2) Center for Science and Technology of Applied Nuclear, BATAN, Bandung
3) Center for Science and Technology of Accelerator, BATAN, Yogyakarta
4) Center for Multi Purpose Reactor, BATAN, Serpong, Tangerang

*Email: imank@batan.go.id

Abstract. BATAN owns and operates three research reactors for supporting R&D in nuclear science and technology, namely TRIGA-2000, 2MW, Kartini, 100 kW and RSG-GAS, 30 MW reactors. The reactors were built in 1965, 1979 and 1987 consecutively whenever the safety recommendations were based on IAEA Safety Series of that period of time. In 2016, IAEA has published a Safety Standard Series namely Specific Requirements for Research Reactor SSR-3. The aim of the paper is to demonstrate the applicability of this new requirements to the BATAN reactors by comparing those to the existing safety analysis reports. The results show that principally the the specific requirements in SSR-3 are applicable to the BATAN reactors although those reactors are classified as old reactors.

Keywords: safety requirement, SSR-3, BATAN research reactors.

1. Introduction
Recently the IAEA has has published a new safety requirement of research reactors SSR No. 3 in 2016[1] which supersedes The IAEA SS No. NS-R-4, 2005. The requirements contain all the important areas of the safety of research reactors, with emphasis on requirements for design and operation. It provides a basis for safety and for safety assessment for all stages in the lifetime of a research reactor. These requirements are made available for use for organizations involved in the design, manufacture, construction, operation, modification, maintenance and decommissioning of research reactor, in safety analysis, verification and review, and in the provision of technical support, and by regulatory bodies.

The requirements are applicable in the area of the site evaluation, design, manufacture, construction, commissioning, operation, including utilization and modification, and decommissioning of research reactors, including critical and subcritical assemblies. It is also to be applied to existing research reactors to the extent practicable. As previously mentioned that BATAN operates 3 research reactors. In the year 1965, the first reactor was built TRIGA 2000 of a TRIGA type reactor, 2 MW upgraded from 250 kW. The seond reactor built in 1979 Kartini reactor, 100 kW, is also a TRIGA type reactor.
The youngest but also already old reactor is the multipurpose reactor RSG-GAS, 30 MW built in 1987, a MTR type reactor. Therefore, the objective of the paper is to review the applicability of the SSR-3 safety requirements to those research reactors. The results is expected to give a figure of the safety level of those research reactors from the new requirements point of view. The main data of safety of those reactors are available in their documents Safety Analysis Reports [1 – 3].

2. Methodology
The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation. This fundamental safety objective can be achieved by ten safety principles, as the basis of which safety requirements are developed and safety measures are to be implemented[4]:

Principle 1: The prime responsibility for safety must rest with the person or organization responsible for facilities.
Principle 2: Effective legal and governmental framework for safety, independent regulatory body, must be established and sustained.
Principle 3: Effective leadership and management for safety must be established and sustained.
Principle 4: Facilities and activities that give rise to radiation risks must yield an overall benefit.
Principle 5: Optimization of protection to provide the highest level of safety that can reasonably be achieved.
Principle 6: Limitation of risks to individuals, ensure that no individual bears an unacceptable risk of harm.
Principle 7: People and the environment, present and future, must be protected against radiation risks.
Principle 8: All efforts must be made to prevent and mitigate nuclear or radiation accidents.
Principle 9: Emergency preparedness and response arrangements must be made for nuclear or radiation incidents.
Principle 10: Protective actions to reduce existing or unregulated radiation risks must be justified and optimized.

To satisfy the safety principles, the facility be kept below the dose limits and kept ALARA, keep all sources of radiation under strict technical and administrative control, emergency arrangements to ensure that the consequences of any accident are mitigated.

The primary means of preventing and mitigating the consequences of accidents is the application of the concept of defence in depth. There are five levels of defence[5]:

a. L-1: to prevent deviations from normal operation and the failure of items important to safety.
b. L-2: to detect and control deviations from normal operational states in order to prevent anticipated operational occurrences from escalating to accident conditions.
c. L-3: it is assumed that, the escalation of certain anticipated operational occurrences or postulated initiating events might not be controlled at a preceding level of defence and a more serious event may develop. This leads to the requirement that ESF be capable of transferring the research reactor first to a controlled state and subsequently to a safe state.
d. L-4: to mitigate the consequences of accidents that result from failure of L-3. The most important objective for this level is to ensure that the confinement function is maintained, thus ensuring that radioactive releases are kept ALARA.
e. L-5: to mitigate the radiological consequences of radioactive releases that could potentially result from accidents. This requires the provision of adequately equipped emergency response facilities and emergency plans and procedures for on-site and, if necessary, off-site emergency response.

Technical and administrative requirements for the safety of research reactors are established in accordance with those above safety concepts and principles in order to achieve the safety objectives. There are 90 (ninety) specific safety requirements covering aspects of regulatory supervision and management (1-6), design (7-66), operation (67-88) and decommissioning (89) and interface between safety and security (90) [5].
The review was then done by implementing those 90 safety requirements to the all three BATAN research reactors. The review are primarily based from the data available in their Safety Analysis Reports (SAR) documents.

3. Results and discussions

The implementation of specific safety requirements of SSR-3 to BATAN research reactors were derived by discussion with the persons responsible for the safety of those reactors on the topics of safety analysis and associates documents mainly the SARs of their reactors. The results are summarized in Table 1.

From the aspects of regulatory supervision and management for safety, all the three reactors meet the requirements no. 1 to 6. They are shown in their SAR documents namely, SAR of the RSG-GAS Reactor[1], Revision 11, 2011, SAR of the Kartini Reactor, Revision 2, Edition 3, 2012[2] and SAR of the TRIGA 2000 Reactor, Revision 0, Edition 2, 2016[3]. Integrated management system has been implemented by their managements in conducting the operation of the reactors. Safety committee are actively established and the reactor safety review are carried out periodically.

As from design aspects, although all the three reactors were designed from the age of 1960 (TRIGA) and 1980 (RSG-GAS), their design still meet the safety requirements of 67 until 88, except requirement no. 52, “Use of computer based equipment in systems important to safety”. The reactors still use the analog system for their systems important to safety. Other important note is that for TRIGA reactors, the building are not fully as the confinement function. Besides that those reactors have only one control room without emergency control room. Nevertheless, their safety are still adequately acceptable.

Aspects of reactor operation, the safety requirements nos. 68 to 88 are already implemented by BATAN reactors. These are in accordance to the Indonesia Regulatory Body. It covers organizational, safety limits, commissioning, operation, maintenance and utilization, modification, radiation protection, emergency respos and aging management as well. One note is that for requirement no. 87 concerning extended shut down, until now BATAN has no policy for extended shut down for their reactors.

From preparation for decommissioning point of view, namely requirement no. 89, all three reactors have been designed according to principles of decommissioning process. Decommissioning program have also been made available in Chapter 19 of their SAR documents. Lastly, requirement no. 90, the interfaces between safety and security have been implemented by physical protection and procedures of security and nuclear material safeguards.

Then, shortly speaking, it can be summarized that the all three reactors meet the safety requirements for management, design, operation and preparation for decommissioning. The reasons are that all reactors are by now in accordance to the safety requirement from the Indonesia Regulatory Body BAPETEN, for design and operations [6,7]. Those national safety regulations are generated from and based on IAEA safety requirements of NSR-4 [8]. In other words, there will be no significant problem to implement the new safety requirements of research reactor, IAEA Safety Standard Series No. SSR-3 (2016).

Table 1. Implementation of specific requirements SSR-3 to BATAN reactors

| No. | Specific Requirements Description | RSG GAS | Notes | Kartini | Notes | Triga 2000 | Notes |
|-----|-----------------------------------|---------|-------|---------|-------|------------|-------|
| 1   | REGULATORY SUPERVISION FOR RESEARCH REACTOR AUTHORIZATION PROCESS | | | | | | |
| 2   | MANAGEMENT FOR SAFETY AND VERIFICATION OF SAFETY FOR RESEARCH REACTOR | | | | | | |
| 3   | Responsibilities in the management | | | | | | |
### DESIGN OF RESEARCH REACTOR FACILITIES

#### PRINCIPAL TECHNICAL REQUIREMENTS

|   |   |   |
|---|---|---|
| 7 | Main safety functions | APP | APP | APP |
| 8 | Radiation protection | APP | APP | APP |
| 9 | Design | APP | APP | APP |
| 10 | Application of the concept of defence in depth | APP | 5 level | 4 level | APP | 4 level |
| 11 | Interfaces of safety with security and the SSAC, nuclear material | APP | APP | APP |
| 12 | Use of the graded approach | NA | APP | APP |
| 13 | Proven engineering practices | APP | Inherent safety features, German standard, | APP | Very high negative reactivity coeff., US standard, | APP | Very high negative reactivity coeff., US standard |
| 14 | Provision for construction | APP | APP | APP |
| 15 | Features to facilitate radioactive waste management and decommissioning | APP | APP | APP |

#### GENERAL REQUIREMENTS FOR DESIGN

|   |   |   |
|---|---|---|
| 16 | Safety classification of structures, systems and components | APP | APP | APP |
| 17 | Design basis for items important to safety | APP | APP | APP |
| 18 | Postulated initiating events | APP | APP | APP |
| 19 | Internal and external hazards | APP | APP | APP |
| 20 | Design basis accidents | APP | APP | APP |
| 21 | Design limits | APP | APP | APP |
| 22 | Design extension conditions | APP | APP | APP |
| 23 | Engineered safety features | APP | APP | APP |
| 24 | Reliability of items important to safety | APP | APP | APP |
| 25 | Single failure criterion | APP | APP | APP |
| 26 | Common cause failures | APP | APP | APP |
| 27 | Physical separation and independence of safety systems | APP | APP | APP |
| 28 | Fail-safe design | APP | APP | APP |
| 29 | Qualification of items important to safety | APP | APP | APP |
| 30 | Design for commissioning | APP | APP | APP |
| 31 | Calibration, test, maintenance, repair, replacement, inspection and monitoring of items important to safety. | APP | APP | APP |
| 32 | Design for emergency preparedness and response | APP | APP | APP |
|   | Design for decommissioning | APP | APP | APP |
|---|----------------------------|-----|-----|-----|
| 34 | Design for radiation protection | APP | APP | APP |
| 35 | Design for optimal operator performance | APP | APP | APP |
| 36 | Provision for safe utilization and modification | APP | APP | APP |
| 37 | Design for ageing management | APP | APP | APP |
| 38 | Provision for long shutdown periods | APP | APP | APP |
| 39 | Prevention of unauthorized access to, or interference with, items important to safety | APP | APP | APP |
| 40 | Prevention of disruptive or adverse interactions between systems important to safety | APP | APP | APP |
| 41 | Safety analysis of the design | APP | APP | APP |

### SPECIFIC REQUIREMENTS FOR DESIGN

|   | Buildings and structures | APP | APP | APP |
|---|--------------------------|-----|-----|-----|
| 42 | Means of confinement | APP | NA | NA |
| 43 | Reactor core and fuel design | APP | APP | APP |
| 44 | Provision of reactivity control | APP | APP | APP |
| 45 | Reactor shutdown systems | APP | APP | APP |
| 46 | Design of reactor coolant systems and related systems | APP | APP | APP |
| 47 | Emergency cooling of the reactor core | APP | APP | APP |
| 48 | Provision of instrumentation and control systems | APP | APP | APP |
| 49 | Reactor protection system | APP | APP | APP |
| 50 | Reliability and testability of I&C systems | APP | APP | APP |
| 51 | Use of computer based equipment in systems important to safety | NA | NA | NA |
| 52 | Control room | APP | APP | APP |
| 53 | Supplementary control room | APP | Emergency control room | NA | - | NA | - |
| 54 | Emergency response facilities on the site | APP | APP | APP |
| 55 | Electrical power supply systems | APP | APP | APP |
| 56 | Radiation protection systems | APP | APP | APP |
| 57 | Handling and storage systems for fuel and core components | APP | APP | APP |
| 58 | Radioactive waste systems | APP | APP | APP |
| 59 | Performance of supporting systems and auxiliary systems | APP | APP | APP |
| 60 | Fire protection systems | APP | APP | APP |
| 61 | Lighting systems | APP | APP | APP |
| 62 | Lifting equipment | APP | APP | APP |
| 63 | AC and ventilation systems | APP | APP | APP |
| 64 | Compressed air systems | APP | APP | APP |
| 65 | Experimental devices | APP | APP | APP |
4. Conclusions
The new specific safety requirements of research reactor safety of IAEA have been tried to be implemented to the all three BATAN research reactors. The results show that principally the specific requirements in SSR-3 are applicable to the all BATAN reactors.

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