Regulatory of Nuclear Power Plant: 
Environmental Safety Aspects on Nuclear Power Plant Operation 

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Abstract 
Nuclear Energy Regulatory Agency also called BAPETEN is a national regulatory authority for nuclear energy uses in Indonesia. Regulatory of Nuclear Power Plants (NPPs) is one of BAPETEN authorities for nuclear energy uses, including NPP operation. Regulatory of NPP consists of 5 (five) steps, there are siting, construction, commissioning, operation, and decommissioning. In this paper, it would be discussed about regulatory of NPP, especially on environmental safety aspects in NPP operation. Operation of NPP is operating a nuclear reactor securely and safely in accordance with the design and purpose of its utilization for power generation. Operating NPP is essential to be observed considering the impact on the natural environment, urban and human population. Environmental safety aspects of nuclear power plant operations must meet the criteria and tight requirements in accordance with the legislations, international standards, assessments, in-depth and reliable studies, including environmental modeling and monitoring of the effluent for all pathways, also evaluation of radiation dose for members of public and emergency-response planning. 

Keywords: BAPETEN, NPP operation, environmental safety. 

Introduction 
Nuclear Energy Regulatory Agency, also called BAPETEN is national regulatory agency for the use of nuclear energy in Indonesia. Nuclear Power Plant (NPP) is one BAPETEN scope of regulatory responsibilities. Regulatory duties, in accordance with Law No. 10 Year 1997 on Nuclear Article 4 Paragraph (2) [1] stated that the regulatory duties performed by Regulatory Agency held through regulation, licensing and inspection. 

While one purpose of regulatory responsibility is to ensure the safety and health of workers, the public and protection of the environment, in accordance with Article 15 item b of that Law. This causes BAPETEN role in nuclear energy programs are very significant and vital. BAPETEN obligation of regulating nuclear power through regulation, licensing, and inspection and supported by assessment of nuclear power plant system and technology. NPP is one of the utilization of nuclear energy for power generation. Licensing of nuclear reactors including regulation of NPP consists of NPP siting, construction, commissioning, operation, and decommissioning. This is synergize to one of Directorate of Inspection for Radiation Facilities and Radioactive Material mission [2] is to set up the infrastructure environmental and radiological inspection systems at the NPP which includes the siting, construction and operation [3]. 

Indonesia National Energy Policy has put nuclear energy as an option to meet the electricity needs of the people of Indonesia at present and in the future. This is reinforced by Government Regulation No. 5 of 2006 on National Energy Policy on Article 2 Paragraph 2 Item b which states that national energy policy objective is the realization of energy (primary) optimal mix in 2025, namely the role of each type of energy to the consumer National energy is a new and renewable energy, in particular Nuclear be more than 5% [4,5]. 

Additionally, the main policy measures should be considered carefully to preserve the environment by applying principles of sustainable development, which includes sustainability of the environment. NPP in the dimensions of sustainability of the environment means that the existence of NPPs must be able to maintain and preserve the environment. Risks and dangers of nuclear technology must be engineered and reduced so as not to disturb the environment as a whole [6]. In this paper, would be discussed regulatory of NPP, especially on environmental safety aspects in NPP operation.
Environmental safety requirements are important thing to satisfy regulation, to propose for an NPP operational license and to be verified on inspection activity. The criteria/requirements are based on regulations and international standards. The problem statement of this paper is the environmental safety requirements for NPP operation are.

Environmental safety aspects in NPP operation are the features that needed by the licensee to keep the site safe and secure for NPP lifecycle, especially in operational stage. The purpose of this study is to describe the environmental safety aspects of NPP operation.

The scope of this research consists of environmental safety aspects of nuclear power plants in operation; but not discuss about radiological safety aspects of nuclear power plants in operation and the type of nuclear reactor operated. Radiological safety aspects of nuclear power plants site will discussed in a separate paper.

Methods
The methodology of this study is descriptive analytic, that is assessment of any kind of data and parameters on environmental aspect in NPP operation. Data and parameters are related to impact of NPP operation, namely discharge of radioactive material from NPP, environmental modelling, dose evaluation for members of public and emergency response planning. Then, parameters to be analyzed and described its sufficient requirements of its acceptability based on regulations and international standards.

The approach will be carried out in this paper is to describe the eligibility criteria for environmental safety in NPP operation. All kind of data obtained from literature study of relevant sources. Study materials in the form of laws and regulations related to nuclear energy, nuclear reactor operations, and other material from the competent international organizations.

Result and Discussion
Nuclear Power Plant (NPP) is a nuclear reactor that serves as a power reactor used for power generation. Nuclear reactor is a device or installation that is run with the nuclear fuel core could generate a chain reaction controlled and used for power generation, or research, and / or the production of radioisotopes. Nuclear power reactor is in the form of nuclear power plants that utilize thermal energy for power generation both for commercial and non-commercial interests (6).

Definition of NPP Operation
According to reference (6) stated that the operation is to operate a nuclear reactor securely and safely in accordance with the design and purpose of its use. So the NPP operation is operating nuclear reactor securely and safely in accordance with the design and purpose of its utilization for electric power generation.

Environmental Safety in NPP Operation
Radiation exposure to the public can be increased because of the discharge (discharges) of radioactive material from NPPs in the form of a gas or liquid, and / or from direct irradiation of the plant. The discharge must be controlled in accordance with the permission of the regulatory body, so that the radiation doses of the public who are exposed (the critical group) around the plant is still in the range of dose limitation. Limitation of the dose prescribed by the regulatory body for the radiation source shall be a fraction of the value of the dose limit for the public (public DLV). The discharge rate is permitted to be determined using the modeling technique to establish the relationship between the dose rate of discharge of potential critical groups, considering all the possible exposure pathways (see Figure 1). Verification of compliance with discharge permits shall be established by monitoring the discharge and monitoring sources in the environment.
Incident and Emergency Response Planning

NPP operational organizations responsible for emergency measures which requiring immediate action to prevent and lessen adverse impacts on human health and safety. Incidents and emergencies should be investigated to determine the cause so that does not happen again. Although all preparedness measures in the design and operation of nuclear power plants, there remains the possibility that an error occurs or a condition that leads to an emergency arise. The discharge of radioactive substances or radiation exposure to workers or the public could potentially occur as a result of the operation of nuclear power plants or transportation of radioactive materials \(^8,9,10\). Operational organization of nuclear power plants shall be alerted the offsite officer to deal with potential emergencies on site and off site the nuclear power plant, including emergencies that occur due to the transport of radioactive materials \(^11,12\). Nuclear emergency preparedness related to environmental safety are:

a. Aid measures if contamination of the environment occurs with the capability of monitoring and implementation of intervention levels should be in accordance with international standards;

b. Coordinate public information by an official source of information after the emergency to provide information on the risks and actions to be taken;

c. analysis of the impact of a terrorist act \(^12\).

Discharge Control of Effluent and Compliance Monitoring

Before the plant operation begins, the operational organization must apply for authorization to the regulatory body to acquire the discharge of gaseous and liquid effluents. In that application must be shown that they can comply with national regulations. The purpose of determination of the rate of discharge is to ensure that the radiation dose due to exposure to the discharge of radioactivity from nuclear power plant operations do not exceed the limit value of the fraction of the dose (dose constraint) to critical group and based on the principle of ALARA (as low as reasonably achievable).

The discharge rate for all plant operation conditions as well as potential changes in future operating conditions must be taken into account in determining the rate of discharge that will be submitted to the regulatory body. Submission of the discharge rate should be based on the estimation of radiological environmental impact assessment modeling. Estimated doses for the highest exposed individuals should also be assessed. This can be determined by a survey of living habits that could potentially be exposed to high as a result of the disposal of effluent from nuclear power operations. This survey is called a critical survey of the population. Another things to consider are related to the critical group of plants, food consumption, sources of food and drinks and other habits that can result in them receiving a radiation dose above average. The regulatory body should establish the level of radioactivity permitted effluent discharge after receiving a request from the operational organization of NPP. All levels
of discharge for operating nuclear power plants should be in the range of the rate of discharge set by the regulatory body.

Adherence to the discharge rate should be maintained and demonstrated by operational organizations with monitoring and recording activity on the source of the discharge and analyzed in the media environment, such as water or air. Monitoring can be carried out continuously or through a representative sampling and measurement at any time as necessary. For discharge at any time into a body of water, the assessment is done by taking representative samples, prior to, during, and after any discharge of radioactivity to the environment. The fast pace should be done if there is the discharge of radionuclide known to be abnormal, perform radiological analysis for the discharge of gaseous and liquid effluents. If effluent discharge rate limit will be or has been exceeded, then the NPP operation organization should investigate. For that NPP operation organization should:

a. Suspend the discharge of effluents into the environment and take corrective action;
b. Calculate and estimate the discharged radioactive substances;
c. Record all matters relating to the problem;
d. Immediately report to the regulatory body in accordance with established procedures;
e. Investigate and identify the cause of not in accordance with the specified discharge. If necessary, immediate action should be initiated.

**Source Monitoring**

Source monitoring is the measurement at the source and the radiation field around the source of the discharge of effluents. Planning of source monitoring should allow the monitoring program to verify compliance with the criteria and limit the discharge of the exposure limit set by the regulatory body. Monitoring of radioactive discharges can be followed by measuring the specific radionuclide or gross activity measurements.

Measurements are typically performed before and at the point of discharge (e.g. chimneys to discharge atmospheric nuclear reactor or the sewer pipe to discharge liquid. For discharge group (batch), the material is discharged into the environment more appropriately characterized / characterized by the sample volume, radionuclide composition of the reservoir before being discharged into the environment.

For air and liquid effluents, there are 3 (three) types of measurements or observations that can be made, namely:

a. online monitoring discharge;
b. continuous sampling and measurement of the concentration of activity in the laboratory;
c. Any time sampling and measurement of the concentration of activity in the laboratory.

While the selection of methods for sampling and measurement procedures must depend on:

a. the characteristics and amount of radionuclides that are discharged and the sensitivity of the measurement system;
b. the variation of time, and the rate of discharge of radionuclide;
c. Possibility of unplanned discharge requires immediate detection and notification.

**Environmental Monitoring**

Environmental monitoring program should be implemented in compliance with the requirements of the regulatory body. Environmental monitoring program should be implemented two to three years before the nuclear power plant commissioning begins. Pre operational environmental monitoring program conducted by measuring radiation background levels and variations between seasons around nuclear installations. These data serve as the basis for implementing the operational phase environmental monitoring program including the collection and analysis of NPP various environmental samples, such as samples of vegetation / plants, air, milk, water, sediment, fish, and the environment of some of the sites identified offsite of the nuclear power plant.

Environmental monitoring program at the stage of plant operation should be carried out as a continuation of the NPP preoperational environmental monitoring program. Environmental samples
taken during NPP operation should be the same as the samples taken at preoperational of NPP, but with different intervals (e.g. milk samples were taken more frequently than in the sample sediment). Environmental monitoring program at the stage of plant operation should be reviewed based on experience and should be modified if necessary. Programs should be designed to provide information with the goal, namely:

a. to demonstrate the ability of controlling the discharge of effluents;
b. to examine the relationship between environmental monitoring with the monitoring data from the source of discharge;
c. to check the validity of the modeling environment used to set the level of the limit;
d. to increase public safety assurance;
e. to examine the trend of radionuclide concentration in the environment.

**Maintenance of Facilities and Equipments**

Operational organization of NPP should prepare and implement a schedule for maintenance, testing, monitoring, and inspection of facilities and equipment for environmental monitoring, management of radioactive wastes that affect safety, including the structure of the building for storage of radioactive waste.

Standards and frequency of maintenance work tailored to the level of reliability and effectiveness of facilities and equipment in accordance with the design assumptions and its purposes. In general, depending on the treatment schedule:

a. analysis of maintenance needs based on previous experience or the available data or from the manufacturer's recommendations;
b. planning work related to the availability of experienced personnel, equipment and materials (including spare parts);
c. monitoring program for radiation protection and industrial safety;
d. the potential loss of confinement, and
e. Management of radioactive waste to be the maintenance requirements, testing, monitoring and inspection of NPP operation \[13\].

**Records and Reports Effluent Disposal and Environmental Monitoring**

Details of liquid and gaseous effluent discharge include estimates of effluent discharge that are not observed must be recorded and stored. The data with meteorological data, the model transport / transfer of radioactive substances, the survey data and metabolic habits will form the basis for the calculation of the critical dose of the public. All the results of the analysis of environmental samples must be recorded and stored.

**Conclusion**

Regulation of NPP is one BAPETEN authority in the utilization of nuclear energy. Environmental safety aspects of nuclear power plant operations must meet the criteria and tight requirements in accordance with the legislations, international standards, assessments and in-depth and reliable studies, including environmental modeling and monitoring of the effluent for all pathways, also evaluation of radiation dose for members of public and emergency-response planning.

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**References**


