# CHALLENGES FOR PHYSICAL PROTECTION OF INDONESIA EXPERIMENTAL POWER REACTOR

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**Abstract**

Currently Indonesia are expecting to build its first Experimental Power Reactor which has HTGR technology. The fuel design of the reactor will have the same type of fuel with HTR-10, a 10 MWt reactor in China. The fuel design of the reactor is pebble bed where the fuel is a collection of nuclear material inserted in small sized spheres containing structural and moderating material and a pebble bed core that will contain a bulk load of spherical fuel elements. The refuelling scheme will use continuous multi-pass cycle where each pebble fuel will go through operation cycles before taken out of the core as a spent fuel. Hence, this fuel design and its fuel cycle management will provide different security challenges than the implementation in the common existing reactors. Modularity and size of the reactor which will be a small modular type of reactor will also have impact on the implemented physical protection. The implementation of Security-by-Design as the design progresses provides an approach to meets the security requirements needed.

# 1. INTRODUCTION

BATAN as the executing body have the task to execute the use of nuclear energy in Indonesia. One of the proposed program is the introduction of an Experimental Power Reactor (EPR) which has HTGR technology. The fuel design of the reactor will have the same type of fuel with HTR-10, a 10 MWt reactor in China. The fuel design and also the fuel cycle management will provide different security challenges than the implementation in the common existing reactors. Modularity and size of the reactor will also have impact on the implemented physical protection.

Security requirements for the existing nuclear installations in Indonesia, just like any other any other nuclear installations in the world, are being heavily upgraded immediately after the 9/11 terrorist attack in 2001. BAPETEN advised existing nuclear facilities to go to the highest level of security. Layered physical measures, such as access controls, water barriers, intrusion detection, and strategically placed guard towers. Together, these make up nuclear installations response to its Design Basis Threat. BAPETEN as the regulatory body regularly reviews Design Basis Threat and adds new requirements when necessary. Provisions for physical protection in Indonesia are stipulated in Government Regulation No. 2 Year 2014 on Licensing of Nuclear Installation and Nuclear Material Utilization, Government Regulation No. 54 Year 2012 on Safety and Security of Nuclear Installation, and BAPETEN Chairman Regulation No. 1 Year 2009 on Provision for Physical Protection System of Nuclear Installations and Materials.

This paper aims to present security requirements for physical protection in Indonesia, challenges for EPR to meet those requirements, and conclusions.

# 2. METHODOLOGY

The study is based on literature study of IAEA security series, Indonesian regulations, and BAPETEN early review on EPR physical protection documents.

# 3. RESULT

## 3.1. IAEA SECURITY SERIES ON PHYSICAL PROTECTION

IAEA Nuclear Security Series No. 13, Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Revision 5) provides requirements both for the state and the operator, while IAEA Nuclear Security Series No. 27-G, Physical Protection of Nuclear Material and Nuclear Facilities (Implementation of INFCIRC/225/Revision 5) provides its implementation guide.

Important recommendations related to EPR in IAEA Security Series are regarding graded approach and categorization of nuclear material. Physical protection requirements should be based on a graded approach, taking into account the current evaluation of the threat, the relative attractiveness, the nature of the nuclear material and potential consequences associated with the unauthorized removal of nuclear material and with the sabotage against nuclear material or nuclear facilities.

For protection against unauthorized removal, the State should regulate the categorization of nuclear material in order to ensure an appropriate relationship between the nuclear material of concern and the physical protection measures. The primary factor in determining the physical protection measures against unauthorized removal is the nuclear material itself. The categorization is based on types of nuclear material in terms of element, isotope, quantity and irradiation. This categorization is the basis for a graded approach for protection against unauthorized removal of nuclear material that could be used in a nuclear explosive device, which itself depends on the type of nuclear material (e.g. plutonium and uranium), isotopic composition (i.e. content of fissile isotopes), physical and chemical form, degree of dilution, radiation level, and quantity.

### 3.2. INDONESIA REGULATION ON PHYSICAL PROTECTION

Physical protection documents for nuclear installations are not formally required to be submitted as licensing requirements until construction licensing process. However, during the site monitoring before design and construction, BATAN as the licensee are required to consider the EPR project in the establishment of their Design Basis Threat, especially as the EPR will be located in the vicinity of Serpong Nuclear Site. Design Basis Threat is going to be the basis for the development of physical protection system of the EPR.

During the design and construction activity, the licensee in performing physical protection shall establish and perform physical protection system that consists of:

a. facility vulnerability assessment;
b. physical protection plan;
c. physical protection system characteristic;
d. communication path control;
e. access provision; and
f. function test of physical protection system.

Main functions of physical protection plan are to deter, detect, assess, delay, and response for all threat and intrusion of nuclear installation and material.

Physical protection specific characteristics are:

a. adjusted to safety system of nuclear installation;
b. implement defense in depth concept;
c. implement minimum consequence of component failure;
d. implement balance protection; and
e. implement graded approach

Content of physical protection plan consist of the following:

a. design basis threat
b. organization and personnel of physical protection system
c. categorization of nuclear material
d. physical protection procedures
e. design and area division physical protection
f. detection system
g. physical barrier system
h. required access system
i. communication system
j. maintenance and surveillance
k. contingency plan
l. documentation

In general, physical protection regulations in Indonesia are in line with recommendations and guides provided in IAEA security series documents. Consequently, compliance to the required regulation will also be a challenge for RDE.

### 3.3. BAPETEN REVIEW ON EPR PHYSICAL PROTECTION

BATAN has provided an early version of its physical protection plan document during the design approval process. Although it is far from a finish article, the document already based on the current regulations and provisions that are being used by BAPETEN as a tools in reviewing the physical protection plan document.

Design basis threat, protection against aircraft, force on force exercises, EPR facility description, detection system, security system, required access system, and communication system are provided although not in detail.

Protection areas and layers of EPR has follow IAEA recommendation in IAEA Nuclear Security Series No. 27-G described in figure below:

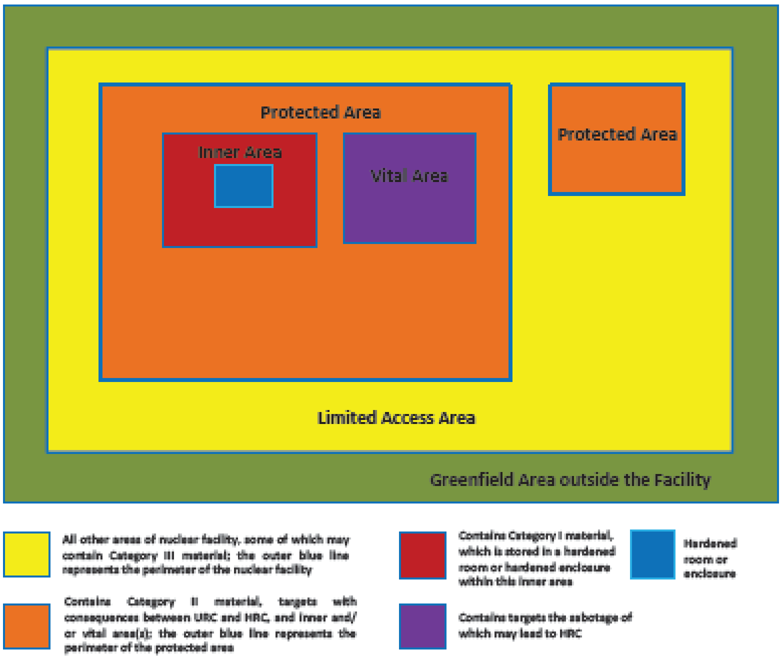


Fig 1. Protection areas and layers

Scheme of Area Division in EPR physical protection that in line with protection areas and layers recommended by IAEA security series are described in figure below:

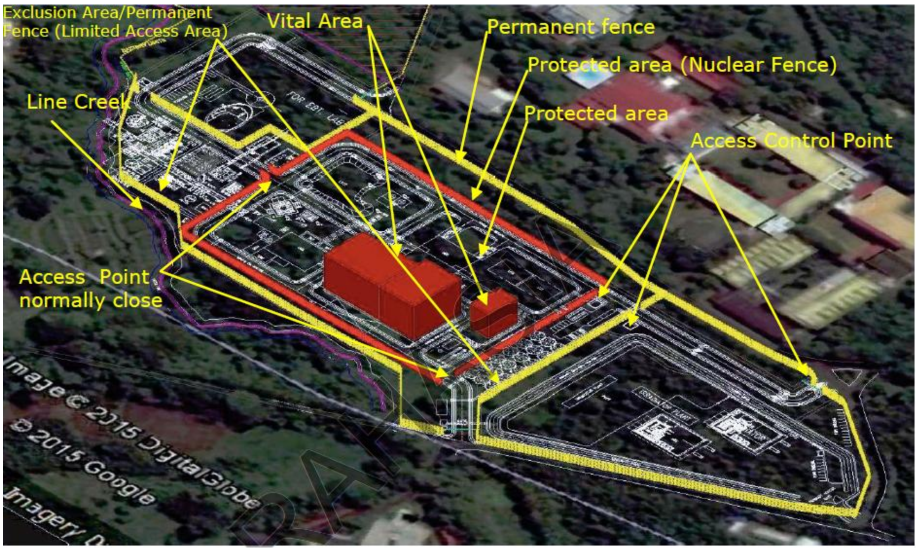


Fig 2. Protection areas and layers

Categorization of nuclear material also has follow IAEA recommendation in IAEA Nuclear Security Series No. 13 are descibed in table below:

| Material | Form | Category I | Category II | Category III[c] |
|---|---|---|---|---|
| 1. Plutonium [a] | Unirradiated[b] | 2 kg or more | Less than 2 kg but more than 500 g | 500 g or less but more than 15 g |
| 2. Uranium-235 ($^{235}U$) | Unirradiated[b]<br>– Uranium enriched to 20% $^{235}U$ or more<br>– Uranium enriched to 10% $^{235}U$ but less than 20% $^{235}U$<br>– Uranium enriched above natural, but less than 10% $^{235}U$ | 5 kg or more | Less than 5 kg but more than 1 kg<br>10 kg or more | 1 kg or less but more than 15 g<br>Less than 10kg but more than 1 kg<br>10 kg or more |
| 3. Uranium-233 ($^{233}U$) | Unirradiated[b] | 2 kg or more | Less than 2 kg but more than 500 g | 500 g or less but more than 15 g |
| 4. Irradiated fuel (The categorization of irradiated fuel in the table is based on international *transport* considerations. The State may assign a different category for domestic use, storage and *transport* taking all relevant factors into account.) | | | Depleted or natural uranium, thorium or low enriched fuel (less than 10% fissile content)[d, e] | |

**Note:** This table is not to be used or interpreted independently of the text of the entire publication.

[a] All plutonium except that with isotopic concentration exceeding 80% in plutonium-238.

[b] Material not irradiated in a reactor or material irradiated in a reactor but with a radiation level equal to or less than 1 Gy/h. (100 rad/h) at 1 m unshielded.

[c] Quantities not falling in Category III and natural uranium, depleted uranium and thorium should be protected at least in accordance with prudent management practice.

[d] Although this level of protection is recommended, it would be open to States, upon evaluation of the specific circumstances, to assign a different category of physical protection.

[e] Other fuel which by virtue of its original fissile material content is classified as Category I or II before irradiation may be reduced one category level while the radiation level from the fuel exceeds 1 Gy/h (100 rad/h) at one metre unshielded.

Table 1. Categorization of nuclear material

### 3.4. CHALLENGES FOR PHYSICAL PROTECTION OF EPR

The fuel design of EPR is pebble bed where the fuel is a collection of nuclear material inserted in small sized spheres containing structural and moderating material and a pebble bed core that will contain a bulk load of spherical fuel elements. The refuelling scheme will use continuous multi-pass cycle where each pebble fuel will go through operation cycles before taken out of the core as a spent fuel.

Physical protection applied to EPR will be based on the type of nuclear material. Based on the IAEA security series, it would need to uniquely identify the fuel items and randomly verify fresh fuel to confirm uranium and/or plutonium content, and verify that the spent fuel is highly irradiated. What is then clear from the outset of this discussion is that this is not practical, considering that the nuclear fuel is dispersed among a huge number of fuel pebbles. Physical protection of the EPR appears to be more similar to safeguarding an enriched uranium or MOX fuel fabrication plant, where the mass uranium U-235, and/or plutonium content of the bulk nuclear material is verified by non-destructive and destructive assay. Consequently, there is a need to consider a physical protection criteria and approach more suited specifically to EPR.

Although the small size will make the reactor easier to protect, modularity of the EPR has the potential to complicate physical protection plan and increase physical protection requirements. The amount of potentially vulnerable fissile or radioactive material may reduce the consequences of a successful sabotage attack. As the detailed design of EPR has not yet been finalized, an implementation of security by design of EPR structures, systems, and components are necessary to be applied as the design progresses provides an approach to meets the security requirements needed.

## 4. CONCLUSIONS

There is a need to consider a physical protection criteria and approach more suited specifically to accommodate fuel design and fuel cycle management of EPR. Modularity and size of the EPR has its advantages and disadvantages compared to common type of NPP.

## REFERENCES


[1] IAEA Nuclear Security Series No. 13, Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Revision 5), 2011.

[2] IAEA Nuclear Security Series No. 27-G, Physical Protection of Nuclear Material and Nuclear Facilities (Implementation of INFCIRC/225/Revision 5), 2018.

[3] Government Regulation No. 54 Year 2012 on Safety and Security of Nuclear Installation.

[4] Government Regulation No. 54 Year 2012 on Safety and Security of Nuclear Installation.

[5] BAPETEN Chairman Regulation No. 1 Year 2009 on Provision for Physical Protection System of Nuclear Installations and Materials.

[6] Mudjiono et al, The Plan of Physical Protection Programme of Experimental Power Reactor, 2016.