STUDY FOR SAFEGUARDS CHALLENGES TO THE MOST PROBABLY FIRST INDONESIAN FUTURE POWER PLANT OF THE PEBBLE BED MODULAR REACTOR

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The GA. Siwabessy Multi Purpose Reactor-BATAN Indonesia

ABSTRACT

In the near future Indonesia, the fourth most populous country, plans to build a small size power plant most probably a Pebble Bed Modular Reactor PBMR. This first nuclear power plant (NPP) is aimed to provide clear picture to the society in regard to performance and safety of nuclear power plant operation. Selection to the PBMR based on several factor including the combination of small size of the reactor and type of fuel allowing the use of passive safety systems, resulting in essential advantages in nuclear plant design and less dependence on plant operators for safety. In the light of safeguards perspective this typical reactor is also quite difference with previous light water reactor (LWR) design. From the fact that there are a small size large number of elements present in the reactor produced without individual serial numbers combine to on-line refueling same as the CANDU reactor. enforcing a new challenge to safeguards approach for this typical reactor. This paper discusses a bunch of safeguards measures have to be prepared by facility operator to support successfully international nuclear material and facility verification. Those are elements of design relevant to safeguards need to be accomplished in consultation to the regulatory body, supplier or designer and the Agency/ IAEA such as nuclear material balance area and key measurement point; possible diversion scenarios and safeguards strategy; and design features relevant to the IAEA equipment have to be installed at the reactor facility. It is deemed that result of discussion will alleviate and support the Agency approaching safeguards measure that may be applied to the purpose Indonesian first power plant of PBMR construction and operation.

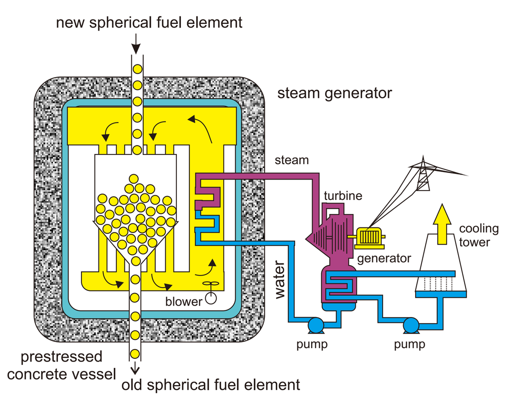
INTRODUCTION

Indonesia has a greater depth of experience and infrastructure in nuclear technology than any other south-east Asian country except Australia. Indonesia has a number of nuclear-related facilities in operation. BATAN operates three research reactors: in Serpong, Banten on the western outskirts of Jakarta (30 MW), Bandung, west Java (2 MW), and in Yogyakarta, central Java (100 kW). The Serpong multipurpose reactor, which started up in 1987, is intended to support the introduction of nuclear power to the country.

Prior to the introduction of large commercial reactors in Indonesia, BATAN is planning to build a test and demonstration high-temperature gas-cooled reactor (HTR) of up to 10 MWe at the same site-Serpong. This is with a view to a number of 100 MWe units following in Kalimantan, Sulawesi and islands. Construction of the demonstration unit is expected to take four years, with the start of operation after 2020.

Selection to the PBMR based on several factor including the combination of small size of the reactor and type of fuel allowing the use of passive safety systems, resulting in essential advantages in nuclear plant design and less dependence on plant operators for safety. A consortium of Russian and Indonesian companies led by NUKEM Technologies had won a contract for the preliminary design of the multi-purpose 10 MWe HTR in Indonesia, which would be “a flagship project in the future of Indonesia’s nuclear program.” It will be a pebble-bed HTR at Serpong

BRIEF DESCRIPTION OF PBMR



The pebble-bed reactor (PBR) is a graphite-moderated gas-cooled nuclear reactor. It is a type of very high temperature reactor (VHTR), one of the six classes of very high nuclear reactors in the Generation IV initiative.

The basic design of pebble-bed reactors features spherical fuel elements called pebbles.

Figure 1: Cross section of Reactor Vessel and non nuclear island

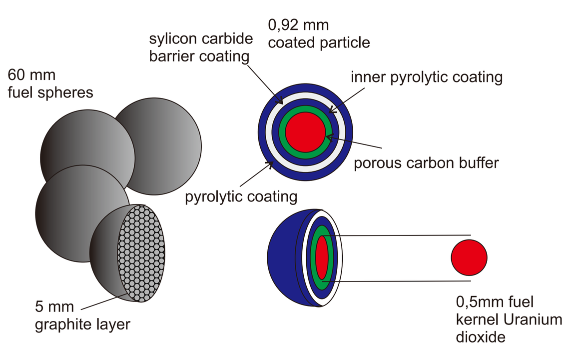


Figure 2: Pebble bed reactor fuel

Pebble bed reactor fuel

These tennis ball-sized pebbles are made of pyrolytic graphite (which acts as the moderator), and they contain thousands of micro-fuel particles called TRISO

Thousands of pebbles are amassed to create a reactor core, and are cooled by a gas, such as helium circulates through the spaces between the fuel pebbles to carry heat away from the reactor.

The nuclear fuel seeds or kernels are very small, approximately 0.5mm in diameter. The kernels typically consist of uranium dioxide enriched in U-235 (between 3% and 19%), but may also contain plutonium and/or thorium, which are coated with high temperature silicon carbide and pyrolytic graphite.

SAFEGUARDS CONCERN TO THE PBMR DESIGN

The purpose of the IAEA safeguards system is to provide credible assurance to the international community that nuclear material and other specified items are not diverted from peaceful nuclear uses. Keys elements of safeguards concern :

- **Design Information Questionnaire (DIQ)**

Information concerning nuclear material subject to safeguards under the agreement and the features of facilities relevant to safeguarding such material” Design information includes the facility description; the form, quantity, location and flow of nuclear material being used; facility layout and containment features; and procedures for nuclear material accountancy and control. This information is used by the IAEA, to design the facility safeguards approach to determine material balance areas and select key measurement points and other strategic points and to develop the design information verification plan

- **Material Balance Area**
- **Diversion Scenario**

Diversion of fresh fuel and core fuel, and/or undeclared introduction of specially designed fuel for target irradiation, spent fuel and possible substitution with dummies ball) and/or undeclared removal of specially designed fuel for target irradiation, via broken-ball storage.

- **Safeguards Approaches**

the approach selected for safeguards implementation at a specific facility, developed by adapting the model approach to account for actual conditions at the facility as compared with the reference plant.

DESIGN INFORMATION

KEY OF SAFEGUARDS BY DESIGN

- IAEA require information to plan safeguards approaches (NMAC’ C/S)
- This is provide by Design Information Questionnaire (DIQ) followed by DIV (Design Information Verification)
- DIQ has to be provided vy the State to the IAEA after the Comprehensive Safeguads Agreement (CSA) between the State and the IAEA has been concluded or new facility is planned

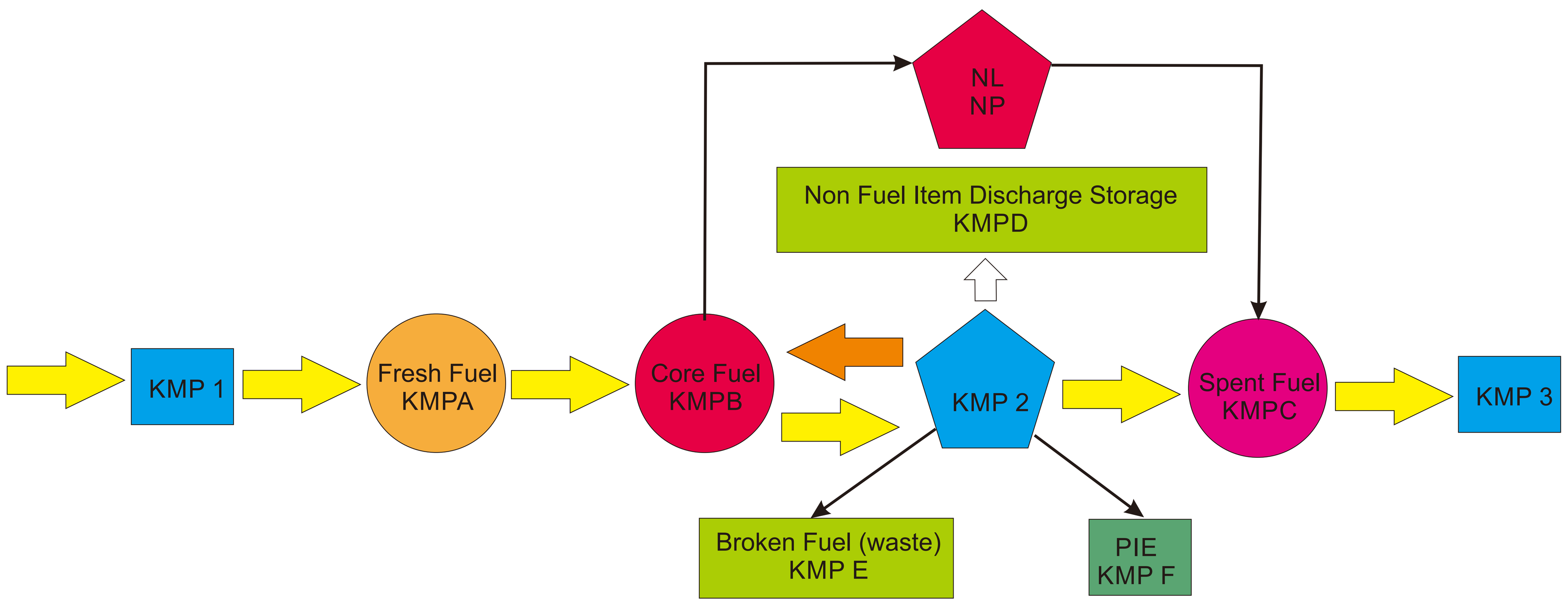


Figure 3: Typical Material Balance Area {MBA} and Key Measurement Point (KMP)
for the PBMR (NL=Nuclear Loss), NP = Nuclear Production, PIE = Post Irradiation Examination)
Source - Los Alamos National Laboratory

DISCUSSION

PBMR may considered as a developmental facility with new design feature requiring research and development and new safeguards approaches

Nuclear fuel in a small pebble form exist without identification number can no longer classify as an item like nuclear fuel present in traditional light water reactor (LWR) then such a research on that matter is a must to establish safeguards approaches suitable to the physical condition

The most important safeguards measures used by the IAEA today for strengthening the safeguarding of new types of nuclear facilities is the design information examination and verification activity (DIE and DIV).

The purpose of the facility design information examination and verification activity is to verify that the nuclear facility is as declared, with regards to name, location, function, process, and capacity.

Countries having planned to construct nuclear power plan (NPP) it is better to adopt Safeguards by Design (SBD) to alleviate complex obstacles requiring huge time and financial support.

Embarking first NPP requiring a set of infrastucture including safeguards, safety and security that should be managed in harmonized manner.

CONCLUSION

Key safeguards elements of Design Information Questionnaire constitute the most important safeguards document should be submitted by State Authority early to the IAEA in order to enable the IAEA establishing safeguards approaches applied to the NPP facility.

In the case of PBMR requiring new approach in order to maintain safeguards goal

REFERENCES

1. IDAHO NATIONAL LABORATORY US-DOE “ The High Temperature Gas-Cooled Reactor Next Generation Nuclear Energy” 2014
2. PHILIP CASEY DURST at all, “Nuclear Safeguards Consideration For The Pebble Bed Modular Reactor” IDAHO NATIONAL LABORATORY US-DOE, 2009.
3. PHILIP CASEY DURST , Safeguards-By-Design For High Temperatur Gas Reactors (HTGRs) With Pebble Fuels. IDAHO NATIONAL LABORATORY US-DOE, 2012
4. CHARLES W FORSBERG AND DAVID L MOSES, ‘Safeguards Challenges for Pebble Bed Reactors Designed by People’s Republic of China” ORNL, 2009 INTERNATIONAL ATOMIC ENERGY AGENCY “ Staying Ahead Of The Game”, IAEA, 2007.