Radiation safety based on the sky shine effect in reactor

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Abstract. In the reactor operation, neutrons and gamma rays are the most dominant radiation. As protection, lead and concrete shields are built around the reactor. However, the radiation can penetrate the water shielding inside the reactor pool. This incident leads to the occurrence of sky shine where a physical phenomenon of nuclear radiation sources was transmitted panoramic that extends to the environment. The effect of this phenomenon is caused by the fallout radiation into the surrounding area which causes the radiation dose to increase. High doses of exposure cause a person to have stochastic effects or deterministic effects. Therefore, this study was conducted to measure the radiation dose from sky shine effect that scattered around the reactor at different distances and different height above the reactor platform. In this paper, the analysis of the radiation dose of sky shine effect was measured using the experimental method.

1. Introduction
Sky shine is a phenomenon of radiation that is only transmitted panoramic (widespread) into the environment from nuclear sources regardless of the type of radiation source and it is difficult to see because the radiation is invisible [1]. Defines sky shine as a phenomenon of radiation that penetrates the containment building. Sky shine is scattered far from its source and after experiencing multiple scattering in the atmosphere, it falling into the surrounding area. When the nuclear reactor operates it produced the radiation field and can penetrate the roofs and walls of containment buildings that are not covered with shields or the shields used is very weak to absorb the radiation. In easier words, when the reactor is operating, the source of radiation generated from the reactor core will be released through the roof and reactor walls. Then, the scattered radiation drops to the surrounding area are known as the sky shine effect. Therefore, radiation sources need to be protected regardless of the intensity of radiation emitted from the source. According to [2], there is no specified dose limit for the dose of sky shine effect but the benchmark for the sky shine effect is when radiation sources are left open, losing encasement, leaks from the reactor and the shield is not thick enough.

Nuclear reactors undergo nuclear fission process when they are operating. This phenomenon occurs when the effect of the chain reaction in the fission process during the reactor core operates and emits neutron, gamma, alpha and beta rays [3]. This incident is likely to cause the resulting light to be reflected out of the roof and reactor walls. The production of the rays will cause the surrounding dose to increase and change the classification area of the work. In order to reduce the sky shine effect...
scattered around, the thick shielding and shielding with the ability to absorbing excess radiation should be used.

Exposure to the high doses will cause a worker likely to receive a stochastic or deterministic effect [4]. To reduce the exposure dose, employees should follow the basic principles of radiation protection, exposure dose control and work area classification. Classification of work areas is important for the safeguard measures and the appropriate safety provisions for each area.

2. Methodology
In order to carry out experimental in this study, the detection device used for monitoring gamma dose and neutron dose is a telescopic survey meter as shown in Figure 1(a). The telescopic survey meter provides readings directly. Additionally, other side materials are measuring tape, PVC conduit pipe as in Figure 1(b) and adhesive tape.

![Telescopic survey meter and PVC conduit pipe](image)

**Figure 1.** (a) Telescopic survey meter and, (b) PVC conduit pipe.

3. Results and Discussion

3.1 Measurement of radiation dose
In this study, dose measurements were taken at 750 kW. The distance is divided into ten points for the measurement. Gamma and neutron radiation dose measurements were detected using telescopic survey meters. Before taking the radiation dose of the sky shine in the reactor, the background dose was taken on the outside of the reactor. Based on Figure 2, the red circle in the diagram is the location of the study during the conduct of the monitoring in the reactor. Besides that, Figure 3 shown ten points that have been chosen for the measurement.
Neutron radiation is the most dominant radiation generated by nuclear reactors. This radiation has a very strong penetration. Strong and thick shielding is needed to absorb neutron radiation. In this reactor, Barytes concrete has been used as a shield [5]. The main shield of the reactor is the vertical built water pool, thick concrete shields and radius-like pool water. The water depth above the core and the concrete thickness was designed to provide more radiation protection to workers and when the reactors operating at 1 MW under the normal conditions. In this study, the shields built in the reactor were able to absorb the neutron light generated from the reactor because the neutron ray dose and the effects of the sky shine could not be seen and detected. The use of water as a moderator and coolant in the reactor is not only effective in slowing down the neutrons and cooling down but also as a shield to the generated radiation inside the reactor core so it will not endanger the reactor operators on the pond during repair and others activity.

Based on Figure 4, the data taken when the reactor operates at 750 kW, result obtains that the dose of radiation decreases at a height of 1 m and at different distances. The radiation charge obtained at the surface of the reactor platform is approximately 1226 μSv/h and decreases as the distance increases up to 9 m is 16 μSv/h.
4. Conclusion
As a result of this study, the determination of the radiation dose of sky shine effect at different distances found that when the distance increases, the radiation dose of the sky shine decreases. For the determination of the radiation dose of sky shine effect at different altitudes, it is found that when height increases, the radiation dose of the sky shine decreases. This proves that the intensity of radiation decreases when the distance or elevation increases. According to [5], the maximum distance of the sky shine effect depends on the activity factor of the radiation source, the type of radiation source used, the height of the shield wall and the loss of a shield.

5. References
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