УДК 629.039.58

ASSESSING SECURITY SYSTEM EFFECTIVENESS USING RISK CALCULATION APPROACH FOR A TYPICAL RADIOLOGICAL FACILITY

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ОЦЕНКА ЭФФЕКТИВНОСТИ СИСТЕМЫ БЕЗОПАСНОСТИ С ИСПОЛЬЗОВАНИЕМ МЕТОДА РАСЧЁТА РИСКА ДЛЯ ТИПОВОГО РАДИОЛОГИЧЕСКОГО ОБЪЕКТА

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Аннотация. *В статье показано, как можно измерить эффективность безопасности, учитывая затраты, связанные с обеспечением безопасности радиологического центра, и предложены меры повышения безопасности путем использования анализа рисков. Продолжается развитие ядерных технологий и областей применения ядерных и радиоактивных материалов. Это развитие связано с потенциальным риском злонамеренного использования радиоактивных материалов, поэтому важно обеспечить физическую защиту ядерных объектов, чтобы противостоять этим угрозам и использовать атомную энергию в мирных целях. Эффективность систем безопасности, установленных на объекте, можно оценить путем анализа рисков, связанных с объектом.*

Introduction. The significance of physical protection to humans and the environment as a whole can not be overlooked since it affects every aspect of life including socio-economic structure of a state and organizations [1]. Physical protection systems are established to prevent, deter and or mitigate loss of treasured assets such as property or life [2]. In the presence of such threats, people have learned to develop measures to safeguard themselves and their properties over time [1]. Physical Protection System (PPS) integrates people, measures, and equipment to provide security for assets or nuclear-related facilities against theft, sabotage or other malicious attacks. The end result of these malicious actions may be theft of radioactive material, sabotage at the radiological facility (fire, destruction, flooding, accident, etc.). The IAEA promotes the idea for all governments to take measures to ensure that effective national control systems operated within their jurisdictions in order to ensure the existence of effective national control systems for the protection of radioactive sources [3]. Hospitals use radioactive materials for treatment of their patients such as teletherapy and thus, in specially built devices, high-energy and high-activity sources are used to deliver radiation doses in a controlled way. This paper presents a modeled hypothetical radiological facility and the possible paths that can be used by adversaries to sabotage the facility. The efficiency of the security systems at this facility is assessed by making the risk analysis.

Materials and methods. For an adversary to target or sabotage a facility, they consider different vulnerable paths and select the most vulnerable with the most maximum consequence. The most vulnerable route selected by the adversary also has the lowest cost of intrusion. Defense effectiveness for a specific material presented in the radiological facility can be determined as:

$$E\ (asset) = Min\ [C(Path_1),\ C(Path_2),\ \dots,C(Path_n)] \qquad (1)$$

Equation (2) below can be used to measure the risk value for a designed security system based on the risk concept of the security system suggested by Hicks:

$$Risk = P(A)*\ P(r)*C \qquad (2)$$

where $P(A)$ is the probability of an attack on a facility holding nuclear or radioactive material, which can be assessed by experts. $P(r)$ is the probability of a successful attack. $P(r)$ describes the protection effectiveness of the security system provided at the facility. The concept can be explained as; higher the protection effectiveness, the lower the possibility of successful attack $P(r)$. C is considered to be a consequence. The whole relation can be mathematically represented as:

$$\mathrm{E(asset)} = \log\frac{1}{P(r)} \qquad (3)$$

Taking into account a facility with a number of safe properties (i.e., radioactive and nuclear materials), the risk of the security system provided can be determined as:

$$Risk = \sum_{i=1}^{n}\left(P(A)_i * \frac{1}{e^{E(asset_i)}} * C_i\right) \qquad (4)$$

where $E(asset_i)$ is the protection effectiveness value of asset i, $P(A)i$ is the probability of an attack for asset i, it can be measured as the annual rate of occurrence of an attack, i C is the value of the protection $asset_i$ [4].

Results. The above equations were used to calculate the risks associated with the modeled hypothetical facility described below. The facility has an X-ray machine and a blood irradiator which uses ^{137}Cs radioactive sources for treatment. An adversary intends to sabotage the radiological facility through certain paths. The risk associated with the two targets or assets with regards to the set parameters was calculated as 1.7×10^4 and 1.8×10^4.

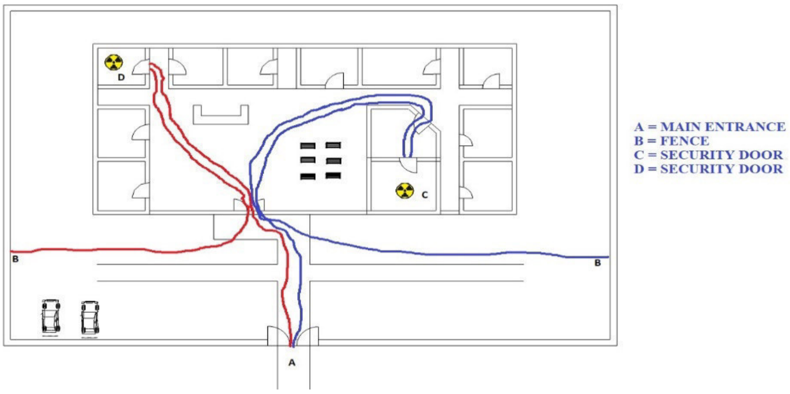

Fig.1. Schematic diagram of the radiological facility with adversary paths

Improvement strategies for protection. By using certain techniques, attempts are made to efficiently reduce the risk of radiological facility protection systems. This was achieved by improving on the factors of the protection units in order to improve their effectiveness. Assuming that the cost of the methods used is 1000 dollars for each target, we use the previous equations to measure the efficacy and risk of the target. Table 1 presents the measured effectiveness of the units following the tactics applied. Both assets are likely to have the same $P(A)=$ 0.65 for a potential attack on the facility.

Table 1

Values for calculating the risk of each asset after the applied tactics

Parameter	Target 1	Target 2
$E(asset_i)$	1.4906	1.4225
$P(A)_i$	0.65	0.65
C_i	101,000	101,000
$Risk_i$	1.6×104	1.7×10^4

Conclusion. The total risk of the facility security system before improvement tactics with regards to the two targets was calculated as 3.5×104. With respect to the two targets, the overall risk of the facility protection system after the improvements was estimated as 3.3×10^4. The risk associated with the radiological facility was decreased by 2.0×104 following the tactics applied, which indicates that the reliability of the protection mechanism given for the hypothetical radiological facility has been enhanced. When this analysis is properly applied to a radiological facility, it may help in making a vital decision when securing a radiological facility.

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