

**DESAIN SISTEM PROTEKSI FISIK THORIUM AQUEOUS HOMOGENEOUS
REACTOR – MOLYBDENUM PRODUCTION SYSTEM TERHADAP ANCAMAN
SABOTASE DI INDONESIA**

oleh

Alifia Rahmawati

13/348212/TK/40825

Diajukan kepada Departemen Teknik Nuklir dan Teknik Fisika Fakultas Teknik

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INTISARI

Thorium Aqueous Homogeneous Reactor – Molybdenum Production System (TAHRMoPS) merupakan reaktor nuklir non daya yang difungsikan untuk produksi Mo-99. Sebagai salah satu instalasi nuklir, TAHRMoPS memiliki ancaman serangan sabotase selama masa operasinya yang dapat menyebabkan konsekuensi radiologis ke lingkungan. Sistem proteksi fisik (SPF) pada TAHRMoPS diperlukan untuk menangkal serangan sabotase karena potensi bahaya yang timbul. Perancangan SPF perlu berlandaskan pada skenario serangan sabotase potensial pada TAHRMoPS yang sampai saat ini belum tersedia. Penelitian ini bertujuan untuk mendapatkan skenario sabotase potensial TAHRMoPS, perancangan desain SPF pada TAHRMoPS dan penentuan efektivitas SPF TAHRMoPS. Skenario sabotase potensial diperoleh dari langkah musuh menuju target dengan pohon serangan. Berdasarkan skenario dari pohon serangan, elemen SPF ditentukan sehingga desain SPF dihasilkan. Desain SPF menggunakan model konseptual Garcia dari *Sandia National Laboratory*. Model tersebut terdiri fungsi deteksi, penunda dan tanggapan, serta komplemen berupa penggentar dan penilai. Efektivitas SPF ditentukan dengan nilai probabilitas keberhasilan serangan melalui pohon serangan pertahanan (PSP). Daun pertahanan berupa elemen SPF yang sesuai desain ditambahkan pada pohon serangan skenario sabotase potensial. Target sabotase potensial pada penelitian ini adalah *receiver* di *hot cell service* yang terdapat pada daerah vital dengan tujuan pelolosan bahan bakar dalam *receiver* ke lingkungan TAHRMoPS. Terdapat tiga taktik untuk mencapai target yakni secara diam-diam (*'stealth'*), penyamaran (*'deceit'*) atau terang-terangan dengan kekerasan (*'force'*). Skenario serangan menuju target dibagi menjadi enam subskenario yakni penetrasi perbatasan, penyelundupan barang terlarang melalui perbatasan, infiltrasi daerah vital, pembawaan barang terlarang ke daerah vital, pemutusan aliran listrik dan sabotase *hot cell service*. Nilai probabilitas keberhasilan sabotase *hot cell service* berdasarkan perhitungan PSP sebesar 0,0512 dengan nilai subskenario serangan penetrasi perbatasan 0,3693, penyelundupan barang terlarang dari perbatasan 0,1014, infiltrasi daerah vital 0,0624, pembawaan barang terlarang ke daerah vital $3,8874 \times 10^{-4}$ dan pemutusan aliran listrik 0,0384. Berdasarkan hasil tersebut, SPF dalam rancangan penelitian ini efektif dalam mereduksi probabilitas keberhasilan serangan dengan kegagalan terbesar berasal dari aksi dengan taktik *'force'*.

Kata kunci: TAHRMoPS, sistem proteksi fisik, keamanan nuklir, sabotase reaktor nuklir, pohon serangan, pohon serangan pertahanan.

Pembimbing Utama : Ir. Haryono Budi Santosa, M.Sc

Pembimbing Pendamping : Ferdiansjah, S.T., M.Eng.Sc.

**DESIGN OF PHYSICAL PROTECTION SYSTEM FOR THORIUM AQUEOUS
HOMOGENEOUS REACTOR – MOLYBDENUM PRODUCTION SYSTEM
AGAINST SABOTAGE THREAT IN INDONESIA**

by

Alifia Rahmawati

13/348212/TK/40825

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ABSTRACT

Thorium Aqueous Homogeneous Reactor – Molybdenum Production System (TAHRMoPS) is a non-power nuclear reactor for Mo-99 production. As one of nuclear facilities, TAHRMoPS has a sabotage threat during its operating time that may cause radiological consequences to the environment. Sabotage attack protection systems at TAHRMoPS are required because of the potential hazards. One of these systems is physical protection system (PPS). The design of PPS is based on potential sabotage attacks on TAHRMoPS. Potential sabotage scenarios and PPS design on TAHRMoPS are not yet available. This research aims to provide information about potential sabotage scenarios of TAHRMoPS, the design of PPS on TAHRMoPS and determination of PPS TAHRMoPS effectiveness. Potential sabotage scenarios provided in attack trees scheme. Based on the scenario of the attack tree, the PPS element is determined. The PPS design uses a Garcia's conceptual model from *Sandia National Laboratory*. The model consists of detection, delay and response functions, and complement consists deterrence and assessment. The effectiveness of PPS is determined by its successful attack probability on attack-defense trees (ADT). Protection element leaves from the PPS design are added to the attack tree of the potential sabotage scenarios. Potential sabotage target in this study is the receiver in hot cell service with the goal of fuel escapement in the receiver to the TAHRMoPS environment. There are three tactics for achieving the goal, the adversary may use 'stealth', 'deceit' or 'force' tactic. The attack scenario towards the target is divided into six sub-scenarios, there are perimeter penetration, smuggling of forbidden goods through the perimeter, infiltration of vital area, the carrying of forbidden goods to the vital area, the disconnection of the electricity and sabotage of the hot cell service itself. The probability of the successful attack of hot cell service sabotage based on ADT calculation is 0.0512 with sub-scenario of perimeter penetration is 0.3693, smuggling of forbidden goods through perimeter is 0.1014, infiltration of the vital area is 0.0624, carrying of forbidden goods to the vital area is 3.8874×10^{-4} and the disconnection of the electricity is 0.0384. Based on these results, PPS in this research is effective with highest failure probability cause by 'force' action.

Keywords: TAHRMoPS, physical protection systems, nuclear security, nuclear reactor sabotage, attack tree, attack defense tree.

Supervisor : Ir. Haryono Budi Santosa, M.Sc

Co-supervisor : Ferdiansjah, S.T., M.Eng.Sc.