RINGKASAN

ANALISIS RISIKO DAN INTEGRASI SAFETY INSTRUMENTED SYSTEM (SIS) PADA SMOKE DETECTOR FIRE AND GAS SYSTEM (FGS) DI CAM BUILDING NORTH FIELD XPANSION PROJECT (NFXP) 18 MENGACU PADA IEC 61511

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CAM Building (Control and Auxiliary Module) pada North Field Expansion Project (NFXP) merupakan pusat integrasi sistem kontrol dan keselamatan yang memiliki risiko kebakaran signifikan akibat keberadaan peralatan listrik, instrumentasi, dan sistem HVAC. Untuk memitigasi risiko tersebut, diterapkan integrasi Fire and Gas System (FGS) dengan Safety Instrumented System (SIS) sebagai sistem keselamatan terinstrumentasi. Penelitian ini bertujuan untuk menganalisis risiko kebakaran, mengidentifikasi Safety Instrumented Function (SIF) pada smoke detector, serta mengevaluasi integrasi SIS–FGS pada CAM Building dengan mengacu pada standar IEC 61511.

Metodologi penelitian meliputi studi dokumen teknis proyek, identifikasi SIF, analisis risiko menggunakan metode Layer of Protection Analysis (LOPA), serta verifikasi Safety Integrity Level (SIL) melalui perhitungan Probability of Failure on Demand average (PFDavg). Analisis difokuskan pada subsistem sensor, logic solver, dan final control element, serta keterkaitannya dengan sistem HVAC dalam mendukung fungsi keselamatan deteksi kebakaran.

Hasil penelitian menunjukkan bahwa integrasi SIS–FGS pada CAM Building telah memenuhi prinsip keselamatan fungsional IEC 61511 dengan pemisahan yang jelas antara sistem kontrol proses dan sistem keselamatan. Smoke detector dan VESDA teridentifikasi sebagai bagian dari SIF deteksi kebakaran dengan kebutuhan SIL pada kategori SIL 1 hingga SIL 2. Perhitungan PFDavg menunjukkan bahwa konfigurasi voting logic 1oo2 menghasilkan SIL Achieved SIL 1, sedangkan konfigurasi 2oo3 mampu menurunkan nilai PFDavg hingga mendekati batas bawah SIL 2. Hasil ini membuktikan bahwa integrasi SIS–FGS memberikan tingkat perlindungan yang memadai terhadap risiko kebakaran dengan tetap mempertimbangkan keandalan keselamatan dan availability sistem HVAC.

Kata kunci : *Safety Instrumented System* (SIS), Fire and Gas System (FGS), *Safety Instrumented Function* (SIF), Smoke Detector, *Layer of Protection Analysis* (LOPA), *Safety Integrity Level* (SIL), IEC 61511, CAM *Building*, HVAC.

SUMMARY

ANALISIS RISIKO DAN INTEGRASI SAFETY INSTRUMENTED SYSTEM (SIS) PADA SMOKE DETECTOR FIRE AND GAS SYSTEM (FGS) DI CAM BUILDING NORTH FIELD XPANSION PROJECT (NFXP) 18 MENGACU PADA IEC 61511

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The Control and Auxiliary Module (CAM) Building in the North Field Expansion Project (NFXP) serves as an integration center for control and safety systems and is exposed to significant fire risks due to the presence of electrical equipment, instrumentation, and HVAC systems. To mitigate these risks, the integration of the Fire and Gas System (FGS) with the Safety Instrumented System (SIS) is implemented as an instrumented safety system. This research aims to analyze fire risk, identify the Safety Instrumented Function (SIF) of smoke detectors, and evaluate the integration of SIS–FGS in the CAM Building with reference to the IEC 61511 functional safety standard.

The research methodology includes a review of project technical documents, SIF identification, risk analysis using the Layer of Protection Analysis (LOPA) method, and verification of the Safety Integrity Level (SIL) through the calculation of the Probability of Failure on Demand average (PFDavg). The analysis focuses on the sensor subsystem, logic solver, and final control elements, as well as their interaction with the HVAC system in supporting fire detection and mitigation functions.

The results indicate that the SIS–FGS integration in the CAM Building complies with the principles of functional safety as specified in IEC 61511, with a clear separation between the process control system and the safety system. Smoke detectors and VESDA are identified as part of the fire detection SIF, with required SIL levels in the range of SIL 1 to SIL 2. The PFDavg calculation shows that a 1oo2 voting logic configuration achieves SIL 1, while a 2oo3 configuration reduces the PFDavg value to approach the lower limit of SIL 2. These findings demonstrate that the SIS–FGS integration provides adequate protection against fire hazards while maintaining a balance between safety reliability and HVAC system availability.

Keywords : Safety Instrumented System (SIS), Fire and Gas System (FGS), Safety Instrumented Function (SIF), Smoke Detector, *Layer of Protection Analysis (LOPA), Safety Integrity Level (SIL),* IEC 61511, *CAM Building*, *HVAC*.