

Safety System Complexity: Ontology-Grounded Llms That Cross-Link Plant Records to Reduce Spurious Trips and Surface Hidden Process Risk

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ABSTRACT

Instrumented safety systems have driven incident rates down, but also create new challenges: the plants they protect are now far more complex. Two problems follow. First, true process risk hides in combinations of latent failures, process variability, corrosion, and degradation, so catastrophic incidents persist despite layered protection. Second, spurious safety-system trips have risen, eroding availability and driving unplanned downtime. The challenge is to keep the safety benefits while giving operations the information needed to run both safely and reliably. We present a case study in which large language models, grounded in a domain-specific process-safety ontology, extract and cross-link evidence across P&IDs, asset registers,

PHAs, management-of-change records, and incident reports. The system surfaces discrepancies between sources and answers operators' questions on demand, at the point of decision, with each answer traceable to its evidence. We report how ontology grounding changes extraction quality and trust, where it failed, and what generalizes to other operations.

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