

AI-Enhanced Documentation Analysis in Regulatory Safety Assessment of Transport Packages

The transportation of radioactive material requires, dependent on type and quantity of the radioactive material, a regulatory approval based on the package type. Safety assessments shall be conducted in compliance with the International Atomic Energy Agency (IAEA) regulations and documented in a comprehensive package design safety report to obtain approval from authority. This comprehensive safety report evaluates a broad range of requirements from the regulations, including mechanical, thermal, shielding, criticality and transport requirements and controls, and testing assessments. Additionally, it encompasses supporting documents such as specifications, inspections, certifications, drawings, and guidelines in a variety of complex documents. Safety and manufacturing reports contain multiple interconnected sub-reports covering various topics. Changes, such as component modifications, material property updates, or regulatory revisions, often impact multiple sections of the safety analysis reports, making even minor adjustments complex and time-consuming. Each transport package has unique requirements to be fulfilled, making every safety report distinct, despite following the same regulatory framework.

Most documentation exists in standard digital formats but is often not machine interpretable, preventing automated analysis of the critical dependencies between them. This paper argues that moving beyond simple digitization towards structured knowledge representation is essential for addressing these challenges. We propose a multi-stage approach, beginning with foundational AI technologies such as Large Language Models (LLMs) and Retrieval-Augmented Generation (RAG), and progressing toward the construction of Knowledge Graphs (KGs). KGs convert unstructured and semi-structured information into a connected, queryable network, enabling precise tracing and visualization of complex interdependencies within the documentation landscape.

By linking interpretable content directly to datasheets, tables, simulations, experimental results, standards, and regulations, such a system would automatically identify changes and interdependencies. Related conditions could be validated using AI-based tools, reducing the need for manual intervention, improving both efficiency and safety.

Human error plays a significant role in drafting, reviewing, and revising safety reports, often requiring iterative review cycles and multiple reviewers before approval. A digital quality infrastructure could reduce iterations and further improve efficiency. Integrating AI into this process could optimize safety assessments and enhance their robustness by leveraging interpretability to enhance safety.

This preliminary study explores the readiness and requirements for using intelligent documentation analysis system in the context of regulatory compliance for package safety for the transport of radioactive material. By analysing current documentation workflows, we identify how LLM-based tools can interpret complex safety reports and highlight critical interdependencies and then demonstrate why a KG-based architecture is necessary to robustly manage and query critical interdependencies. This lays the groundwork for future agentic AI systems capable of proactively supporting the safety assessment lifecycle, while stressing the importance of robust data governance and AI reliability in this highly regulated context.

Country or International Organization

Instructions

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