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# Safety-in-Design (SiD): Ensuring Process Safety in Novel Technologies

Lisa Hein

GPA

Lisa.hein@gpaeng.com.au

**ABSTRACT**

Safety-in-Design (SiD) is a proactive approach that integrates safety considerations into the design phase of projects to identify and mitigate potential hazards early. This methodology is crucial in process safety, as it helps prevent accidents and reduce risks through thoughtful design choices. Novel technologies present unique challenges due to untested failure modes, regulatory gaps, and operational unknowns. These technologies often lack historical safety data and established standards, making traditional risk assessments insufficient.

Novel technologies demand stronger SiD principles for several reasons. Firstly, they introduce uncharted risks that traditional risk assessments might overlook. Secondly, emerging technologies often lack established standards and historical safety data, leading to regulatory gaps. Thirdly, the integration of novel technologies with legacy systems can create unforeseen risks. Lastly, early-stage technologies may function safely in controlled environments but become hazardous when scaled up for commercial use.

Several case studies highlight the importance of SiD in managing risks associated with novel technologies. In the hydrogen economy, safety considerations for hydrogen storage, transport, and refueling infrastructure are paramount. Carbon capture and storage (CCS) projects must address risks of $CO_2$ leakage and high-pressure pipeline failures. The use of methylcyclohexane (MCH) as a hydrogen carrier introduces risks related to its flammability and potential for toxic exposure. Ammonia production and handling present significant hazards due to its toxicity and potential for explosive reactions.

Implementing SiD in novel technologies involves several best practices. Front-loading safety in the design phase through the use of HAZOP, LOPA, bowties, and other risk assessment tools is essential. Cross-disciplinary collaboration, engaging safety engineers, material scientists, and operational teams from the start, ensures comprehensive safety strategies. Proactive regulatory engagement helps shape safety guidelines before widespread deployment.

Learning from the mistakes and improvements made in more mature industries like oil and gas and refining is crucial. These industries have developed robust safety protocols through years of experience and incident analysis. By applying lessons learned from these sectors, such as root cause analysis and continuous improvement practices, we can enhance safety measures in novel technologies and prevent similar incidents. Industry collaboration is crucial in developing safety standards for emerging fields, ensuring that safety keeps pace with innovation.

In conclusion, the necessity of SiD for novel technologies cannot be overstated. By integrating safety considerations early in the design process, we can mitigate risks and ensure safer implementation of innovative technologies. A proactive safety culture in innovation is essential for sustainable and safe technological advancements

**KEY WORDS**

- *Safety in design*
- *Novel technologies*
- *Hydrogen*
- *Renewable fuels*
- *Process safety*
- *Lessons learned*

**BIOGRAPHY**

Lisa is a seasoned risk and process safety leader with over 25 years of technical and leadership experience in top tier oil and gas companies (Santos Ltd/ ExxonMobil) and as a principal risk consultant at GPA. She has proven capability to influence all levels from shop floor to executive. She has a track record of delivering significant safety and reliability risk reduction programs and projects. Lisa has broad experience in leadership, reliability & maintenance, safety risk reduction and process engineering.

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