Abstract: Psychological Safety as a Catalyst for Strengthening Process Safety in High-Hazard Industries

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Process safety in high-hazard industries traditionally focuses on engineering controls, inherently safer design, and robust risk-management systems. While these elements are indispensable, they are insufficient on their own to prevent catastrophic incidents. A substantial proportion of process safety failures arise not from lack of technical safeguards but from human and organizational factors—particularly the failure to recognize weak signals, report near misses, challenge unsafe norms, or admit errors. This paper explores **psychological safety** as a critical yet underutilized enabler of process safety excellence and incident prevention.

Drawing on the four-stage psychological safety model articulated by Edmondson (1999) and Clark (2020)—Inclusion Safety, Learner Safety, Contributor Safety, and Challenger Safety—this work examines how fostering psychologically safe environments empowers employees to detect, escalate, and mitigate process safety risks at much earlier stages. Through four real-world, hypothetical case studies from complex chemical manufacturing operations, the paper demonstrates the direct influence of psychological safety on averting major incidents.

In **Case 1**, Inclusion Safety enabled a technician to confidently report a deformed flange on toxic-gas piping, preventing a large-scale chemical release. **Case 2** shows how Learner Safety encouraged an operator to admit a mistake in inhibitor addition during THF distillation, averting a peroxide-driven explosion. **Case 3** illustrates Contributor Safety, where an operator's investigation of abnormal alarm patterns triggered corrective actions in cooling-tower performance before a runaway reaction could occur. **Case 4**, centered on Challenger Safety, highlights how an operator proposed an unconventional cleaning method to prevent thermal decomposition and deflagration in a paddle dryer.

These examples illustrate a powerful truth: psychologically safe employees act as early-warning sensors capable of detecting deviations long before instrumentation or engineering models do. When individuals feel respected, empowered, and unafraid to speak up, they convert tacit knowledge into actionable risk intelligence that enhances process reliability.

This paper argues that integrating psychological safety into process safety management systems is not a "soft" intervention but a strategic, high-impact mechanism to reduce unknown and emergent risks—those often overlooked in conventional hazard studies. By

cultivating a culture where people feel safe to voice concerns, learn, contribute, and challenge, organizations can strengthen their defenses against catastrophic events and unlock new avenues for safer, more resilient operations.