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Hydrogen Blowout in a Salt Cavern**

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## MECHANICAL STABILITY FOLLOWING A HYDROGEN BLOWOUT IN A SALT CAVERN

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### Abstract

Underground Hydrogen Storage (UHS) in salt caverns for energy purposes, will scale only if mechanical integrity under accidental scenarios is demonstrably robust. Among the critical hazards is a blowout: an uncontrolled release that drives rapid depressurization, severe gas cooling, and transient thermo-mechanical loads at the cavern wall.

This study quantifies the mechanical stability during and in the two weeks after a hydrogen blowout using coupled thermo-mechanical finite-element simulations for two real caverns (GA, GB), two discharge paths (casing vs. tubing), and two injection temperatures (30/45°C or 86/113°F). The flow path controls discharge duration: 4 days for casing and 18-19 days for tubing; temperature acts mainly as a level shift. Near-wall cooling forms a thin area (approximately 5-10 m (16-33 ft)) with wall temperatures dropping to -27 to -15°C (-17 to 5°F), depending on the configuration.

The pressure-temperature trough produces rapid early convergence, with cumulative volume losses of approximately 2% (GA-casing, 30/45°C (86/113°F), 4 days), 2.7% (GB-casing, 45°C / 113°F, 4 days), and 3.1% (GB-tubing, 45°C / 113°F, 18 days). Following the blowout, additional losses of 0.46-0.96% accrue by +7/+14 days, while rates decay significantly.

Bérest effective stress criterion and the Factor of Safety maps confine tensile/dilatant conditions to a narrow wall-bounded annulus; the far field remains compressive ( $FoS > 4$ ). Overall, the flow path is the primary driver of blowout persistence and cooling, whereas geometry/depth governs the magnitude; injection temperature is secondary.

The results delineate where damage is most likely (roof-proximal, first tens of meters (30-100 ft)), provide quantitative bounds on capacity loss, and inform design and operating envelopes for safe hydrogen cavern storage.

**Keywords:** Blowout; hydrogen; salt caverns; thermo-mechanical coupling; convergence; Bérest effective stress; dilatancy; Factor of safety.