Hydrogen Salt Cavern Working Gas and Energy

Hydrogen mass at maximum and minimum pressure in a salt cavern, the working gas, cushion gas and stored energy, using the Abel-Noble real-gas equation.

Method: Real-gas inventory of a constant-volume store

Input parameters

Unit system: SI

Parameter	Value	Unit
Cavern volume	500,000	m³
Maximum operating pressure	18.000	MPa
Minimum operating pressure	6.0000	MPa
Gas temperature in the cavern	45.000	°C
Abel–Noble co-volume (about 7.69 × 10⁻³ m³/kg for hydrogen)	0.007691	m³/kg

Calculated results

Parameter	Value	Unit
Hydrogen at maximum pressure	6,204.5	t
Cushion gas at minimum pressure	2,208.7	t
Working gas	3,995.8	t
Working gas energy (LHV)	133.13	GWh
Energy per m³ of cavern (kWh)	266.27	
Cushion gas fraction	35.598	%

Notes for this case

• Abel–Noble density ρ = p/(RT + bp) at the cavern temperature (isothermal). Pressure limits come from the salt's mechanical stability and the casing shoe depth; temperature swings during fast cycling change the inventory.

Formula and method

$$\rho = \frac{p}{RT + bp}, \quad m_{wg} = V[\rho(p_{max}) - \rho(p_{min})], \quad E = m_{wg} LHV$$

Variables

V	Cavern volume	m³
p_{max}	Maximum operating pressure	Pa
p_{min}	Minimum operating pressure	Pa
T	Gas temperature in the cavern	K
b	Abel–Noble co-volume (about 7.69 × 10⁻³ m³/kg for hydrogen)	m³/kg
m_{max}	Hydrogen at maximum pressure	kg
m_{cush}	Cushion gas at minimum pressure	kg
m_{wg}	Working gas	kg
E	Working gas energy (LHV)	J
E/V	Energy per m³ of cavern (kWh)	-
m_{cush}/m_{max}	Cushion gas fraction	-

Method and standards

Underground hydrogen inventory.

Assumptions and limits

- Isothermal cavern; pure hydrogen.

References

Real-gas inventory of a constant-volume store

Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/environmental/hydrogen-fuel-cells/hydrogen-salt-cavern-storage

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Reopens the calculator with the inputs of this report.