Steam Accumulator Storage Capacity (Ruths)

Steam a Ruths steam accumulator releases when its pressure falls from charging to discharge pressure, from its volume and water filling (IAPWS-IF97).

Method: Flash of saturated water between two pressures (Ruths principle); IAPWS R7-97 IF97

Input parameters

Unit system: SI

Parameter	Value	Unit
Accumulator volume	100.00	m³
Water filling at charge, share of volume	90.000	%
Charging pressure (absolute)	16.000	bar
Discharge (minimum) pressure (absolute)	6.0000	bar

Calculated results

Parameter	Value	Unit
Steam released	6,936.3	kg
Steam released per m³ of accumulator volume	69.363	kg/m³
Water held at charge	77.675	t
Share of the charged water released as steam	8.9299	%

Notes for this case

- The water swells as it heats during charging; the filling must leave steam space for it and for separation.

Formula and method

$$m_w = \phi V \rho_f(p_1) \qquad \frac{dm}{m} = \frac{dh_f}{h_{fg}} \qquad x = 1 - \exp\left(-\int_{T_2}^{T_1} \frac{dh_f}{h_{fg}}\right) \qquad m_s = m_w\, x$$

Variables

V	accumulator volume	m³
ϕ	water filling at charge	–
p_1	charging pressure	Pa
p_2	discharge pressure	Pa
m_s	steam released	kg
m_s/V	steam released per m³ of accumulator volume (not a density)	kg/m³
m_w	water at charge	kg
x	share of the charged water released as steam	–
m	water left in the vessel during discharge	kg
$T_1\$, \$T_2$	saturation temperatures at p_1 and p_2	K
ρ_f	saturated water density (IF97)	kg/m³
h_f, h_{fg}	saturated liquid enthalpy and latent heat (IF97)	J/kg

Method and standards

Saturated water flashing as the pressure falls from charging to discharge pressure (Ruths principle). The steam leaves as it forms, so the energy balance of the water left, d(m h_f) = h_g dm, gives dm/m = dh_f/h_fg; it is integrated over the saturation temperature with FireCAD's IAPWS-IF97.

Assumptions and limits

- Water saturated at charging pressure; no heat loss; steam leaves dry.

- Gradual discharge with the steam leaving as it forms; this gives about 1 % less than a single-step flash of the whole charge at the discharge pressure. The steam already in the steam space at charge is not counted.
- The filling is the share at charge (after the water has swelled); leave steam space above it for separation.

References

- Flash of saturated water between two pressures (Ruths principle)
- IAPWS R7-97 IF97

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/boilers-power-plant/steam/steam-accumulator

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.