Natural Circulation Driving Head (Downcomer vs Riser)

Driving pressure of a natural-circulation loop from the drum pressure, the circuit height and the mean riser quality (homogeneous model, IF97 densities).

Method: Δp = g H (ρ_l − ρ_r) with homogeneous riser density; IAPWS-IF97 saturated densities

Input parameters

Unit system: SI

Parameter	Value	Unit
Drum pressure (absolute)	70.000	bar
Height of the heated riser above the downcomer bottom	25.000	m
Mean riser quality	5.0000	%

Calculated results

Parameter	Value	Unit
Downcomer water density (saturated)	739.72	kg/m³
Mean riser density (homogeneous)	376.90	kg/m³
Driving head	88.953	kPa

Notes for this case

- The head must balance the friction and acceleration losses of the loop at the circulation ratio chosen; head falls as drum pressure rises.

Formula and method

$$\rho_r = \left(\frac{\bar{x}}{\rho_v} + \frac{1-\bar{x}}{\rho_l} \right)^{-1}, \quad \Delta p_d = gH(\rho_l - \rho_r)$$

Variables

p_d	Drum pressure (absolute)	Pa
H	Height of the heated riser above the downcomer bottom	m
$\bar{x}$	Mean riser quality	-
ρ_l	Downcomer water density (saturated)	kg/m³
ρ_r	Mean riser density (homogeneous)	kg/m³
Δp_d	Driving head	Pa

Method and standards

Hydrostatics of the loop: the driving head is g H times the density difference between the saturated water in the downcomer and the two-phase riser mixture, with the riser density from the homogeneous (no-slip) model at the mean quality and IAPWS-IF97 saturated densities.

Assumptions and limits

- Saturated downcomer water.
- Homogeneous (no-slip) riser density at one mean quality: slip and the averaging of density along the riser both raise the true riser density, so the head is overstated (an upper bound).

References

- Δp = g H (ρ_l − ρ_r) with homogeneous riser density; IAPWS-IF97 saturated densities

Report details

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Release checks	2 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/boiler-pressure-parts/natural-circulation-driving-head

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.