Downcomer Sizing from Circulation Ratio

Circulating water flow from steam flow and circulation ratio, the downcomer area and bore for an allowed water velocity (IF97 density), and the riser exit quality.

Method: Mass balance ṁ_w = CR ṁ_s; continuity with IAPWS-IF97 saturated density

Input parameters

Unit system: SI

Parameter	Value	Unit
Steam generated	60.000	t/h
Circulation ratio (water / steam)	15.000	
Drum pressure (absolute)	46.000	bar
Allowed downcomer velocity	2.5000	m/s
Number of downcomers	4.0000	

Calculated results

Parameter	Value	Unit
Circulating water	900.00	t/h
Saturated water density	785.52	kg/m³
Total downcomer area	0.12730	m²
Bore of each downcomer	201.30	mm
Riser exit quality 1/CR	6.6667	%

Notes for this case

- Keep downcomers unheated and free of steam: entrained steam lowers the circulation head.

Formula and method

$$\dot{m}_w = CR\,\dot{m}_s, \quad A = \frac{\dot{m}_w}{\rho_l v}, \quad d = \sqrt{\frac{4A}{n\pi}}, \quad x_e = \frac{1}{CR}$$

Variables

$\dot{m}_s$	Steam generated	kg/s
CR	Circulation ratio (water / steam)	-
p_d	Drum pressure (absolute)	Pa
v	Allowed downcomer velocity	m/s
n	Number of downcomers	-
$\dot{m}_w$	Circulating water	kg/s
ρ_l	Saturated water density	kg/m³
A	Total downcomer area	m²
d	Bore of each downcomer	m
x_e	Riser exit quality 1/CR	-

Method and standards

Mass balance: the water circulated is the circulation ratio times the steam made; continuity at the allowed velocity with the IAPWS-IF97 saturated water density gives the area, split equally over the downcomers.

Assumptions and limits

- Saturated downcomer water. Feedwater mixed in the drum leaves the downcomer water slightly subcooled and denser, so the area needed is a little smaller.

References

- Mass balance ṁ_w = CR ṁ_s; continuity with IAPWS-IF97 saturated density

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/downcomer-sizing

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.