Boiler Drum Flash Steam on Pressure Drop (Swell)

Steam flashed from the boiler water when drum pressure falls, its volume and the average steam surge: the cause of drum level swell on a sudden load increase.

Method: IAPWS R7-97(2012) IF97; first law of thermodynamics

Input parameters

Unit system: SI

Parameter	Value	Unit
Water in drum, downcomers and risers	10.000	t
Drum pressure before (absolute)	45.000	bar
Drum pressure after (absolute)	40.000	bar
Time over which the pressure falls	60.000	s

Calculated results

Parameter	Value	Unit
Steam flashed from the water	202.61	kg
Average extra steam generation	12,157	kg/h
Volume of that steam at the lower pressure	10.085	m³
Flash fraction of the water	2.0261	%

Notes for this case

- The bubbles swell the drum level before they escape; how much they lift it depends on the drum and riser design, so the drum level control must ride through the swell rather than cut the feed.

Formula and method

$$x = \frac{h_f(p_1) - h_f(p_2)}{h_g(p_2) - h_f(p_2)} \qquad m_{fl} = M_w\, x \qquad V_{fl} = m_{fl}\, v_g(p_2) \qquad \dot{m}_{fl} = \frac{m_{fl}}{\Delta t}$$

Variables

M_w	water in drum, downcomers and risers	kg
p_1	drum pressure before, absolute	Pa
p_2	drum pressure after, absolute	Pa
Δt	time of the pressure fall	s
m_{fl}	steam flashed	kg
$\dot{m}_{fl}$	average extra steam generation	kg/s
V_{fl}	volume of the flashed steam	m³
x	flash fraction	–
$h_f\$, \$h_g$	saturated liquid and vapour enthalpy (IF97)	J/kg
v_g	saturated vapour specific volume (IF97)	m³/kg

Method and standards

Energy balance of saturated water cooling to the new saturation temperature, with saturation properties from FireCAD's IAPWS-IF97. Heat released by the steel is neglected, so the flash is slightly understated.

Assumptions and limits

- Water saturated at the starting pressure; no heat from the metal or the fire during the drop; the level rise itself depends on the drum and riser design and is not calculated.
- One-step flash on the initial water mass; for a large pressure drop a stepwise balance, in which the water mass falls as it flashes, gives slightly less steam.

References

- IAPWS R7-97(2012) IF97
- first law of thermodynamics

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/boiler-pressure-parts/drum-flash-on-pressure-drop

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.