Hydrotest: Water to Pressurise and Pressure Drop per Litre

Extra water needed to raise a filled boiler or vessel to test pressure by water compressibility (IF97), and the pressure fall caused by each litre that leaks.

Method: Mass balance with IAPWS-IF97 densities at both pressures (rigid shell); test pressure itself is a code value entered by the user

Input parameters

Unit system: SI

Parameter	Value	Unit
Water volume of the system	60.000	m³
Water temperature	30.000	°C
Starting pressure (absolute)	1.0132	bar
Test pressure (absolute)	160.00	bar

Calculated results

Parameter	Value	Unit
Water mass to add	417.56	kg
Water volume to add (at starting pressure)	419.38	L
Pressure fall for each litre leaked (pressure per L)	0.37910	bar

Notes for this case

- Rigid shell assumed. The shell also stretches under pressure: for large thin vessels this can add as much water as the compression, or more, and lowers the pressure fall per litre. Air pockets add much more.

Formula and method

$$\Delta m = V[\rho(p_2, T) - \rho(p_1, T)], \quad \Delta V = \frac{\Delta m}{\rho_1}, \quad \Delta p/L = \frac{p_2 - p_1}{\Delta V / 0.001\ \mathrm{m^3}}$$

Variables

V	Water volume of the system	m³
T	Water temperature	K
p_1	Starting pressure (absolute)	Pa
p_2	Test pressure (absolute)	Pa
Δm	Water mass to add	kg
ΔV	Water volume to add (at starting pressure)	m³
$\Delta p/L$	Pressure fall for each litre leaked	Pa per L
$\rho_1, \rho(p, T)$	Water density at the starting pressure; at pressure p and T (IF97)	kg/m³

Method and standards

Mass balance at constant temperature: the water added is the system volume times the rise in IAPWS-IF97 density from the starting to the test pressure. The pressure fall per litre leaked is the pressure rise divided by that added volume in litres, a linear (constant compressibility) estimate.

Assumptions and limits

- Rigid shell; constant temperature. Shell dilation can add a comparable volume for large thin vessels, so the water needed is then higher and the pressure fall per litre lower.

References

- Mass balance with IAPWS-IF97 densities at both pressures (rigid shell); test pressure itself is a code value entered by the user

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/hydrotest-water-compression

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.