Boiler Water Content (Drum, Tubes, Headers)

Water volume and mass in a water-tube boiler from the drum at its water level, the tubes and the headers, with saturated water density (IAPWS-IF97).

Method: Circular segment geometry; IAPWS R7-97 IF97

Input parameters

Unit system: SI

Parameter	Value	Unit
Working pressure (absolute)	66.000	bar
Drum inside diameter	1.5000	m
Drum length	9.0000	m
Water level above the drum bottom	0.75000	m
Number of tubes	600.00	
Tube inside diameter	57.000	mm
Mean tube length	12.000	m
Number of headers	8.0000	
Header inside diameter	250.00	mm
Header length	6.0000	m

Calculated results

Parameter	Value	Unit
Total water volume	28.681	m³
Water mass at working pressure (all tubes full of saturated water)	21.423	t
Water in the drum	7.9522	m³
Water in the tubes	18.373	m³
Water in the headers	2.3562	m³

Notes for this case

- Dished drum ends, downcomers and economiser are not included unless entered as tubes or headers. Cold water for a hydraulic test is denser: use the cold density for that.

Formula and method

$$V_d = L_d\left[R^2\cos^{-1}\frac{R-h}{R} - (R-h)\sqrt{2Rh-h^2}\right] \qquad V_t = n_t\frac{\pi d_t^2}{4}l_t \qquad V_h = n_h\frac{\pi d_h^2}{4}l_h \qquad M_w = \rho_f V$$

Variables

p	working pressure	Pa
D	drum inside diameter	m
R	drum radius, D/2	m
L_d	drum length	m
h	water level above drum bottom	m
n_t	tubes	–
d_t	tube bore	m
l_t	tube length	m
n_h	headers	–
d_h	header bore	m

l_h	header length	m
V	total water volume	m³
M_w	water mass	kg
V_d	drum water	m³
V_t	tube water	m³
V_h	header water	m³
ρ_f	saturated water density (IF97)	kg/m³

Method and standards

Circular segment for the drum, full cylinders for tubes and headers; saturated water density from FireCAD's IAPWS-IF97.

Assumptions and limits

- Drum without dished ends; tubes and headers full of saturated water. In operation the risers carry steam, so the operating water mass is lower than shown; the figure is the flooded-to-level content.

References

- Circular segment geometry
- IAPWS R7-97 IF97

Report details

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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/boiler-water-volume

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.