Combined Separating and Throttling Calorimeter

Dryness fraction of wet steam from a separating calorimeter followed by a throttling calorimeter: x = x_1 × x_2 from the water separated, the condensate and the throttled state.

Method: IAPWS-IF97 (water and steam); Throttling at constant enthalpy (textbook)

Input parameters

Unit system: SI

Parameter	Value	Unit
Steam pressure in the main (absolute)	10.000	bar g
Water collected in the separator	0.50000	kg
Condensate from the throttling calorimeter	10.000	kg
Pressure after throttling (absolute) Absolute: the barometric pressure when the calorimeter exhausts to air. The main pressure above may be typed as gauge; it is converted with the standard atmosphere.	1.0132	bar
Temperature after throttling	115.00	°C

Calculated results

Parameter	Value	Unit
Dryness from the separator x_1 = m_c / (m_c + m_w)	95.238	%
Dryness from the throttling calorimeter	96.280	%
Dryness fraction of the steam x = x_1 x_2	91.696	%
Enthalpy of the steam in the main	2,614.7	kJ/kg
Superheat after throttling	15.026	K

Formula and method

$$x_1 = \frac{m_c}{m_c + m_w}$$

$$h_{f1} + x_2\, h_{fg1} = h(p_2, T_2)$$

$$x = x_1\, x_2, \quad h = h_{f1} + x\, h_{fg1}, \quad \Delta T_{sh} = T_2 - T_{sat}(p_2)$$

Variables

p_1	Steam pressure in the main (absolute)	Pa
m_w	Water collected in the separator	kg
m_c	Condensate from the throttling calorimeter	kg
p_2	Pressure after throttling (absolute)	Pa
T_2	Temperature after throttling	K
x_1	Dryness from the separator x_1 = m_c / (m_c + m_w)	-
x_2	Dryness from the throttling calorimeter	-
x	Dryness fraction of the steam x = x_1 x_2	-
h	Enthalpy of the steam in the main	J/kg
ΔT_{sh}	Superheat after throttling	K
$h_{f1}\$, \$h_{fg1}$	saturated liquid enthalpy and latent heat at the main pressure	J/kg
$T_{sat}(p_2)$	saturation temperature after throttling	K

Method and standards

Separator mass balance, then throttling at constant enthalpy into the superheated region; IAPWS-IF97 properties at the main and calorimeter states.

Assumptions and limits

- At least about 5 K of superheat after the throttle; a warning is given below that.
- Heat loss from the calorimeter neglected; the pressure drop across the separator is neglected (the throttle inlet is taken at the main pressure).
- x_2 above 1 is reported with a warning (the steam leaving the separator was superheated, or a reading is wrong).
- The main pressure may be entered as gauge (converted with the standard atmosphere, 101.325 kPa); the pressure after throttling is absolute.

References

• IAPWS-IF97 (water and steam)
• Throttling at constant enthalpy (textbook)

Report details

Report reference	FCC-1XCE-8Q62 (the same inputs always give the same reference)
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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/steam/separating-throttling-calorimeter

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Reopens the calculator with the inputs of this report.