Steam Blow-Off or Vent Line Flow (Choked Flow with Friction)

Steam flow from a vessel through a blow-off, vent or discharge pipe, from vessel pressure, pipe size and total resistance K, choked or subsonic.

Method: Ganapathy; Industrial Boilers and Heat Recovery Steam Generators (Marcel Dekker, 2003); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Vessel pressure (absolute)	11.721	bar
Steam temperature (≤ saturation = dry saturated)	0	°C
Pressure at the pipe outlet (absolute)	1.0132	bar
Pipe inside diameter	52.502	mm
Total resistance (f_D L/d + fittings, velocity heads)	10.000	
Isentropic exponent of steam	1.3000	

Calculated results

Parameter	Value	Unit
Specific volume in the vessel	0.16697	m³/kg
Mach number at the pipe inlet	0.24172	
Steam flow	5,503.7	kg/h
Pressure at the pipe outlet plane	2.5551	bar
Choked at the outlet (1 = yes)	1.0000	

Notes for this case

- Steam treated as a perfect gas with the γ entered (1.3) and the vessel specific volume from IAPWS-IF97; isentropic entry and adiabatic friction along the pipe. Ganapathy's tabulated method (Crane) gives results within a few per cent.
- Dry saturated steam used (the temperature entered is at or below saturation).

Formula and method

$$\frac{f_D L^*}{d} = \frac{1 - M_1^2}{\gamma M_1^2} + \frac{\gamma + 1}{2\gamma} \ln \frac{(\gamma+1) M_1^2}{2 + (\gamma - 1) M_1^2} = K \ \text{(choked)}$$

$$p_1 = p_0 \left(1 + \frac{\gamma - 1}{2} M_1^2\right)^{-\gamma/(\gamma-1)}, \quad W = M_1 \sqrt{\gamma p_1 \rho_1} \, \frac{\pi d^2}{4}$$

Variables

p_0	Vessel pressure (absolute)	Pa
T_0	Steam temperature (≤ saturation = dry saturated)	K
p_b	Pressure at the pipe outlet (absolute)	Pa
d	Pipe inside diameter	m
K	Total resistance (f_D L/d + fittings, velocity heads)	-
γ	Isentropic exponent of steam	-
v_0	Specific volume in the vessel	m³/kg
M_1	Mach number at the pipe inlet	-
W	Steam flow	kg/s

p_2	Pressure at the pipe outlet plane	Pa
choked	Choked at the outlet (1 = yes)	-

Method and standards

Isentropic entry plus Fanno flow; subsonic case solved for the outlet pressure.

Assumptions and limits

- Perfect-gas steam with the γ you enter; adiabatic; no condensation or real-gas effects along the line (about 4 % below Ganapathy's Crane-based figure in his example).
- Dry saturated or superheated steam only: a temperature at or below saturation is taken as dry saturated (a note says so); wet steam cannot be entered.

References

- Ganapathy
- Industrial Boilers and Heat Recovery Steam Generators (Marcel Dekker, 2003)
- Q7.33 (flow in steam blow-off lines); Fanno-line relations; IAPWS-IF97 vessel state

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/steam/steam-blowoff-line-flow

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Reopens the calculator with the inputs of this report.