Steam Main Condensate Load (Warm-Up and Running)

Condensate formed in a steam main during warm-up and in normal running, from the steel mass, steam pressure, warm-up time and heat loss, for steam trap sizing.

Method: Energy balance on the pipe (Spirax Sarco, The Steam and Condensate Loop, method); IAPWS R7-97(2012) IF97

Input parameters

Unit system: SI

Parameter	Value	Unit
Mass of pipe, flanges and fittings to heat Pipe mass per metre × length, plus flanges and valves. DN150 schedule 40 is 28.3 kg/m, DN100 is 16.1 kg/m (ASME B36.10).	2,830.0	kg
Specific heat of the pipe material Carbon steel about 0.49 kJ/(kg·K).	0.49000	kJ/(kg·K)
Starting (ambient) temperature	25.000	°C
Steam pressure (absolute)	10.500	bar
Warm-up time	30.000	min
Heat loss of the main in normal running From the pipe insulation heat loss calculator (W/m × length).	6.2000	kW

Calculated results

Parameter	Value	Unit
Mean condensate rate during warm-up	216.99	kg/h
Condensate formed during warm-up	108.50	kg
Running condensate load	11.122	kg/h
Steam saturation temperature	182.02	°C
Latent heat of the steam	2,006.8	kJ/kg

Notes for this case

- Latent heat at the final pressure: warm-up condensate is slightly high (safe for trap sizing). For a superheated main the running load is an upper bound.

Formula and method

$$m_w = \frac{W c_p (T_{sat} - T_a)}{h_{fg}} \qquad \dot{m}_w = \frac{m_w}{t_w} \qquad \dot{m}_r = \frac{\dot{Q}_l}{h_{fg}}$$

Variables

W	mass of pipe, flanges and fittings	kg
c_p	specific heat of the pipe material	J/(kg·K)
T_a	starting temperature	K
p	steam pressure, absolute	Pa
t_w	warm-up time	s
$\dot{Q}_l$	heat loss in normal running	W
$\dot{m}_w$	mean condensate rate during warm-up	kg/s
m_w	condensate formed during warm-up	kg
$\dot{m}_r$	running condensate load	kg/s
T_{sat}	steam saturation temperature	K

h_{fg}	latent heat of the steam	J/kg

Method and standards

Energy balance: the steel is heated to the saturation temperature by condensing steam (the method of Spirax Sarco's The Steam and Condensate Loop), and in running the heat loss is made up by condensation. Saturation temperature and latent heat from FireCAD's IAPWS-IF97.

Assumptions and limits

- Insulation mass and the heat loss during warm-up are neglected (a few per cent).
- The mean warm-up rate; the peak at the start is higher.
- Superheated steam mains form little running condensate while the superheat lasts; the running load here uses the latent heat as if saturated, so for a superheated main it is an upper bound.
- Warm-up uses the latent heat at the final steam pressure. During warm-up the main is at lower pressure, where the latent heat is larger, so the warm-up condensate is slightly overestimated (on the safe side for trap sizing).

References

• Energy balance on the pipe (Spirax Sarco, The Steam and Condensate Loop, method)
• IAPWS R7-97(2012) IF97

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/steam/steam-trap-condensate-load

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.