# Condensate Return Line Sizing with Flash Steam

Flash steam fraction, mixture volume and velocity in a condensate return line after the steam trap, and the line size for an allowed velocity, by the homogeneous model.

**Method:** IAPWS-IF97 saturation properties; Homogeneous two-phase flow model

## Input parameters

Unit system: SI

| Parameter | Value | Unit |
|---|---|---|
| Condensate flow | 5,000.0 | kg/h |
| Pressure before the trap (absolute)<br>The condensate is taken as saturated water at this pressure. | 11.000 | bar |
| Pressure in the return line (absolute) | 1.5000 | bar |
| Allowed mixture velocity<br>Your design limit for the steam–water mixture in the return line. | 15.000 | m/s |
| Inside diameter of the line to check | 80.000 | mm |

## Calculated results

| Parameter | Value | Unit |
|---|---|---|
| Flash fraction (steam per kg of condensate) | 14.111 | % |
| Flash steam | 705.55 | kg/h |
| Specific volume of the mixture | 0.16450 | m³/kg |
| Volume flow of the mixture | 822.51 | m³/h |
| Smallest inside diameter for the allowed velocity | 139.26 | mm |
| Mixture velocity in the line checked | 45.454 | m/s |

**Notes for this case**

- Homogeneous model: steam and water move at one velocity. Real lines slip and can slug; allow for lift after the trap and for start-up loads.
- The velocity in the line checked (45.5 m/s) exceeds the allowed 15.0 m/s: use at least the smallest inside diameter shown.

## Formula and method

$$x = \frac{h_{f1} - h_{f2}}{h_{g2} - h_{f2}}$$

$$v_m = x\, v_{g2} + (1 - x)\, v_{f2}$$

$$\dot{V} = \dot{m}\, v_m, \quad d_{min} = \sqrt{\frac{4\dot{V}}{\pi u_{max}}}, \quad u = \frac{4\dot{V}}{\pi d^2}$$

### Variables

| | | |
|---|---|---|
| $\dot{m}$ | Condensate flow | kg/s |
| $p_1$ | Pressure before the trap (absolute) | Pa |
| $p_2$ | Pressure in the return line (absolute) | Pa |
| $u_{max}$ | Allowed mixture velocity | m/s |
| $d$ | Inside diameter of the line to check | m |
| $x$ | Flash fraction (steam per kg of condensate) | - |
| $\dot{m}_{fs}$ | Flash steam | kg/s |

| | | |
|---|---|---|
| $v_m$ | Specific volume of the mixture | m³/kg |
| $\dot{V}$ | Volume flow of the mixture | m³/s |
| $d_{min}$ | Smallest inside diameter for the allowed velocity | m |
| $u$ | Mixture velocity in the line checked | m/s |
| $h_{f1}$ | Enthalpy of saturated water before the trap | J/kg |
| $h_{f2}, h_{g2}$ | Saturated water and steam enthalpy in the return line | J/kg |
| $v_{f2}, v_{g2}$ | Saturated water and steam specific volume in the return line | m³/kg |

### Method and standards

Saturated condensate at the trap inlet pressure flashes at the lower return line pressure; the flash fraction follows from the energy balance with IAPWS-IF97 enthalpies. The homogeneous mixture volume then gives the velocity in a chosen pipe and the smallest pipe for an allowed velocity.

### Assumptions and limits

- Condensate saturated at the trap inlet; steady flow.
- Homogeneous model; slip and slug flow are not modelled.
- Condensate taken as saturated at $p_1$; subcooled condensate (traps that back up) flashes less, so the result is on the safe side.
- One return line pressure: the pressure drop along the line, and the extra flash it causes, are not modelled.
- A warning appears when the velocity in the line checked exceeds the allowed velocity.

### References

• IAPWS-IF97 saturation properties
• Homogeneous two-phase flow model

## Report details

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|---|---|
| Report reference | FCC-GZ0S-QTY9 (the same inputs always give the same reference) |
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| Calculator | Condensate Return Line Sizing with Flash Steam |
| Method last reviewed | 12 November 2026 |
| Software release | FireCAD Calc, release of 17 November 2026 |
| 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/condensate-line-flash-sizing

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.