Willans Line: Steam Consumption at Part Load

Steam consumption of a turbine at any load from its no-load and full-load steam flows (Willans line), with the steam rate per kWh at that load.

Method: Willans line: steam flow linear in load for throttle governing (steam turbine texts)

Input parameters

Unit system: SI

Parameter	Value	Unit
No-load steam flow	1.2000	t/h
Full-load steam flow	10.000	t/h
Full-load output	2,000.0	kW
Load of interest	1,200.0	kW

Calculated results

Parameter	Value	Unit
Steam flow at the load	6.4800	t/h
Specific steam consumption	5.4000	kg/kWh
Full-load specific steam consumption	5.0000	kg/kWh

Notes for this case

- Holds for throttle-governed turbines; nozzle-governed machines follow a series of lines.

Formula and method

$$\dot{m} = \dot{m}_0 + (\dot{m}_1 - \dot{m}_0)\frac{P}{P_1}, \quad SSC = \frac{\dot{m}}{P}$$

Variables

$\dot{m}_0$	No-load steam flow	kg/s
$\dot{m}_1$	Full-load steam flow	kg/s
P_1	Full-load output	W
P	Load of interest	W
$\dot{m}$	Steam flow at the load	kg/s
SSC	Specific steam consumption	kg/J
SSC_1	Full-load specific steam consumption	kg/J

Method and standards

Willans line.

Assumptions and limits

- Throttle governing.
- At no load the steam rate is unbounded and not shown; a load above full load is an extrapolation and is flagged.

References

Willans line: steam flow linear in load for throttle governing (steam turbine texts)

Report details

Report reference	FCC-V2F5-YKD5 (the same inputs always give the same reference)
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Release checks	2 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-turbines/willans-line

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.