Labyrinth (Gland) Seal Steam Leakage by Martin's Formula

Steam leakage through a turbine labyrinth or gland seal from upstream steam state, downstream pressure, number of throttles and clearance area by Martin's formula.

Input parameters

Unit system: SI

Parameter	Value	Unit
Upstream pressure (absolute)	30.000	bar
Upstream steam temperature (≤ saturation = dry saturated)	300.00	°C
Downstream pressure (absolute)	1.2000	bar
Number of throttles (teeth)	12.000	
Shaft diameter at the seal	400.00	mm
Radial clearance	0.40000	mm
Flow coefficient	0.70000	

Calculated results

Parameter	Value	Unit
Clearance area	502.65	mm²
Upstream specific volume	0.081175	m³/kg
Leakage	1,972.3	kg/h
Pressure ratio p_n/p_0 below which the last throttle chokes, 0.85/√(N + 1.5)	0.23134	

Notes for this case

- Martin's formula assumes subsonic flow at the last throttle and full carry-over loss between teeth; the flow coefficient K (0.6–0.8 for sharp teeth) carries the geometry. Clearances open with rubs: use measured values for existing machines.
- The pressure ratio 0.040 is below 0.231: the last throttle chokes, so the leakage no longer rises as the downstream pressure falls and Martin's formula overstates it. Treat the result as an upper bound, or add teeth.

Formula and method

$$\dot{m} = KA\sqrt{\frac{p_0}{v_0}}\sqrt{\frac{1-(p_n/p_0)^2}{N-\ln(p_n/p_0)}}, \quad A = \pi Dc, \quad r_{cr} = \frac{0.85}{\sqrt{N+1.5}}$$

Variables

p_0	Upstream pressure (absolute)	Pa
T_0	Upstream steam temperature (≤ saturation = dry saturated)	K
p_n	Downstream pressure (absolute)	Pa
N	Number of throttles (teeth)	-
D	Shaft diameter at the seal	m
c	Radial clearance	m
K	Flow coefficient	-
A	Clearance area	m²
v_0	Upstream specific volume	m³/kg
$\dot{m}$	Leakage	kg/s
r_{cr}	Pressure ratio p_n/p_0 below which the last throttle chokes (Stodola)	-

Method and standards

Martin's formula.

Assumptions and limits

- Straight-through or stepped labyrinth with flow coefficient K.
- Subsonic flow at the last throttle is assumed. A note appears when p_n/p_0 is below r_cr = 0.85/√(N + 1.5), Stodola's criterion for choking at the last throttle; the formula then overstates the leakage, and no choked-flow model is applied.
- At 22 MPa and above the upstream state is taken at the entered pressure and temperature.

Report details

Report reference	FCC-NHME-S09B (the same inputs always give the same reference)
Generated	23 November 2026, 17:43 UTC
Calculator	Labyrinth (Gland) Seal Steam Leakage by Martin's Formula
Method last reviewed	13 November 2026
Software release	FireCAD Calc, release of 22 November 2026
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/labyrinth-seal-leakage-martin

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Reopens the calculator with the inputs of this report.