Penstock Head Loss, Net Head and Hydro Power

Velocity, friction factor, penstock head loss, net head and electrical output of a hydro plant from flow, gross head and penstock size, roughness and fittings.

Method: Darcy–Weisbach with Colebrook–White in a hydro penstock

Input parameters

Unit system: SI

Parameter	Value	Unit
Design flow	7,200.0	m³/h
Gross head	80.000	m
Penstock length	300.00	m
Penstock inside diameter	0.90000	m
Wall roughness (welded steel about 0.05 mm)	0.050000	mm
Sum of minor loss coefficients (intake, bends, valves)	2.5000	
Water temperature	15.000	°C
Turbine and generator efficiency	85.000	%

Calculated results

Parameter	Value	Unit
Penstock velocity	3.1438	m/s
Reynolds number	2,485,016	
Darcy friction factor	0.011744	
Head loss	3.2325	m
Net head	76.767	m
Head loss as a share of gross head	4.0407	%
Electrical output	1,278.7	kW

Notes for this case

• Darcy–Weisbach with the Colebrook–White friction factor and minor losses: h_L = (fL/D + ΣK)v²/2g; P = ηρgQH_n. Designers usually keep penstock losses near 5–10 % of gross head; check water hammer and the economic diameter separately. Water properties from IAPWS-IF97.

Formula and method

$$h_L = \left(f\frac{L}{D} + \Sigma K\right)\frac{v^2}{2g}, \quad H_n = H_g - h_L, \quad P = \eta\rho g Q H_n$$

Variables

Q	Design flow	m³/s
H_g	Gross head	m
L	Penstock length	m
D	Penstock inside diameter	m
ε	Wall roughness (welded steel about 0.05 mm)	m
ΣK	Sum of minor loss coefficients (intake, bends, valves)	-
T	Water temperature	K
η	Turbine and generator efficiency	-

v	Penstock velocity	m/s
Re	Reynolds number	-
f	Darcy friction factor	-
h_L	Head loss	m
H_n	Net head	m
h_L/H_g	Head loss as a share of gross head	-
P	Electrical output	W

Method and standards

Penstock hydraulics.

Assumptions and limits

- Steady full-pipe flow; uniform diameter.

References

Darcy–Weisbach with Colebrook–White in a hydro penstock

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/hydro-power/penstock-net-head-power

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.