

STEEL PENSTOCK LOSSES & THICKNESS CALCULATION

SITE NAME

Sample

Quantity

Symbol

Unit

PENSTOCK LOSS CALCULATIONS

Input Data

Flow	Q	70 l/s
Gross head	H _g	22 m
Penstock length	L	60 m
Penstock internal diameter	d	190 mm

Calculations

Velocity in penstock $V = 1,273 \cdot \left(\frac{Q}{d^2}\right) = 2.47 \text{ m/s}$

Friction head loss in penstock $H_f = 12 \cdot 8 \times \left(\frac{V^2 \cdot L}{d}\right) \times \frac{1}{\left(\log\left[\frac{1}{37d} + \frac{1}{(93 \cdot 8 \cdot V \cdot d)^{0.9}}\right]\right)^2} = 1.81 \text{ m}$

Net head at end of penstock $H_n = H_g - H_f = 20.2 \text{ m}$

Penstock efficiency $\eta_{pen} = \frac{H_n}{H_g} \times 100 = 91.8 \%$

PENSTOCK THICKNESS CALCULATIONS

Input Data

Penstock thickness	t	2.5 mm
% of flow stopped	z	50 %
valve closure time	T _{close}	4 s
Corrosion allowance	t _{cor}	1.5 mm
Overall safety factor	SF _{tot}	4

Calculations

Wave velocity in penstock $V_{wave} = \sqrt{\frac{2 \cdot 1 \times 10^8 \cdot t}{(100t + d)}} = 1092 \text{ m/s}$

Penstock critical time $T_{crit} = \frac{2L}{V_{wave}} = 0.11 \text{ s}$

Surge head for T_{close} ≤ T_{crit} $H_{surge} = \frac{V_{wave} \cdot z \cdot V}{980} = - \text{ m}$

OR

For T_{close} ≥ T_{crit} $K_c = \left(\frac{L \cdot z \cdot V}{980 H_g \cdot T_{close}}\right)^2 = 0.01$

Surge head for T_{close} ≥ T_{crit} $H_{surge} = H_g \cdot \left(\frac{K_c}{2} + \sqrt{K_c + \frac{K_c^2}{4}}\right) = 1.97 \text{ m}$

Total head at surge $H_{tot} = H_{surge} + H_g = 24 \text{ m}$

Required penstock thickness $t_{req} = \frac{H_{tot} \cdot d \cdot SF_{tot}}{83,700} + t_{cor} = 1.72 \text{ mm}$

Values of Constants Used

Gravity	g	9.8 m/s
Bulk modulus of water	K_w	2.1 kN/mm ²
Density of water	ρ_o	1000 kg/m ³
Kinematic viscosity of water (5°C)	ν	1.53 cSt
Penstock roughness coefficient	k	0.1 mm
Penstock Young's Modulus	E_p	210 kN/mm ²
Penstock UTS	σ_{ult}	410 N/mm ²