Surge Tank: Thoma Stable Area, Upsurge and Oscillation Period

Thoma's minimum stable area of a simple surge tank, the frictionless upsurge after full load rejection and the mass oscillation period of tunnel and tank.

Input parameters

Unit system: SI

Parameter	Value	Unit
Headrace tunnel length to the surge tank	3,000.0	m
Tunnel diameter	4.0000	m
Surge tank diameter	15.000	m
Steady flow	144,000	m^3/h
Tunnel head loss at the steady flow	6.0000	m
Net head at the turbines	150.00	m

Calculated results

Parameter	Value	Unit
Tunnel velocity	3.1831	m/s
Tunnel area	12.566	m^2
Surge tank area	176.71	m^2
Thoma minimum stable area	21.639	m^2
Area ratio (1.5 or more recommended)	8.1665	
Maximum upsurge, frictionless	14.846	m
Mass oscillation period	412.11	s

Notes for this case

- Thoma's criterion for small oscillations of a simple surge tank with turbines governed to constant power; friction reduces the real upsurge below the frictionless value.

Formula and method

$$A_{th} = \frac{L A_t V_0^2}{2 g h_{f0} H_0}$$

$$Z_{max} = V_0 \sqrt{\frac{L A_t}{g A_s}}, \quad T = 2\pi \sqrt{\frac{L A_s}{g A_t}}$$

Variables

L	Headrace tunnel length to the surge tank	m
D_t	Tunnel diameter	m
D_s	Surge tank diameter	m
Q_0	Steady flow	m^3/s
h_{f0}	Tunnel head loss at the steady flow	m
H_0	Net head at the turbines	m
V_0	Tunnel velocity	m/s

A_t	Tunnel area	m²
A_s	Surge tank area	m²
A_{th}	Thoma minimum stable area	m²
A_s/A_{th}	Area ratio (1.5 or more recommended)	-
Z_{max}	Maximum upsurge, frictionless	m
T	Mass oscillation period	s

Method and standards

Rigid-column mass oscillation of a tunnel and simple surge tank.

Assumptions and limits

- Simple (unrestricted) tank; small-oscillation Thoma criterion.

Report details

Report reference	FCC-E4D7-FCCD (the same inputs always give the same reference)
Generated	23 November 2026, 17:43 UTC
Calculator	Surge Tank: Thoma Stable Area, Upsurge and Oscillation Period
Method last reviewed	17 November 2026
Software release	FireCAD Calc, release of 22 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/hydro-power/surge-tank-thoma-stability

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.