Bollard Pull from Propeller Power (Momentum Theory)

Static bollard pull of a tug from delivered power, propeller diameter and number, open or nozzle propellers and a figure of merit, by actuator disc theory.

Method: Momentum (actuator disc) theory at zero advance

Input parameters

Unit system: SI

Parameter	Value	Unit
Delivered power per propeller	1,500.0	kW
Propeller diameter	2.6000	m
Number of propellers	2.0000	
Duct factor (2 open, up to 4 ideal nozzle)	2.0000	
Static figure of merit	60.000	%
Water density	1,025.0	kg/m³

Calculated results

Parameter	Value	Unit
Pull per propeller	206.58	kN
Total bollard pull	42.131	tf
Pull per 100 kW (tf)	1.4044	
Mean velocity through the disc	4.3566	m/s

Notes for this case

• Actuator disc at zero speed: ideal power P = T^{3/2}/√(2ρA), so T = (2ρA)^{1/3}(ηP)^{2/3} for an open propeller; an ideal nozzle carrying half the thrust raises the constant from 2 to 4 (26 % more pull). The figure of merit η (about 0.5–0.65 for real propellers) covers profile losses and swirl. Rules of thumb for tugs: about 1.0–1.1 tf per 100 kW open and 1.3–1.5 with nozzles. Bollard pull trials remain the reference.

Formula and method

$$T = (k_d \rho A)^{1/3} (\eta_s P_D)^{2/3}, \quad A = \frac{\pi D^2}{4}$$

Variables

P_D	Delivered power per propeller	W
D	Propeller diameter	m
n	Number of propellers	-
k_d	Duct factor (2 open, up to 4 ideal nozzle)	-
η_s	Static figure of merit	-
ρ	Water density	kg/m³
T_1	Pull per propeller	N
T	Total bollard pull	N
T/P	Pull per 100 kW (tf)	-
v_i	Mean velocity through the disc	m/s

Method and standards

Bollard pull.

Assumptions and limits

- Zero speed; deep water; no interaction between propellers or with the hull.

References

Momentum (actuator disc) theory at zero advance

Report details

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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/mechanical/marine/bollard-pull-estimate

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.