Winch Drum Rope Pull by Layer and Capstan Holding Force

Winch rope pull at each drum layer from torque and layer pitch diameter, and the holding force on a capstan from friction and wrap (capstan equation).

Method: Capstan (Euler–Eytelwein) equation and drum statics (definitions)

Input parameters

Unit system: SI

Parameter	Value	Unit
Drum torque	20,000	N·m
Bare drum diameter	400.00	mm
Rope diameter	20.000	mm
Layer number	3.0000	
Load-side tension on the capstan	10.000	kN
Rope–capstan friction coefficient	0.25000	
Turns of wrap	3.0000	

Calculated results

Parameter	Value	Unit
Pitch diameter at the layer	500.00	mm
Rope pull at the layer	80.000	kN
Holding force on the capstan	89.833	N
Capstan force ratio	111.32	

Notes for this case

• Layer pitch diameter assumes rope layers stacked one rope diameter apart (simplified). Capstan equation: T_load = T_hold·e^(μφ).

Formula and method

$$D_n = D + (2n-1)d, \quad F_n = \frac{2M}{D_n}, \quad \frac{T_{load}}{T_{hold}} = e^{\mu\varphi}, \ \varphi = 2\pi n_w$$

Variables

M	Drum torque	N·m
D	Bare drum diameter	m
d	Rope diameter	m
n	Layer number	-
T_{load}	Load-side tension on the capstan	N
μ	Rope–capstan friction coefficient	-
n_w	Turns of wrap	-
D_n	Pitch diameter at the layer	m
F_n	Rope pull at the layer	N
T_{hold}	Holding force on the capstan	N
T_{load}/T_{hold}	Capstan force ratio	-

Method and standards

Drum statics and capstan equation.

Assumptions and limits

- The layer number is a whole number. The drum section (pull by layer) and the capstan section (holding force) are independent calculations on one page; the capstan inputs do not affect the drum results and vice versa.
- Uniform friction; inextensible rope.

References

- Capstan (Euler–Eytelwein) equation and drum statics (definitions)

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/mechanical/material-handling/winch-capstan-rope-pull

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.