Power Pump Displacement, Volumetric Efficiency and Torque

Displacement of a single- or double-acting plunger pump, plunger speed, volumetric efficiency with liquid compressibility, delivered flow, power and torque.

Input parameters

Unit system: SI

Parameter	Value	Unit
Plunger or piston diameter	2.0000	in
Stroke (full plunger travel)	5.0000	in
Number of plungers	3.0000	
Crankshaft speed	360.00	rpm
Action	Single acting	
Piston rod diameter (double acting)	0	m
Differential pressure	1,500.0	psi
Liquid compressibility	3.2000e-06	1/psi
Ratio r = (C + D)/D	4.0000	
Slip	3.0000	%
Mechanical efficiency	90.000	%

Calculated results

Parameter	Value	Unit
Displacement	73.440	US gal/min
Mean plunger speed	300.00	ft/min
Volumetric efficiency (suction basis)	95.553	%
Volumetric efficiency (discharge basis)	95.080	%
Delivered flow (suction basis)	70.174	US gal/min
Displacement power	47.919	kW
Input power	53.243	kW
Input torque	1,412.3	N·m

Notes for this case

• The ratio r is the liquid volume between the valves at the end of the suction stroke (clearance C plus displacement D) over D. Compressibility matters above about 400 bar for water, and much earlier for light hydrocarbons. Standards limit plunger speed to about 0.7-1.4 m/s.

Formula and method

$$D = A\,m\,n\,s \quad (\text{double acting}: \ (2A-a)mns), \quad VE_s = \frac{1-P_{td}\beta r}{1-P_{td}\beta} - S, \quad VE_d = 1 - P_{td}\beta r - S$$

$$P_{in} = \frac{D\,P_{td}}{ME}, \quad M = \frac{P_{in}}{\omega}$$

Variables

d_p	Plunger or piston diameter	m
s	Stroke (full plunger travel)	m
m	Number of plungers	-

n	Crankshaft speed	rad/s
acting	Action	-
d_r	Piston rod diameter (double acting)	m
P_{td}	Differential pressure	Pa
β	Liquid compressibility	1/Pa
r	Ratio r = (C + D)/D	-
S	Slip	-
ME	Mechanical efficiency	-
D	Displacement	m³/s
S_p	Mean plunger speed	m/s
VE_s	Volumetric efficiency (suction basis)	-
VE_d	Volumetric efficiency (discharge basis)	-
Q	Delivered flow (suction basis)	m³/s
P_{displ}	Displacement power	W
P_{in}	Input power	W
M	Input torque	N·m

Method and standards

Power pump theory.

Assumptions and limits

- Constant compressibility over the pressure range.

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/pumps/power-pump-volumetric-efficiency

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.