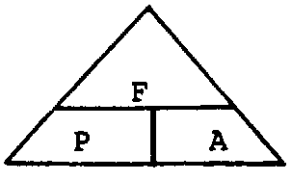
R2K Contracting
Hydraulics Sales & Service

Power Hydraulics

FORMULAE SHEET

1. Force, pressure, area relationships



F = force in Newton's (N)

P = pressure in megapascal (MPa)

A = area in square mm (mm^2)

2. Cylinder thrust on extension

$$F\,(ext.) = P \times D^2 \times 0.7854$$

D = cylinder diameter

3. Cylinder thrust on retraction

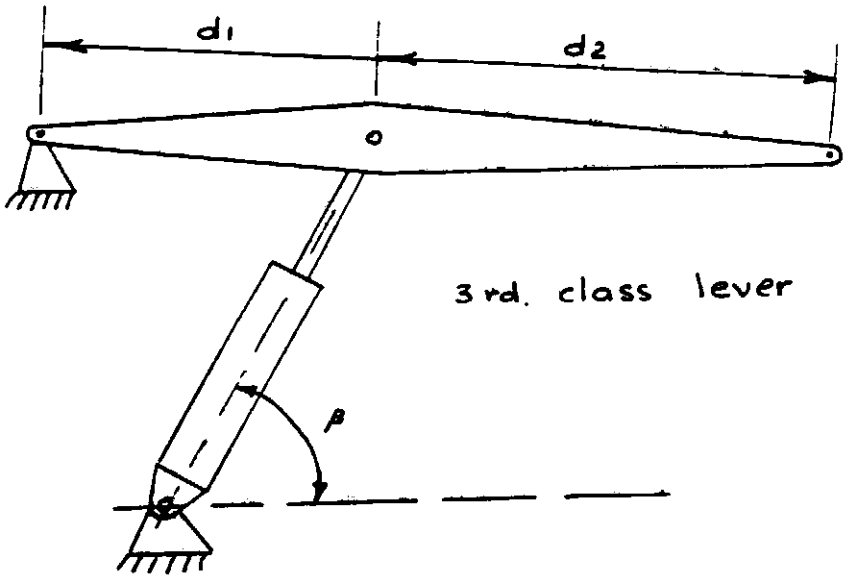
$$F\,(ret.) = P \times \left(D^2 - d^2\right) \times 0.7854$$

d = rod diameter

4. To calculate diameter of a cylinder.

$$D = \sqrt{\left(\frac{A}{0.7854}\right)}$$

5. Vertical lifting capacity of a cylinder. $Lift\ (kg) = \dfrac{Force\ (N)}{9.807}$



6. Third class level (Hydraulic crane) $Lift\ (kg) = \dfrac{Force \times Sine^{\beta} \times d_1}{9.807 \times (d_1 + d_2)}$

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7. Sizing a reservoir - Industrial

$$Capacity\ (\ell) = Q(\ell/s) \times 185\ (or\ 200)$$ Add 10% for air space.

$$(\ell) = 3 \times \ell/\min$$ Add 10% for air space.

-Mobile

$$Capacity\ (\ell) = Q(\ell/s) \times 85\ (or\ 100)$$ Add 10% for air space.

$$(\ell) = 1.5 \times \ell/\min$$ Add 10% for air space.

8. Pump flow (speed variations)

$$Q = \frac{rated\ rev/\min \times actual\ Q}{actual\ rev/\min}$$

9. Pump volumetric Efficiency %

$$VE\% = \frac{Q\ at\ \max\ test\ P \times 100}{Q\ at\ zero\ p}$$

10. Input power (sizing prime mover)

$$Input\ Power\ (kW) = \frac{Q(\ell/s) \times P\ (MPa)}{Vol.eff.}$$ Or $$kW = \frac{Q(\ell/\min) \times P\ (Bar)}{600 \times Vol.eff.}$$

11. Mechanical Efficiency %

$$Mech.eff.\% = \frac{Output\ Power \times 100}{Input\ Power}$$

12. Overall efficiency %

$$O.eff.\% = \frac{Vol.eff.\% \times Mech.eff.\%}{100}$$

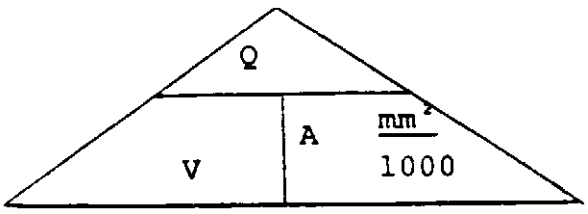
13. Heat gain (kilojoules / second)

$$Heat\ (kJ/s) = Q \times \Delta P\ (MPa)$$

N.B. ΔP is pressure drop or pressure differential

14.

Q = Flow //s
V = Velocity mm/s
A = cross sectional area $\frac{mm^2}{1000}$



15. Velocity cylinder extension $(mm/s) = \frac{Q \times 1000}{D^2 \times 0.7854}$

16. Velocity cylinder retract $(mm/s) = \frac{Q \times 1000}{(D^2 - d^2) \times 0.7854}$

Where D = cylinder bore dia & d = rod dia

17. Thrust on extension $(kg) = \frac{P\,(MPa) \times D^2 \times 0.7854}{9.807}$

18. Thrust on retract $(kg) = \frac{P\,(MPa) \times (D^2 - d^2) \times 0.7854}{9.807}$

19. Lift, vertically $(kg) = \frac{Force\,(N)}{9.807}$

20. Time, cylinder extension $(s) = \frac{D^2 \times 0.7854 \times stroke(m)}{1000 \times Q}$

21. Time, cylinder retract $(s) = \frac{(D^2 - d^2) \times 0.7854 \times stroke(m)}{1000 \times Q}$

22. Recommended Velocity of oil flow

(a) Suction 0.5 to 1.5 m/s
(b) Reservoir up to 2 m/s
(c) Pressure lines up to 2 m/s

23. Heat dissipation ability of a reservoir in Joules/second.

J/s =13.3 x T.D. x area of wetted surface

Where 13.3 = a constant
T.D. = temp diff ^0C
Area is m^2

24. Torque (hydraulic motor)

Torque $(Nm) = \frac{output\,(kW) \times 159.15}{rev/\sec}$

Torque $(Nm) = \frac{V_D\,(cm^3) \times \Delta P\,(kPa) \times \eta_{mh}\,(decimal)}{1000 \times 6.2832}$

Torque $(Nm) = V_D\,(l/rev) \times \Delta P\,(MPa) \times \eta_{mh} \times 159.15$

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25. Power (hydraulic motor)

$$\text{Power } (watts) = Torque\,(Nm) \times rev/s \times 6.2832$$

$$\text{Power } (kW) = \frac{Torque(Nm) \times Rpm}{9550}$$

26. $$\text{Rpm } (hydraulic\ motor) = \frac{Q\,(\ell/\min)}{motor\ displacement\ (\ell)}$$

27. Pump lift pressure (-kPa)

$$P\,(-kPa) = Height\,(m) \times R.D. \times g$$

OR $$P\,(inches\ Hg) = \frac{Height\,(ins.) \times 0.036 \times R.D.}{0.491}$$

N.B. 1" Hg. = 3.388 kPa
g. = 9.807
R.D. = 0.86

Force = Mass x Gravitational Acceleration Weight of oil = 9.807 kPa / m or 0.433 psi / foot

28. $$\text{Lift Height } (m) = \frac{P + \Delta P}{R.D. \times g}$$

Where P = allowable suction P (-kPa)
ΔP of hoses and fittings (kPa)

MISCELLANEOUS (not S.I.)

29. $$\text{Torque } (in\ lbs.) = \frac{P\,(psi) \times motor\ displacement\ (in^3/rev)}{2 \times 3.1416(2\pi)}$$

30. $$\text{Motor shaft speed } (rev/\min) = \frac{Q\,(USGPM) \times 231}{motor\ displacement\ (in^3/rev)}$$

31. $$\text{Hydraulic } (HP) = \frac{Q\,(USGPM) \times P\,(psi)}{1714}$$

32. Hydraulic Motor Torque

$$\text{Torque } (ft\ lbs.) = \frac{Displacement\ (in^3/rev) \times \Delta P\,(psi)}{24 \times 3.1416(24\pi)}$$

N.B. ΔP is pressure drop across motor

33. $$\text{Torque } (ft\ lbs.) = \frac{HP \times 5252}{rev/\min}$$

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34. Pump Flow $(USGPM) = \frac{Rpm \times Displacement\ (in^3 / rev)}{231}$

35. Oil velocity

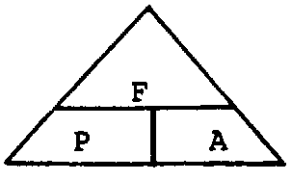
Suction lines 2 to 4 feet per second
Return lines 10 to 15 feet per second
Medium pressure lines 15 to 20 feet per second
High pressure lines up to 30 feet per second

36. Force, pressure, area relationships

F = force in pounds (lb.)

P = pressure in pounds per square inch (psi)

A = area in square in. (in^2)



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$F\ (ext.) = P \times D^2 \times 0.7854$ D = cylinder diameter

38. Cylinder thrust on retraction

$F\ (ret.) = P \times (D^2 - d^2) \times 0.7854$ d = rod diameter

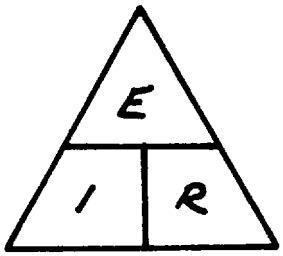
39. To calculate diameter of a cylinder.

$$D = \sqrt{\left(\frac{A}{0.7854}\right)}$$

ELECTRICAL CONTROL

40. Ohm's Law

$$\text{Current} = \frac{\text{Voltage}}{\text{Resistance}}$$



$$I = \frac{V}{R} \qquad \text{OR} \qquad I = \frac{E}{R}$$

41. POWER

$$\text{Power}\,(\text{Watts}) = \text{Voltage}\,(\text{Volts}) \times \text{Current}\,(\text{Amps})$$

$$P = V \times I$$

I = Current in Amperes
E = Potential in Volts
R = Resistance in Ohms
P = Power in Watts

$$I = \frac{E}{R} = \frac{P}{E} = \sqrt{\left(\frac{P}{R}\right)} \qquad R = \frac{P}{I^2} = \frac{E^2}{P} = \frac{E}{I}$$

$$E = \sqrt{(P \times R)} = \frac{P}{I} = I \times R \qquad P = I^2 \times R = \frac{E^2}{R} = E \times I$$

42. Resistors in series

$$R_T = R_1 + R_2 + R_3 \, etc.$$

43. Resistors in parallel

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \, etc. \qquad \text{Or} \qquad R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

44. Voltage Drop

$$\text{Circular mils}\,(\cdot 000'') = \frac{\text{Distance in feet} \times \text{Amperage} \times 22}{\text{Voltage Drop}}$$

$$\text{Voltage Drop} = \frac{\text{Distance in feet} \times \text{Amperage} \times 22}{\text{Circular mils}\,(\cdot 000'')}$$

$$\text{Circular}\,(\text{mm}^2) = \frac{\text{Distance in meters} \times \text{Amperage}}{\text{Voltage Drop} \times 21.5}$$

$$\text{Voltage Drop} = \frac{\text{Distance in meters} \times \text{Amperage}}{\text{Circular}\,(\text{mm}^2) \times 21.5}$$

45. Electric Motor Power

$$Power = \sqrt{3} \times Volts \times Amps \times eff. \times Power\ Factor$$