VELOCITY AND PRESSURE DROP IN PIPES

Velocity

The velocity of hydraulic fluid through a conductor (pipe, tube or hose) is dependent on flow rate and cross sectional area. Recommended fluid velocities through pipes and hoses in hydraulic systems are as follows:

Service	Velocity (ft/sec)	Velocity (m/sec)
suction/intake	2 - 4	0.6 – 1.2
return	4 – 13	1.5 - 4
pressure/discharge	7 - 18	2 – 5.5

Use values at the lower end of the range for lower pressures or where operation is continuous. Refer to the flow/velocity nomograms on pages four and five for more information. Alternatively, fluid velocity can be calculated using the following formula:

$$v = \frac{Q \times 0.408}{D^2}$$

Where

v = velocity in feet per second (ft/sec)
Q = flow rate in US gallons per minute (US gpm)
D = inside diameter of pipe or hose in inches (in.)

In metric units

$$v = \frac{Q \times 21.22}{D^2}$$

Where

v = velocity in metres per second (m/sec)
Q = flow rate in litres per minute (L/min)
D = inside diameter of pipe or hose in millimetres (mm)

Pressure drop

Friction between the fluid flowing through a conductor and its inside wall causes losses, which are quantified as pressure drop. Pressure drop in conductors is an important consideration for the designer, especially in systems where long pipe or hose runs are necessary. The pressure drop over a length of pipe or hose can be calculated using the following formula, which for ease of calculation uses metric units. Before proceeding to the pressure drop calculations, the following variables need to be determined:

Flow rate in litres per minute (L/min)	Q
Inside diameter of pipe or hose in millimetres (mm)	D
Kinematic viscosity of fluid (at operating temperature) in centistokes (cSt)	ν
Density of the fluid in kilograms per cubic metre (kg/m³)	ρ
Length of the pipe, tube or hose in metres (m)	L

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1. Calculate fluid velocity:

$$v = \frac{Q \times 21.22}{D^2}$$

Where

v	=	velocity in metres per second (m/sec)
Q	=	flow rate in litres per minute (L/min)
D	=	inside diameter of pipe or hose in millimetres (mm)

2. Calculate the Reynolds Number (Re):

$$Re = \frac{1000 \times v \times D}{\nu}$$

Where

Re	=	Reynolds Number
v	=	velocity in metres per second (m/sec)
D	=	inside diameter of pipe or hose in millimetres (mm)
ν	=	kinematic viscosity of fluid (at operating temperature) in centistokes (cSt)

3. Calculate the friction factor (f):

The formula used to calculate the friction factor is dependent on the magnitude of the Reynolds Number.

If the Reynolds Number is less than 2300, flow is laminar and the following formula is used to calculate the friction factor:

$$f = \frac{64}{Re}$$

Where

f	=	friction factor
Re	=	Reynolds Number < 2300

If the Reynolds Number is between 2300 and 4000, flow is transition and greater than 4000 flow is turbulent. For Reynolds Numbers greater than 2300 and less than 100,000 the following formula can be used to calculate the friction factor:

$$f = 0.3164 \times Re^{-0.25}$$

Where

f	=	friction factor
Re	=	Reynolds Number > 2300 and < 100,000

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In instances where the Reynolds Number is greater than 100,000, friction is highly dependant on the roughness of the conductor's inner surface. In these cases *Colebrook's* equation, which considers pipe roughness, is used to calculate the friction factor. However, due to the relatively low fluid velocities and high fluid viscosities present in hydraulic systems, Reynolds Numbers of this magnitude should not be encountered.

4. Calculate the pressure drop:

Finally, pressure drop can be calculated using the following formula:

$$\Delta p = \frac{v^2 \times f \times L \times \rho}{2D}$$

Where

Δp	=	pressure drop in Pascals (Pa)
v	=	velocity in metres per second (m/sec)
f	=	friction factor
L	=	length of pipe or hose in metres (m)
ρ	=	density of the fluid in kilograms per cubic metre (870-890 kg/m³ for hydraulic oil)
D	=	inside diameter of pipe or hose in metres (m)

Conversions				
SUS (32 – 99)	cSt = 0.2253 × SUS – (194.4 ÷ SUS)			
SUS (100 – 240)	cSt = 0.2193 × SUS – (134.6 ÷ SUS)			
SUS (> 240)	cSt = SUS ÷ 4.635			
US gallon	×	3.785	=	litre
inch	×	25.4	=	millimetre
inch	×	0.0254	=	metre
feet	×	0.3048	=	metre
lb/ft³	×	16.02	=	kg/m³
Pascal (Pa)	÷	100000	=	bar
Pascal (Pa)	×	0.000145	=	psi

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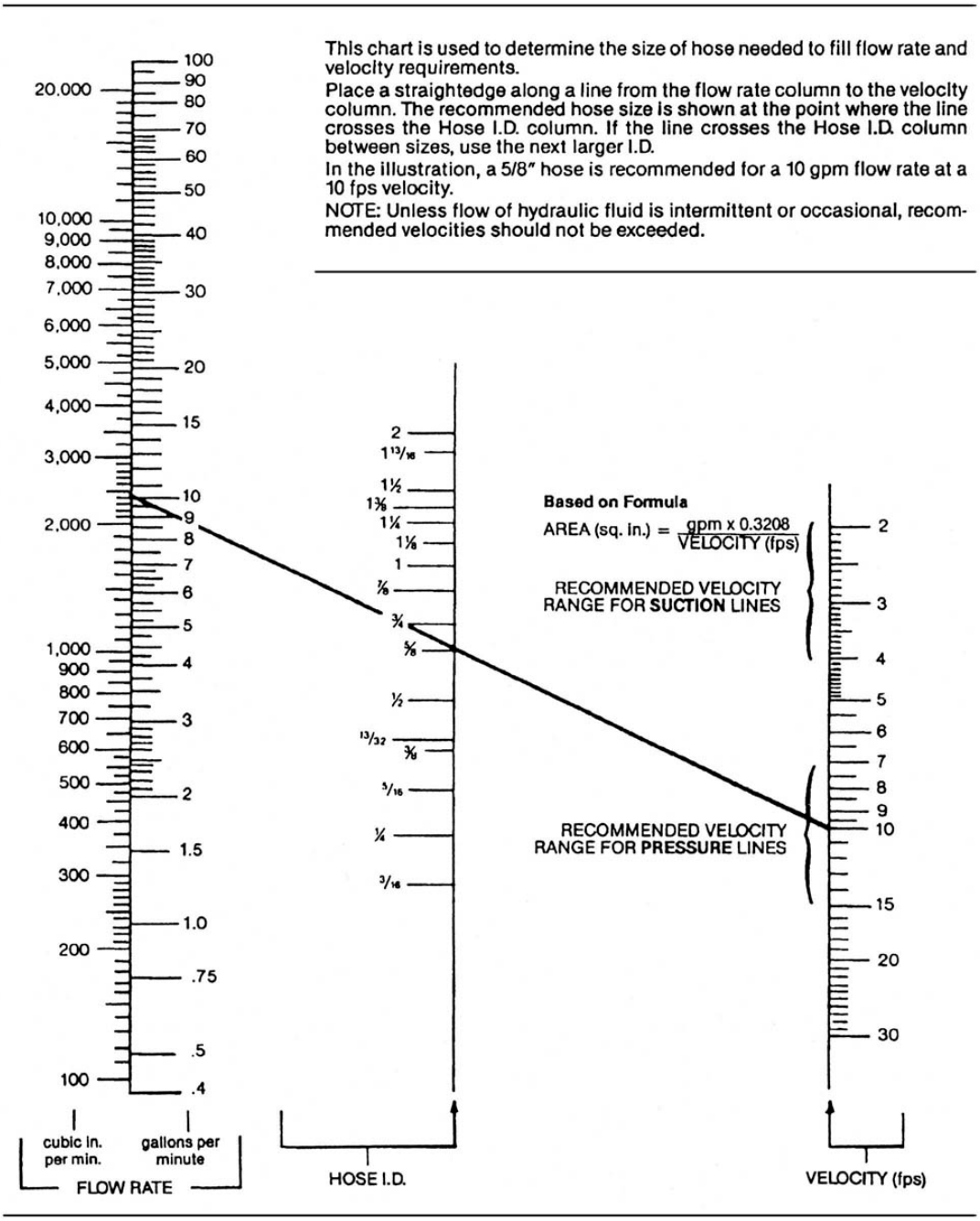
Flow / velocity nomogram (U.S.)



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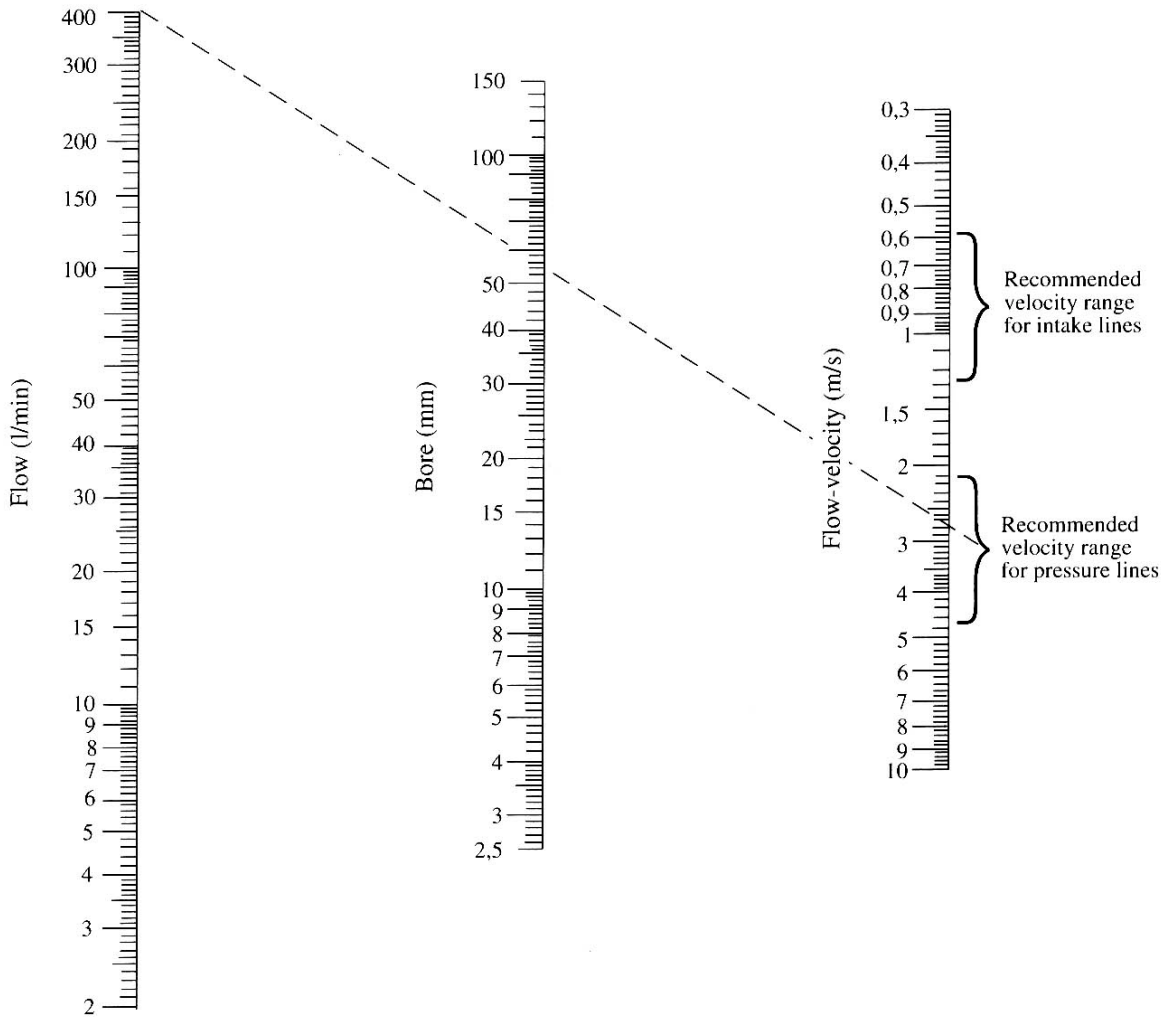
Flow / velocity nomogram (metric)



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