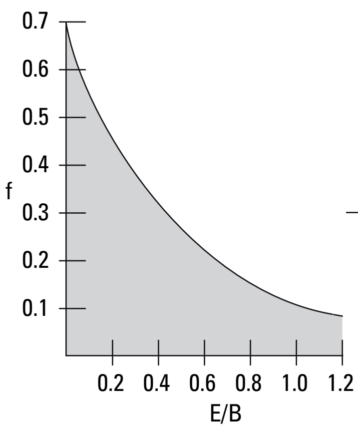
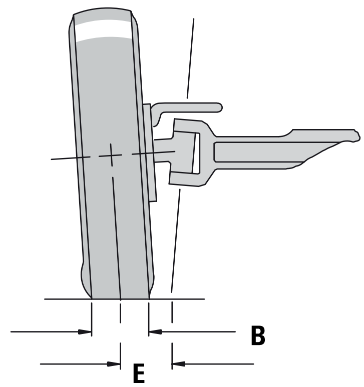
Sizing and Application—

Ackermann Type Steering

Step One: Kingpin Torque





Typical values based on rubber tired vehicles on dry concrete.

$$T = w \cdot f \sqrt{\frac{B^2}{8} + E^2}$$

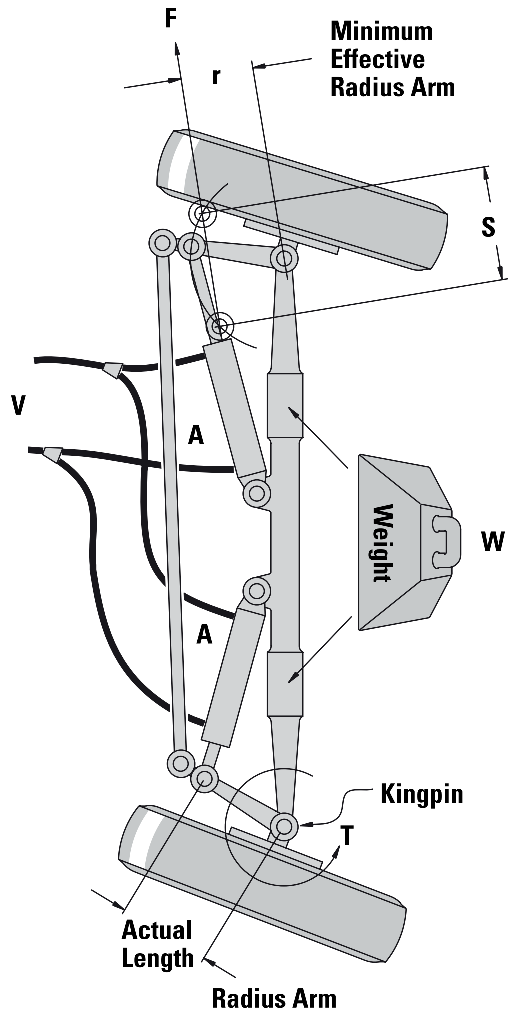
T = Total Kingpin Torque required to steer axle.

W = Vehicle Weight supported by the steered axle.

f = Coefficient of friction (dimensionless). Based on 0.7 as a Maximum. Determine from chart at left.

B = Nominal width of the tire print (see diagram above).

E = Kingpin Eccentric (use nominal tire width).



Step Two:

Force Required

$$F = \frac{T}{r}$$

F = Force required for the axle.

T = Kingpin torque as determined in Step 1. The value calculated in Step 1 is the total torque for the axle. If the steered axle is power driven, double this value to approximate the additional dynamic loads.

r = Effective radius arm about the kingpin axis at which the cylinder force is applied. The effective radius is the mini mum distance from kingpin to the axis of the cylinder … not the actual length of the arm.

Cylinder Area

$$A = \frac{F}{P}$$

A = Cylinder area for the axle cylinder set.

F = Force required

P = Hydraulic pressure

For vehicle with a steered axle that can never be overloaded use 80% of the steering circuit relief valve setting. For moderately loaded vehicles use 60%. For vehicles that can be severely overloaded use 30%.

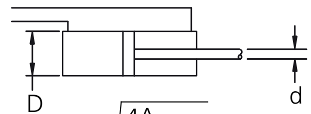
Cylinder Diameter

Once the required cylinder set area is determined, the cylinder diameter can be calculated.

D = Inside diameter of cylinder.

d = Rod diameter as required.

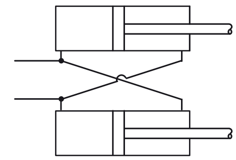
Differential Cylinder



$$D = \sqrt{\frac{4A}{\pi} + d^2}$$

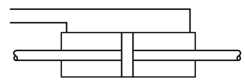
$$\text{Note: } \left(\frac{d}{D}\right)^2 \leq .15$$

Cross Connected Cylinder



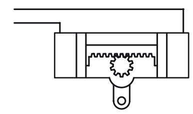
$$D = \sqrt{\frac{2A}{\pi} + \frac{d^2}{2}}$$

Balanced Cylinder



$$D = \sqrt{\frac{4A}{\pi} + d^2}$$

Opposed Cylinder



$$D = \sqrt{\frac{4A}{\pi}}$$

Cylinder Stroke

S = Stroke Length

The cylinder stroke is determined by axle geometry. That is, the required stroke is a function of the radius arm and the total angle through which the arm turns.

Differential Cylinder (Large Volume) $V = S \times \frac{\pi}{4} \times D^2$

Differential Cylinder (Small Volume or Balanced Cylinder) $V = S \times \frac{\pi}{4} \left(D^2 - d^2\right)$

Cross Connected Cylinder $V = S \times \frac{\pi}{4} \left(2\,D^2 - d^2\right)$

Cylinder Volume V = Volume $V = S \times A$

The volume of oil required to move cylinder rod(s) through the entire stroke.

Step Three:

Selecting Steering Unit Displacement

Before proceeding further, a decision must be made as to the number of steering wheel revolutions desired for the application to steer the axle from full one side to the other. Depending on vehicle usage, this will vary, normally 2 1/2 to 5 1/2 with 4 being a good typical value

$$\text{Displ.} = \frac{V}{N}$$

V = Volume full stroke

N = number of steering wheel revolutions lock to lock

Once this calculation is complete, select the closest standard steering unit displacement from the catalog information.

Now the number of steering wheel revolutions should be recalculated.

$$N = \frac{V}{\text{displ.}}$$

displ. = Steering unit displacement per revolution.

Note: for different cylinder applications, the cylinder volume will be different for right and left turns and the value N will vary accordingly.

Step Four:

Calculating Required Pump Flow

Pump sizing is important to assure adequate power for steering under all operating conditions. The required pump flow can be calculated by the following equation.

Q_P = Rmax. x displ.

Q_P (L/min): Required pump flow.

R_{max} = Max. steering wheel input of steering control unit (SCU).

displ. = Displacement of steering control unit per revolution.

Before proceeding to evaluation required pump flow the maximum required steering wheel speed must be determined. Typically 120 revolutions per minute (RPM) is used for Rmax.

- It is important at engine low idle condition that the maximum steering wheel speed should be more than 60 rpm.
- For engine normal idle condition, maximum steering wheel speed should be more than 100 rpm if possible.
- When using open center SCU connected with pump directly, maximum pump flow should be less than 1.4 times of SCU rated flow. Higher flow into SCU increases pressure-loss of the steering system. If higher flow is unavoidable, install a flow divider valve into the system or use a load sensing system.