



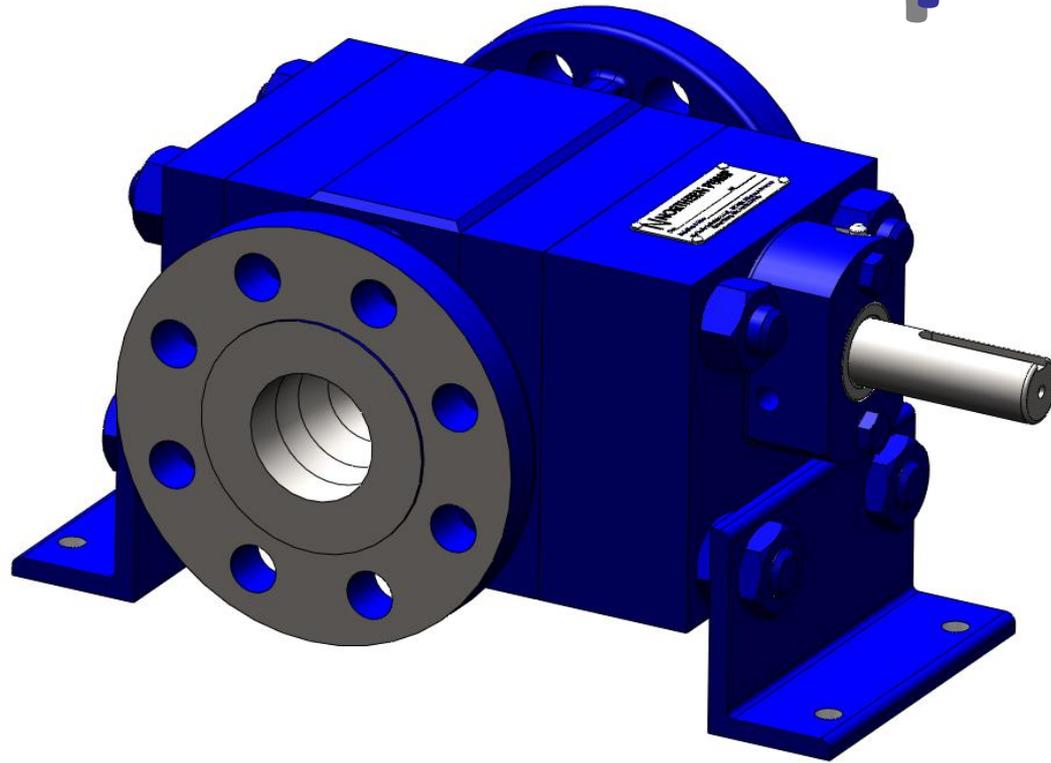
P&PE

PUMPS & PROCESS EQUIPMENT INC.

To Request a Quote,

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Gear Pump 101



Lesson 2: Gear pumping Terms*

**With Information from ANSI / HI 3.6-2000*

Gear Pump 101 Lesson 2: Gear Pumping Terms

Symbols						
Symbol	Term	Metric Unit	Abbreviation	US Customary Unit	Abbreviation	Conversion factor ^a
A	Area	square millimeter	mm ²	square inches	in ²	645.2
D	Displacement	milliliters/revolution	mL/rev	cubic inches/revolution	in ³ /rev	16.39
d	Diameter	millimeter	mm	inches	in	25.4
Δ (delta)	Difference	dimensionless	-	dimensionless	-	1
η (eta)	Efficiency	percent	%	percent	%	1
F	Force	Newton	N	pound-force	lbf	4.448
g	Gravitational acceleration	meter/second squared	m/s ²	feet/second squared	ft/sec ²	0.3048
γ (gamma)	Specific weight			pounds/cubic foot	lb/ft ³	
h	Head	meter	m	feet	ft	0.3048
n	Speed	revolutions/minute	rpm	revolutions/minute	rpm	1
NPIPA	Net positive inlet pressure avail.	kilopascal	kPa	pounds/square inch	psi	6.895
NPIPR	Net positive inlet pressure required	kilopascal	kPa	pounds/square inch	psi	6.895
ν (nu)	Kinematic viscosity	millimeter squared/sec	mm ² /s	centistoke	CST	1
π	pi = 3.1416	dimensionless	-	dimensionless	-	1
p	Pressure	kilopascal	kPa	pounds/square inch	psi	6.895
P	Power	kilowatt	kW	horsepower	hp	0.7457
Q	Rate of Flow (capacity)	cubic meter/hour	m ³ /h	US Gallons/minute	gpm	0.2271
s	Specific gravity	dimensionless	-	dimensionless	-	1
S	Slip	cubic meter/hour	m ³ /h	US Gallons/minute	gpm	0.2271
t	Temperature	degrees Celsius	°C	degrees Fahrenheit	°F	(°F-32) x ⁵ / ₉
τ (tau)	Torque	Newton - meter	N·m	pounds-feet	lb-ft	1.356
v	Velocity	meter/second	m/s	feet/second	ft/sec	0.3048
x	Exponent	none	none	none	none	1
Z	Elevation guage distance above or below datum	meter	m	feet	ft	0.3048

^a Conversion factor x US units = metric units

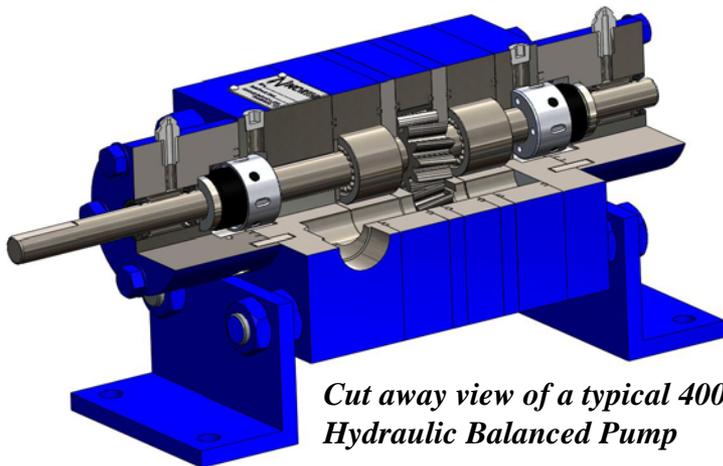
Gear Pump 101 Lesson 2: Gear Pumping Terms

● Inlet pressure (p_s) –

The inlet pressure is the algebraic sum of the gauge pressure, the velocity pressure and the elevation pressure as measured at the pump inlet:

$$\text{(Metric)} \quad p_s = p_{gs} + 9.8s \left[Z_s + \frac{v^2 s}{2g} \right] \quad \text{(US Units)} \quad p_s = p_{gs} + .0433s \left[Z_s + \frac{v^2 s}{2g} \right]$$

The symbol (p_s) may be positive or negative with reference to atmospheric pressure and may, therefore, have positive or negative values. The symbol is called inlet pressure when positive and inlet vacuum when negative. It is typically measured in Pounds per Inch² for positive and Inches of Mercury for negative values.



Cut away view of a typical 4000 Series Hydraulic Balanced Pump

Northern® Fast Fact.....

Northern 4000 series can comfortably operate with suction pressures as high as 1200 PSI. See our custom pump page for a diagram of our hydraulic balanced pump option for suction pressures at or above 25 PSI.

Gear Pump 101 Lesson 2: Gear Pumping Terms

● Discharge Pressure–

Discharge pressure is the amount of gage pressure that the pump must produce to force the liquid out of the pump and into the system piping, as well as overcome the potential combination of:

- All pressure loss in pipe from elbows, valves, filters, connections etc.
- Elevation of system piping
- Any system design that requires hydraulic force to operate

● Speed (n) –

The speed of a rotary gear pump is the number of revolutions per minute of the drive shaft and gear, and as a result, the driven shaft and gear.

Northern Pumps commonly operate at standard motor speeds of 1150, 1750, and 3600 RPM. Our pumps are often controlled by VFD or by the use of gear reducers to deliver the exact rate of flow required. Our pumps can produce a consistent flow and delivery at as low as 5 RPM!

Northern® Fast Fact.....

Nearly all standard Northern 4000 series pumps can comfortably operate with discharge pressures up to 2000 PSI.

Gear Pump 101 Lesson 2: Gear Pumping Terms

● Differential pressure (Δp) –

The differential pressure is the algebraic difference of the discharge pressure and inlet pressure, with terms expressed in like units:

$$\Delta p = p_d - p_s$$

● Maximum differential pressure (Δp_{\max}) -

The maximum differential pressure is the maximum allowable difference between the absolute pressure of the fluid at the discharge port and the absolute pressure of the fluid at the suction port.

Northern® Fast Fact.....

Most 4000 series pumps are designed to operate with a (Δp_{\max}) of 2000 PSI.

Gear Pump 101 Lesson 2: Gear Pumping Terms

● Rate of flow (Q) –

The rate of flow of a gear pump is the quantity of fluid actually delivered per unit of time, including both the liquid and any dissolved or entrained gases, at stated operating conditions.

In the absence of any vapor entering or forming within the pump, rate of flow is equal to the volume displaced per unit of time, less slip. This value is typically expressed in Gallons Per Minute. (GPM)

● Pump volumetric efficiency (η_v) –

The pump volumetric efficiency is ratio of the actual pump rate of flow to the volume displaced per unit of time. The formula for computing volumetric efficiency in percent is:

$$\text{(Metric)} \quad \eta_v = \frac{16.7 \times 10^3 Q}{Dn} \times 100$$

$$\text{(US Units)} \quad \eta_v = \frac{231Q}{Dn} \times 100$$

Northern® Fast Fact.....

Most 4000 series pumps are volumetrically efficient to at least 80%. The benefit is an energy savings that contributes to a green environment.

Gear Pump 101 Lesson 2: Gear Pumping Terms

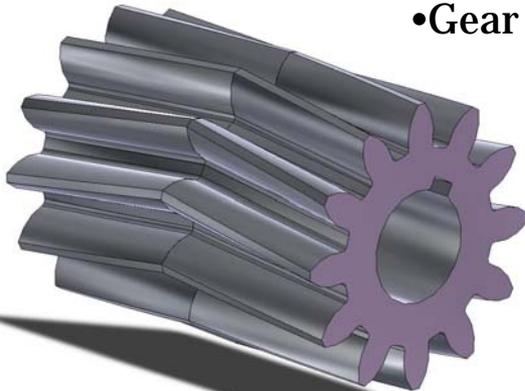
● Displacement (D) –

The displacement of a rotary gear pump is the volume displaced during one complete revolution of the gears. It may be calculated from the physical dimensions of the gears, or it may be determined as the volume of fluid pumped per revolution at zero differential pressure. The unit of displacement for most Northern Pumps can be calculated and expressed in cubic inches, gallons, or cubic centimeters per revolution.



Variables that allow us to easily match the displacement in a Northern[®] Gear Pump to your application are:

- Gear Length- Longer gears = More displacement
- Number of teeth- More teeth = Less displacement
- Gear Diameter- Larger diameter gears = More displacement



Northern[®] Fast Fact.....

Northern 4000 Series pumps are capable of producing a range of .3 to over 200 Gallons per Minute at 1750 RPM!

Gear Pump 101 Lesson 2: Gear Pumping Terms

● Slip (S) –

The Slip is the quantity of fluid which leaks through internal clearances of a pump per unit of time. It is dependent upon the internal clearances, the differential pressure, the characteristics of the fluid handled, and, in some cases, on the speed. Slip is determined from the following equation:

$$S = \left(\frac{Dn}{231} \right) - Q$$

The main factors for predicting the amount of slip are:

- Bore clearance* - Greater clearance around the outside diameter of the gear = more slip
- Side Clearance* - Greater clearance between the gear and bearing or liner plate = more slip

** See the next slide for a diagram of bore & side clearance*

- Liquid viscosity – Lower viscosity (*thinner liquid*) = more slip
- Differential Pressure – Higher differential pressure = more slip

- The Northern[®] Pump performance calculator takes in all of these factors to predict pump performance, using the following formula:

$$\left((1.493 \times 10^5) \frac{\Delta P}{V^c} \right) \left(2 \left(\frac{C^B}{2} \right)^3 \right) \left(\left(\frac{G^L}{V^T} \right) + \left((C^S)^3 \left((C^S) \left(\left(\frac{V^2}{V^3} \right) + \left(\frac{V^4}{V^5} \right) \right) \right) \right) \right)$$

Northern[®] Fast Fact.....

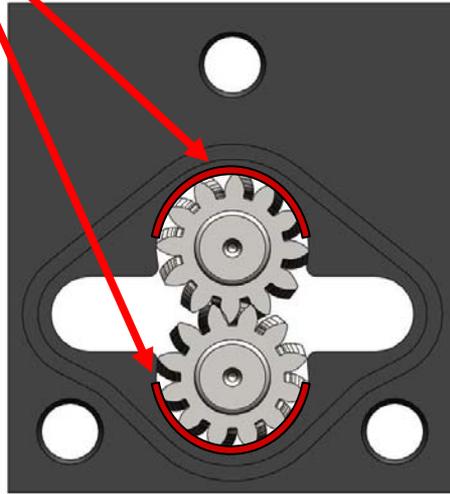
Slip is not affected by pump RPM.
Slip is a result of viscosity, pressure,
and available space to pass through.

Gear Pump 101

Lesson 2: Gear Pumping Terms

● Bore Clearance –

The bore clearance is in the gap between the outside diameter of the gear and the inside diameter of the cylinder



● Side Clearance –

The side clearance is in the gap between the side of the gear and the wear surface of the bearing plate.

