# Northern® Pump
**Division of McNally Industries**

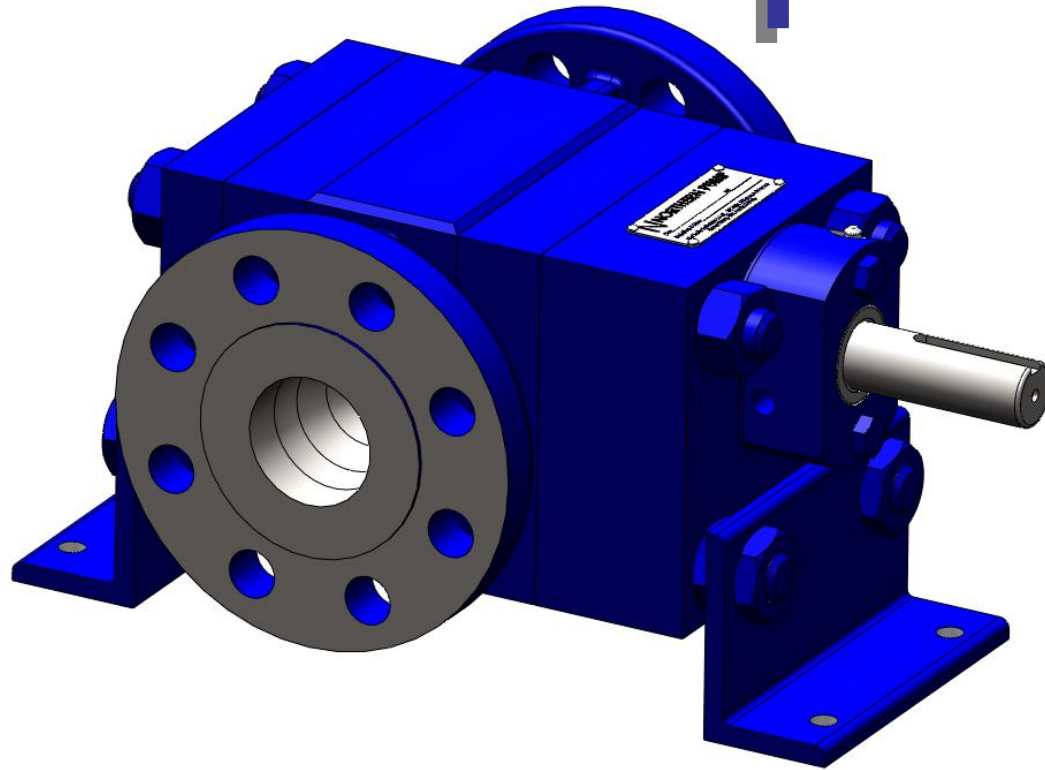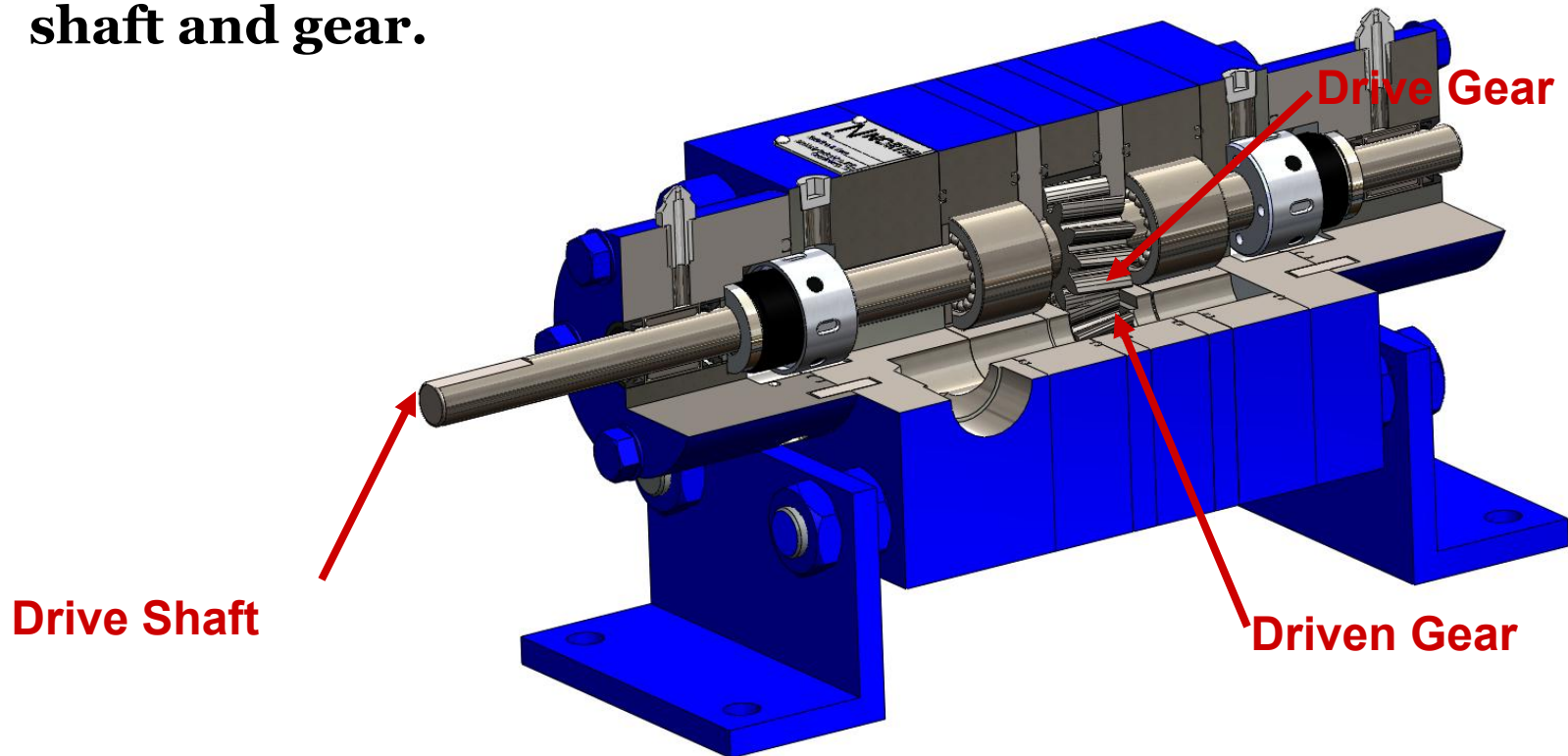*Golden Gear Program*

# Gear Pump 102
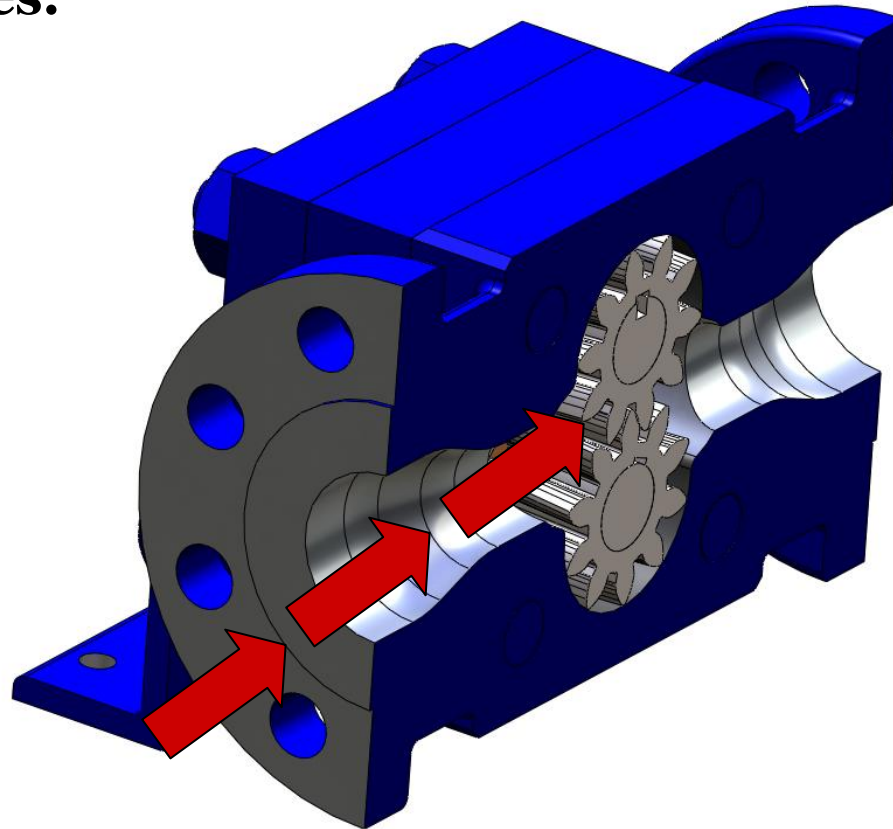
# Lesson 1: Gear Pump Basics

- **Northern Pump manufactures gear pumps that are positive displacement, rotary pumps, with two gears of equal size.**

- **The drive shaft and gear is rotated by a motor or by extension of a auxiliary motion shaft. The drive gear turns the driven shaft and gear.**
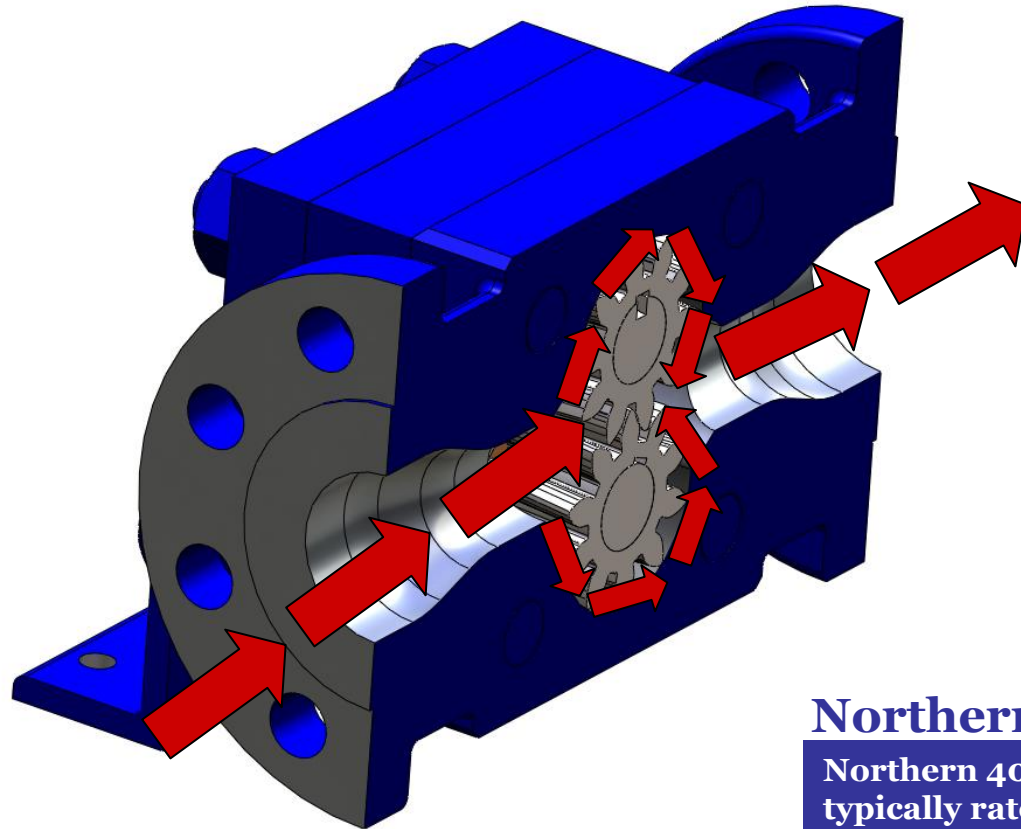
**Drive Gear**

**Drive Shaft**

**Driven Gear**

🔴 **Fluid is pulled into the pump by the hydraulic vacuum force created from the pump, or forced into the pump by either gravity or a charge pump. Typically, a charge pump is only needed for extremely high viscosities, or for exceptionally high flow rates.**

🔴 **Next, the fluid is carried around the gears in the area between the teeth. As the gears begin to mesh, the fluid is forced out of the area between the teeth. This mechanical force is able to generate an exceptionally high amount of hydraulic pressure.**
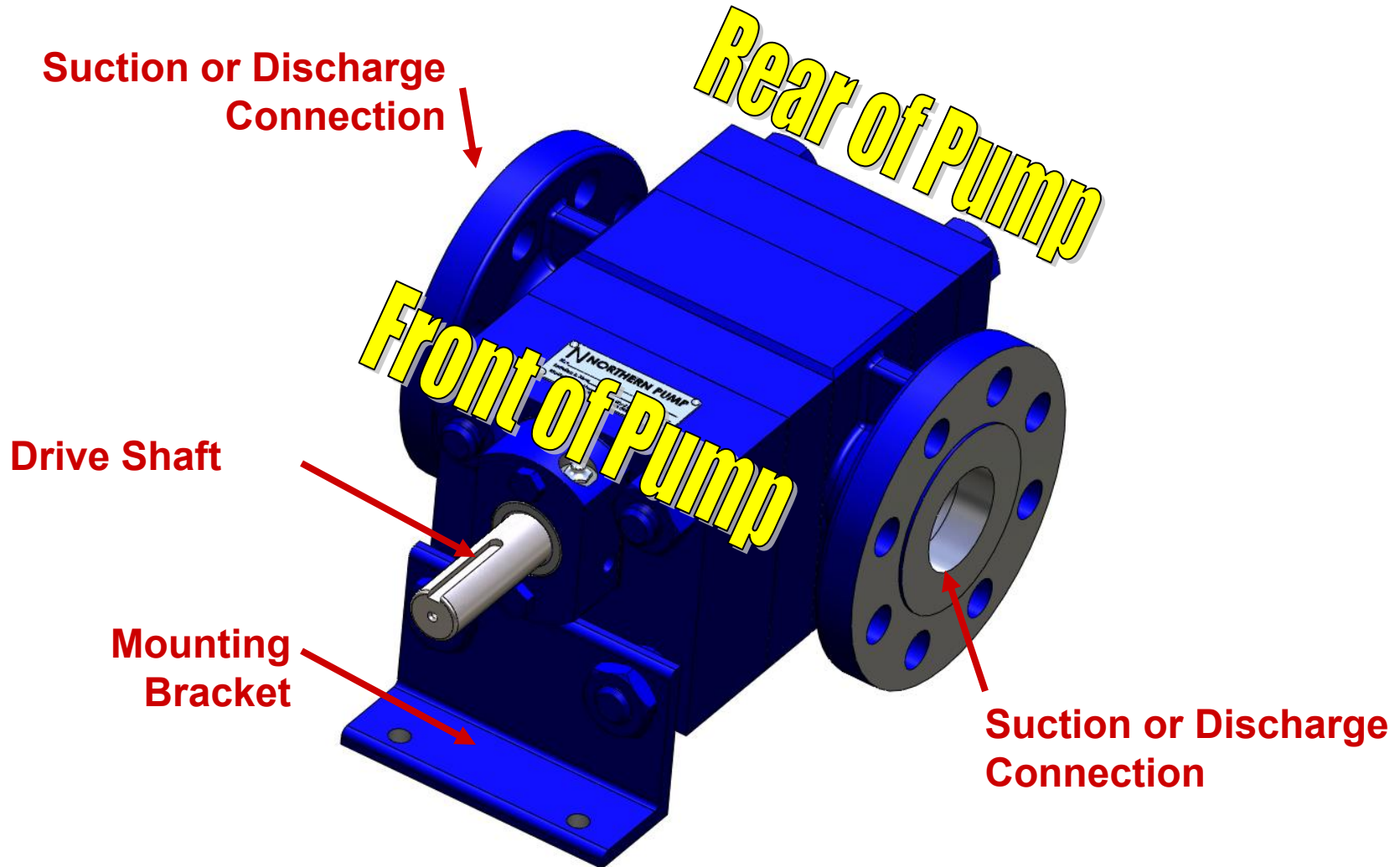
**Northern® Fast Fact.....**

Northern 4000 Series pumps are typically rated to generate up to 2000 pounds per inch2 (PSI)

# BASIC PUMP LAYOUT



Suction or Discharge Connection

Rear of Pump

Front of Pump

Drive Shaft

Mounting Bracket

Suction or Discharge Connection

🔴 **Pump rotation is determined by standing over the motor, and Look at the front of the pump. It is described as Clockwise, or Counter Clockwise.**

**Suction-CW Rotation**
**Discharge-CCW Rotation**
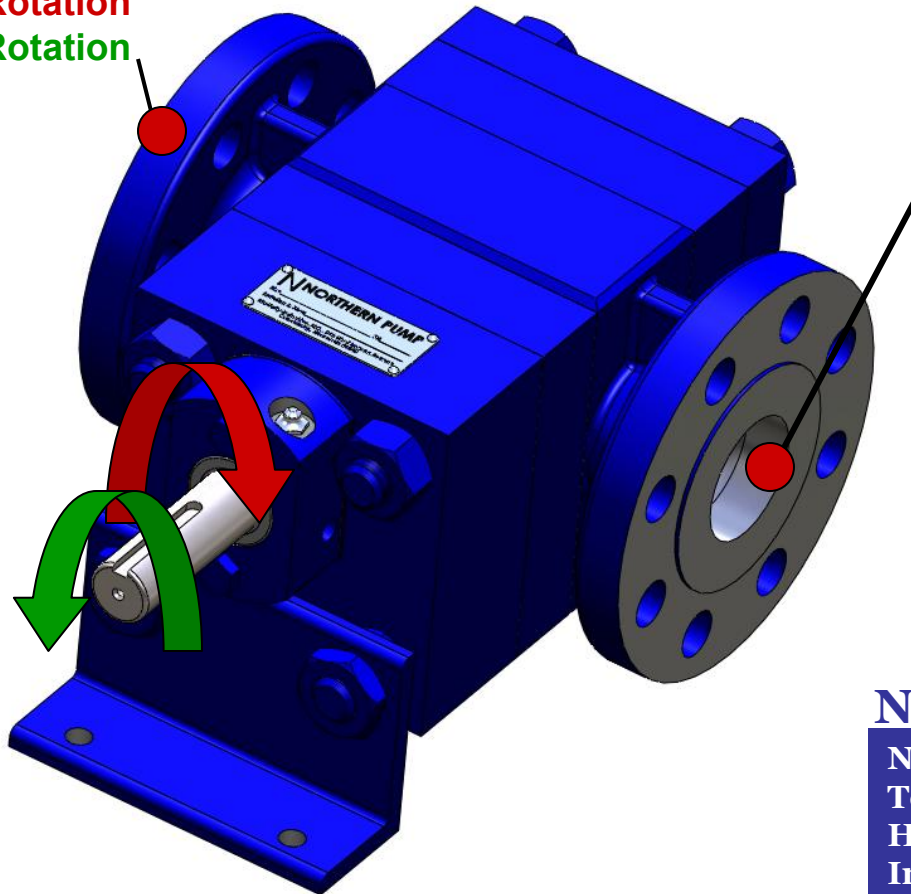
**Discharge-CW Rotation**
**Suction-CCW Rotation**

NORTHERN PUMP

**Northern® Fast Fact.....**

Northern pumps can be designed
To operate in either direction,
However they can only operate
In the manner they are designed.

## ● 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:

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

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

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.
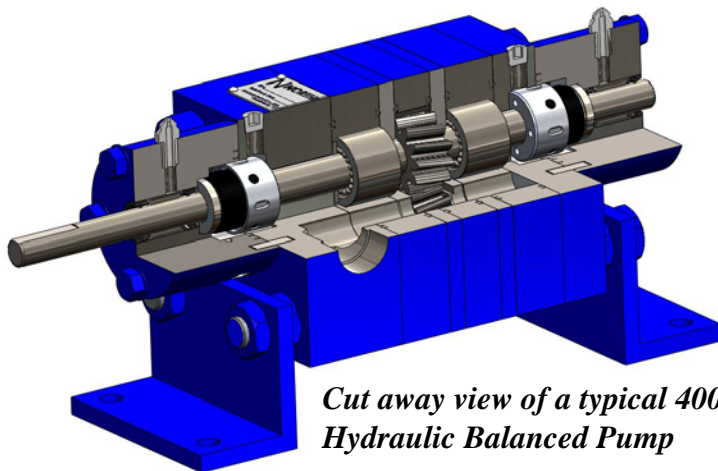


*Cut away view of a typical 4000 Series Hydraulic Balanced Pump*

## 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.

## ● 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.**

● **Differential pressure ($\Delta p$) –**

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 ($\Delta p_{max}$) -**

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 ($\Delta p_{max}$) of 2000 PSI.**

## ● 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 ($\eta_v$) –

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:

(Metric) $\quad \eta_v = \dfrac{16.7\,x10^3\,Q}{Dn} \times 100$

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

**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.**

## ● 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
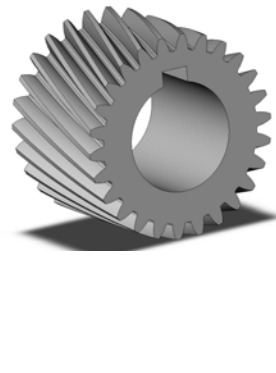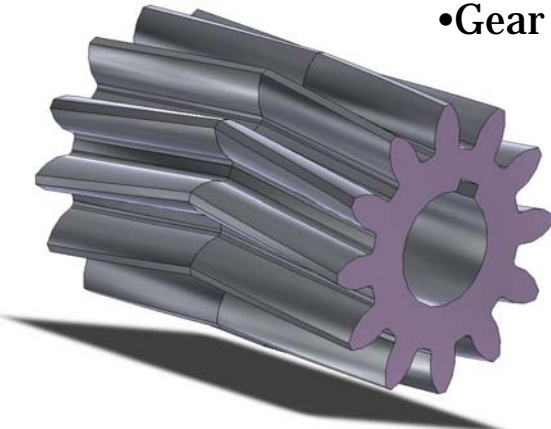
### Northern® Fast Fact.........

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

🔴 **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:

$$\left( \left( 1.493 \times 10^5 \right) \frac{\Delta P}{V^c} \right) \left( 2 \left( \frac{C^B}{2} \right)^3 \right) \left( \left( \frac{G^L}{V^1} \right) + \left( (C^S)^3 \left( (C^S) \left( \left( \frac{V^2}{V^3} \right) + \left( \frac{V^4}{V^5} \right) \right) \right) \right) \right)$$
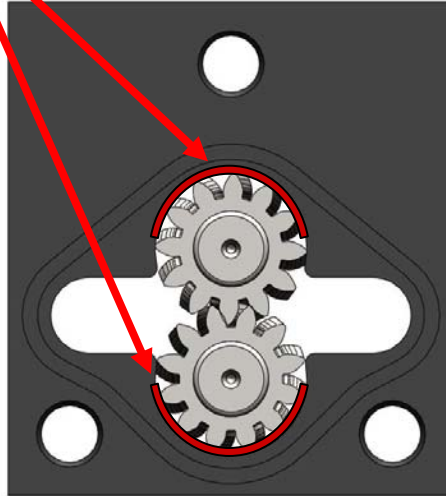
**Northern® Fast Fact.........**

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

## ● Bore Clearance –

The bore clearance 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.