Performance calculations for rotary positive displacement blowers require the use of several equations. These equations are presented below in the calculation order that is most logical. Typical equations are provided for both Roots and Sutorbilt.

Slip represents the amount of gas (air) which leaks back through the very small clearances which are present between the impellers and headplate, the impellers and the cylinder and between the impellers. The slip is the RPM (Revolutions per Minute) required to compensate for this leakage

$$Slip_{corrected} = Slip_{application} \cdot \sqrt{\frac{\Delta P_a}{\Delta P_s} \cdot \frac{P_s}{P_a} \cdot \frac{T_a}{T_s} \cdot \frac{G_s}{G_a}}$$

Where:

$Slip_{corrected}$	Slip of the unit at actual operating conditions (RPM)
$Slip_{application}$	Slip of the unit at 1 psi (measured in RPM)
ΔP_a	Differential Pressure in psi
ΔP_s	Standard Pressure rise = 1 psi
P_s	Standard Absolute Pressure in psia
P_a	Actual absolute inlet pressure in psia
T_a	Actual absolute inlet temperature in °R (°F+460)
T_s	Standard absolute inlet temperature in °R, 528°R
G_s	Standard Specific Gravity of air, 1.0
G_a	Actual Specific Gravity of gas

$Slip_{application}$ is determined by blanking off the discharge of a blower and rotating the blower at the speed that will generate a 1 psi at the discharge. This is also referred to as 1 psi slip.

G_a is determined by dividing the molecular weight of the desired gas by 28.964 which is the molecular weight of dry air.

$$G_a = \frac{MW_{Gas}}{28.964}$$

Blower or vacuum pump inlet volume can be calculated with the following equation:

$$Q_a = cfr \cdot \left(N - Slip_{corrected} \right)$$

Where:

Q_a	Actual Inlet Volume in cfm
cfr	Cubic Feet per Revolution (displacement)
N	Speed of unit in RPM (revolutions per minute
$Slip_{corrected}$	Slip of unit at actual operating conditions

If cfr is not known for a unit, one could estimate it with the following equation:

$$cfr = GD^2 \cdot CL \cdot 0.00137$$

Where:

GD	Gear Diameter in inches
CL	Cylinder Length in inches

This calculation for cfr assumes an 80% involute profile design.

The brake horsepower required to drive the blower is calculated with the following equation:

$$BHP = GHP + FHP$$

Where:

BHP	Brake Horsepower
GHP	Gas Horsepower
FHP	Friction Horsepower

A quick method to calculate Brake Horsepower to get you in the ball park is to use the following equation:

$$BHP = 0.00474 \cdot \Delta P \cdot N$$

Where:

ΔP	Differential Pressure between inlet and discharge in psi
N	Speed of the unit in RPM
0.00474	Represents a constant that includes 7.8% for friction losses

If you want to fine tune your brake horsepower calculation, the Gas Horsepower will be calculated separately from the Friction Horsepower. Gas Horsepower for a conventional rotary positive displacement blower can be calculated with the following equation:

$$GHP = 0.00436 \cdot cfr \cdot N \cdot \Delta P$$

The formula that is used for a Whispair® unit (jet - assisted) is:

$$GHP = F_g \cdot cfr \cdot N \cdot \Delta P$$

Fg must be obtained from a graph that has gear tip speed on the x-axis and Fg on the y-axis. This curve is specific for a particular series of units or a specific unit and is typically proprietary for the blower manufacturer.

Friction Horsepower can be calculated using several different strategies. All strategies require a Friction Horsepower provided by the manufacturer. This friction horsepower is typically based on either Friction Horsepower per 1000 RPM or Friction Horsepower at the maximum RPM which in turn can be related to gear tip speed.

Friction Horsepower per 1000 RPM can be defined as follows:

$$FHP = \frac{FHP \cdot N}{1000}$$

Friction horsepower defined by the maximum friction horsepower at the maximum speed is:

$$FHP_N = \left(\frac{N}{N_{max}}\right)^3 \cdot FHP_{max}$$

FHP/1000, FHP_N, FHP_{max} and N_{max} are supplied by the manufacturer.

Gear tip speed in fpm (feet per minute)can be calculated with the following equation:

$$0.262 \cdot GD \cdot N$$

Where:

GD   Gear Diameter in inches
N   Speed of shaft in RPM

We can now calculate temperature rise on the unit. Temperature rise is a critical calculation since the blower has limits on thermal growth. To much temperature rise and the impellers will expand into the headplates causing the unit to seize and possibly causing extensive damage to the unit.

Two formulas can be used. The first formula is only applicable to air and is as follows:

$$\Delta T = \frac{T_a \cdot BHP \cdot F_t}{0.01542 \cdot P_a \cdot Q_a}$$

The following formula can be used for any gas:

$$\Delta T = \frac{T_a \cdot BHP \cdot F_t \cdot (k-1)}{0.00436 \cdot P_a \cdot Q_a \cdot k}$$

Where:

T_a	Actual absolute inlet temperature in °R (°F+460)
BHP	Brake Horsepower
F_t	Temperature rise factor from manufacturers table
K	Ratio of specific heats for a gas c_p/c_v
P_a	Actual absolute inlet pressure in psia
Q_a	Actual Inlet Volume in cfm

Temperature rise exerts a couple additional limitations on rotary positive displacement blowers. Most manufactures impose an average temperature rule as well as a reduction in maximum allowable temperature rise when inlet gas temperatures exceed ambient conditions.

These two rules can be expressed mathematically as follows:

$$\frac{T_{suction} + T_{discharge}}{2} \leq 250°F$$

$$\Delta T_{allowable} = \Delta T_{max} - \frac{2}{3} \cdot \left(T_{suction} - T_{ambient} \right)$$

Where:

$T_{suction}$	Inlet Temperature in °F at blower inlet
$T_{discharge}$	Discharge Temperature in °F at blower discharge
$\Delta T_{allowable}$	Revised maximum allowable temperature rise
ΔT_{max}	Manufacturers maximum allowable temperature rise
$T_{ambient}$	Ambient Temperature around the blower in °F