Pump Basics

Affinity Laws
Affinity Laws for Centrifugal Pumps
The Affinity Laws - Formulas

- The Affinity Laws describe how changes in RPM (N) affect GPM, HEAD, and HP in centrifugal pumps. There are three laws:

\[
\text{GPM}_2 = \left( \frac{N_2}{N_1} \right) \times \text{GPM}_1
\]

\[
\text{HEAD}_2 = \left( \frac{N_2}{N_1} \right)^2 \times \text{HEAD}_1
\]

\[
\text{HP}_2 = \left( \frac{N_2}{N_1} \right)^3 \times \text{HP}_1
\]
Affinity Laws - The Effect

- Law 1 means that as RPM is reduced, flow (GPM) is reduced in a linear relationship. For example, if RPM drops to 70% of the original, GPM drops to 70% of the original.
The Affinity Laws - The Affect

- Law 2 means that as RPM is reduced, pressure (feet of head) is reduced by the square. For example, if RPM dropped to 70% of the original, feet of head would drop by \((70\% \times 70\%) = (0.7 \times 0.7) = 0.7^2 = 0.49 = 49\%\) of the original value.
The Affinity Laws - The Affect

- Law 3 means that as RPM is reduced, power consumption (brake horsepower) is reduced by the cube. In the same example, the power would drop to \((0.7 \times 0.7 \times 0.7) = (0.7)^3 = 0.343 = 34.3\%\) of the original value!
Original Performance

New Performance

System Curve (Friction)

Performance #2 Curve, 1050 RPM
Affinity Laws
An Example

- A UMC 50-80 circulator is operating at 1750 RPM. Flow is 50 GPM. Feet of head (friction) is 19 ft. Brake horsepower is 0.40. RPM decreases to 60% of maximum (1050 RPM). No other changes occur to the system.
- What is the new GPM?

\[
GPM_2 = \frac{1050}{1750} \times 50 \text{ GPM} = 30 \text{ GPM}
\]
Affinity Laws
An Example

• What is the new Head?

\[
\text{Ft. of Head}_2 = \left( \frac{1050}{1750} \right)^2 \times 19 \text{ Ft.} = 6.8 \text{ Ft.}
\]

• What is the new HP demand?

\[
\text{Horsepower}_2 = \left( \frac{1050}{1750} \right)^3 \times 0.40 \text{ hp} = 0.09 \text{ hp}
\]

A drop in horsepower of 78%!
THE BAD NEWS - The previous explanations and examples apply to systems where the system curve had not changed. Only RPM changed. When system curves change or when constant head or flow are required, the calculations become more complex.

THE GOOD NEWS - Affinity law theory helps us understand the principle of flow, head, and power dynamics. In practical application, Grundfos provides all the information you need to easily determine your energy savings with E-Pumps and BoosterpaQs. All you need to know is the system head and flow requirements to determine the right pump for the job. Grundfos pumps do the rest ... automatically!