

PART 1 From Mechanical Restriction to High-Efficiency Variable Speed Control

Date: March 2, 2026 Published by B&K Electric – Cliff Jones & Ethan Duvall

Executive Summary

In many legacy HVAC and industrial water systems, flow control is achieved through mechanical resistance. While effective for basic process control, methods like throttling valves and dampers are inherently wasteful, forcing motors to work at full capacity against artificial obstructions.

As a leading ABB VFD distributor, B&K Electric provides the technology and expertise to transition these systems from restricted flow to high-efficiency speed control. This white paper—the first in a two-part series—explores the inefficiency of mechanical restrictions. Part 2 will focus on the specific programming and parameter configuration of ABB VFDs to extract maximum energy savings from your application.

1 Legacy Control: The High Cost of Restriction

Centrifugal fans and pumps (non-positive displacement) typically utilize three primary "restriction" methods. These are considered "inefficient" because the motor continues to run at 100% line speed regardless of the required output.

Centrifugal Pumps: Discharge Throttling

A control valve is placed on the discharge side. To reduce flow, the valve is partially closed, increasing the system resistance.

- **The Inefficiency:** The pump operates at full speed; excess energy is dissipated as heat, vibration, and noise across the valve.
- **System Impact:** The System Curve shifts upward and becomes steeper, forcing the operating point back along the fixed-speed pump curve (see graph below).

Centrifugal Fans: Outlet Dampers

Dampers act as a mechanical "choke" at the fan discharge.

- **The Inefficiency:** High static pressure builds up behind the damper, leading to air turbulence and wasted Brake Horsepower (BHP).
- **System Impact:** Similar to pump throttling, this shifts the system resistance curve to the left, increasing pressure while decreasing volume.

Centrifugal Fans: Inlet Vane Control

Vanes located at the fan intake "pre-spin" the air in the direction of rotation.

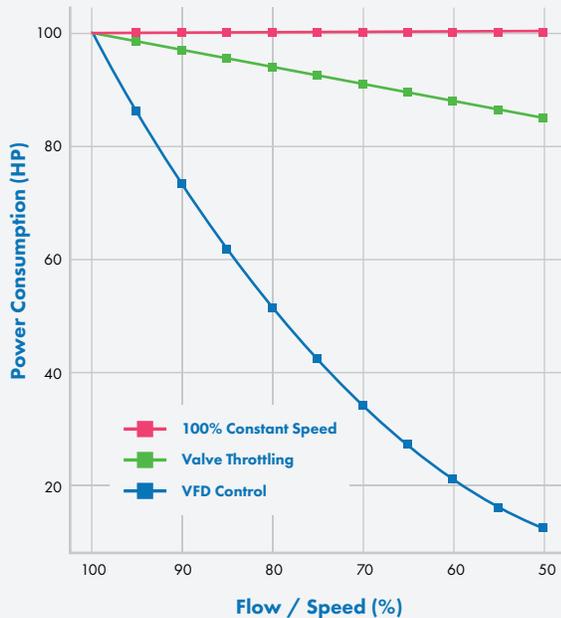
- **The Inefficiency:** While more efficient than outlet dampers, vanes still maintain a constant motor speed. Efficiency drops off sharply when flow is reduced below 80%.

2 The Efficiency Gap: Visualizing Performance

The fundamental difference between restriction and speed control is governed by the Affinity Laws. When using an ABB VFD to reduce speed rather than using a valve to restrict flow, power consumption drops by the cube of the speed reduction.

Operating Point Comparison

Pump Energy Consumption (100 HP Pump)



Efficiency Data Table:

METHOD	FLOW REDUCTION	POWER CONSUMPTION (APPROX.)
Discharge Throttling	50%	~85%
Inlet Guide Vanes	50%	~65%
ABB VFD (Unrestricted)	50%	~12.5%

3 Calculating Your ROI

B&K Electric utilizes the following formula to help our clients estimate the savings of moving to an unrestricted system:

The Power Formula:

$$P_{\text{new}} = P_{\text{base}} * (Q_{\text{target}} / Q_{\text{design}})^3$$

- **Example:** On a 100 HP pump motor throttled to 70% flow, an ABB VFD allows the motor to consume only 34.3 HP, whereas a throttling valve would likely still require 90 HP.

4 B&K Electric Best Practices: Preparing for VFD Integration

To ensure a successful transition to variable speed control, B&K Electric recommends the following pre-installation checklist:

- **Motor Insulation:** Verify the motor is "Inverter Duty" (NEMA MG-1 Part 31) to handle voltage spikes.
- **Bearing Protection:** For motors over 20 HP, we recommend shaft grounding rings to prevent electrical discharge machining (EDM).
- **Remove Mechanical Choke Points:** To maximize VFD ROI, fully open all manual valves and dampers. The VFD should be the sole "governor" of the system.
- **Filter Considerations:** If the cable run exceeds 50–100 feet, B&K Electric recommends a dV/dt filter to protect the motor windings.
- **Harmonic Mitigation:** We offer ABB drives with built-in impedance or active front-ends to minimize harmonic distortion on your building's grid.