Pioneering for You

Missing the Mark

Why Your Pump Isn't Operating at BEP

Every **centrifugal pump** is designed to operate most efficiently at a specific flow rate known as the **Best Efficiency Point (BEP).** At BEP, hydraulic forces inside the pump are more evenly distributed, resulting in smooth operation, minimal wear, and optimal energy efficiency.

BEP is not just a pump characteristic. It reflects how the pump and system interact. In real systems, pumps may operate away from BEP due to system changes, control methods, or selection issues.

What Is BEP?

The Best Efficiency Point (BEP) is the flow rate at which a pump operates most efficiently. At BEP, hydraulic forces inside the pump are balanced, resulting in:

- Maximum efficiency
- Minimum vibration and noise
- Lowest bearing and seal loads
- Longest equipment life

Operating close to BEP is a key goal of good pump system design.

Why Operating at BEP Matters

When a pump operates at or near BEP:

- Energy consumption is minimized
- Mechanical stress on bearings, seals, and shafts is reduced
- Reliability and uptime are improved
- Maintenance and lifecycle costs are lower

Deviating too far from BEP increases wear, energy use, and the risk of failure.

Consequences of Operating Away from BEP

Most pumps perform best when operating within the Preferred Operating Region (POR) (Image 1), defined by the Hydraulic Institute as *"the range of flow rates above and below BEP within which pump efficiency and operational reliability are not substantially degraded."* For pumps operating continuously at speeds of ≤ 4,500 rpm, the typical POR is 70% to 120% of BEP flow. Continuous operation outside this range should generally be avoided unless specifically approved by the pump manufacturer.

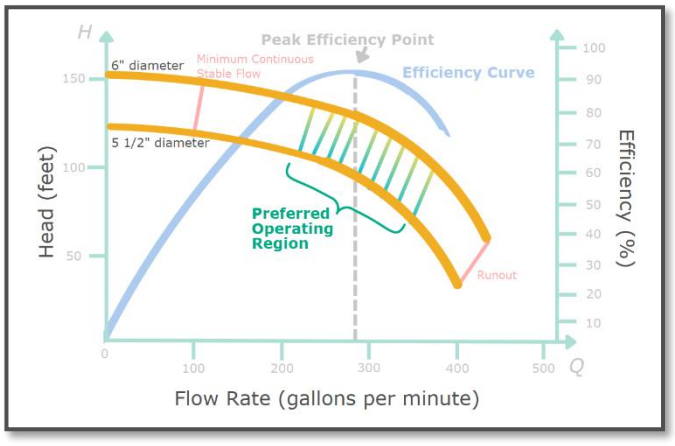

Image 1: *Preferred Operating Region*

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Operation far from BEP increases hydraulic instability, energy consumption, and the risk of premature equipment failure.

Operating Too Far Left (Low Flow)

- Increased radial thrust
- Higher vibration
- Internal recirculation
- Overheating
- Seal and bearing failures

Operating Too Far Right (High Flow)

- Cavitation due to increased NPSH required
- Motor overload from excessive power demand
- Increased vibration and hydraulic instability

Common Reasons a Pump is Not Operating at BEP

Reason	Explanation
System resistance changes	Valves partially closed, fouled strainers, scaling, or added system components shift the system curve and move the operating point away from BEP.
Pump oversized or improper selection	Pump flow or head exceeds actual system requirements, causing operation to fall left or right of BEP.
Operating conditions differ from design	Variable demand, seasonal changes, or intermittent operation prevent consistent operation at BEP.
Control method limitations	Excessive throttling, on/off cycling, or poorly tuned VFDs force the pump off its optimal point.
Wear or internal damage	Worn impellers, wear rings, or erosion increase internal losses, shifting BEP and reducing efficiency.
Air entrapment or cavitation	Trapped air, vapor pockets, or low **NPSH** reduce effective flow and efficiency, moving the operating point away from BEP.
Fouling (accumulation of unwanted material on internal surfaces) or blockages	Deposits in pipes, heat exchangers, or strainers reduce flow and head, preventing operation at the designed BEP.

How to Identify Potential BEP Problems in the Field

- Pump is noisy or vibrating excessively
- Frequent seal or bearing failures
- High energy consumption
- Flow or pressure does not match expectations
- Motor running near overload or lightly loaded

Remedies and Best Practices

Correcting off-BEP operation requires understanding whether the issue is operational, mechanical, or system-related. Some improvements can be made quickly in the field, while others require design or equipment changes.

Examples of Short-Term Remedies

Reason	Explanation
Adjust control valves or setpoints	Modifying valve positions or control setpoints changes system resistance or demand, shifting the operating point along the pump curve. This can bring the pump closer to BEP without changing the pump itself. Excessive throttling should be avoided due to energy loss.
Verify actual flow, head, and power	Measuring real operating conditions confirms if the pump is performing as expected. Comparing flow, differential pressure, and motor power to the pump curve identifies whether the pump is too far left or right of BEP and whether the issue is system-related, control-related, or due to internal wear.
Inspect for fouling, blockages, or air entrainment	Deposits in strainers, fouled heat exchangers, partially closed valves, or trapped air increase system resistance and reduce flow. Removing these restrictions restores the system curve closer to the original design, allowing operation nearer BEP and improving efficiency and stability.

Examples of Long-Term Remedies

Reason	Explanation
Resize or trim the impeller	Trimming the impeller reduces head and flow to match actual system requirements, shifting the pump curve, so the operating point aligns closer to BEP. This improves efficiency and reduces mechanical stress without replacing the pump.
Add or optimize VFD control	VFD adjusts pump speed to match system demand instead of throttling. Reducing speed moves the operating point toward BEP when the pump is oversized for the system, lowering energy consumption, vibration, and wear during part-load operation.
Select a pump better matched to actual operating conditions	If actual conditions differ from design, selecting a pump with a BEP closer to the true duty point minimizes off-design operation, improving long-term efficiency and reliability.
Redesign system piping or controls, if necessary	Pipe sizing, excessive fittings, valve placement, or improper control logic can prevent BEP operation. Updating the system improves hydraulic balance, reduces losses, and allows the pump to operate as intended.

Short-term fixes can improve performance quickly, but long-term reliability and efficiency are achieved by aligning the pump, system, and control strategy, so normal operation occurs near BEP.

Wilo is Your Solutions Provider

Operating near BEP is essential for achieving reliable, efficient, and long-lasting pump performance. When pumps operate away from BEP, the root cause is often a mismatch between the pump, the system, and actual operating conditions. **Wilo** supports system designers, engineers, and operators by applying proven hydraulic expertise to accurately match pumps to their applications. Through proper selection, system analysis, and control strategies, Wilo helps ensure pumps operate as close to BEP as possible, maximizing efficiency, protecting equipment, and delivering long-term system reliability.

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