Reading Centrifugal Pump Curves — Duty Point, Affinity Laws and NPSH Without Mystery

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How a Q-H curve and the system curve pick the duty point for you, what the affinity laws honestly promise when speed or impeller diameter changes, NPSH available versus required with the margin that prevents cavitation, and minimum-flow discipline — the four ideas behind every correct pump purchase.

Two curves, one operating point

A centrifugal pump delivers along its Q-H curve (head falls as flow rises); the pipework demands along the system curve (static head plus friction rising with flow squared). The pump runs where they cross — not where the datasheet's rated point sits. Every oversizing story is a system curve crossing the pump curve far right or left of best efficiency: right of BEP eats NPSH margin and motors, left of it recirculates, heats and shakes. Specify by the real system curve, then choose a pump whose BEP straddles it — the stocked CR10-5 (type key logic in the decoder) and NB32-125 families exist in fine steps for exactly this reason.

Affinity laws: proportional, squared, cubed

Change speed (or trim impeller) | Effect |

Flow | " n — half speed, half flow |

Head | " n^2 — half speed, quarter head |

Power | " n^3 — half speed, one-eighth power |

That cube is why VFDs (VLT guide) pay for themselves on friction-dominated systems — and why they disappoint on high-static-head systems, where reduced speed soon fails to reach the static lift at all. Impeller trimming follows the same laws approximately over modest trims; the NB type key carries the trim diameter openly (NB32-125).

NPSH: the suction side writes the rules

NPSHa (available) = atmospheric pressure + static suction head " friction losses " vapour pressure, all at the impeller eye. Hot liquids slash it through vapour pressure; suction strainers (guide) slash it through friction as they load.

NPSHr (required) is on the pump curve, rising steeply with flow.

Rule: NPSHa "e NPSHr + 0.5 m margin (more for hot or volatile media). Below it, cavitation: gravel noise, falling head, eaten impellers — and a seal life measured in months (seal guide).

Minimum flow and the dead-head myth

A centrifugal pump at closed valve does not build infinite pressure — it churns its shut-off head and turns the power into heat. Small pumps survive moments of it; run continuously below minimum continuous flow (per curve, often ~10–30 % of BEP flow), the liquid overheats, flashes and destroys seals and bearings. Systems that can dead-head get a bypass/min-flow line. Vibration at the nozzles is the compensator guide's subject; the positive-displacement world plays by opposite rules (ROTAN guide — there, a relief valve is mandatory).

For a sizing enquiry, five numbers answer everything: flow, total head (or the system's static head + pipe run), medium and temperature, suction condition, and electrical supply — quoted against stocked ranges within 24 hours.

Frequently asked questions
Why does my pump deliver more flow than rated — and trip the motor?The system has less resistance than designed, so the duty point slid right down the curve into higher flow and power. Trim the impeller, throttle to the design point, or accept the re-rate after checking NPSH — run-out operation is the classic oversized-pipe surprise.How much speed reduction can a VFD give on a pump?On friction-dominated circuits, plenty — power falls with the cube of speed. With high static head, little: below the speed whose shut-off head equals the static lift, flow stops entirely. Plot the system curve before promising savings.What actually causes cavitation?Local pressure at the impeller eye falling below the liquid's vapour pressure — bubbles form and collapse against metal. It is always a suction-side accounting problem: NPSH available fell below NPSH required plus margin.Can a centrifugal pump run against a closed discharge valve?Briefly — it churns at shut-off head while the power heats the trapped liquid. Continuous operation below minimum flow cooks seals and bearings; sustained dead-head needs a minimum-flow bypass. (Positive-displacement pumps must never be dead-headed at all.)What is the best efficiency point and why does it matter for reliability?The flow where the impeller and casing geometry match the velocity triangles — minimum recirculation, radial load and vibration. Pumps live longest within roughly 80–110 % of BEP flow; the further off, the faster bearings and seals pay.

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