Centrifugal Pump Performance Modification

Presenter: Randal Ferman, PE

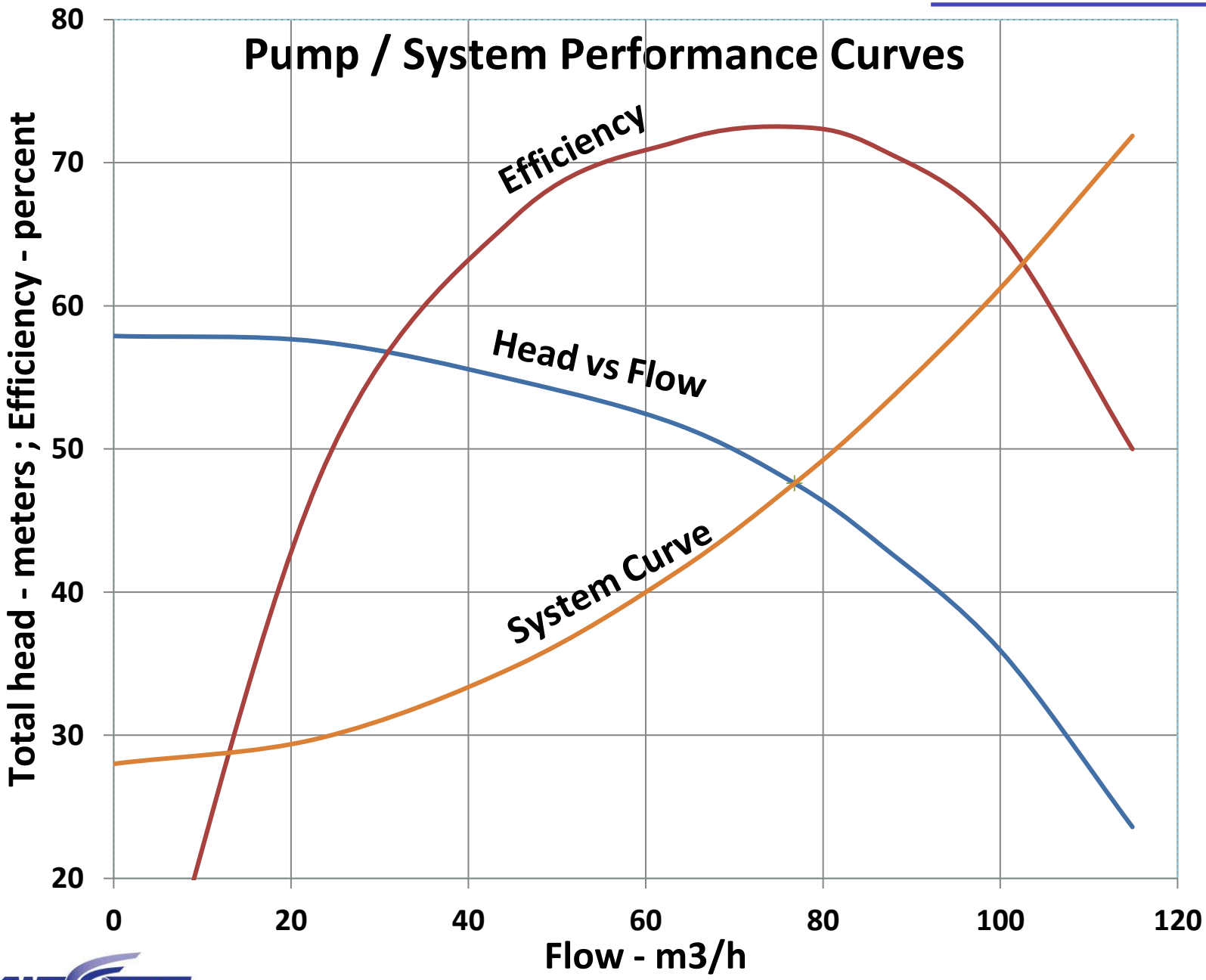
Empowering Pumps & Industry Conference
November 8 – 9, 2023
The Water Tower, Buford, Georgia

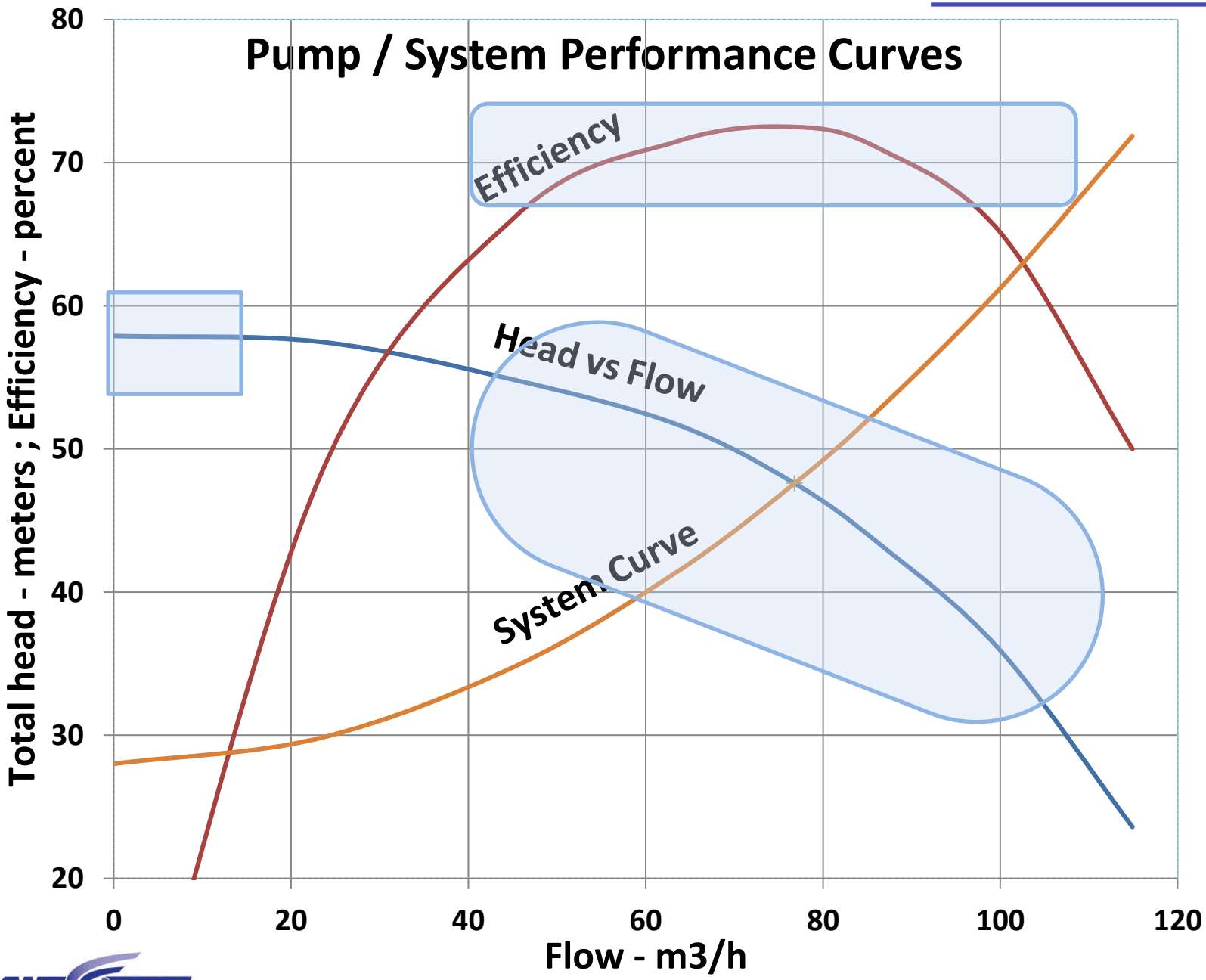
EKWESTREL

Performance modification options

- Total Head and Rate of Flow
- Head rise characteristic
- Shutoff (closed valve) head
- Best Efficiency Point (BEP)
- Efficiency improvement

EKWESTREL





Performance modifications (cont.)

- NPSH Required
- Onset of recirculation
- Pressure pulsations

EKWESTREL

Modification elements

- Impeller
  - diameter trim
  - vane exit tip filing
  - vane inlet trimming and shaping
- Volute or diffuser
  - tongue cut-back or diffuser vane trim
  - leading edge shaping
  - install insert or new diffuser

EKWESTREL

Modification elements (cont.)

- Clean, polish, or coat surfaces
- Flow conditioning
  - Upstream
  - Discharge

EKWESTREL

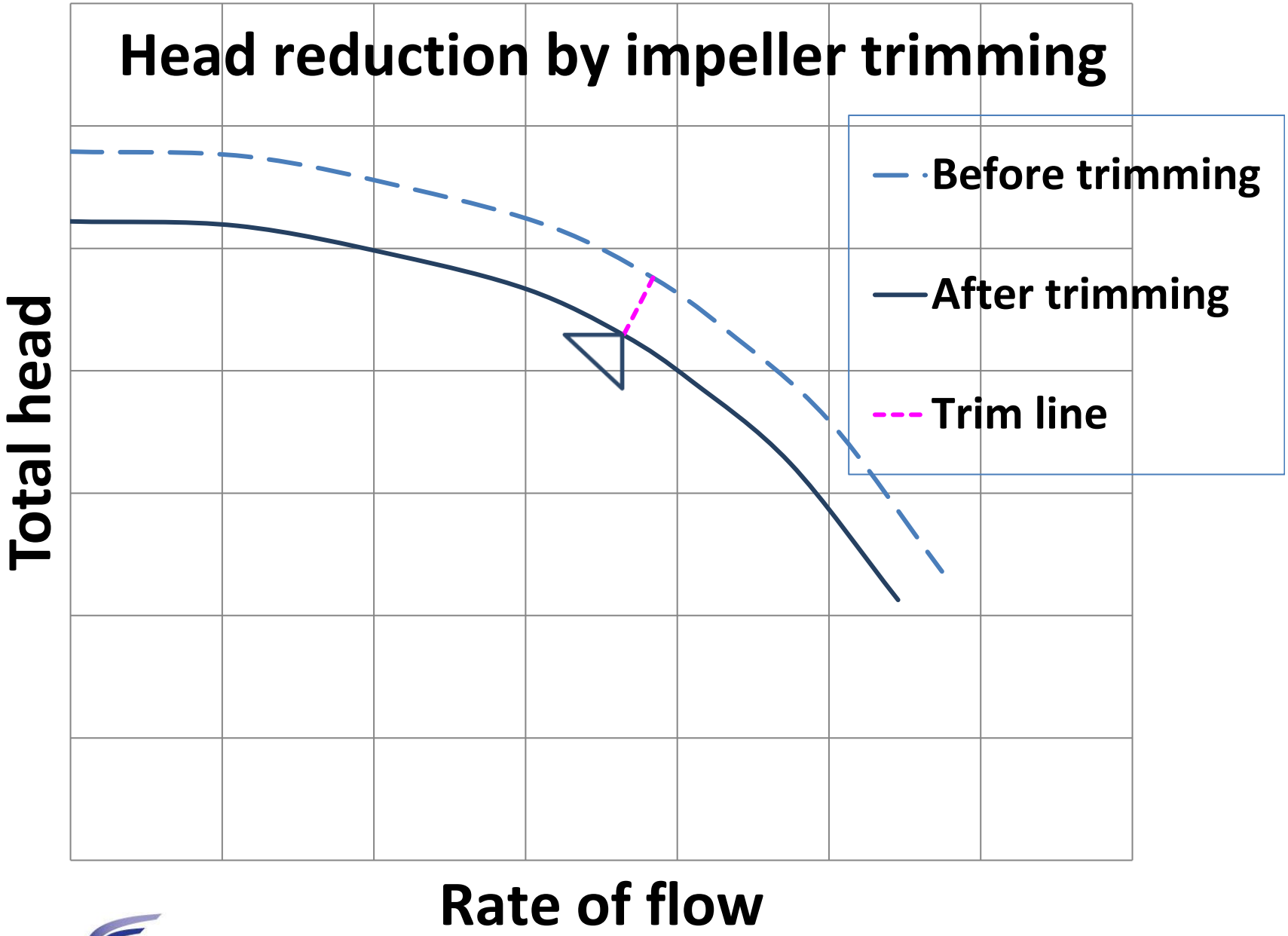
Head Rise Adjustment

‘Total Head’ Nomenclature

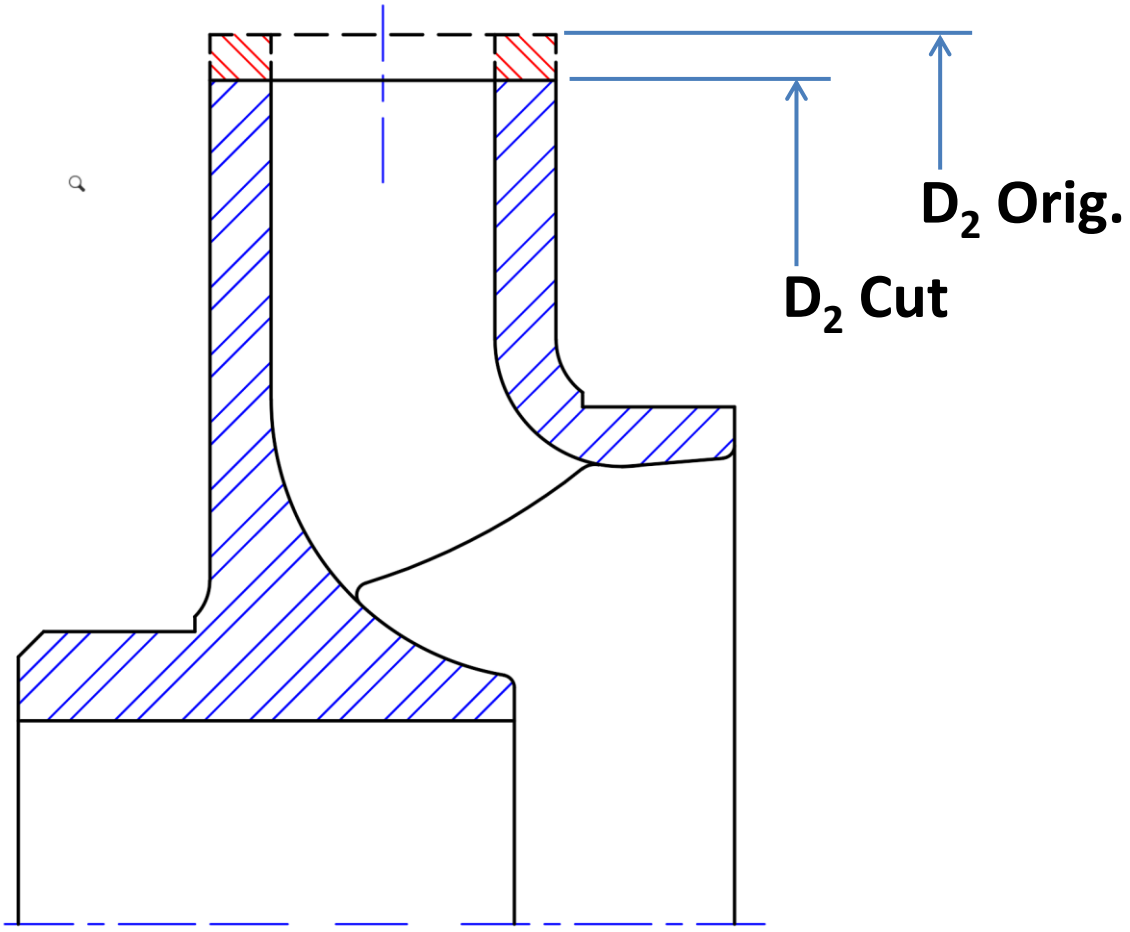
also known as:

- Head
- Developed Head
- Total Dynamic Head (TDH)
- (Pump) Differential Pressure
- Lift (sort of a misnomer)

EKWESTREL



Impeller trim – normal straight cut



Affinity laws (rules) for impeller trim

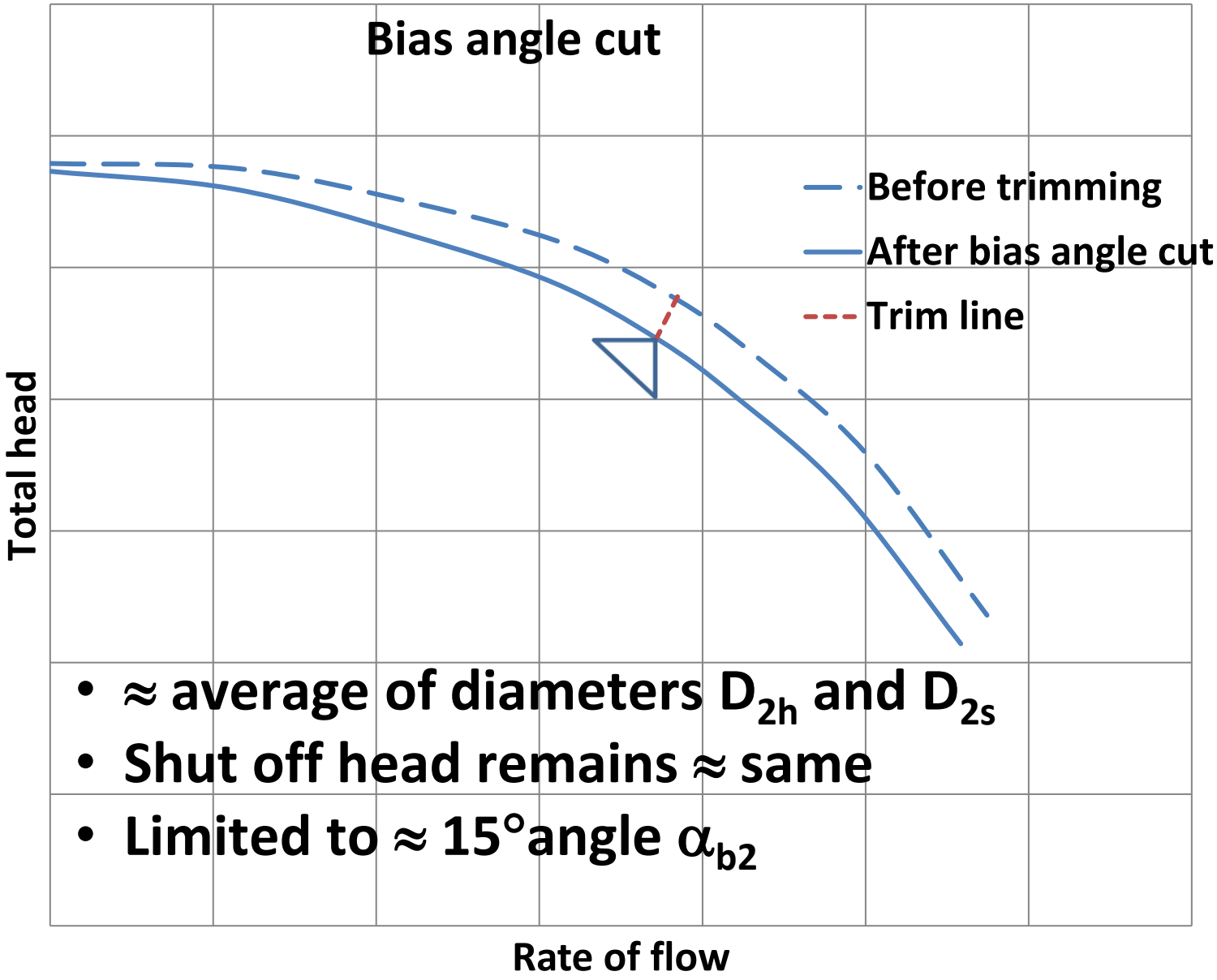
$$Q' = Q \times \left({D_2}' / D_2 \right)$$

$$H' \cong H \times \left({D_2}' / D_2 \right)^2$$

Highly predictable* when (D2’ / D2) ≥ 0.95

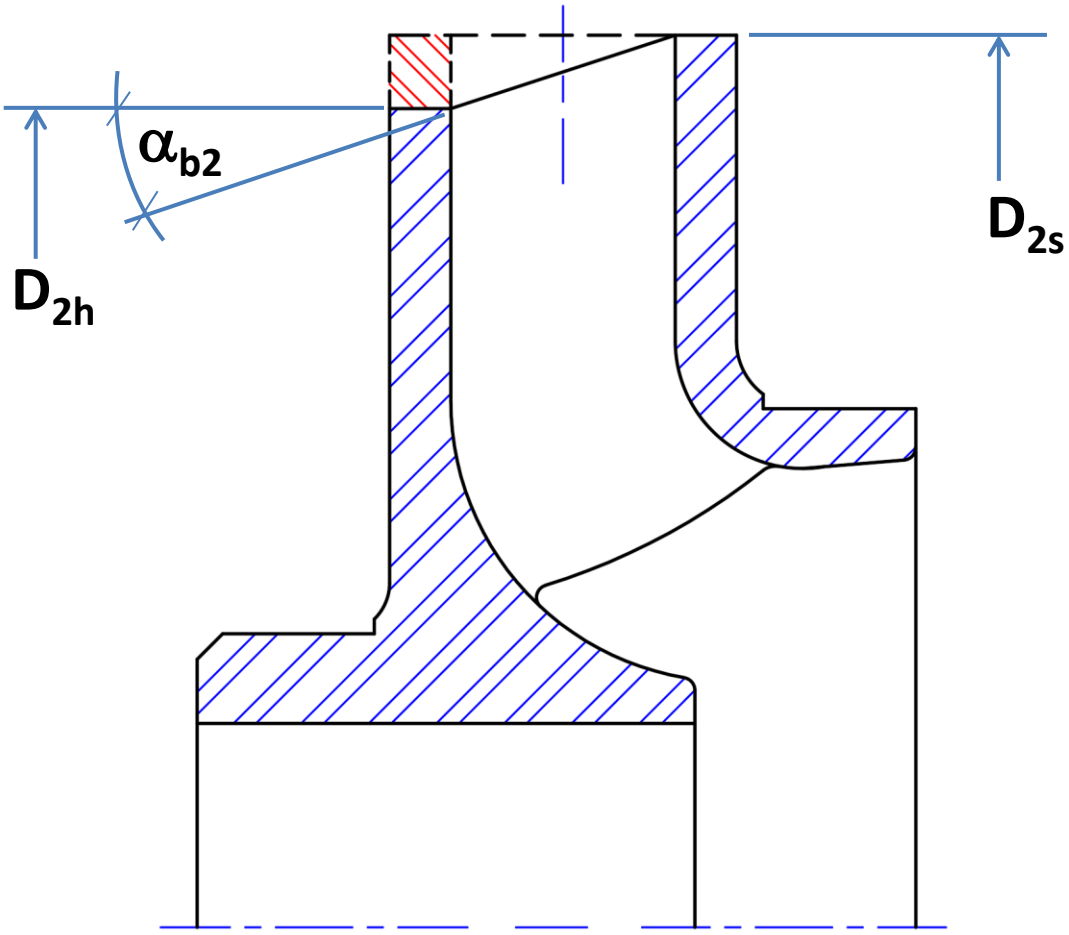
*** for low to medium values of Ns**

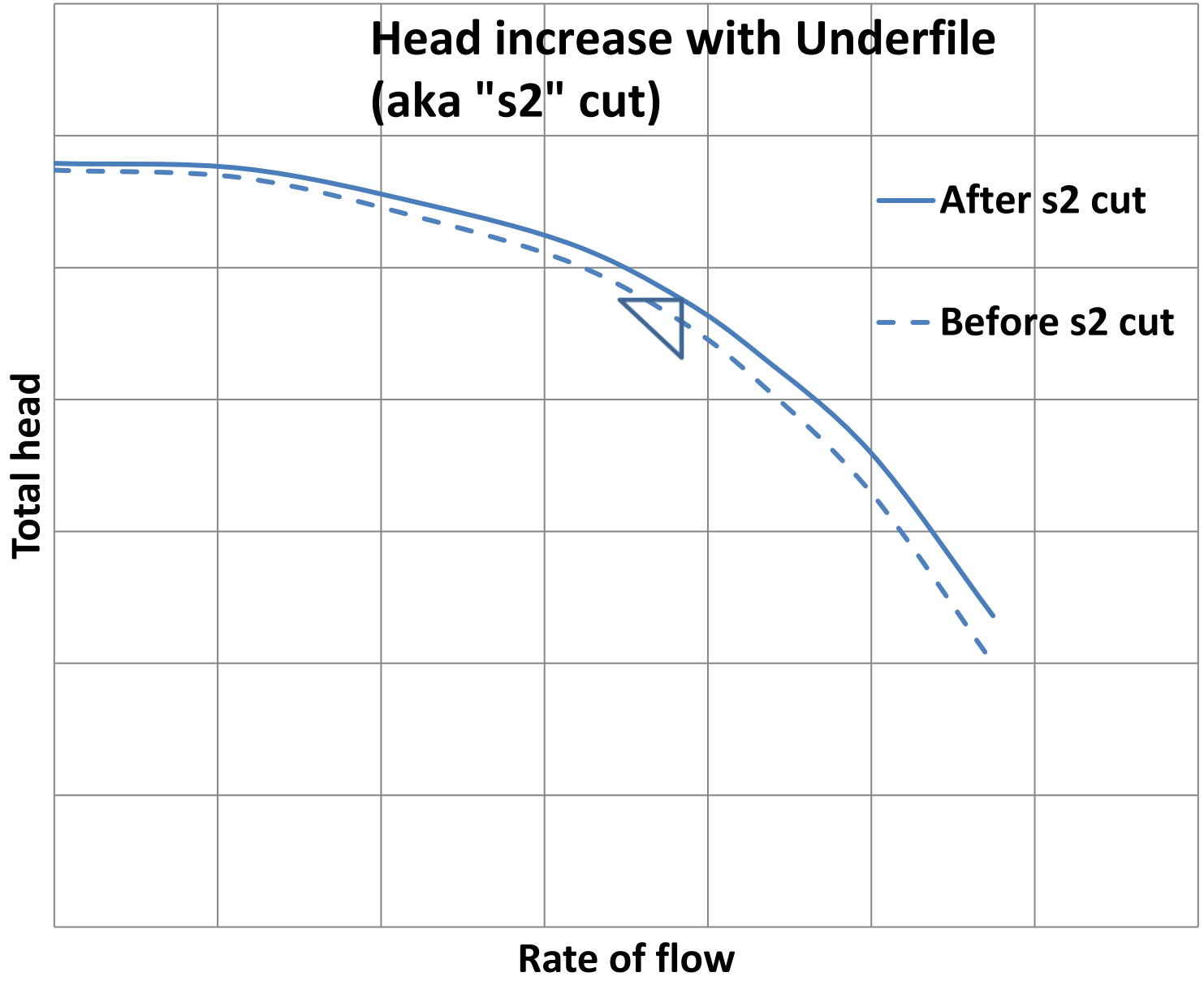
EKWESTREL



- ≈ average of diameters D_{2h} and D_{2s}
- Shut off head remains ≈ same
- Limited to ≈ 15°angle α_{b2}

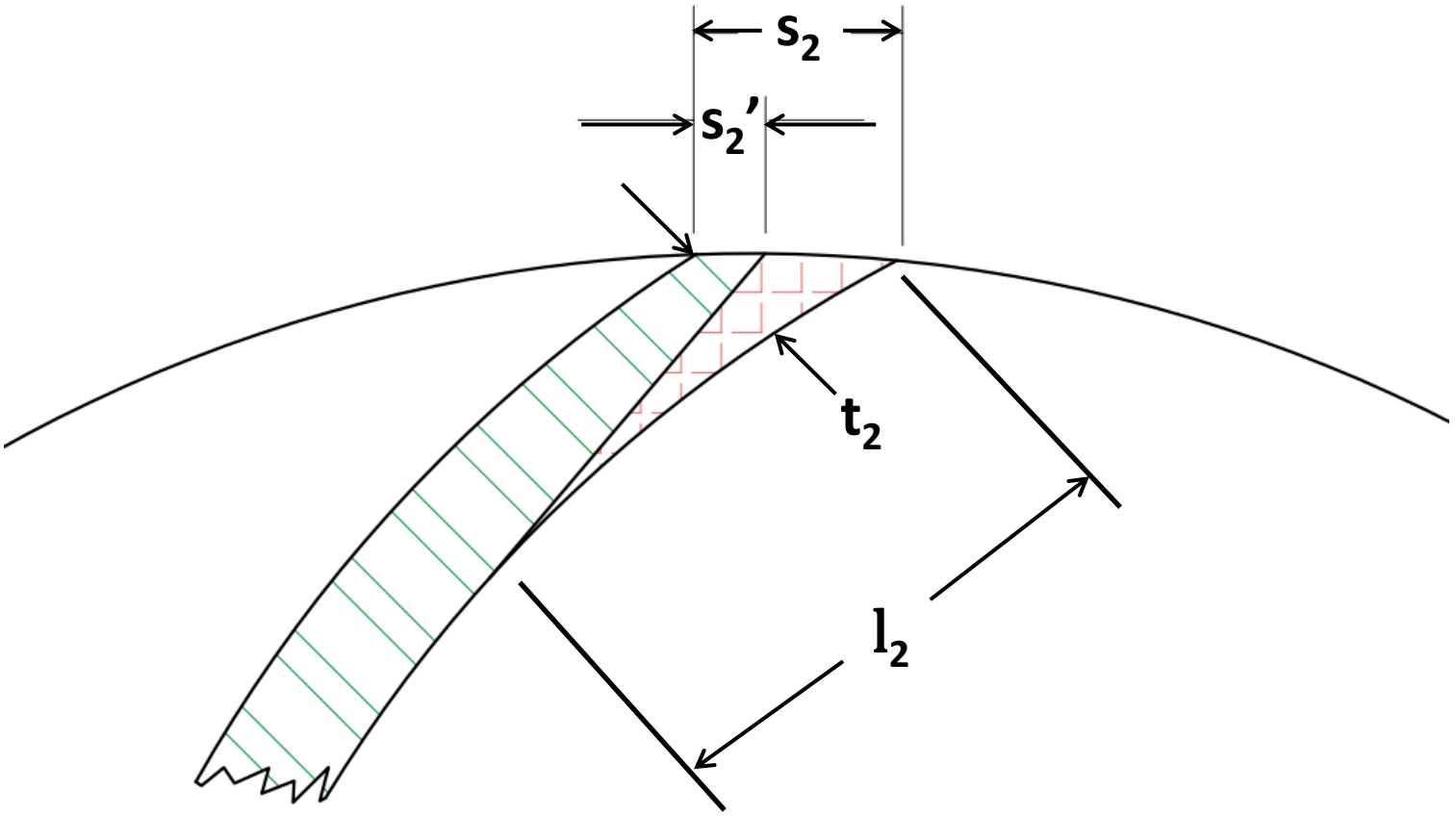
Impeller trim – bias angle cut





EKWESTREL

Vane underfile (s_2 cutting)

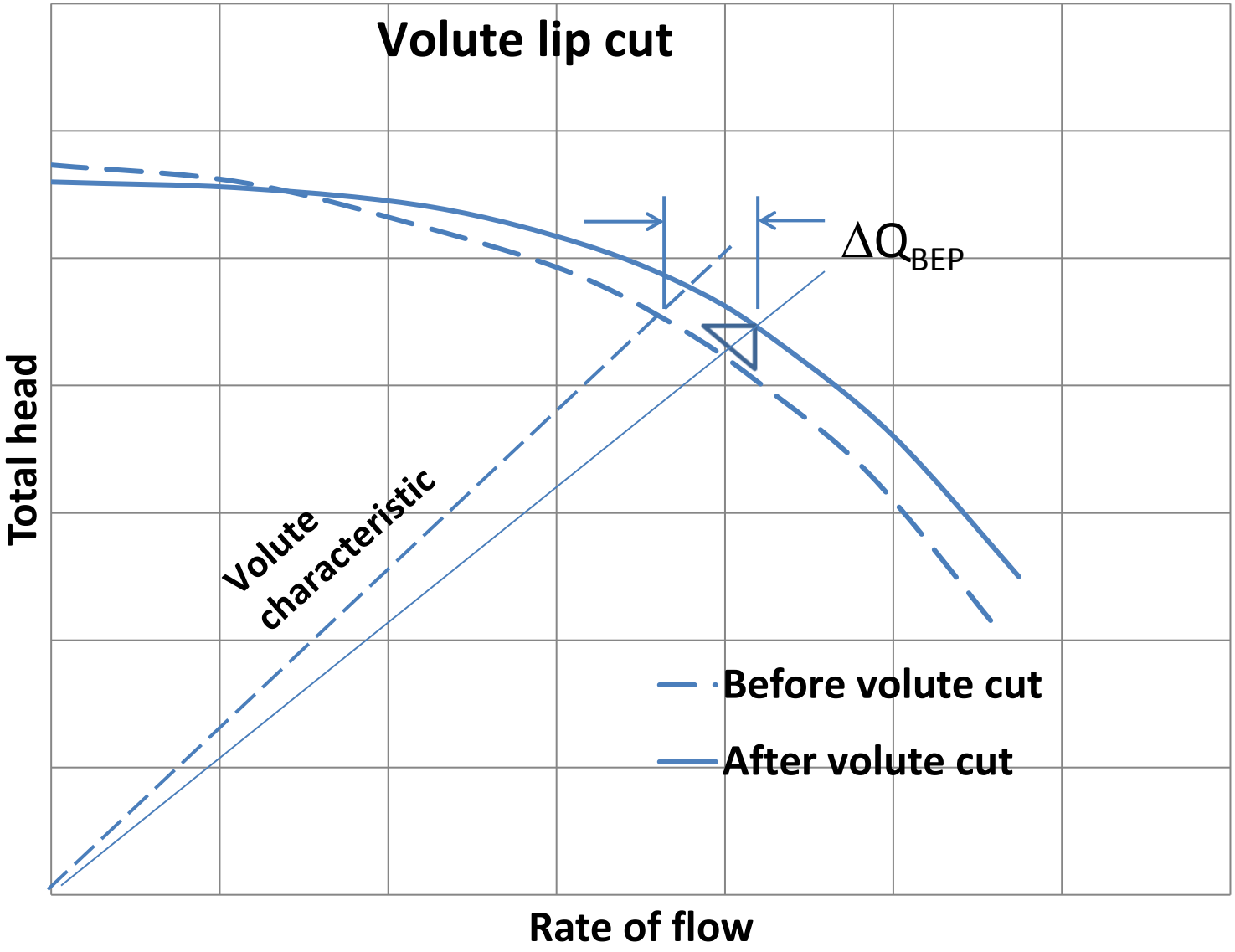


Underfile (s_2 cutting)

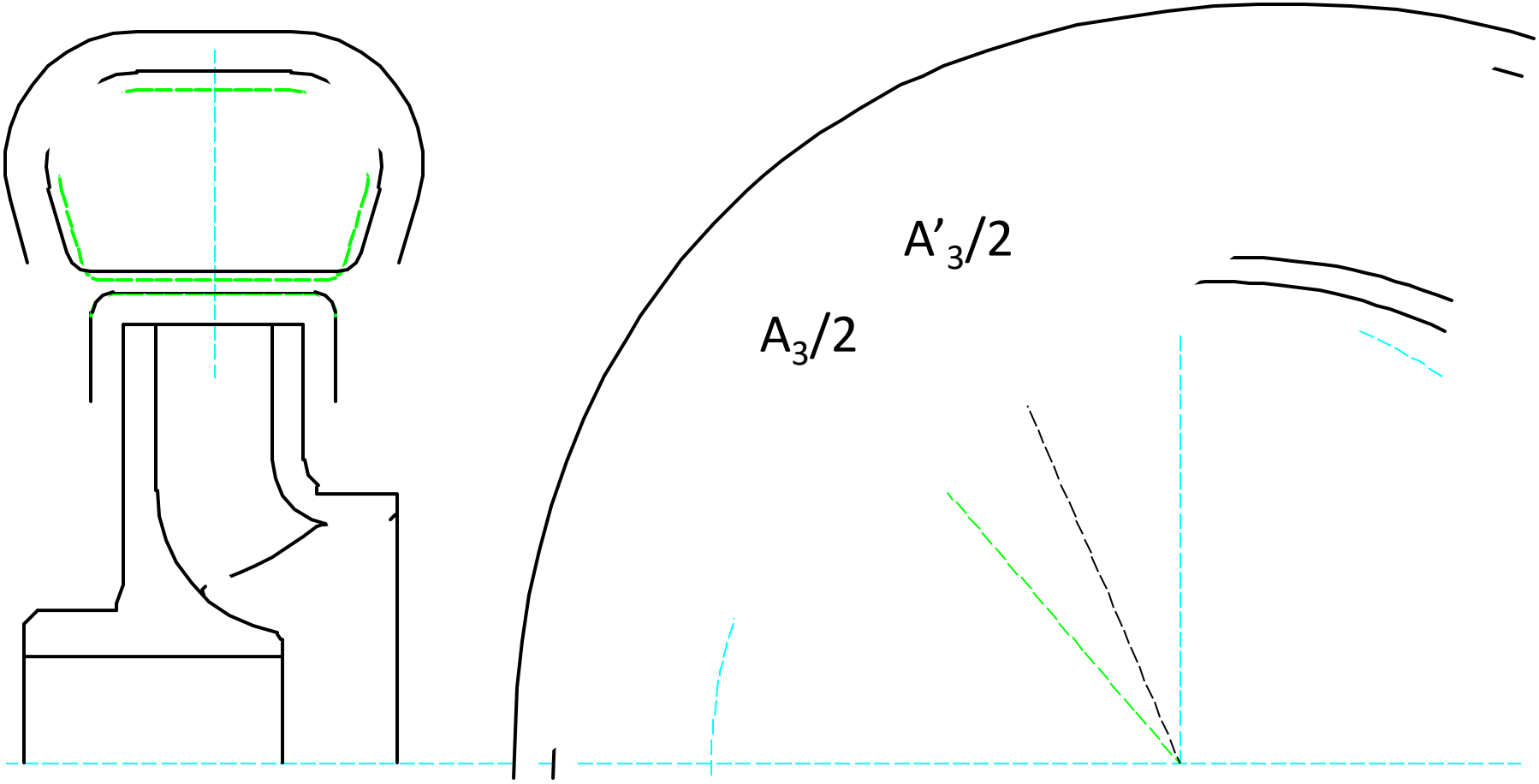
- Initial s_2 cut yields greatest increase
- Max. head increase approx. 4% to 10%
- Factors:
  - pump specific speed (N_S)
  - vane number (Z)
  - vane thickness (t_2)
- Analytical estimates are possible

EKWESTREL

Stator (Volute or Diffuser) Adjustments



Volute / diffuser cut-back



Volute lip cut-back

Approximate change in BEP flow, $\Delta QBEP$

$$\Delta QBEP \approx QBEP \times \left({A_3}' / A_3 \right)^{0.50}$$

A_3 – initial volute throat area

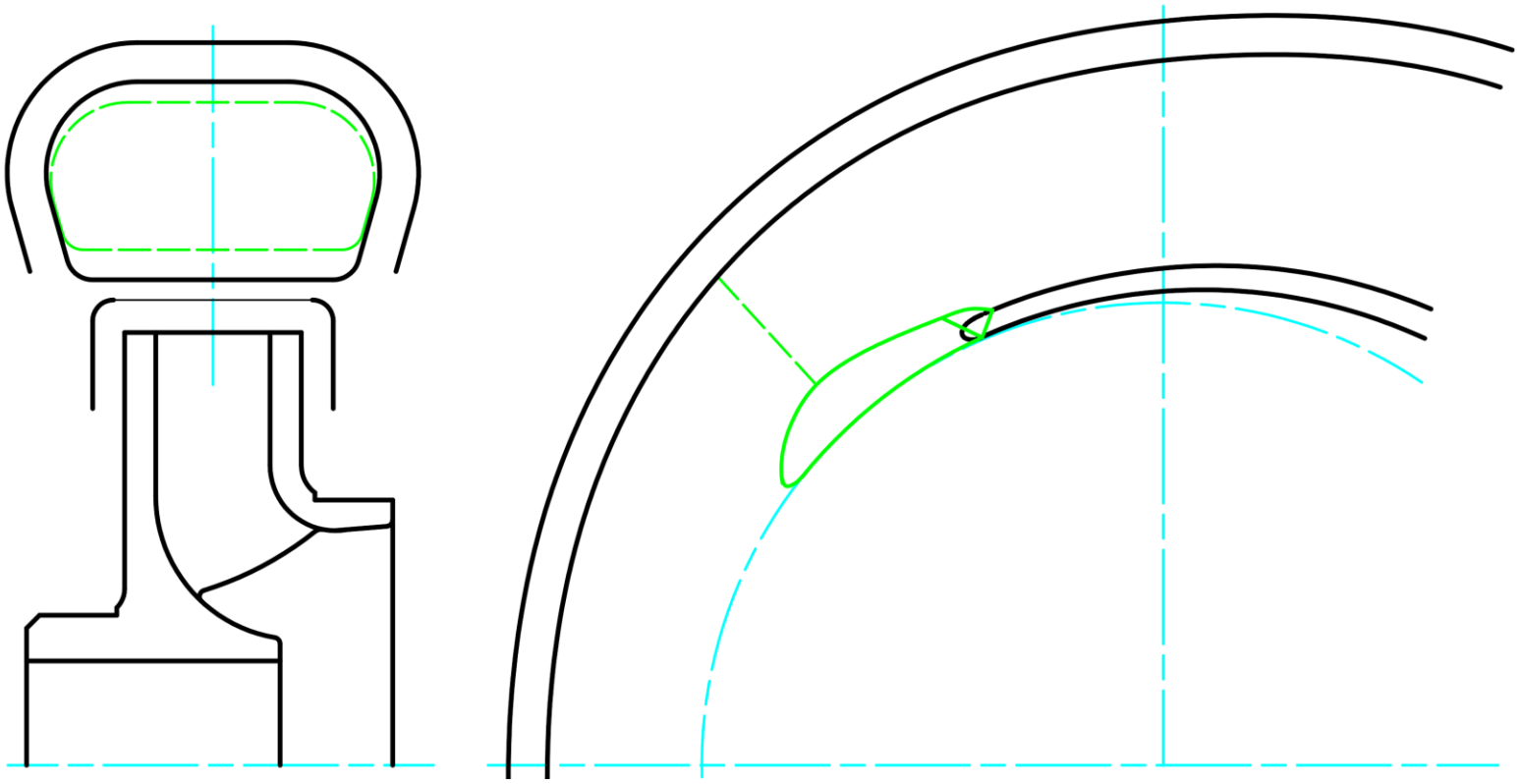
A_3' – modified volute throat area

Alternatively, use scaling rules:

Start with scale factor f ≅ $\left({A_3}' / A_3 \right)^{0.50}$

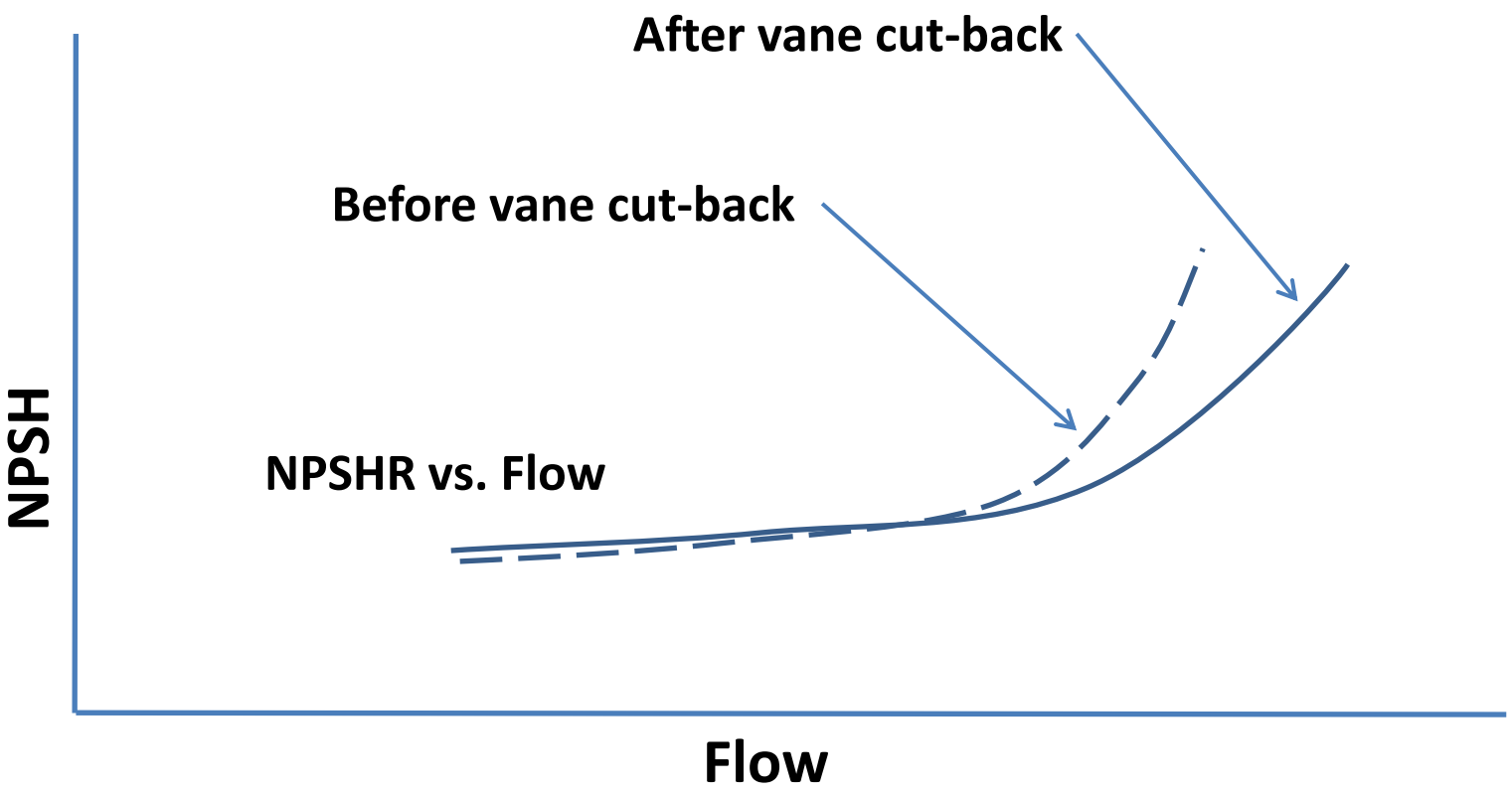
EKWESTREL

Volute throat area reduction

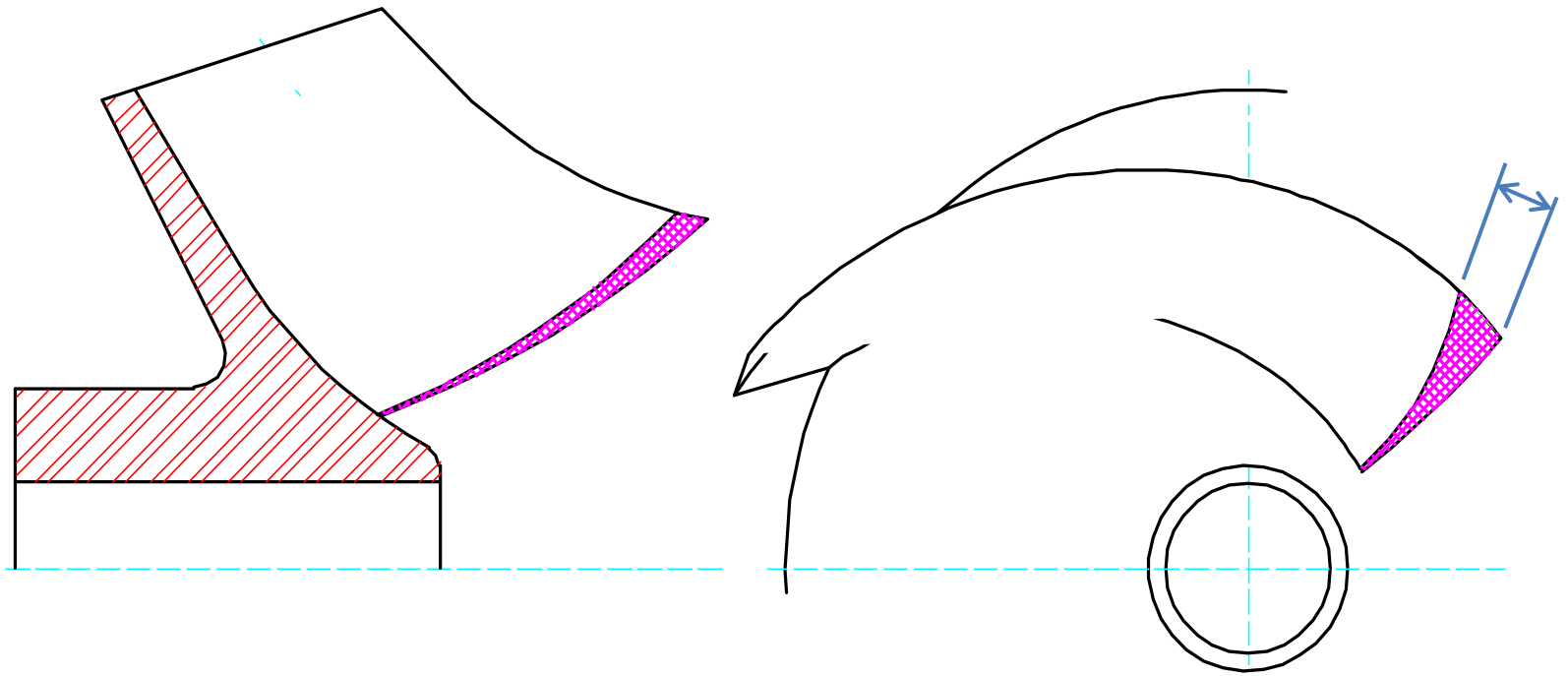


Suction Flow or NPSH Adjustment

NPSHR modification



Impeller vane leading edge cut-back

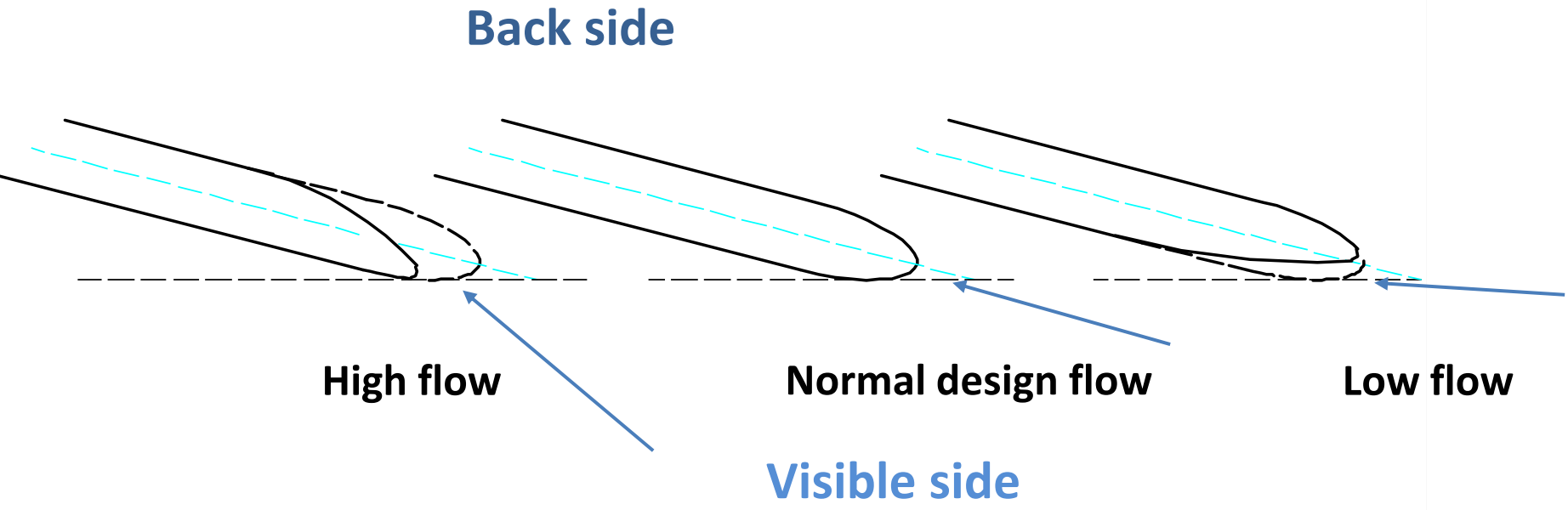


Leading edge performance modification factors

- Suction design flow
- Intake arrangement
- Vane number
- Blade thickness
- Area between vanes
- Shape of leading edge

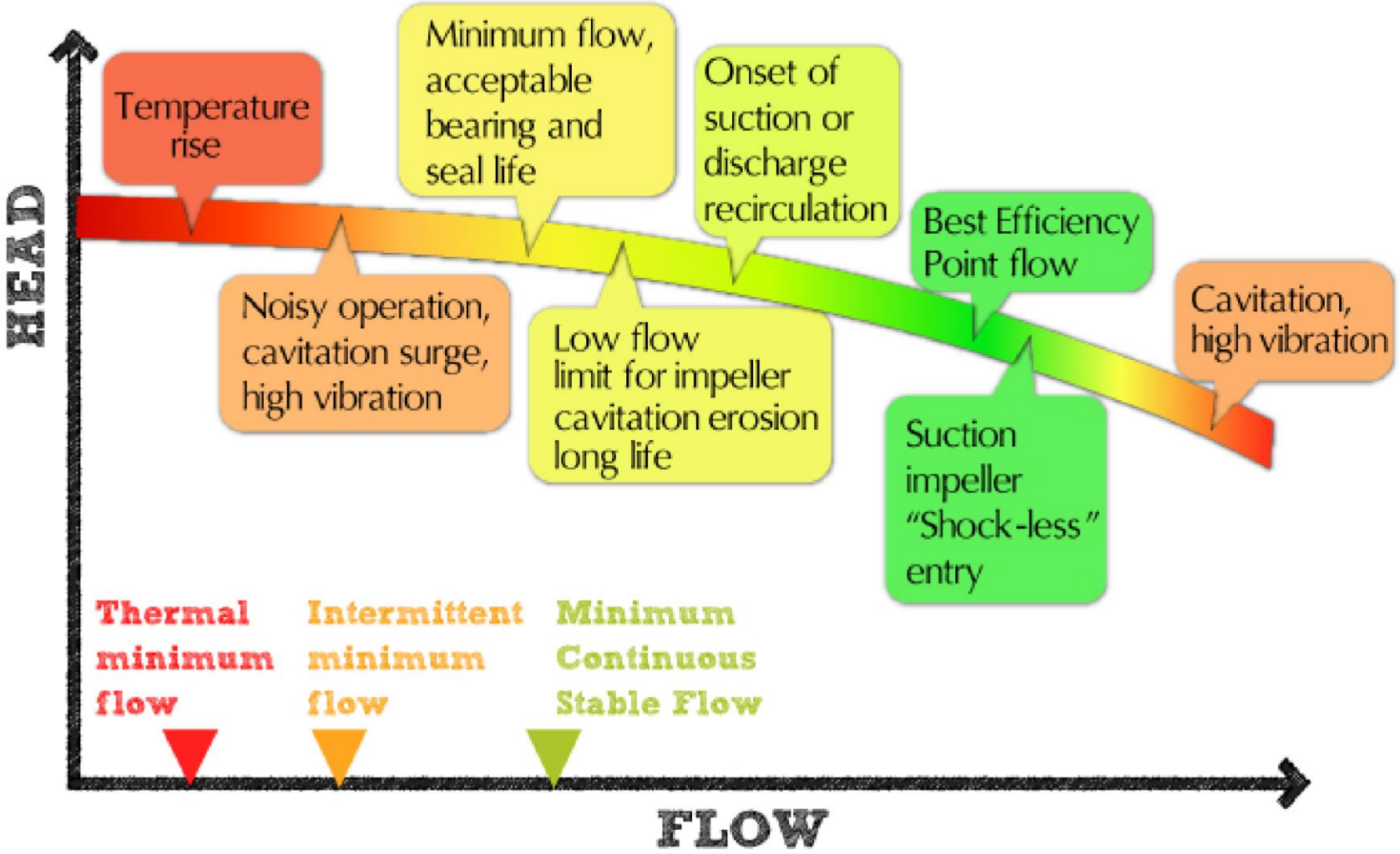
EKWESTREL

Leading edge modification



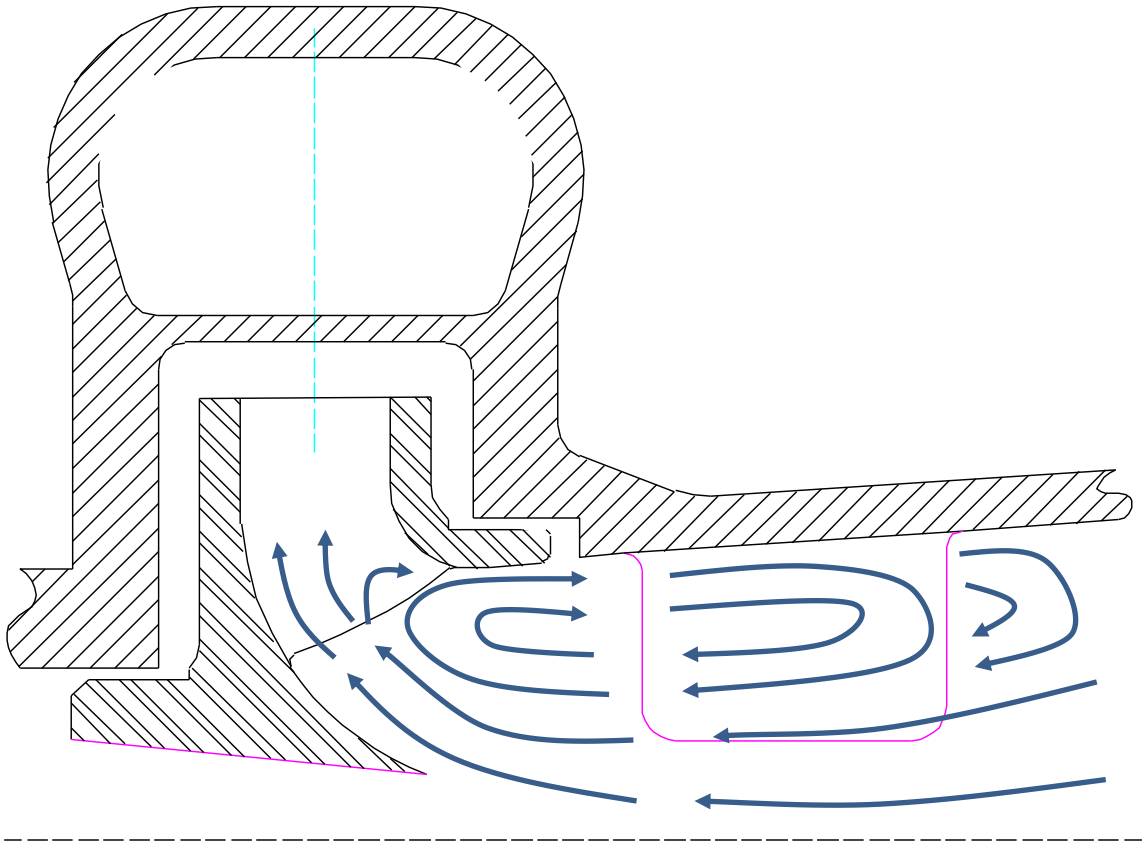
Off Design Effects

Pump phenomena versus flow

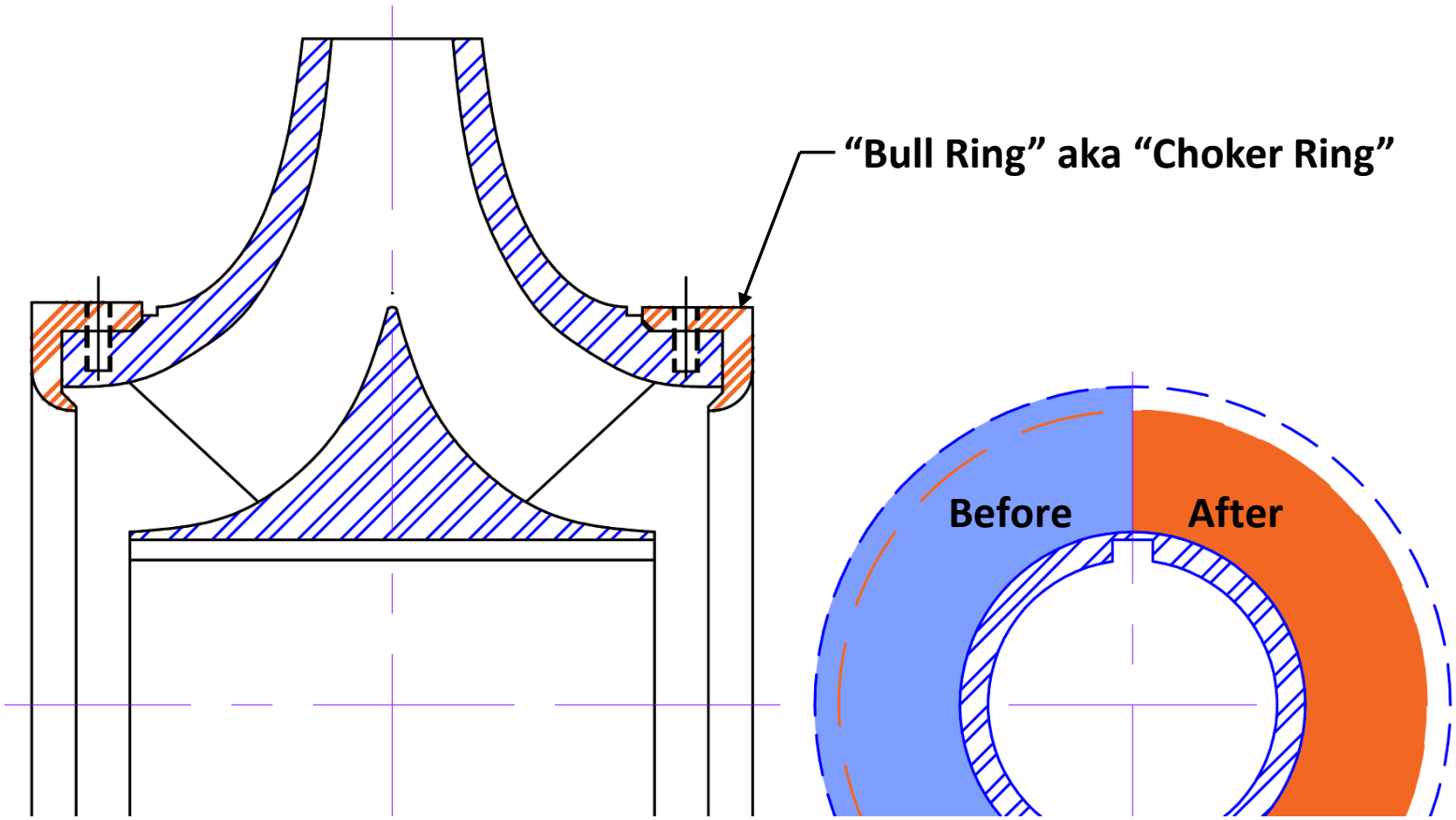


EKWESTREL

Suction recirculation

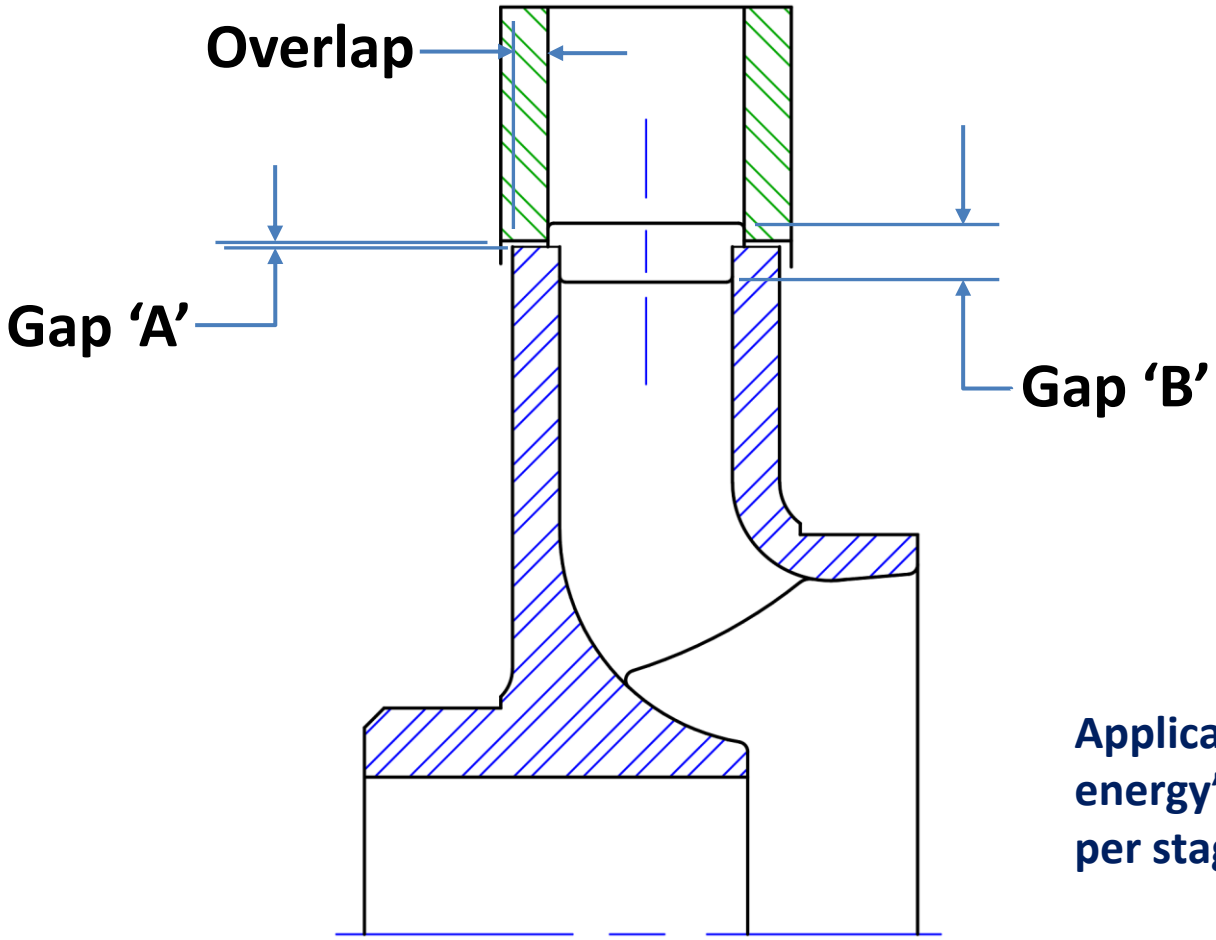


Eye Area Modification



EKWESTREL

Shroud-to-Casing Gap



Applicable to ‘high energy’ / high head per stage pumps.

EKWESTREL

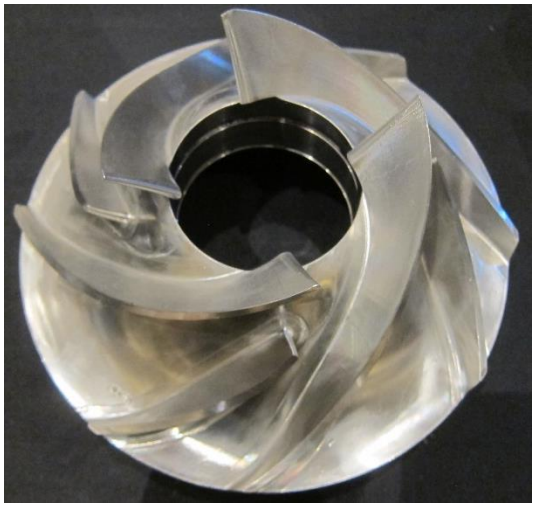
Surface roughness and polishing

Efficiency improvement factors:

- Physical size of pump
- Relative change in surface roughness
  - small pumps, up to +3 to +5 points
  - medium size pumps, +1 to +2 points
  - large scale pumps, < +1 point

EKWESTREL

Surface Finish Examples



EKWESTREL

Final slide for: Centrifugal Pump Performance Modification