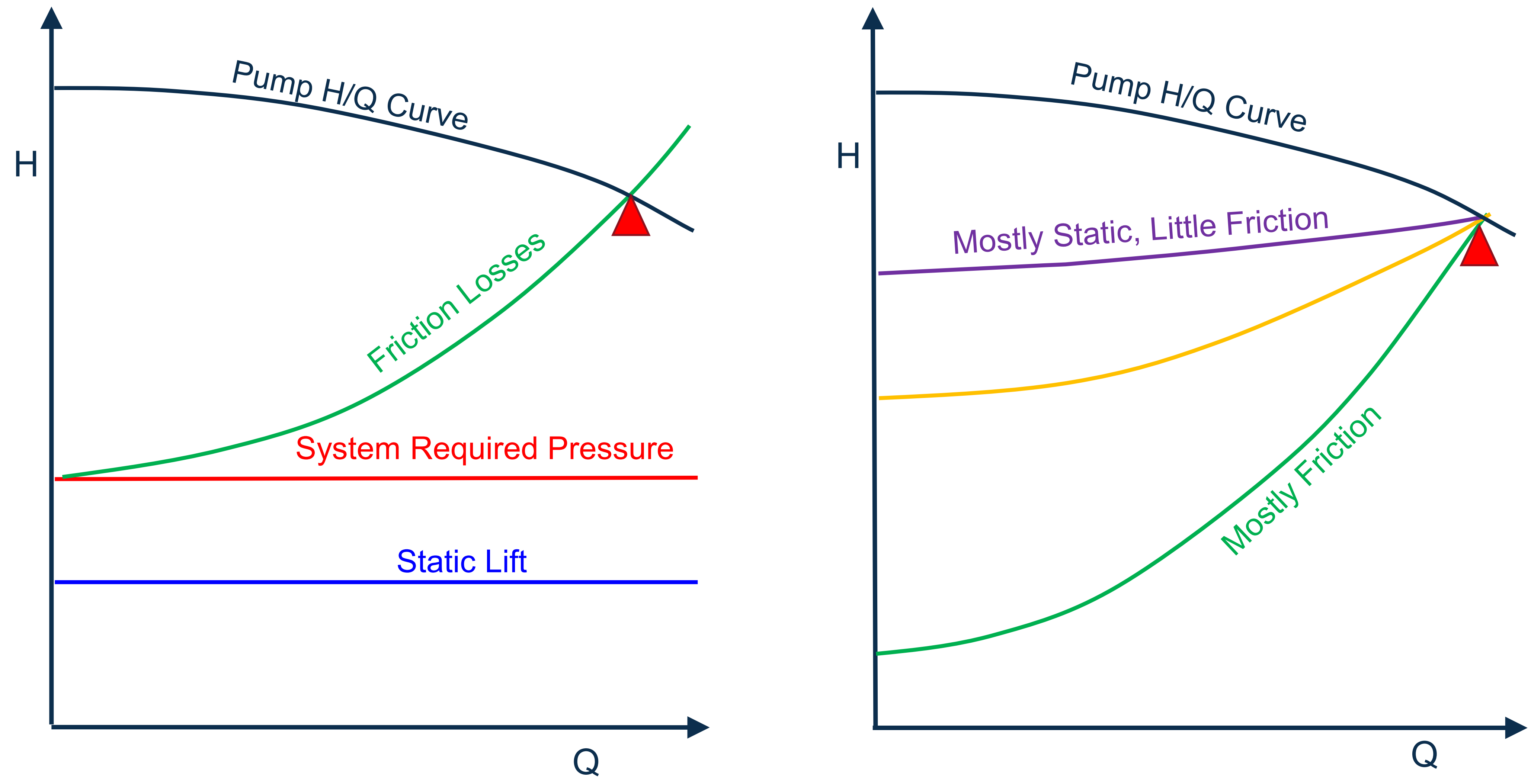
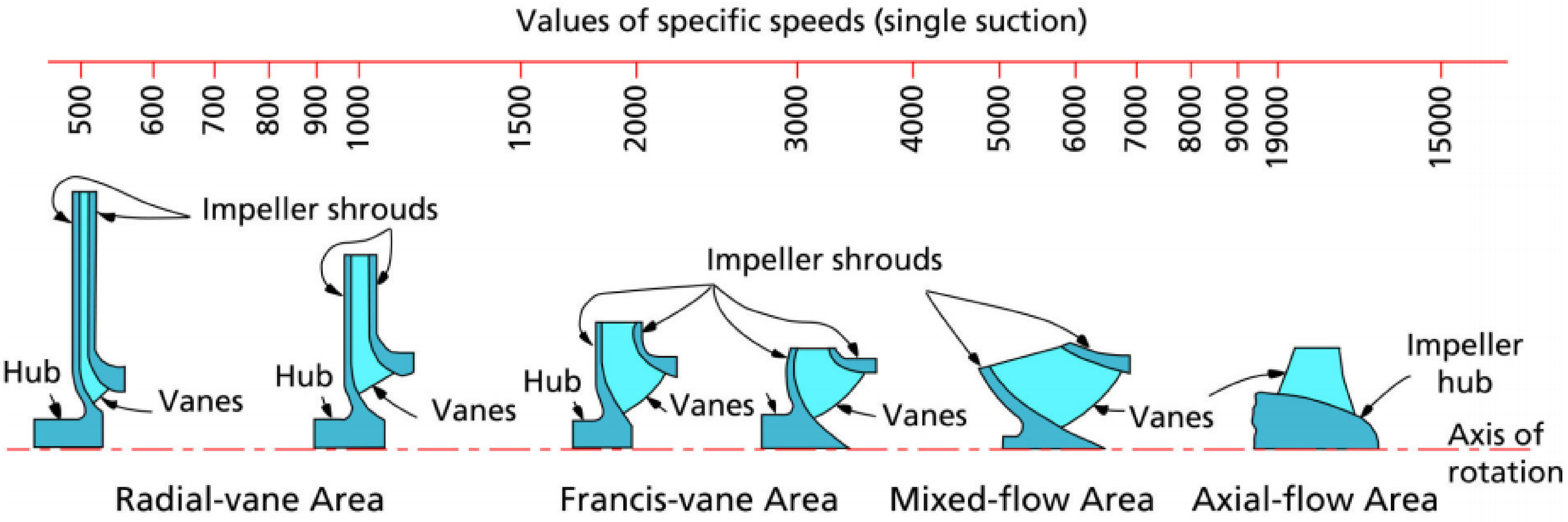
Session 3

“The Importance of Using System Curves in Pump Selection and on Successful Pump Operation”

System Head Curve



Pump Curve Shape vs Specific Speed

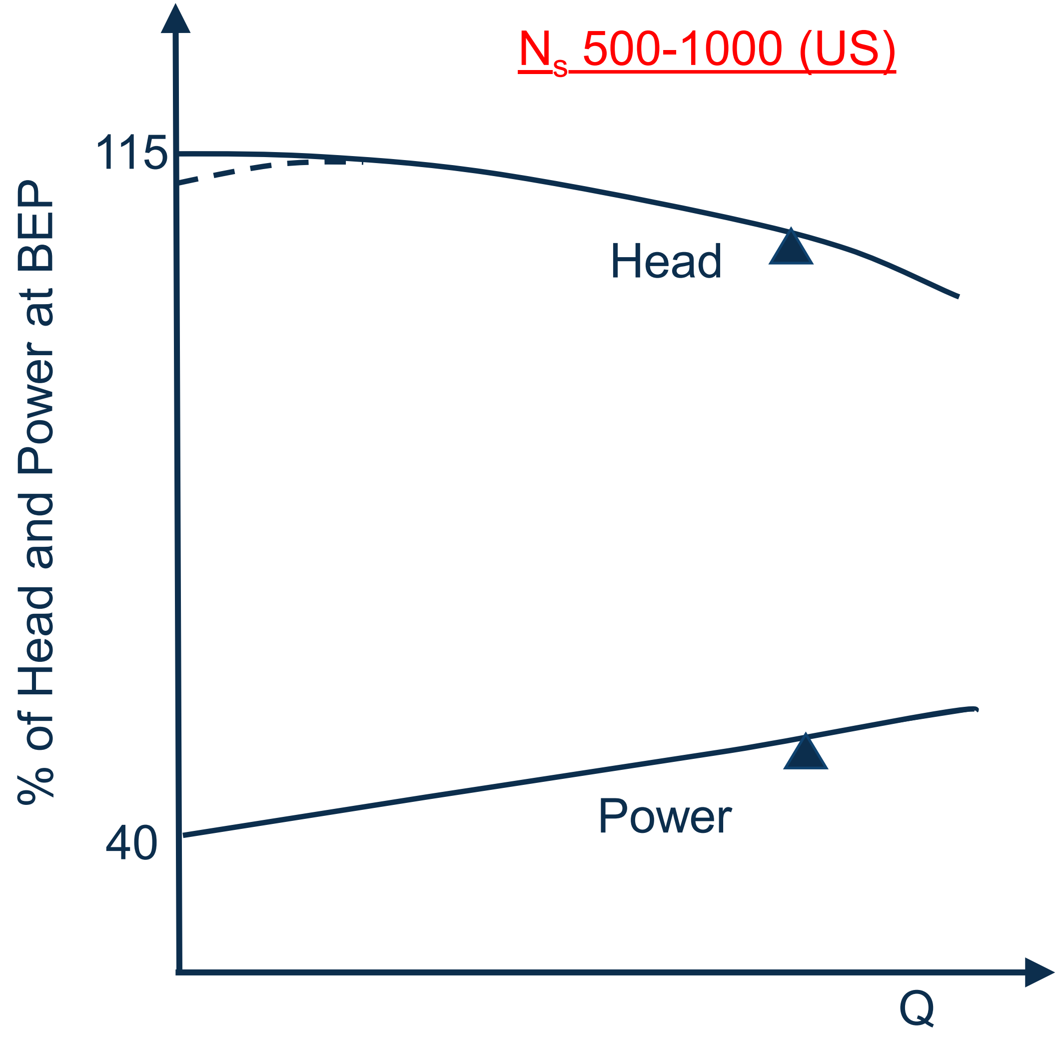


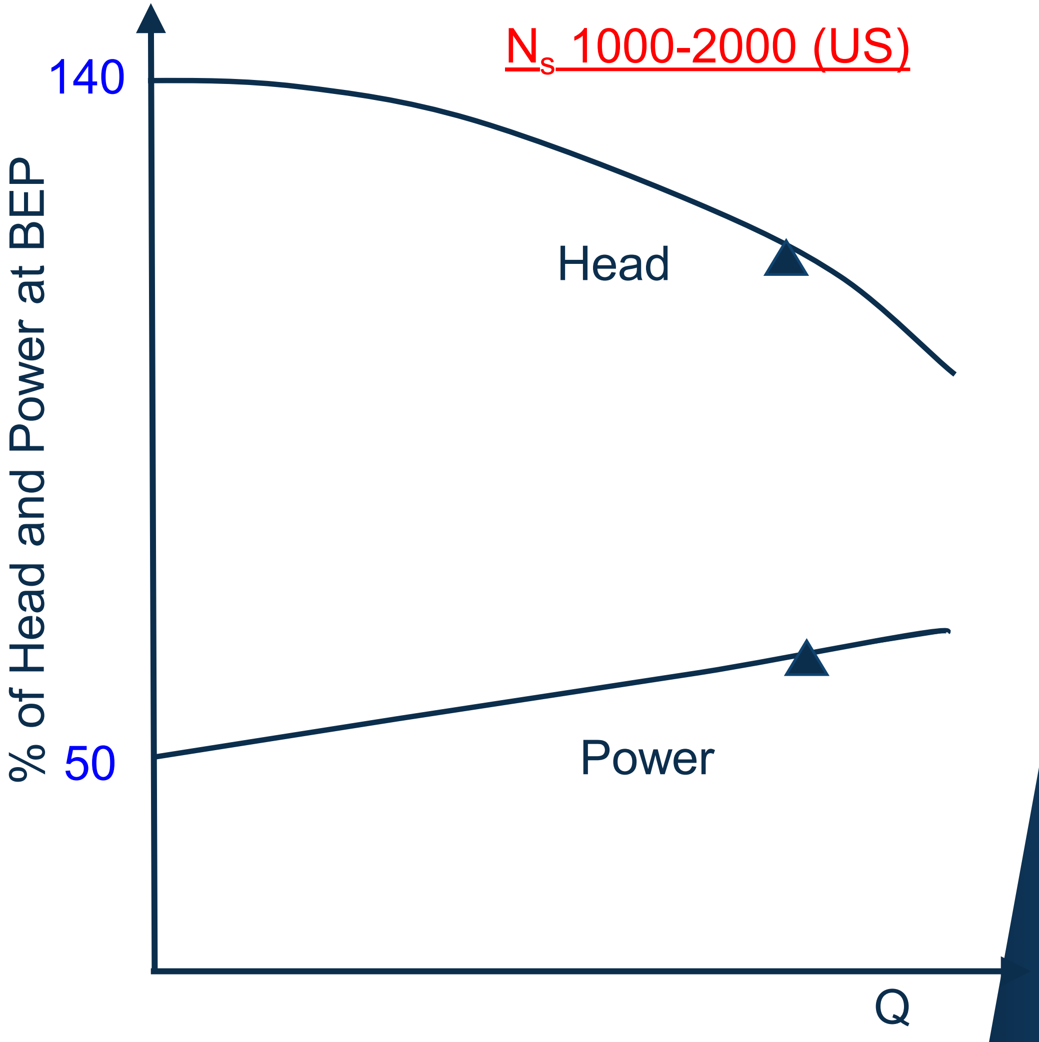
$N_S = N_{(RPM)}\, Q_{(BEP\ Full\ Dia)}^{\ 0.5} \,/\, H_{(BEP\ Full\ Dia)}^{\ 0.75}$

$N_{S(Metric)} = N_{S(US)} \times 1.16$ (m^3/hr, m, rpm)

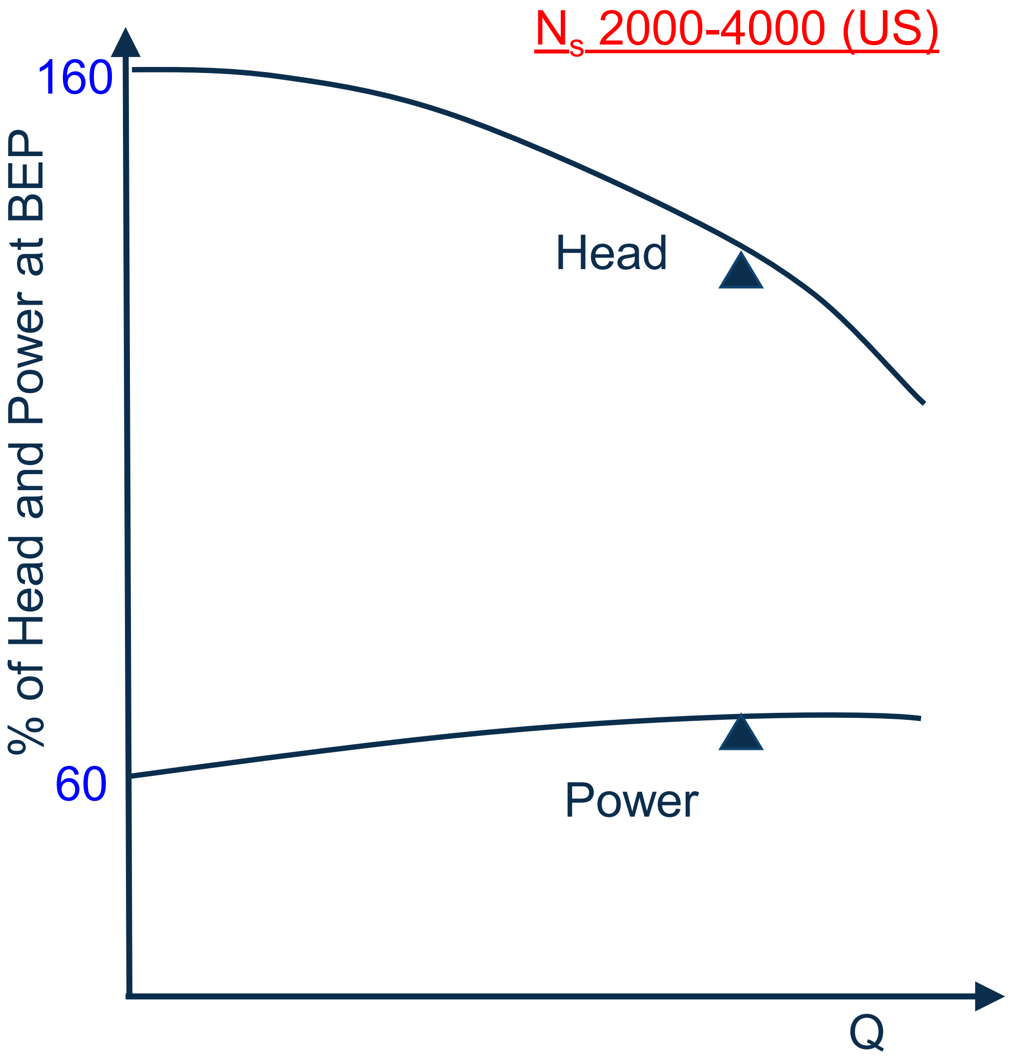
$N_{S(Metric)} = N_{S(US)} \times 0.02$ (m^3/s, m, rpm)

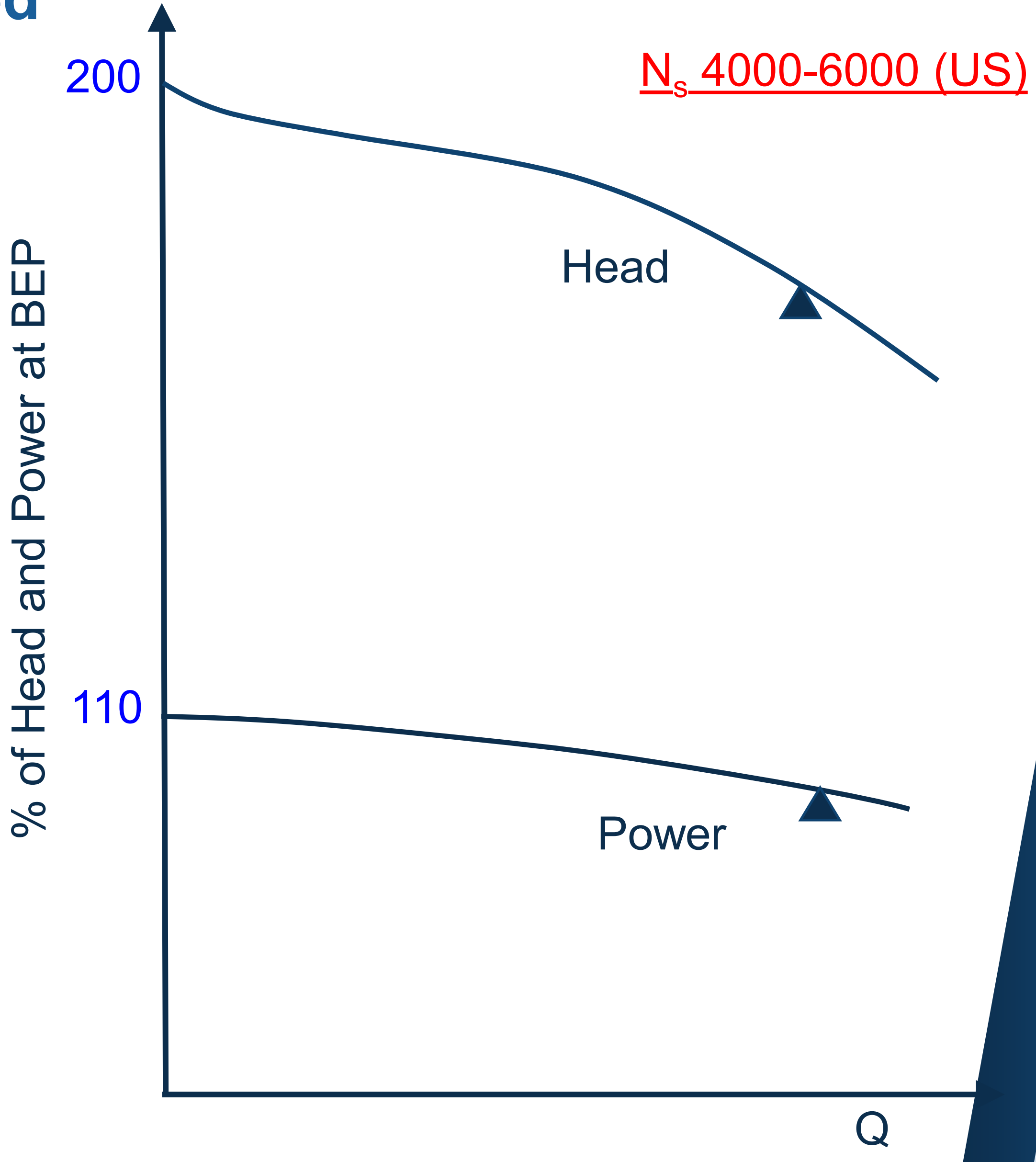
Pump Curve Shape vs Specific Speed





Pump Curve Shape vs Specific Speed





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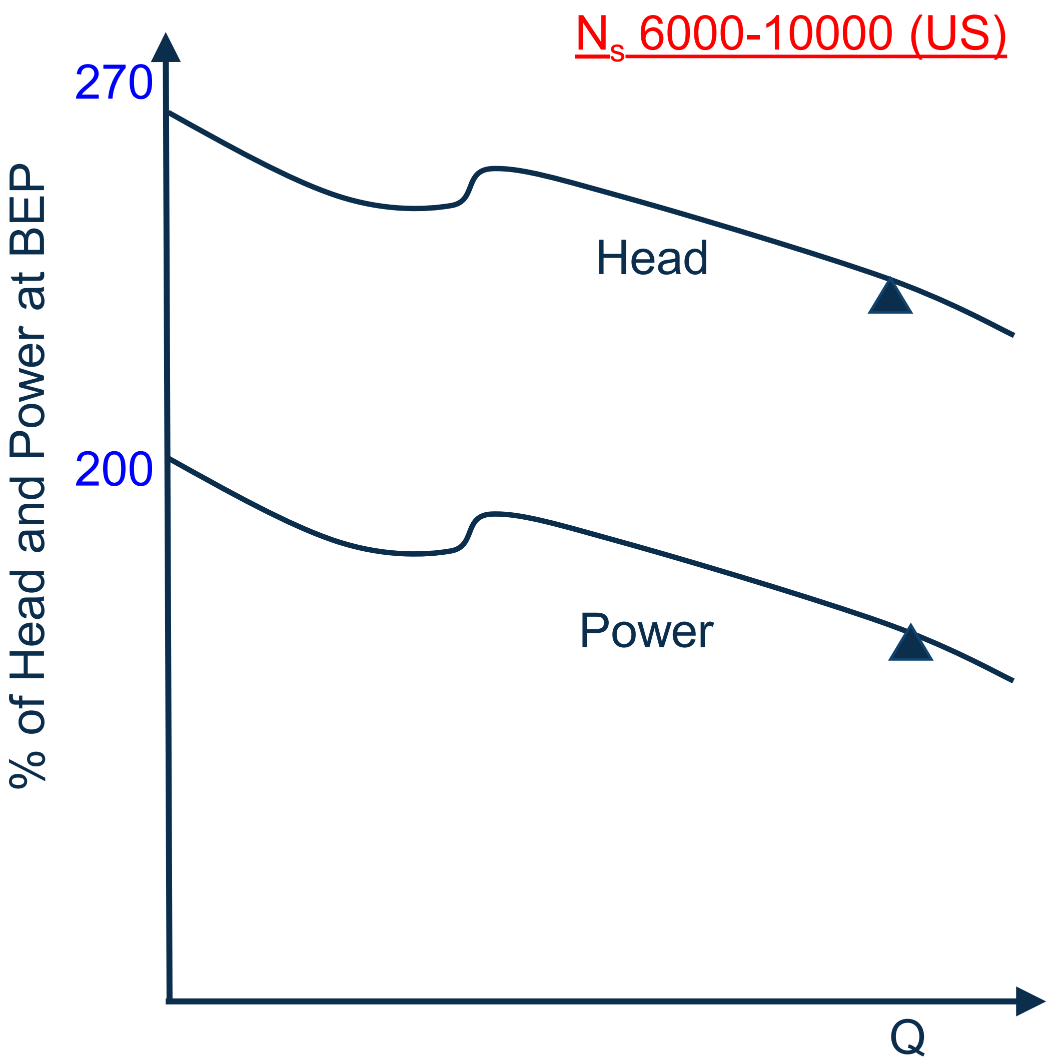
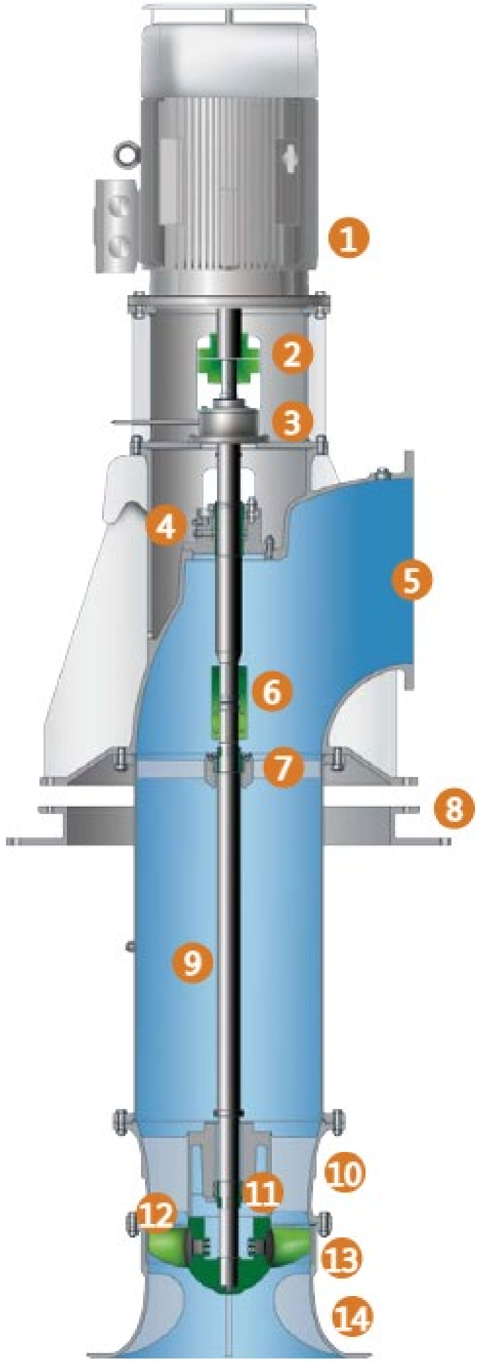




Operating Bands

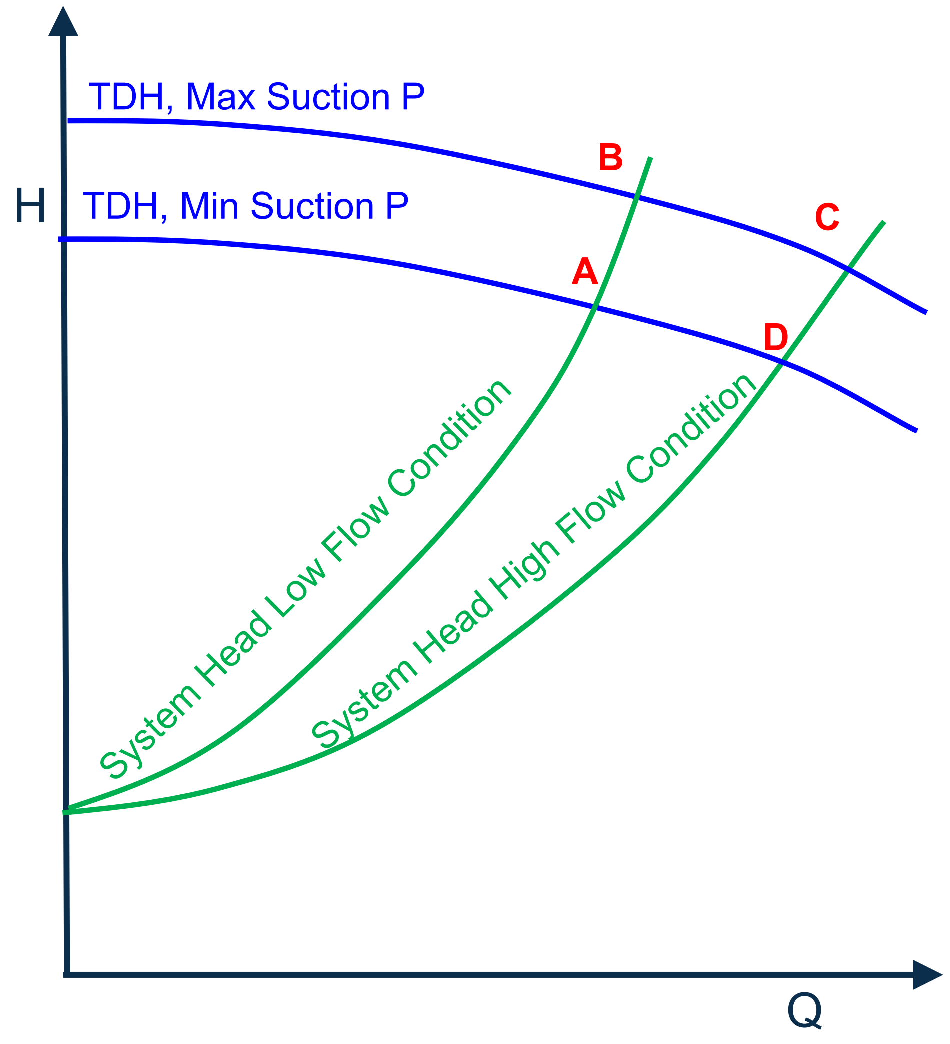
You will probably have a range of Suction Pressures and a range of Flow Rates to fulfill, and the pump might be asked to perform anywhere within the area A-B-C-D-A.

Condition D is probably the Rated Condition (worst case)

Some kind of system control will be required.

This might be

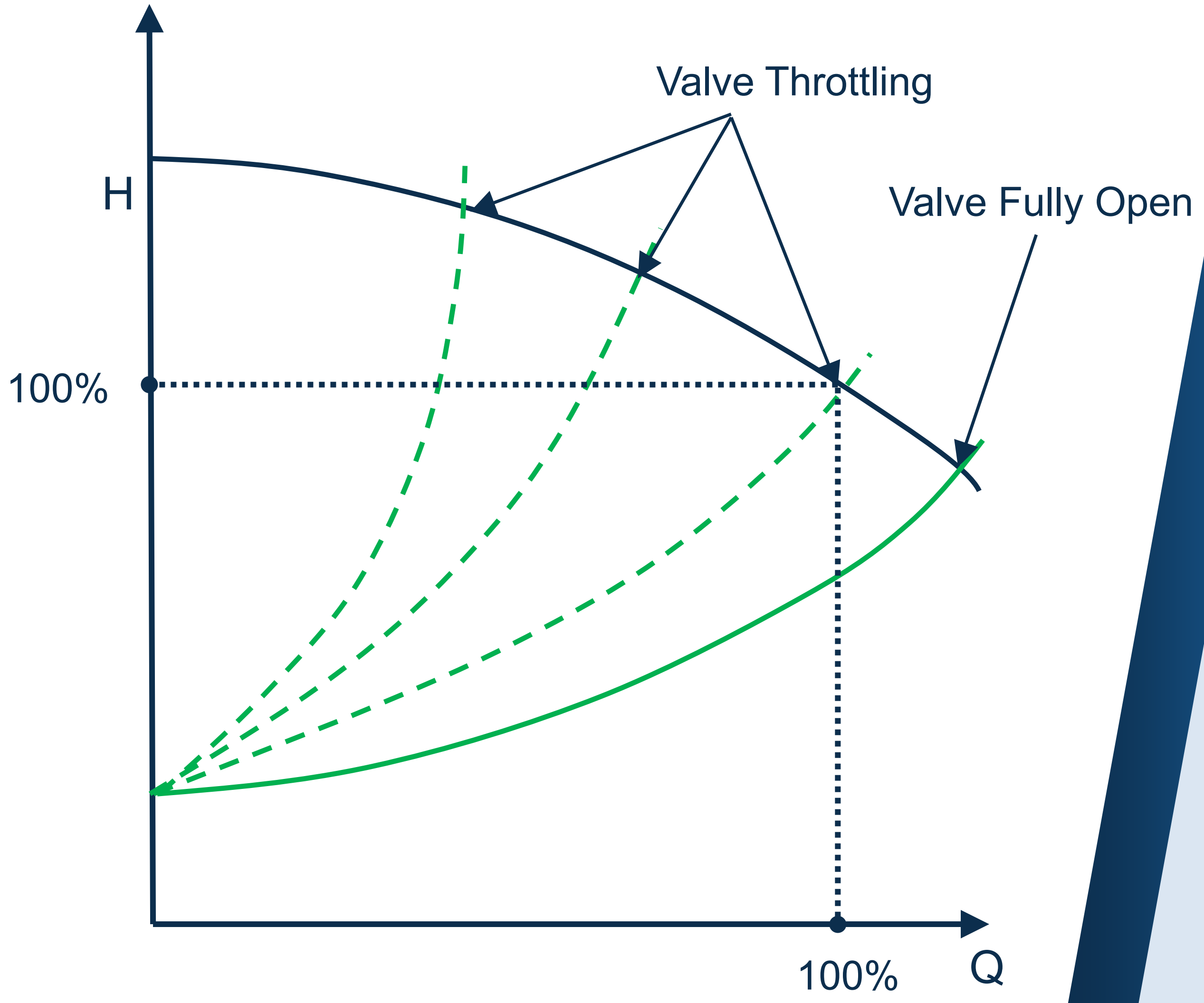
- Bypassing
- Valve Throttling
- Series or Parallel Pumping
- Variable Speed



System Control by Throttling

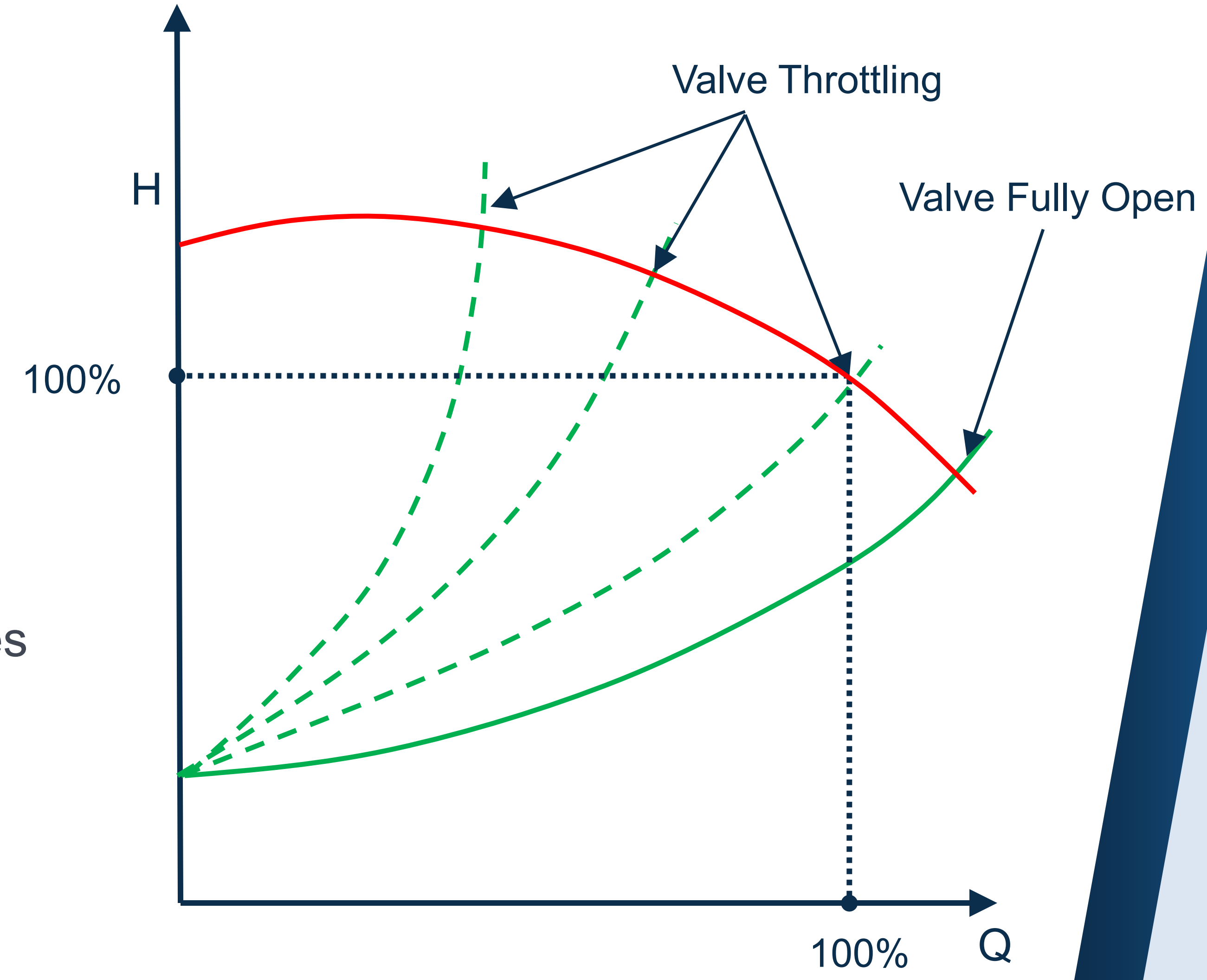
Probably the most common system control.

By opening or closing a control valve on the pump discharge, a “family” of system curves are created reflecting the ever-increasing frictional component of the system head.



System Control by Throttling – Hooked Curve (Gasp!)

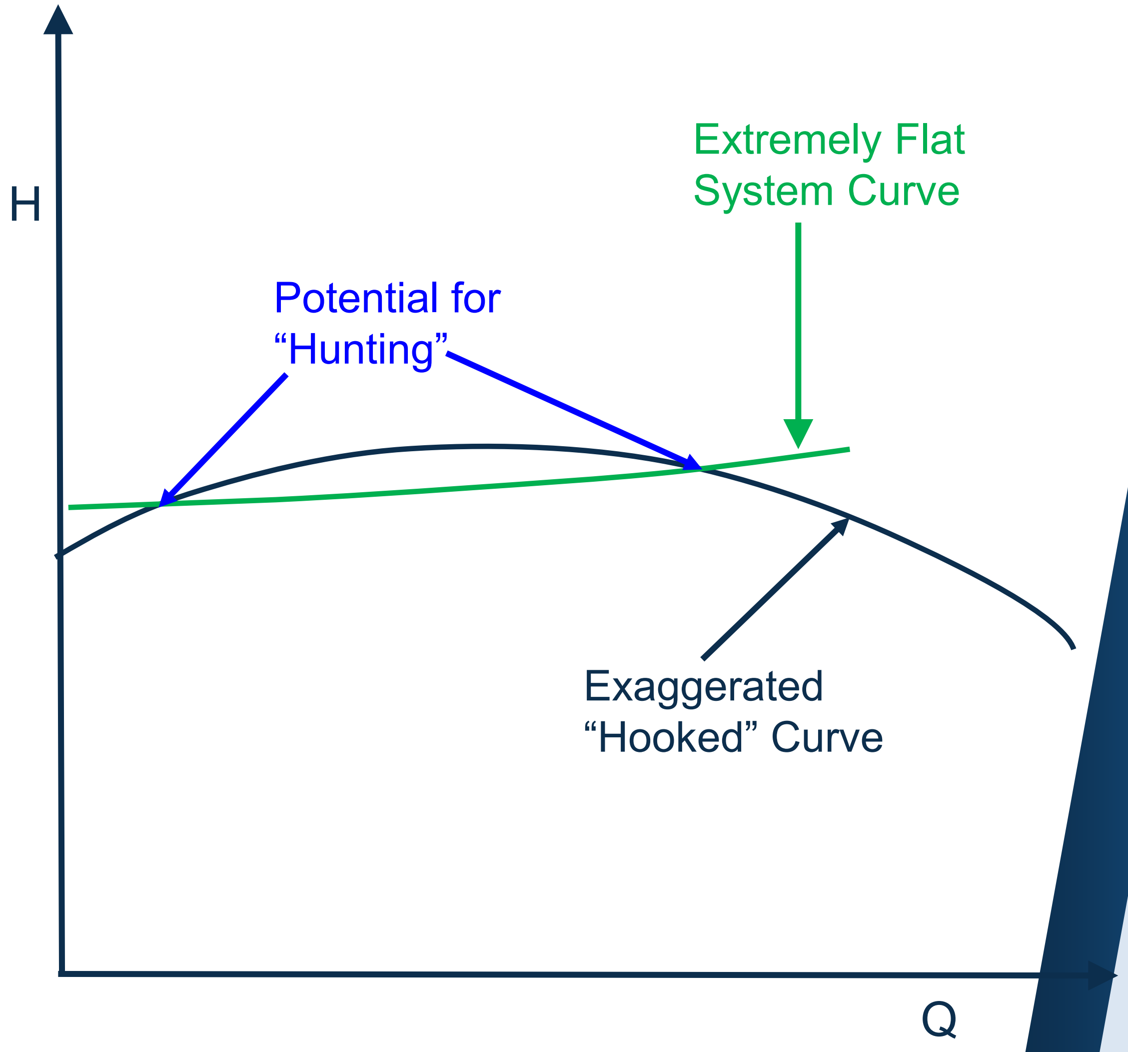
- Many specifiers run a mile from a hooked curve believing they are unstable.
- **A pump will only operate where the system permits – where the system curve crosses the pump curve.**
- **"The pump is slave to the system" ***
- Even as the control valve is gradually closed, each system curve only crosses the pump curve once.
- So no "hunting" is possible



* Simon Bradshaw

System Control by Throttling – Hooked Curve (Gasp!) Extreme Case

Only in the extremely rare case of an almost totally flat system curve (nearly all static head, very low frictional head) and a ***severely*** hooked curve might the system curve cross the pump curve more than once.

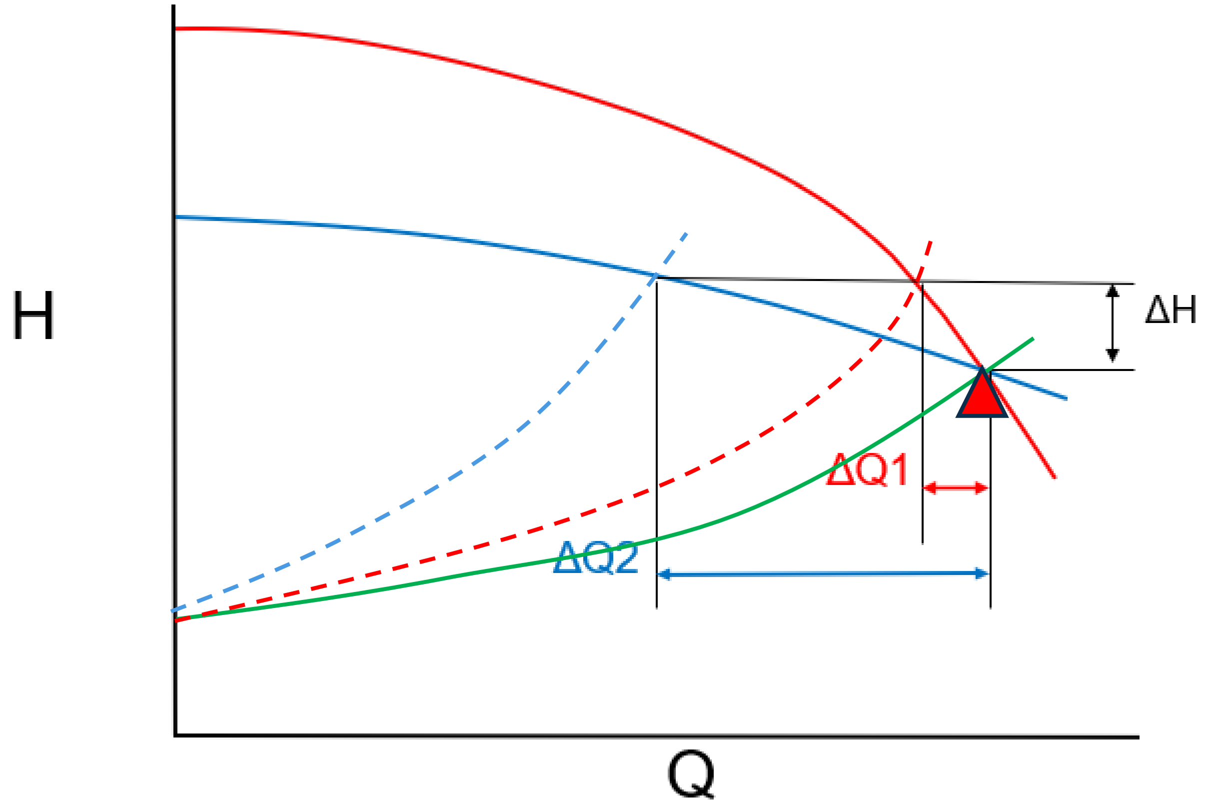


Steep or Flat Pump Curve?

- The question is “What do you want to achieve?”
- With a Flat pump curve **small** changes in System Head lead to **large** changes in Flow.
- With a steep pump curve **small** changes in System Head lead to **small** changes in Flow.

Impact of Curve Shape on Controllability

- A small change in Head (H) will have far less impact on the Flow Rate (Q) with a steep curve (red) than with a shallow curve (blue).



Variable Speed

Affinity Laws

$Q1/Q2 = RPM1/RPM2$

$H1/H2 = (RPM1/RPM2)^2$

Flow changes in DIRECT proportion to the speed change.

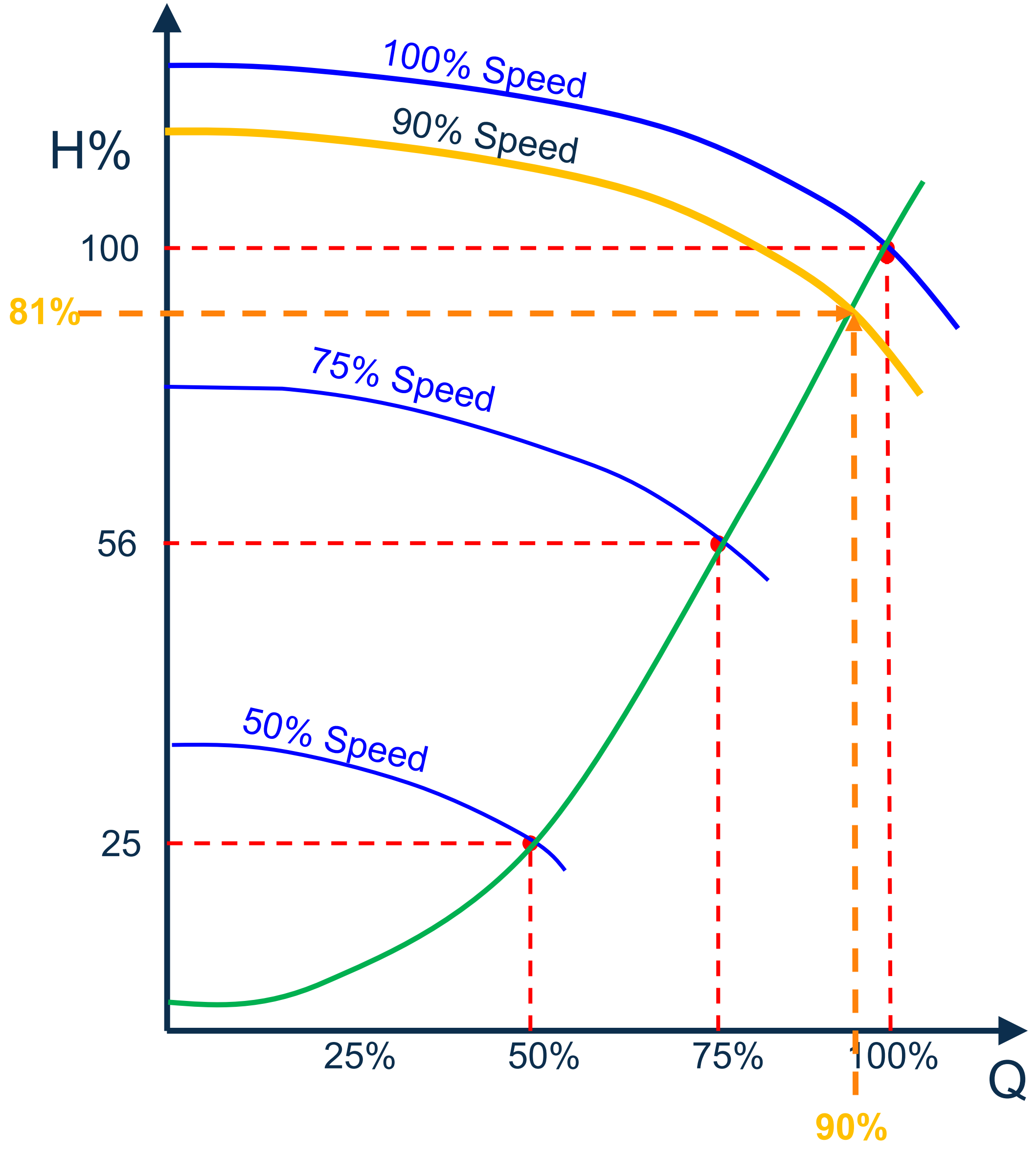
Developed Head changes by the SQUARE of the speed change.

So…reduce the speed to 90% of full

Flow reduces to 90% of full flow

TDH reduces to 81% of full head

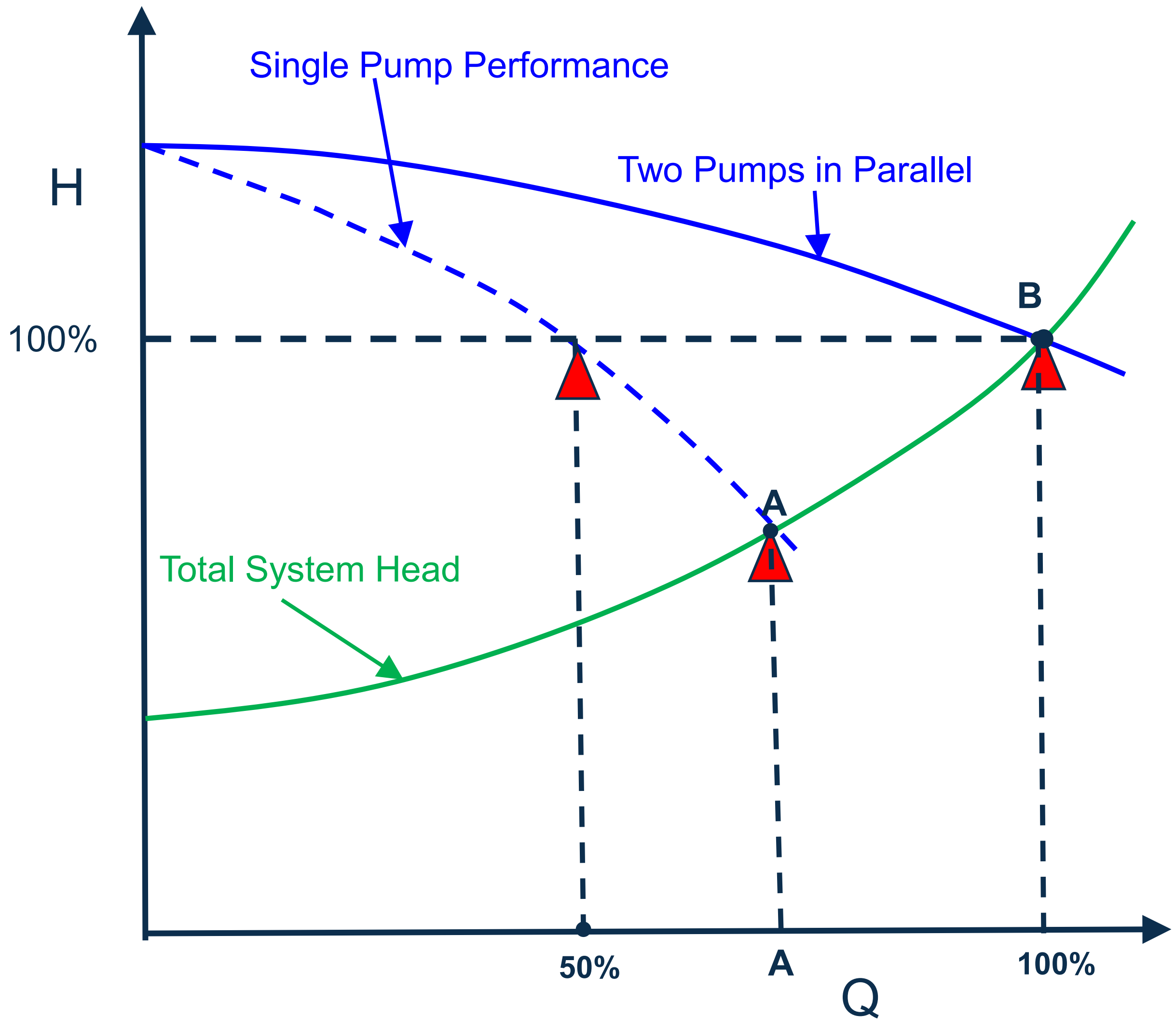
Variable Speed is not the "Cure-All" that many people expect!



Parallel Flow

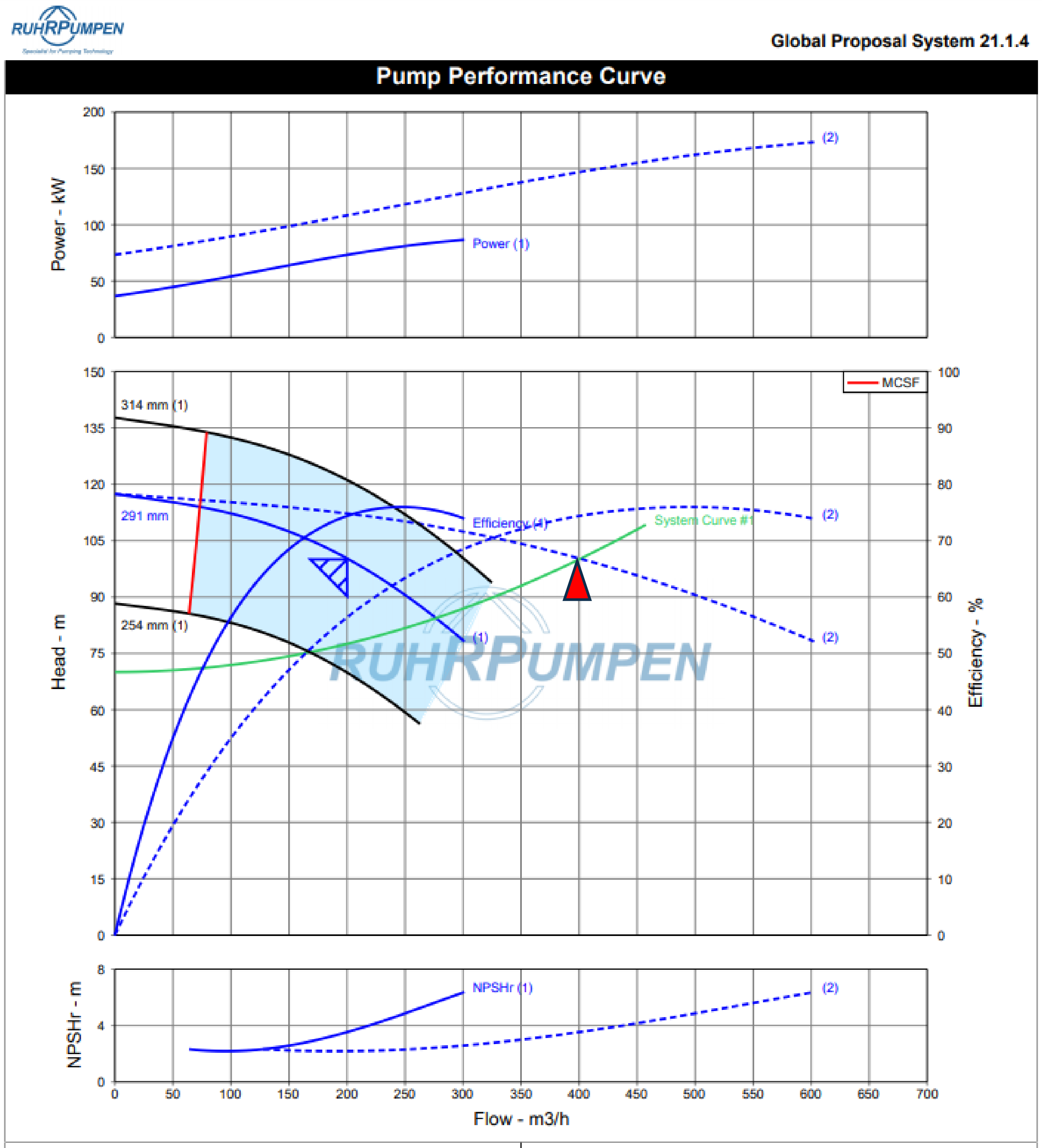
When operating in parallel, pumps will always develop an identical head value at whatever their equivalent flow rate is for that developed head, and the sum of their capacities will equal the system flow.

With one pump operating, system flow will occur at point A and with both pumps in operation, flow will occur at point B.



Parallel Flow

Typical manufacturer's curve with the system curve superimposed for parallel operation.



API610 12th & Parallel Flow

- *6.1.13 If parallel operation is specified and the pumps are not individually flow controlled, the following is required:*

  a) the pump head curves shall be continuously rising to shutoff;

  b) the head rise from rated point to shutoff shall be at least 10 %;

  c) the head values of the pumps at any given flow within the preferred operating range shall be within 3 % of each other for pumps larger than 3 in. (80 mm) discharge.

Here is why this is so important.

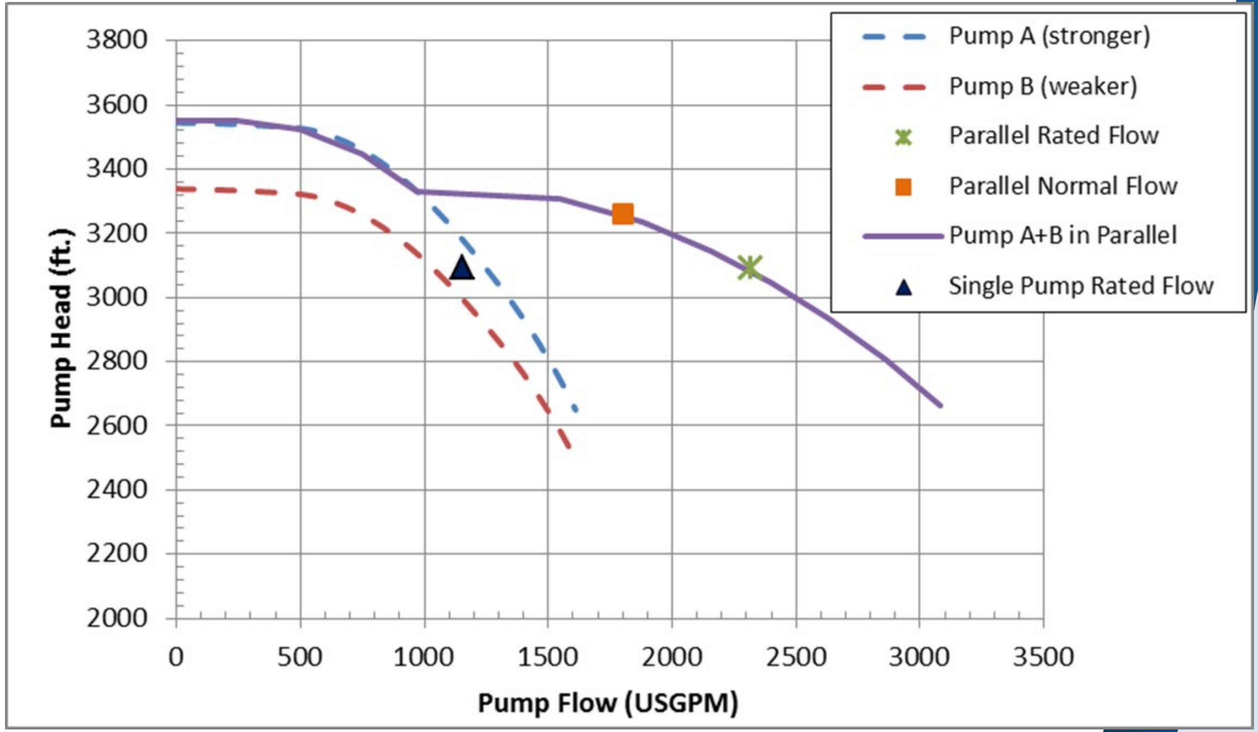
API Table 16 allows Performance Tolerances +/-3% at rated flow +/- 5%, 8% or 10% (depending on head) at shutoff.

So without this change two "identical" pumps could easily have a "stronger pump" operating in parallel with a "weaker pump" as illustrated below.

API610 12th & Parallel Flow

The resulting combined Pump A+B parallel curve is discontinuous due to the mismatching of the two pumps. This exhibits itself as a step at around 1000 USGPM. (Below that point Pump B would operate at zero flow resulting in rapid failure).

In this scenario Pump A being stronger will force Pump B to operate back on its curve. If the system is operated at its Parallel Normal Flow, **Pump B will be running at around only 50% of BEP**. This is well outside the preferred operating range and will result in Pump B seeing higher wear and ultimately needing repair *much* sooner.

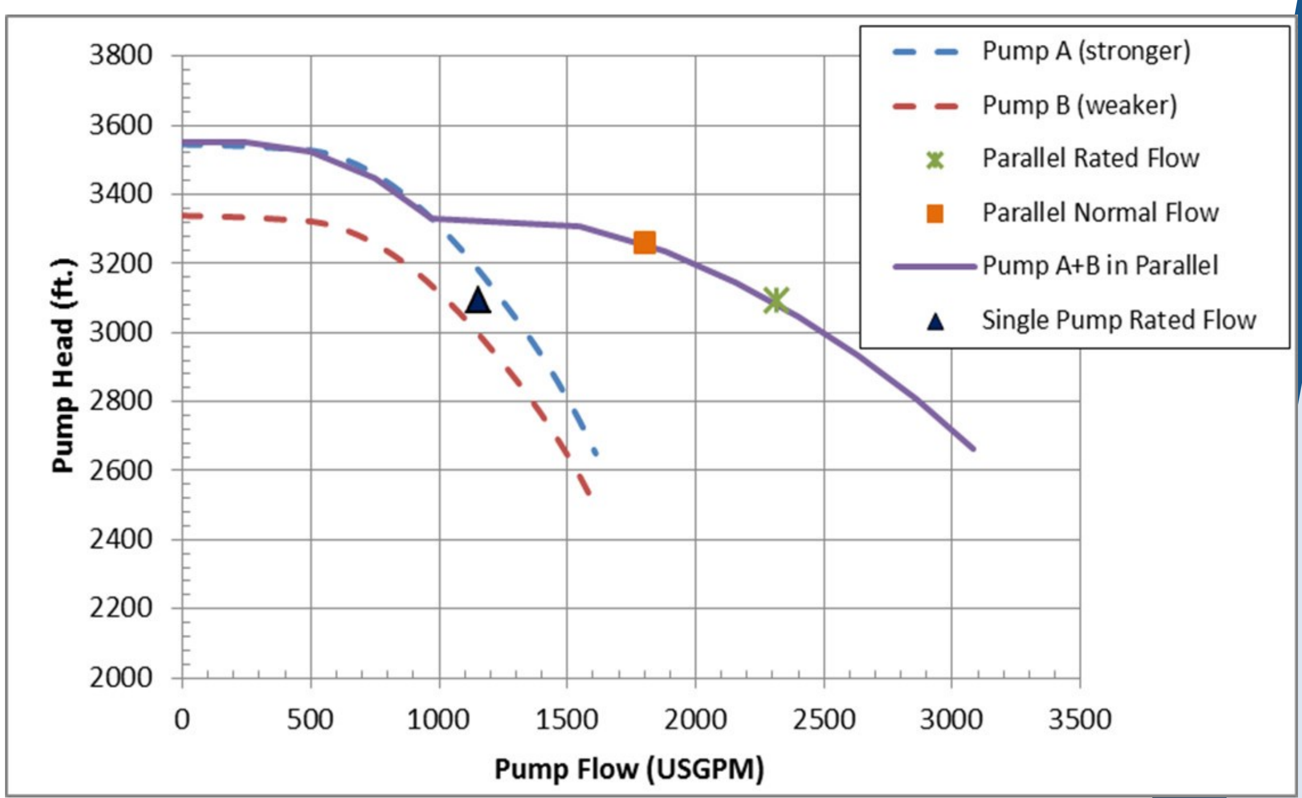


(Source – Simon Bradshaw, Director Engineering, CIRCOR)

Parallel Flow

Non-Identical Pumps in Parallel

Two non-identical pumps <u>can</u> still work in parallel but you will need to control the outlet stream of each pump independently. Otherwise one pump may well push the other out of its allowable operating range.

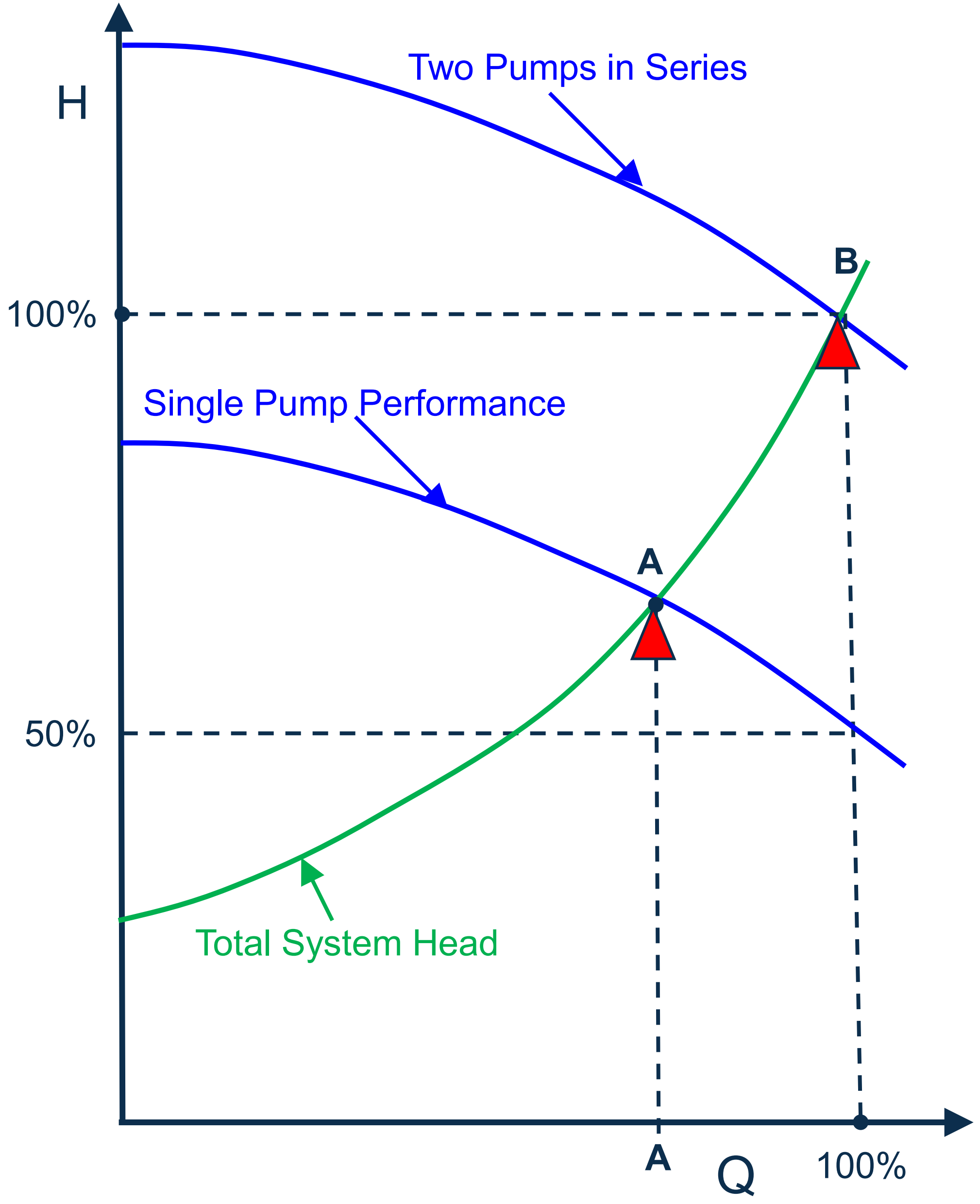


Series Flow

When operating in series, the total developed head will be the sum of the heads developed by each pump at any given flow.

Each pump must be selected to operate satisfactorily at the system design flow.

With one pump operating, system flow will occur at point A and with both pumps in operation, flow will occur at point B which is the System Design Flow



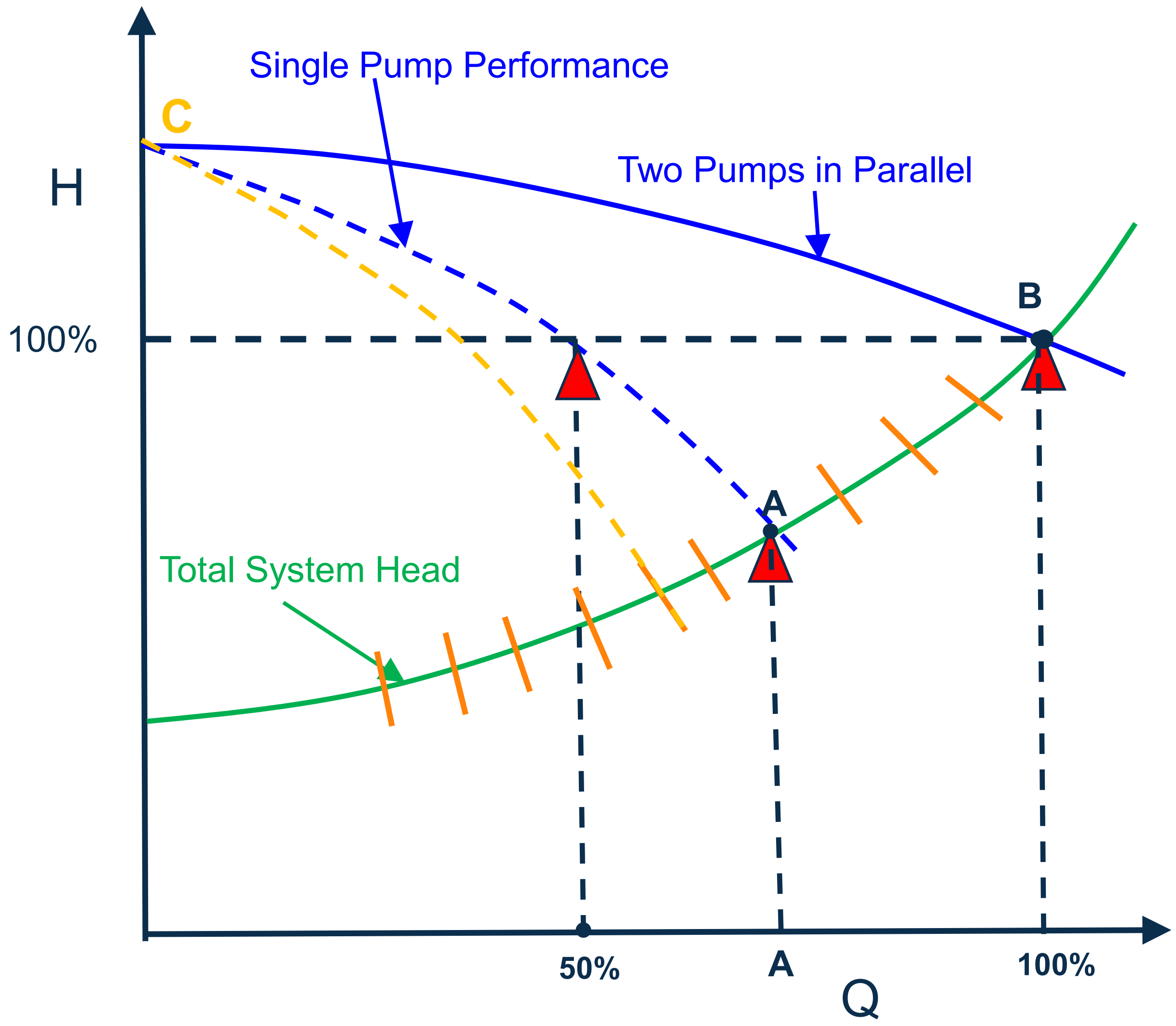
Parallel Flow with Variable Speed

With variable speed you have an infinite number of Pump Curves (partial curves illustrated in orange)

Typically you would start the lead pump under variable speed.

It would climb the system curve until it reached Point A at which point it is at full speed and would be locked at that speed.

The second (lag) pump would start under variable speed and continue to climb the system curve from Point A to Point B

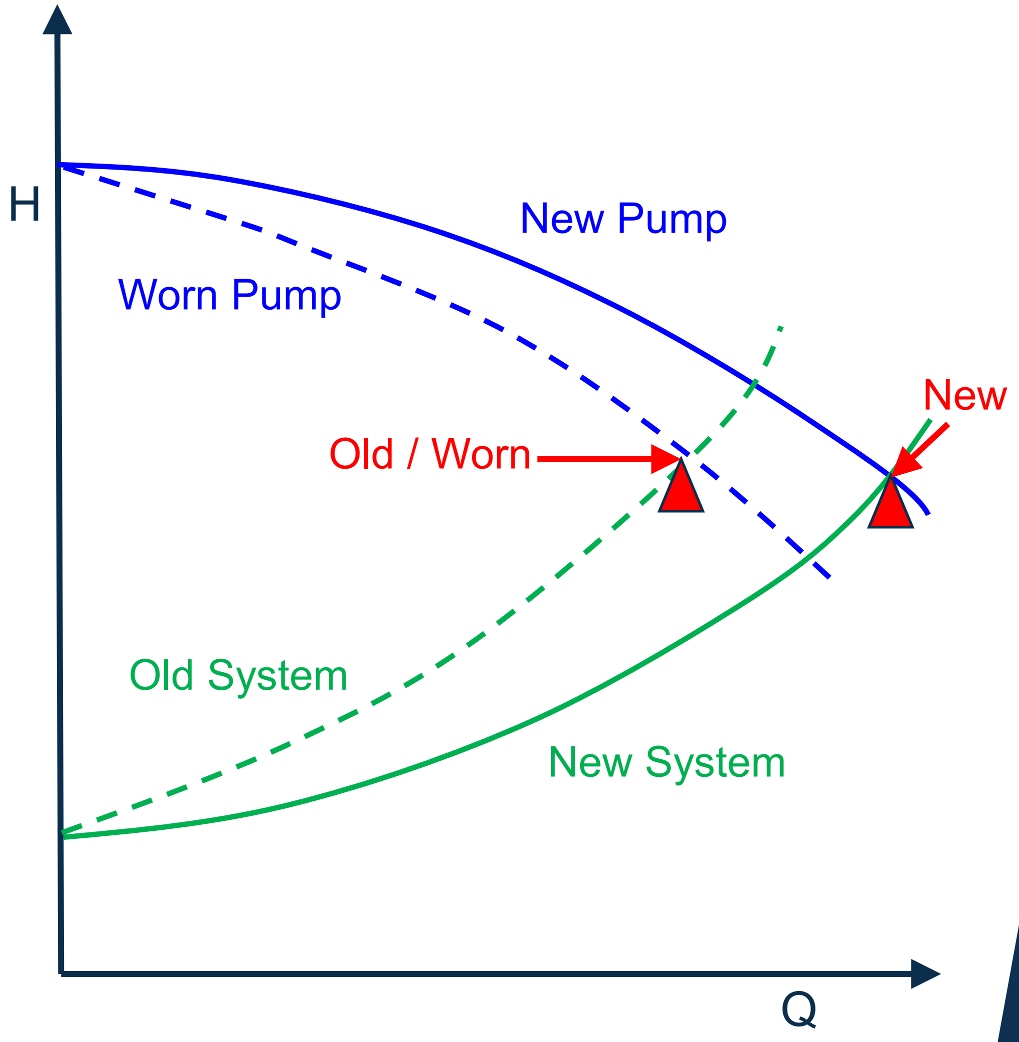


Old Age

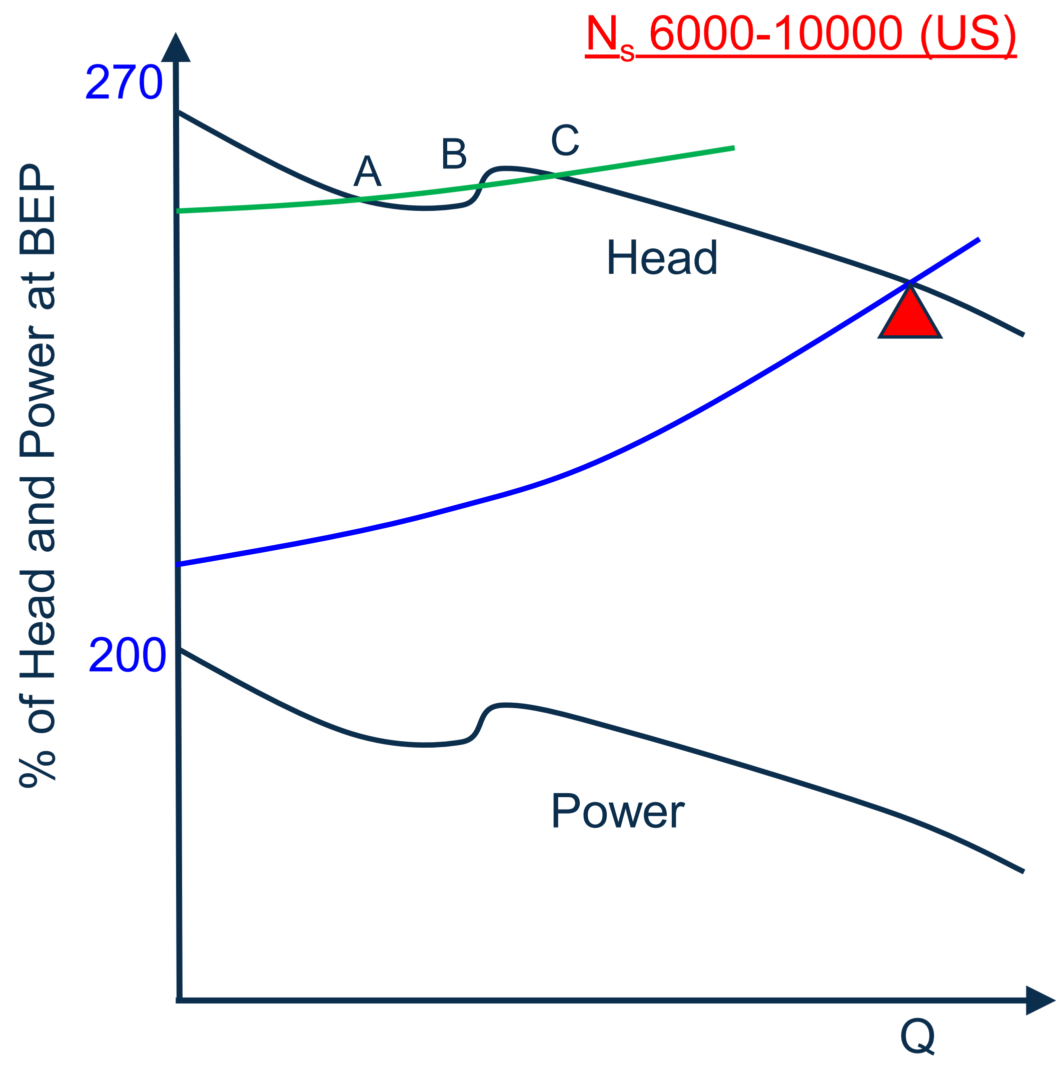
(It comes to us all!)

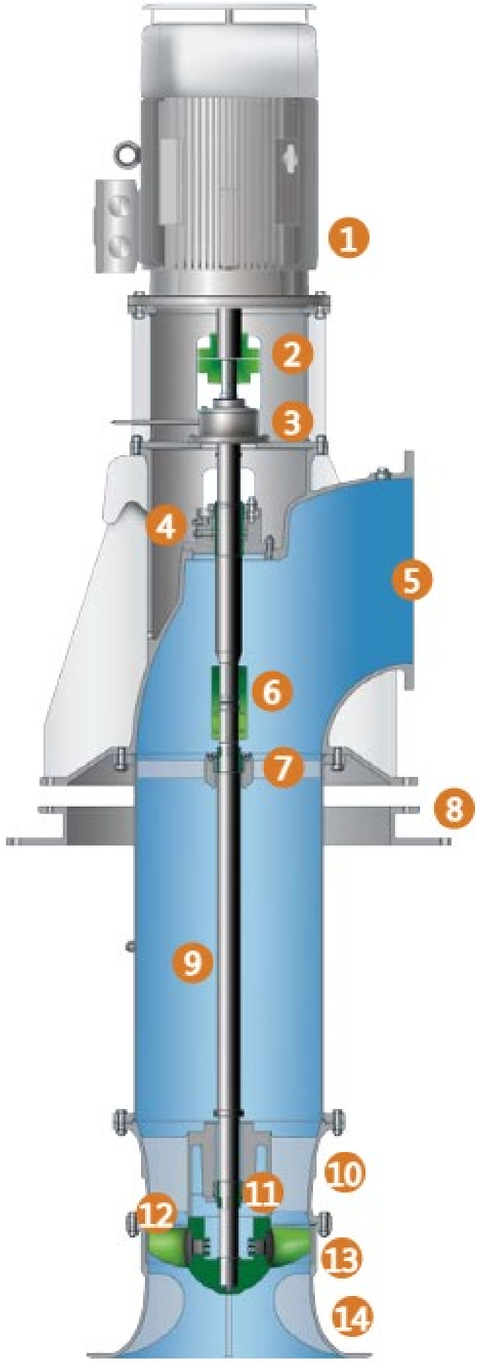
A worn pump will see its performance curve fall off as shown by the dashed line.

Similarly frictional resistance will increase in an aging system due to corrosion and scale build up.



Operating Near the "Saddle"





Operating Near the “Saddle”

If you operated with a flat system curve (green) in the region of the “saddle” - yes you could get hunting between flows A,B&C.

In practice you are unlikely to have a flat system curve like this (all static head very little friction) and more importantly you would **never** operate this far back on the curve of this type of pump.

These are huge flow axial flow pumps and they are operated within +/-10% of BEP.

Note how the power and head increase dramatically away from BEP.

Coming Attractions ☺

"Selecting the Right Pump for the Application"

Thur 17th June – 08.00 (UK BST) (Eastern Hemisphere) & 17.00 (UK BST) (Western Hemisphere)

Aimed at Process and Mechanical Engineers and Consultant Engineers specifying pumping equipment as well as Applications & Sales Engineers selecting and quoting them. Develop an understanding as to which type of pump is appropriate for different applications.

Will cover such topics as when to transition from an OH2 to a BB2, when to consider VS6 pumps, Barrel vs Horizontal Split Case multi-stage pumps.

Future subjects in preparation include:

- "NPSH made simple (or "simpler" anyway!)"