# API 610 - pump selection & curve evaluation guide

**white papers**

API 610 11th edition offers guidelines for pump selection to assist users with selecting pumps that will run uninterrupted for a minimum of 3 years and provide many years of reliable service. Each manufacturers pump has a set of performance curves detailing the head, flow, best efficiency, power and NPSH requirements for the pump. Evaluating and using these curves to select the right pump for the duty is crucial, both in meeting the API 610 standard and ensuring the pump runs optimally over its full lifetime. There can often be some confusion around some of the terminology relating to the curves, specifically that relating to the operating regions – preferred, rated and allowable.

A typical API 610 pump performance curve looks like this:

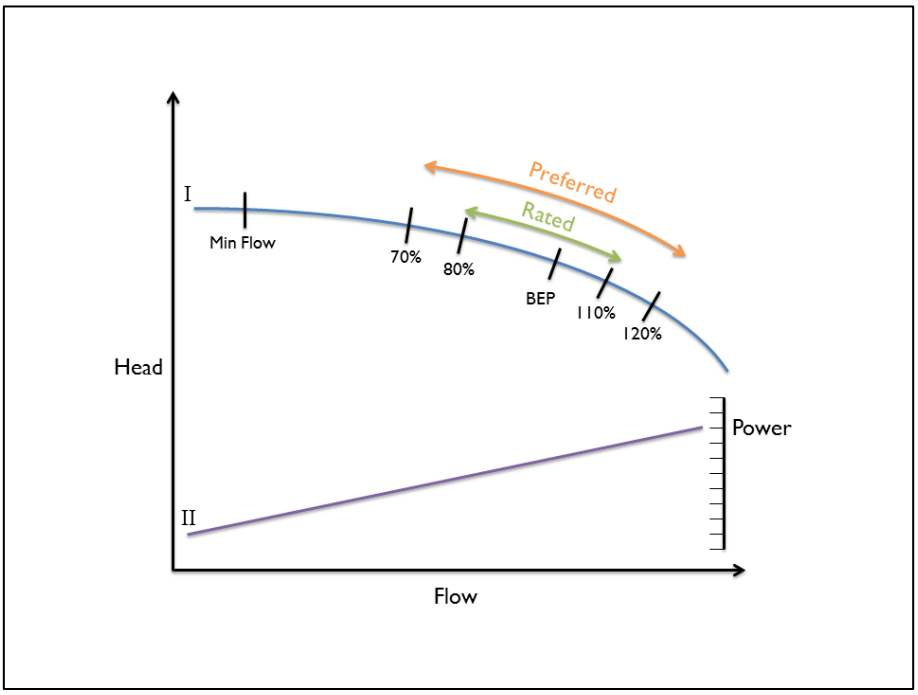


Figure 1

The main curve (I and in blue) is known as the head/flow curve – in simple terms the higher the head the lower the flow and vice-versa. The curve II in purple is known as the power curve. As the flow increases then the power needed to drive the pump also increases, fairly linearly, and by taking a vertical line through both the head/flow curve and the power curve, you are able to assess how much power is needed to pump the required flow and also assess the generated head at that flow.

Additional points are marked on the graph to assist the user. Min flow is the minimum flow below which the pump should not be operated otherwise it could be in danger of premature failure. There are two types of minimum flow that need to be understood:

- Minimum continuous stable flow – This is set by the manufacturer as the "*lowest flow at which the pump can operate without exceeding the vibration limits imposed by API 610"*
- Minimum thermal flow. This is used for higher volatility or hot liquids where cavitation can occur earlier in these liquids. It's defined as the *"lowest flow at which the pump can operate without its operation being impaired by the temperature rise of the pumped liquid"*

Every pump has a Best Efficiency Point (BEP) which is the flow at which it is operating at its highest efficiency, and so to achieve the lowest running costs a pump should be selected for a Customer Duty (the rated head and flow) where the duty point is as close as possible to the BEP.

Of course, it is not usually possible to get the Customer Duty and BEP totally aligned as the costs of designing a pump for every customers exact duty requirements are prohibitive. Therefore customers' duty points are known as being to the right of BEP, or to the left of BEP. The further away the customers duty point is from the pump BEP (i.e. its optimal design point), the less efficient it becomes, and quite often the more it will vibrate and generate additional noise, which can lead to premature wear and ultimately early pump failure. This is particularly relevant for high head and high flow machines, but less relevant to low energy pumps (i.e. those defined as operating under 300kW or less than 3600rpm).

To help make sure the customer's duty does not fall within a region that will lead to premature pump failure, API 610 defines various operating regions and suggests that a customer's duty point should sit within set regions to ensure the best possible life for the pump. The operating regions defined by API 610 are:

- Rated region (see Figure 1): API 610 recommends that the rated flow is located between 80% - 110% of BEP.
- Preferred operating region (see Figure 1): API 610 states that the preferred operating region should be between 70% - 120% of the BEP.

To understand this further we need to understand the difference between an "Operating" point and a "Rated" point.

- Operating point – this is where the pump is expected to operate under normal conditions. There will often be a min and max operating point defined by the customer, but API 610 is most interested in the "normal operating" point.
- Rated point – This is a point the customer chooses to rate the pump at (to allow for other losses such as system losses or adjustments that may occur as the pump begins to wear over time). The pump generally will not operate permanently at its rated point, but it is designed and tested by the manufacturer there.

To use an analogy of a car, the normal operating point may be 50mph, but it needs to be rated to handle 70mph, so all the selections and testing would be around the 70mph rather than the 50mph values.

The reason for selecting pumps within one of these regions is that API 610 states that pumps must be designed and constructed for a minimum service life of 20 years and at least 3 years of uninterrupted operation for a Customer Duty in the Preferred operating region. These guidelines apply to all pumps, whether they are relatively small, for example pumping 4 $m^3/h$, or considerably larger, for example pumping 2000 $m^3/h$. In addition, customers' specifications will often require pumps to operate to the left of BEP, effectively restricting the rated region even further to between 80 – 100%.

However, one size does not always fit all and small roto dynamic pumps, such as those from Amarinth, can operate reliably outside of these regions and so **API 610 does not make either the Preferred or Rated ranges mandatory** but allows discussion between the customer and the pump supplier regarding this criteria. Clause 6.1.12 of API 610 11th edition states:

*"Setting limits for preferred operating region and the location of rated flow is not intended to lead to the development of additional sizes of small pumps or preclude the use of high-specific-speed pumps. Small pumps that are known to operate satisfactorily at flows outside of the specified limits and high specific speed pumps that may have a narrower preferred operating region than specified should be offered…"*

This helps explain the final operating region;

- The Allowable operating region (see Figure 2): This is the region set by the manufacturer as the allowable region that the pump is able to operate in whilst conforming to predefined API 610 vibration limits.

To prevent manufacturers setting their Allowable operating regions as wide as possible thus potentially making their selections API 610 compliant, strict vibration limits define where the min and max allowable operating ranges should be. It is well documented that excessive vibration will lead to premature life of a pump and so the vibration limits set by API 610 are used to control the min and max allowable operating region. This can be found under clause 6.9.3.1 in API 610 11th edition.

API 610 states that vibration levels must be less than 3mm/s for horizontal pumps and less than 5mm/s for vertical pumps within the Preferred operating region and that this can increase by 30% when moving outside the Preferred operating region. For this reason, and because each pump manufacturer will have different manufacturing methods and designs, each manufacturer will have a unique allowable operating range for each pump they offer.

When a pump's vibration curve) is projected onto the head/flow curve using these vibration limits it shows an operating region that keeps the pump within these vibration limits - the Allowable operating region (see Figure 2). It can be the same, larger, or in some cases smaller than the API 610 Rated or Preferred operating region. In fact for some pumps, the theoretical allowable operating region based on vibration alone can extend below the minimum flow.

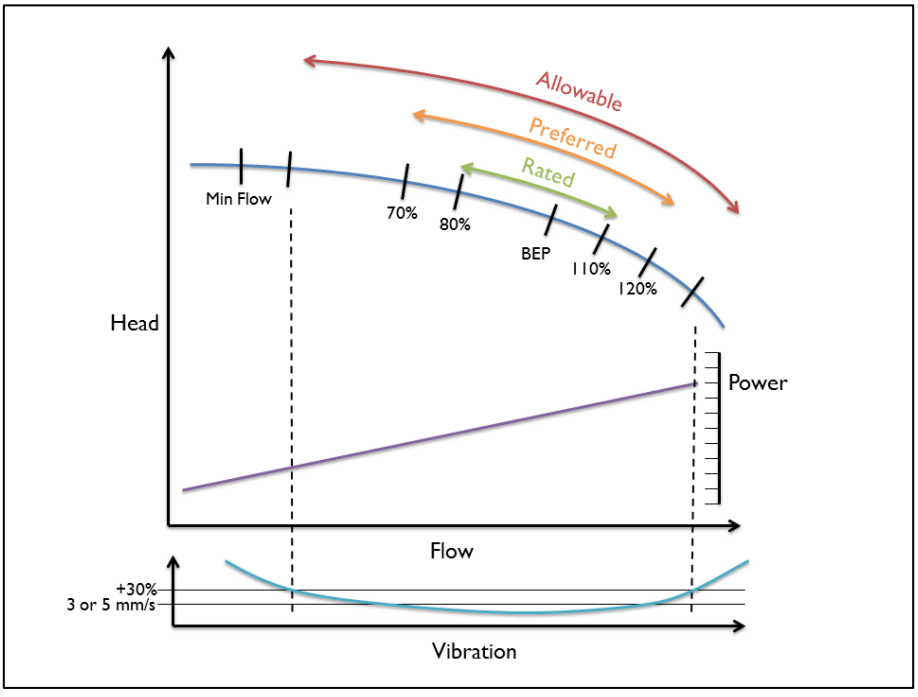


Figure 2

There is a common misconception that an API 610 pump must only be selected within the Rated or Preferred operating regions. However, the diagrams above show that a small pump can be perfectly acceptable even when the rated flow is outside either the Rated or Preferred operating regions so long as the pump is operating within the Allowable region (and above the minimum flow). This ensures that the pump will be operating within the vibration limits defined by API 610. You can easily end up with a poorly manufactured pump, having worn quickly over time, with its duty within the preferred operating range, subsequently vibrating significantly more than a well manufactured pump with its duty outside of the preferred range, but within its allowable operating range.

Finally, other factors such as whether the pump is operated intermittently or whether it is in continuous use should also be taken into consideration before deciding which guidelines to adopt as a pump operating only 30% of the time should last considerably longer than one operating 100% of the time.

Fundamentally, if a manufacturer can guarantee low noise and vibration limits (still within the API 610 limits) for a duty outside of the rated and preferred operating ranges but within the allowable operating range it should be considered as a perfectly acceptable option. Many times pumps are withdrawn from the offer as the customers duty does not fit within the preferred range, often leading to a more expensive solution being implemented which is not necessarily required.

▼ Revision history

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