Quincy VACUUM

Vacuum Level: What's a Few Inches Here or There?

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Over the last 10 years, the vacuum industry has been exercising. Not in the form of running on treadmills or lifting weights, but in the form of reducing footprints, eliminating waste, and saving clients money. Perhaps a vacuum salesperson has even visited your facility describing the advantages of variable speed machines. Whether these "fat burning" initiatives are presented as centralized systems or variable speed pumps, the underlying objective is generally the same - use ONLY the energy required to accomplish the mission…no more, no less. On the journey to "slimmer" vacuum usage, you (the end-user) are at the helm, and the most important variable in determining success is the required *vacuum level*.

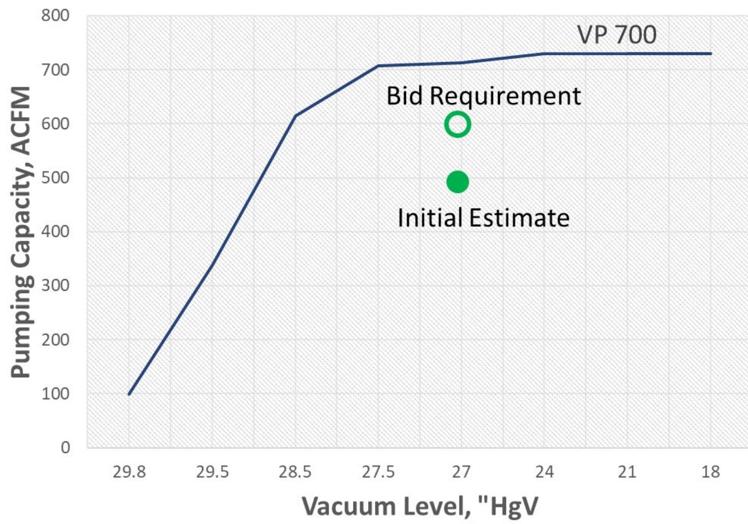
Plenty of vacuum users maintain tight control on their operating vacuum level…Insufficient vacuum and a million-dollar batch of product could be ruined. On the contrary, many users simply turn on their pumps and the vacuum level "is what it is". More a result of circumstance than a specified and controlled operating parameter. Sound familiar?
The purpose of the paper is to describe why just a few inches of mercury ("HgV) here or there could make a big difference on your company's bottom line.

Quantifying the Vacuum Requirement

When a need for vacuum is first identified, an evaluation is often done by a plant engineer or maintenance supervisor (with occasional guidance from an OEM) to estimate the requirements. For the purpose of this example, let's say an engineer has estimated the vacuum requirement to be 500 ACFM at 27"HgV for a new paper handling machine. The flowrate was estimated by the number of vacuum ports on the new machine, and 27"HgV is what's observed on existing machines in the facility. Being responsible for selecting the right equipment can be intimidating, and nobody wants to be the reason why equipment doesn't work properly. There's also uncertainty in the needs of the future. So to be sure the solution has enough "umph", the engineer applies a 20% safety margin to the estimate and goes shopping for pump that can provide 600 ACFM at 27"HgV.

Selecting the Vacuum Pump

After some online research and consulting other stakeholders, the engineer determines that a simple low-cost pump is what's best for their budget. Suppliers issue quotations to the company's purchasing team, and it's decided to purchase the VP 700. This is a fix speed vacuum pump with an excellent reputation for longevity.



(Figure 1 – Original Selection)

Vacuum Pump Commissioning

Once the paper handling machine and the vacuum pump are installed, the team hits the start button and is pleased to observe a deeper vacuum level than they specified. High-fives ensue, and the project is deemed a success. On to the next challenge.

The Assessment

The above scenario may seem like a common and logical chain of events. Let's look in more detail to what happened….*(ref. figure 2 below)*

1. When the 20% safety factor was applied before going out for bid, the company unknowingly exceeded an alternative sizing solution (VP 550) which could have been offered by manufacturers AND still provide some safety margin.

2. Seldom does a vacuum requirement land exactly on a pump performance curve. In this case, since the VP 700 provides roughly 700 ACFM at 27"HgV (vs. the true requirement of 500 ACFM), what takes place in reality is a balancing act between the process demand and pump capability. Applying the principles of the ideal gas law with fix mass flow, the resulting vacuum level can be calculated with the equation:

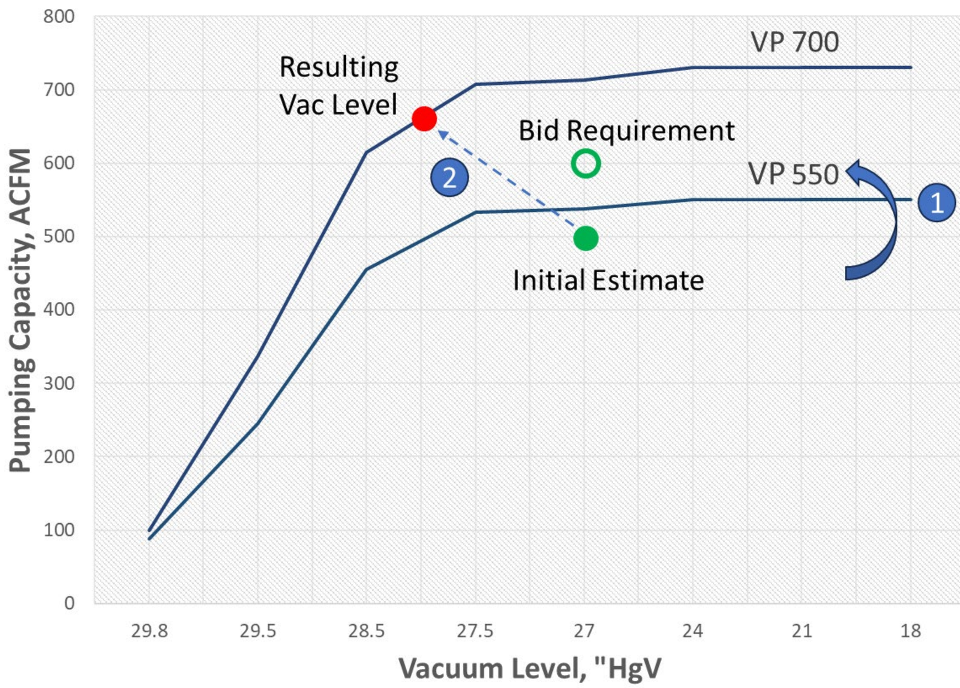
$$P_1 \times V_1 = P_2 \times V_2$$

where:

P_1 = Specified Vacuum Level, 27"HgV (3"HgA)
V_1 = True Requirement, 500 ACFM
P_2 = Resulting Vacuum Level, "HgA
V_2 = Actual Pump Capability, 700 ACFM

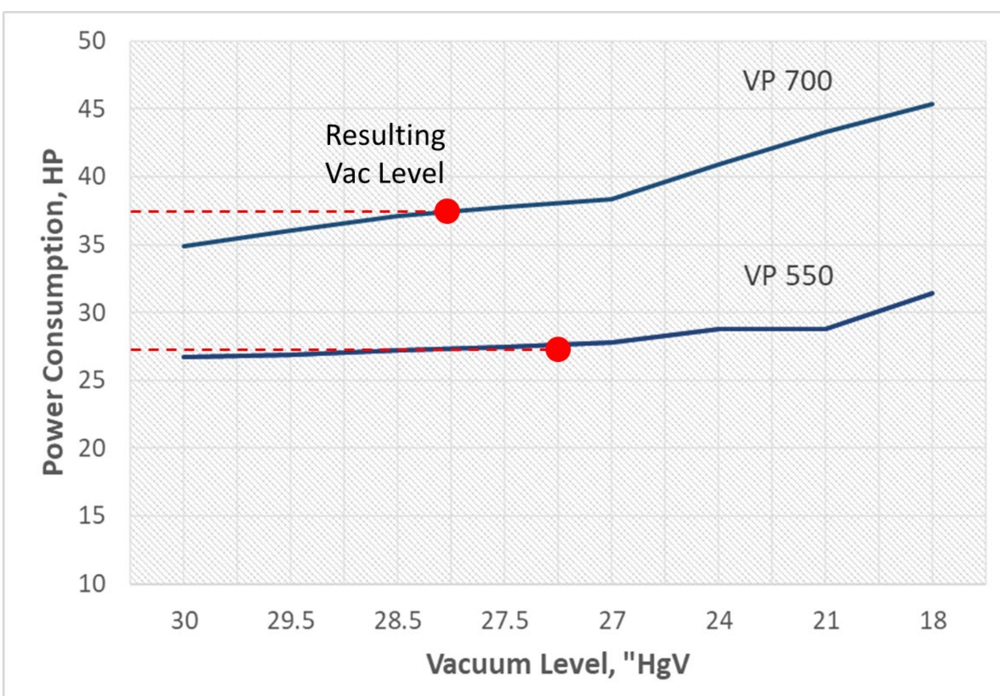
$$P_2 = \frac{P_1 \times V_1}{V_2} = \frac{3"HgA \times 500\ ACFM}{700\ ACFM}$$

$$= 2.1"\text{HgA} \ (\approx 28"HgV)$$



(Figure 2 – Initial Estimate vs. Result)

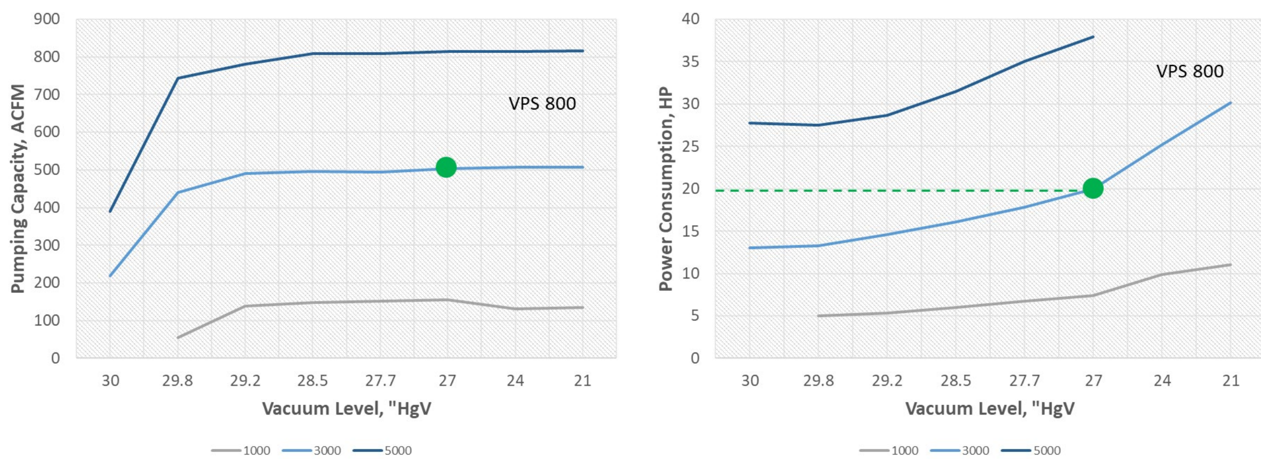
In this example, the application operates at a deeper vacuum level than specified. You may be asking, "what's the big deal?!". First, deeper vacuum isn't always desirable. In some applications this can increase the likelihood for failure (tearing of filter paper in laboratories, breaking of fragile products during pick-and-place). Secondly, using a larger sized machine than necessary uses more energy than necessary. As shown below, the VP 700 will draw approximately 37.5HP at the equilibrium vacuum level of 28"HgV. Yet the VP 550 would have stabilized at approximately 27.3"HgV and consumed only 27.5 HP.



(Figure 3 – Fixed Speed Power Consumption)

The moral of the story isn't just to be careful in applying safety margins to pump selection (although that is important). The key takeaway is understanding the relationship between vacuum level, required volumetric capacity and power consumption. The deeper the vacuum level, the larger the volume occupied (for the same given mass). This larger volume requires a pump with more capacity, which comes at a cost in the form of horsepower.

So how can one responsibly meet the duty point AND allow for safety margin and potential future plant expansions? The answer rests in one of those "fat-burning" energy conscious solutions - Variable Speed Vacuum Pumps. Following the example above, the variable speed pump selection would be the VPS 800. Based on the model number alone, that may Intuitively seem much too large. However, at the duty point of 500 ACFM at 27"HgV it would rotate at only 3,000 RPM. At this speed, the pump would draw approximately 20 HP. At higher rotational speeds, the VPS 800 can accommodate unforeseen demands or future facility expansions.



(Figure 4 – Variable Speed Alternative)

To put this into financial perspective, if the pump operates 6,000 hrs per year to support the paper machine operations and electricity is estimated as 0.10 $/kW-hr, the use of a variable speed pump could save close to 52% of the electricity costs.

COST OF ELECTRICITY SUMMARY:	**1 x VP 700**	**1 x VP 500**	**1 x VPS 800**	**vs. VP 700**	**vs. VP 500**
Annual Electricity Costs:	$ 18,336.89	$ 13,447.05	$ 8,858.92	51.7%	34.1%

In an era of automation, green initiatives, and increased competition, optimizing efficiency is critical. As it relates to vacuum, this starts by establishing the vacuum level essential for successful operation. The vacuum level will often govern things like product quality and throughput, which are likely to have a much greater impact on bottom line profits. If necessary, try operating at higher/lower vacuum levels until the lowest acceptable vacuum level is established. As shown in this article, an inch here or there can make a big difference. Then consider the use of a variable speed vacuum pump to accommodate variation in operation, future expansion, and safety margin. This will ensure stable vacuum levels and only use the amount of energy required…no more, no less. Salads for dinner and hours on the treadmill not required.