VACUUM LAW

BY DANIEL PASCOE

VACUUM IS A PRESSURE CONDITION and can be defined as a known volume of air under a lower pressure than the air surrounding it. Therefore, if you generated a vacuum condition inside a vacuum vessel, the air on the outside of the vacuum vessel is higher than that on the inside. Consequently, if you had a small leak in the vacuum vessel, air "rushes" into this void to equalize the two pressure areas. Simple enough to visualize.

One of the more confusing and misunderstood vacuum problems facing engineers is how to compensate for leakage in a vacuum system. Very much like the leak on the vacuum vessel, how do you correctly size a larger vacuum pump to compensate for the leakage and enable the system to maintain a vacuum level of choice rather than a consequence?

Fig 1 shows a simple vacuum system comprised of a compressed air vacuum generator, tubing between the vacuum generator and vacuum cup, and a vacuum gauge. The product being handled is a small cardboard box that has a leak due to the porosity of the cardboard material. How do you calculate the size of vacuum generator that will create a higher vacuum level than that being experienced? If the vacuum generator is capable of 10 scfm maximum vacuum flow, a maximum vacuum level of 27"Hg, and the vacuum level being generated is only 15"Hg, it is because air is being drawn into the system through the cardboard box. Therefore, if you want to create a vacuum level of 24"Hg, what size vacuum generator do you need to overcome this leakage?

Boyles Law can be used to determine this large vacuum generator. More details concerning this law can be found at http://en.wikipedia.org/wiki/Boyle's_law.

Boyles Law states that $\mathbf{P_1 \times V_1 = P_2 \times V_2}$ where the following is applicable:

P1 - The existing pressure (vacuum level)
P2 - The pressure needed (desired vacuum level)
V1 - The volume of vacuum flow produced by the current vacuum generator
V2 - The volume of the larger vacuum generator needed

IMPORTANT – The vacuum level MUST be in an absolute measurement. Therefore, the following applies:

P1 - 15"Hg(a) (30"Hg-15"Hg)
P2 - 6"Hg(a) (30"Hg-24"Hg)
V1 - 10
V2 - ?

V2 is what we want to know. Transpose this formula and you have the calculation shown in *Fig 1*.

As the calculation demonstrates in *Fig. 1,* the vacuum generator needs to increase to 25-scfm vacuum, which is a factor of 2.5 compared to the original 10-scfm unit.

This simple calculation removes the guesswork and indeed unnecessary cost often associated with this type of improvement exercise.

This article is intended as a general guide and as with any industrial application involving machinery choice, independent professional advice should be sought to ensure correct selection and installation.

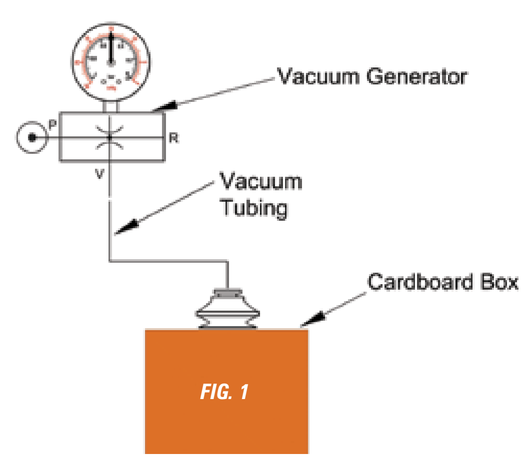

FIG. 1

$$P_1 V_1 = P_2 V_2$$

$$V_2 = \frac{P_1 V_1}{P_2}$$

$$V_2 = \frac{15 \times 10}{6}$$

$$V_2 = 25$$

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