# Vacuuming Textiles: A New Kind of Cost Benefit Analysis


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Vacuuming is a method of mechanical cleaning, not unlike using a scalpel to remove accretions of dirt from an object. When we vacuum a textile, we are employing a current of air (rather than a blade) to apply enough force to overcome the physical and chemical forces acting between the dirt and the textile.

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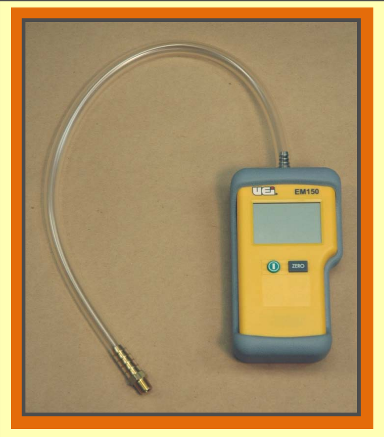
In this cartoon, the tree represents a textile and the kite represents dirt. The string of the kite represents the forces acting to keep them together, and the wind is working to separate them and carry the kite (dirt) away.

## Introduction

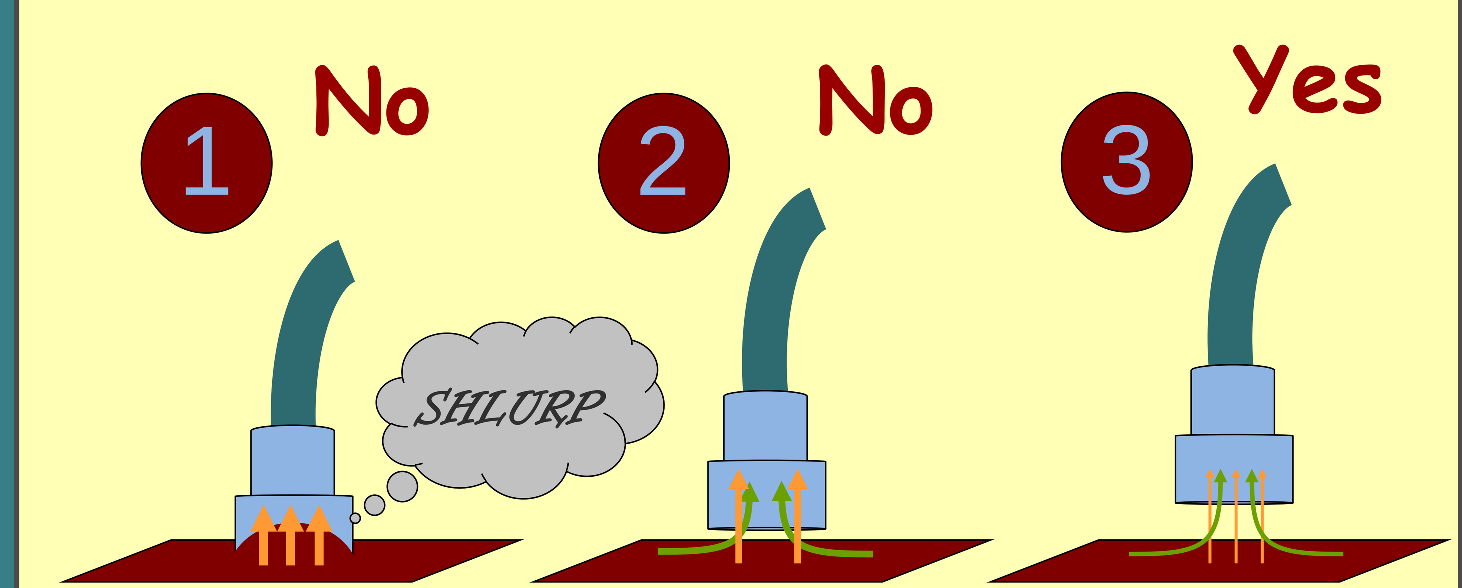
**With inexpensive instruments, we can measure the forces acting on textiles during vacuuming and ultimately use this data to establish more standardized methods of gentle and effective vacuuming.**



Normal (perpendicular) forces acting on a textile during vacuuming can be measured directly with a MANOMETER. A manometer (a.k.a. a water lift gage) measures how many inches of water the vacuum can pull into a tube. These measurements can be converted to the SI derived unit for pressure/stress, the pascal (Pa), or pounds per square inch (psi).

Shear (parallel or tangential) forces acting on a textile during vacuuming can be measured indirectly with an ANEMOMETER. An anemometer measures the volume of air pulled through a tube or opening during a given period of time. These measurements can be converted to miles per hour.

## A Continuum of NORMAL and SHEAR Forces

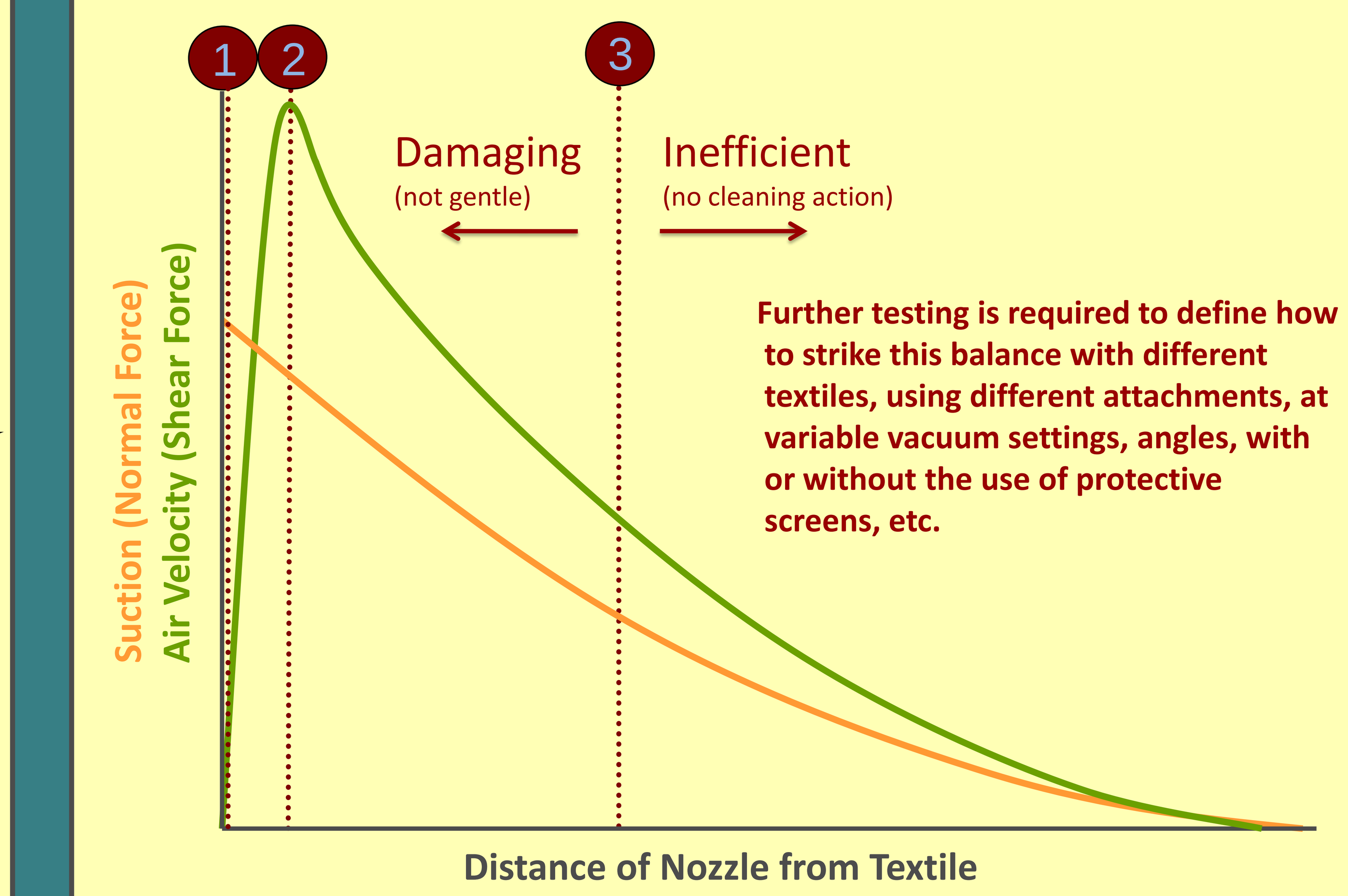



1. When the nozzle is ON the textile, normal forces are maximized and shear forces are minimized as the textile is drawn up into the nozzle.
2. When the distance between the nozzle and the textile is very small, normal forces are substantially reduced and shear forces are maximized.
3. As this distance is increased, normal and shear forces are reduced further (eventually cleaning potential is also reduced).

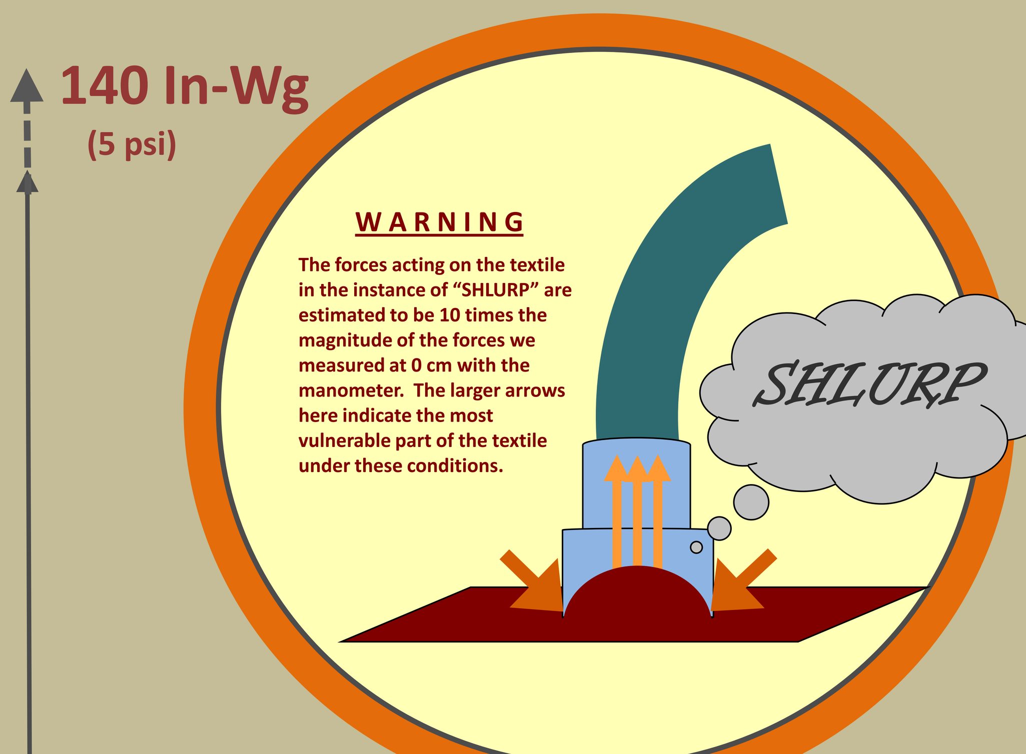
NORMAL FORCE MEASURED DIRECTLY (IN-WG) WITH MANOMETER

SHEAR FORCE MEASURED INDIRECTLY AS AIR VELOCITY (FT /MIN) WITH THE ANEMOMETER.

## A Continuum of NORMAL and SHEAR Forces

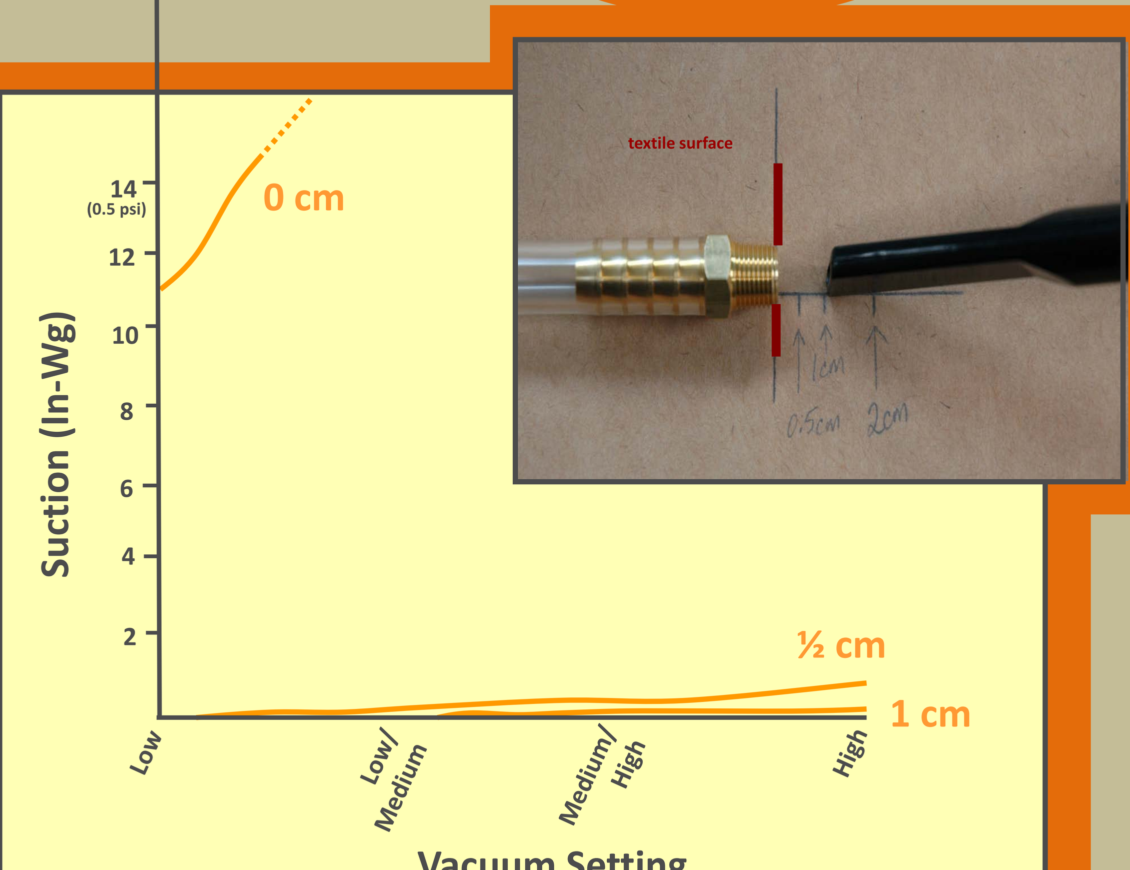



Further testing is required to define how to strike this balance with different textiles, using different attachments, at variable vacuum settings, angles, with or without the use of protective screens, etc.



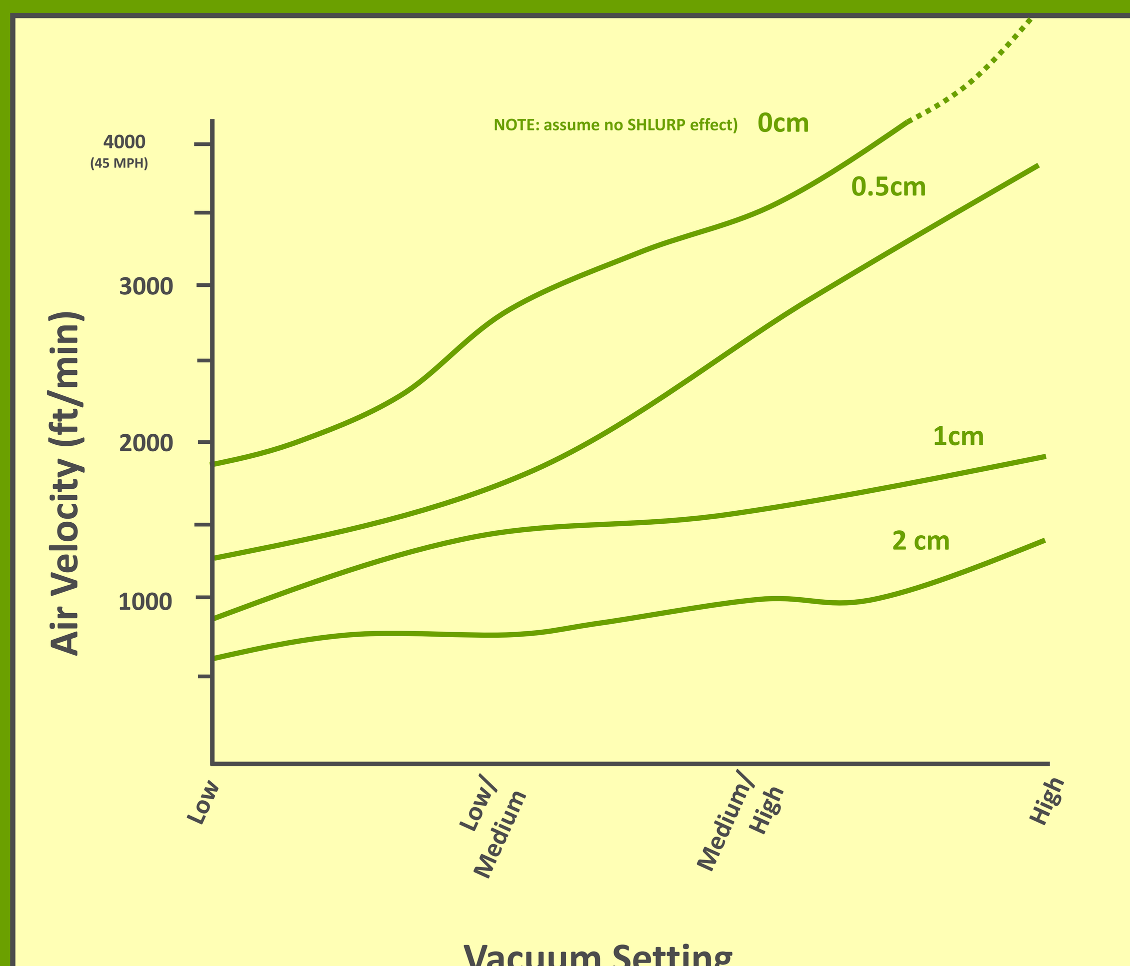

**WARNING**

The forces acting on the textile in the instance of "SHLURP" are estimated to be 10 times the magnitude of the forces we measured at 0 cm with the manometer. The larger arrows here indicate the most vulnerable part of the textile under these conditions.

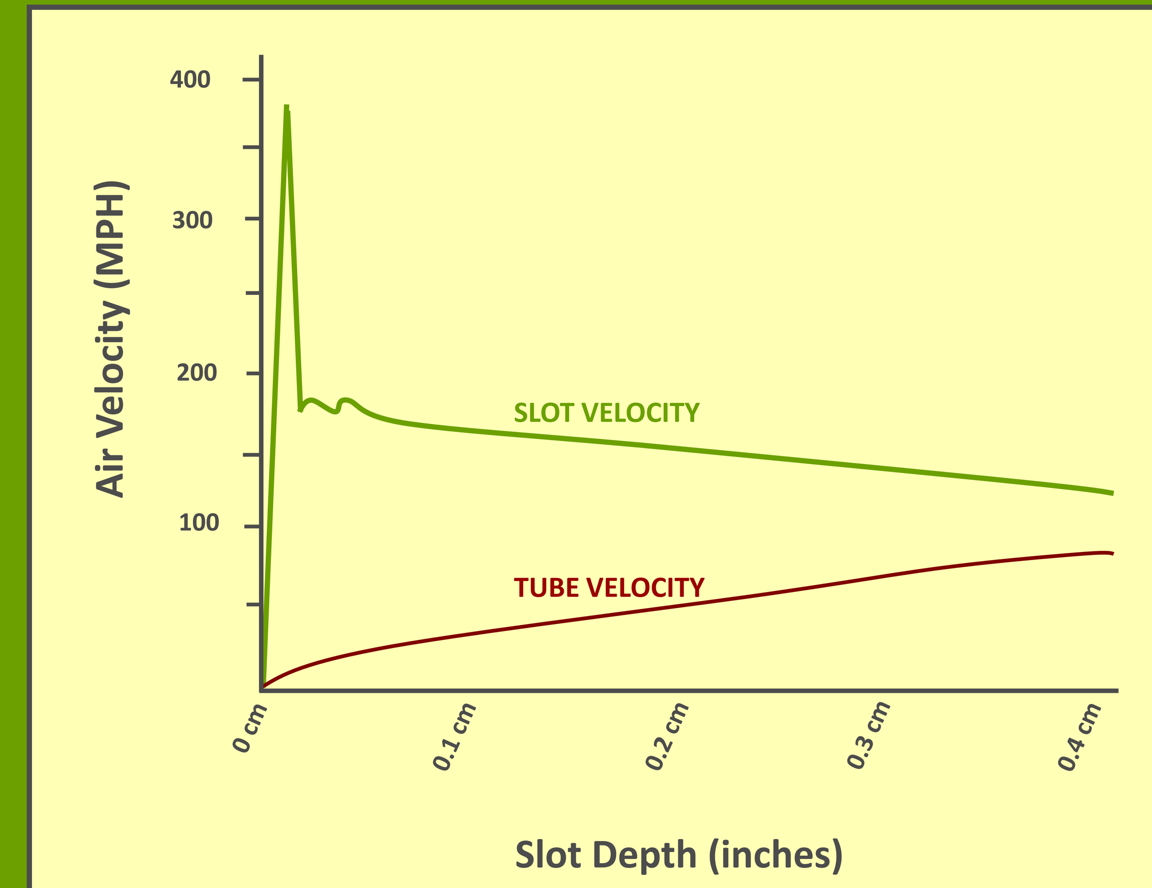



Note the dramatic drop in the magnitude of normal force (suction) with the detailer if the nozzle is kept just ½ cm off the surface of the textile. The decrease in magnitude of normal force is marginal at greater distances, but the risk of SHLURP is also considerably less at greater distances.

This setup measures air flow at the textile surface. These readings are highly variable. The chart below represents the average of six runs of the same setup. The standard deviation for these data ranged from 15-87, indicating their questionable accuracy due to the lack of precision in these setups. Still, there are undeniable trends in the data. One way to improve the data would be to reproduce these setups using an ammeter to quantify the output of the vacuum at various settings.




Shear force (i.e. friction, measured indirectly as air flow) drops off more gradually than normal force (suction). The suction of the vacuum creates air flow, which moves the dirt off of the textiles. The amount of air flow that exerts too much force on the textile or not enough force on the dirt, will vary according to the makeup and condition of the textile, the vacuum setting, attachment, and technique used by the individual operator (distance, angle, use of a screen, etc.).




This setup measures the flow of air through the tube of the vacuum rather than at the textile surface, and provides the most stable and consistent readings with the anemometer.

The data above were recorded with no vacuum attachment at the highest vacuum setting, but the magnitude of shear force (i.e. friction, measures indirectly as air flow) was alarmingly high even at lower vacuum settings. For example, the slot velocity calculations for the upholstery brush attachment at the low/medium vacuum setting, and more than 1 inch off the textile surface, were still more than 60 MPH!

**Calculations**

Slot area = slot depth X 2(slot width)

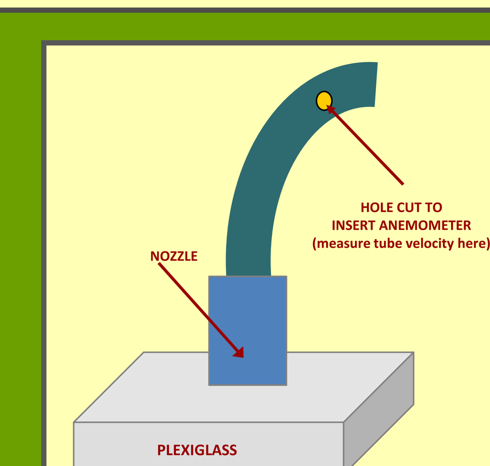
Slot depth built up with layers of electrical tape, each layer 0.007 inches thick

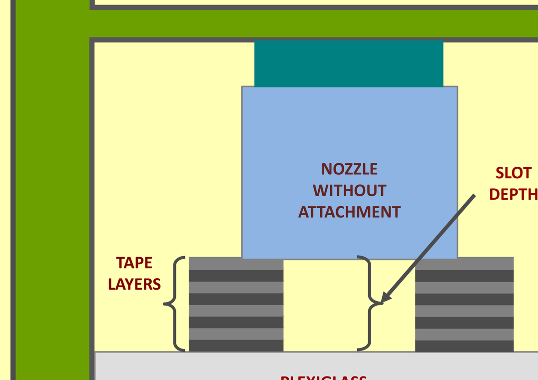
Tube area = $\pi r^2$ (nozzle without attachment)

Tube velocity measured with anemometer, corrected for reading obtained for "perfect" vacuum (converted to mph).

$$\text{Slot velocity} = \frac{\text{tube velocity} \times \text{tube area}}{\text{slot area}}$$

(converted to mph)




## Conclusions

**The more efficient you are while vacuuming, the less gentle you will be and vice versa. The standard practice of noting the vacuum setting is grossly insufficient to gauge either.**

**The technique of the individual operating the vacuum will play the crucial role in determining how gentle and efficient a vacuuming campaign will be, and we CAN measure this.**

**With continued testing, it may be possible to extrapolate aggregate data to establish general and/or treatment specific protocols for more efficient and more gentle vacuuming techniques.**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