

HIGH VACUUM

The term *high vacuum* is often misused. In general industrial applications, a true high vacuum is rarely required. This article offers basic examples of what is meant by the terms *rough vacuum*, *medium vacuum*, and *high vacuum* and their general application in manufacturing.

Table 1 demonstrates widely acknowledged terminology used in industry.

Torr is used in the reference numbers above, as this is often the unit of measurement used in North America. However the SI unit (International System of Units) of pressure is *Pascal* (symbol - Pa). The Pascal unit is derived from the force pressure exerted by a 1 Newton force exerted over 1 square meter (1N/m²). Table 2 shows a conversion of this to other common units used.

The biggest challenge is not in the selection of vacuum pumping equipment, which is able to achieve the high vacuum level, but the accessory equipment that prevents leaks in the total system. This could be gauging equipment, valves, or simply connections to apparatus. Pipe threads in medium- and high-vacuum applications are never used. Instead, flange connections are utilized offering a secure seal as shown in *Fig. 1*.

Unlike rough vacuum applications, the end users in high vacuum fields are very aware of good vacuum practice. This is normally born from problems they have experienced before in the practicalities of achieving and maintaining a medium or high, leak-free vacuum system.

Vacuum is a pressure condition. This needs to be understood. It is key in the comprehension, particularly by the technical vacuum novice, of what a “high” vacuum is. When referring to a “high vacuum” we mean a “deep” or “a lot of vacuum”—a condition in which the pressure has been reduced, by a very large amount, from the atmospheric pressure.

Rough Vacuum can be achieved using a variety of means using positive displacement pumps where a cavity is expanded to capture a volume of air and then exhausted out of the pump. Reciprocating piston pumps, commonly found in such apparatus as refrigerant circuits (just like the domestic models found in your home), are characterized by the dead space above the piston and leakage between the cylinder and piston. This leakage therefore limits the maximum final vacuum achievable by this type of technology. A common rough vacuum pump is the rotary sliding vane type offered by many manufacturers and under good conditions with high-quality equipment, a vacuum level of <0.1Torr is easily achieved. Applications such as meat packaging or freeze drying require vacuum levels beyond 1 Torr.

Medium Vacuum can be achieved by using rotary sliding vane pumps also, but the choice of manufacturers is more limited. Medium vacuum is commonly defined as one that can be achieved with a single vacuum pump but cannot be measured by a mechanical gauge, instead requiring a capacitive or thermal gauge. Applications such as incandescent light bulb and thermos flask manufacturing, as well as vacuum ovens, are typical of a medium vacuum pump system.

High Vacuum is often defined using the term MFP (mean free path). This means the distance between each gas molecule. This is demonstrated in *Fig. 2*. Therefore, if the pumping chamber or volume being evacuated is larger than the MFP, it is a high vacuum. Multiple pump systems are required to generate high vacuum where you would use a “roughing” pump such

TABLE 1

10⁻⁷Torr refers to 0.0000010Torr where 1 Torr is 1mm of Hg (mercury) of pressure

Term	Vacuum Level
Rough Vacuum	760Torr to 1Torr
Medium Vacuum	1Torr to 10 ⁻³ Torr
High Vacuum	10 ⁻³ Torr to 10 ⁻⁷ Torr
Ultra High Vacuum (UHV)	10 ⁻⁷ Torr and beyond

TABLE 2

	Pascal (Pa)	Bar	Atmosphere (atm)	Torr (mmHg)	Pound / in ² (psi)
1 Pa	1	10 ⁻⁵	9.8692×10 ⁻⁶	7.5006×10 ⁻³	145.04×10 ⁻⁶
1 Bar	100000	1	0.98692	750.06	14.5037744
1 ATM	101325	1.01325	1	760	14.696
1 Torr	133.322	1.3332×10 ⁻³	1.3158×10 ⁻³	1	19.337×10 ⁻³
1 psi	6.894×10 ³	68.948×10 ⁻³	68.046×10 ⁻³	51.715	1



FIG. 1

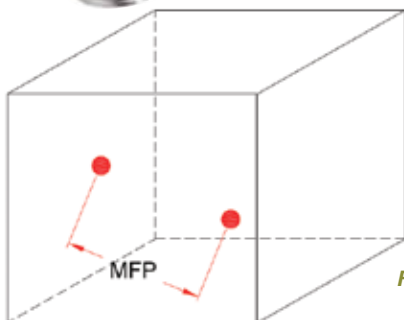
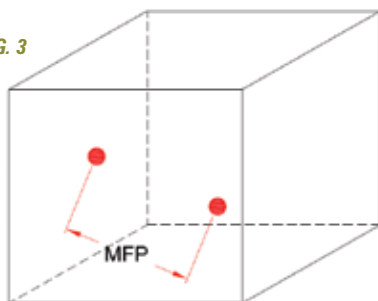


FIG. 2

FIG. 3



as a vane pump as used in medium vacuum. Coupled to this, a high-vacuum pump would be used to exhaust into the intake of the roughing pump. High-vacuum pumps such as turbomolecular models are unable to pump from atmospheric pressure simply because there are too many gas molecules to transfer. Do not forget that in simplistic terminology, a vacuum is a volume devoid of matter, such as gas molecules. High-vacuum applications are that of space simulation or laboratory test applications where the volume being tested has to be as media-free as possible to prevent contamination of the process.

To achieve high vacuum, certain conditions have to exist such as large pumping tubes between pumping apparatus to offer ease of gas flow, low-out gassing materials such as certain grades of stainless steels (certain materials will exhaust gases into a high-vacuum stream preventing system final pressure), smooth tubing channels without pits and crevices that trap air bubbles, removal of all oils and liquids within the vacuum apparatus to prevent off gassing, and so on.

Experts in this field are widespread particularly in North America and Europe where innovation in product development is common from invention and continuous exploration into high-vacuum engineering.

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.

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