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## Application Note Number 30: Using the Extorr Probe during 100°C Bake-out

**Abstract:** The flange on the Extorr probe is designed to separate vacuum from the electronics package. This makes operation of the quadrupole possible during 100°C bake-outs. Why this may want to be done is also discussed.

The construction of the Extorr probe's vacuum flange is such that vacuum wall is separated from the aluminum clad electronics package by a half inch long stainless steel tube. The thermal conduction of the tube is minimal and the electronics box can easily dissipate the heat conducted through this tube. The net effect is that the probe, which may be baked to 350°C when the electronics package is removed, may be heated to 100°C when the electronics are plugged in. The unit may therefore be operated during a 100°C bake-out.

Although the Pirani gauge may not be used, the thermometer on the flange may be used to measure the probe temperature. Thermal measurement is also available inside the electronics box. This may be found in the VacuumPlus software under Outputs>Electronics Temperature.

This brings us to the question of why would you want to heat your vacuum system during operation of the residual gas analyzer. Typically, if the object is to reduce the partial pressures of all residual gases to their lowest possible levels, a way of peeling the loosely bound volatile molecules from the inside walls of the vacuum system, would be desirable. The most common way of doing this is to bake out the system.

Molecules can only be pumped from the inside of a vacuum system when they travel within the inside volume of the chamber. They can not be pumped if they are attached to the inside walls of the system. The residence time of a molecule, bound to the walls of the chamber, is the oscillation period,  $t_0$  of the molecule within the bonding potential well times  $e^{\epsilon/kT}$  where  $\epsilon$  is the bonding energy to the wall,  $k$  is Boltzmann's constant and  $T$  the temperature in Kelvin.  $t_0$  is typically  $10^{-12}$  seconds.

The velocity of water vapor at room temperature is about 600 m/s. If the vacuum system walls are 0.3 meters apart the time in flight is 0.5 ms. If water is bound to a surface with energy of 0.5 eV (a typical hydrogen bond) then we get a residence time of 0.5 ms. The water, with this binding energy, is off the wall a large fraction of the time and these molecules should pump out quickly. If, however the water is not bound to the surface with a single hydrogen bond but is bound by, say 0.8 eV then the same calculation gives the wall residence time as 23 seconds! Now the water is almost always on the surface, not in the volume, and no amount of pumping will speed up the pumping of this water from the surface.

Doing the same calculation, but this time increasing the temperature from 300 to 400 K, will decrease this residence time to about 26 milliseconds and once again water may be pumped. The net effect is that water now makes billiard ball type collisions on the hot walls of the vacuum system.