Extorr Inc.
307 Columbia Road
New Kensington, PA 15068
724-337-3000
Fax 724-337-8322

Application Note Number 30:
Using the Extorr XT Series Probe during 100 ºC Bake-out

Abstract: The Extorr XT Series probe is designed to separate the vacuum wall from the electronics Command and Control Unit (CCU). This makes operation of the RGA possible during 100 ºC vacuum bake-outs. Why this may want to be done is also discussed.

The Extorr XT Series probe has the vacuum wall of the feed through separated from the electronics Command and Control Unit (CCU) by a half inch long stainless steel tube. The thermal conduction of this tube is minimal and the aluminum CCU enclosure can easily dissipate the heat that is conducted. This allows the RGA to operate while the probe is heated to 100 ºC with the CCU attached.

The temperature of the probe can be monitored using the Sensor Temperature reading on the Outputs tab of the VacuumPlus software. This is temperature of the Pirani gauge RTD sensor on the flange and must not exceed 100 ºC. The temperature inside the CCU box is also shown on the Outputs tab as the Electronics Temperature reading and should remain below 50 ºC during bake-out.

This brings us to the question of why you would want to heat your vacuum system during RGA operation.

Every time a vacuum chamber is opened to ambient air, the internal surfaces become coated with many layers of water molecules.
When the chamber is pumped down some of the outer layers of the water molecules, along with the air, are quickly removed from the system but many layers of water remain adsorbed on the interior surfaces. At a total pressure of 1×10^{-6} Torr in a chamber with no air leaks, water vapor may make up 90% or more of the residual gas during the initial pump down.

As the chamber continues to pump some of the remaining water molecules desorb from the surfaces and move freely through the inside volume of the vacuum chamber along with the other residual gases. All of these molecules move in random directions frequently colliding with the chamber walls. The velocities of the gas molecules at room temperature are about 500 m/s and so they can easily travel from one end of a large chamber to the other in just milliseconds. Eventually they enter the vacuum pump and are removed from the system lowering the pressure.

When gas molecules collide with the chamber wall, they do not bounce off immediately but remain on the surface for a short period of time. This is known as residence time and depends on the temperature of the surface and the strength of the chemical bond between the molecules.

The top layers of water molecules are weakly bound to each other and have residence times on the order of 0.5 ms or so. These molecules spend a large fraction of time moving freely through the chamber (off the walls) and should pump away quickly.

Closer to the chamber wall, the chemical bonds are stronger and the residence times can be many seconds or tens of seconds at room temperature. These molecules are almost always on the surface, not freely moving through the chamber, and are unlikely to enter the vacuum pump and be removed from the system.

Baking out the vacuum system by heating the chamber to 100 °C can transfer enough energy to the water molecules near the chamber surface to overcome the stronger chemical bonds. This can reduce the residence times from many seconds or tens of seconds to a millisecond or less. The water molecules then spend a large fraction of time off the wall moving freely through the chamber and are likely to enter the vacuum pump and be removed from the system.

The Extorr XT Series RGA can monitor the total pressure of the vacuum system and the partial pressures of the residual gasses during bake out.

As the chamber is heated, the total pressure and partial pressure of water will initially increase as molecules desorb from the interior surfaces. The pressures will reach a peak value and then slowly decrease over time. Eventually the pressure will decrease to some level and not go any further. The heaters can then be turned off. The pressure will decrease further as the chamber cools and very little residual water should remain in the system. The bake out process may be repeated whenever the chamber is vented to atmosphere to quickly reduce the residual water in the system.

Use care when baking your vacuum system. Do not allow the Sensor Temperature reading on the Outputs tab of the VacuumPlus software to exceed 100 ºC or damage to the CCU will occur. Do not bake systems with O-ring seals. The O-rings can soften or degrade at high temperatures and cause a catastrophic vacuum failure. Heat the vacuum system evenly to avoid cold spots. Water molecules that were desorbed from a hot area of the chamber can collect on a cold spot instead of being pumped away.