Extraordinary steps are required to reach UHV, including but not limited to the following:

• High pumping speed — possibly multiple vacuum pumps in series and/or parallel
• Minimize surface area in the chamber
• High conductance connections to pumps — minimize elbows, maximize diameters, and reduce lengths
• Use low (5X10-8 to 3X10-13 T lcc/s) outgassing materials such as certain stainless steels, 304, 304L, 316, 316L, 316LN, 321, and 347
• OFHC Copper and 6061- T6 Aluminum also are acceptable for use in UHV systems.
• Avoid creating pits of trapped gas behind bolts, welding voids, etc. normally refered to as virtual leaks
• Electropolish all metal parts after machining or welding
• Use low vapor pressure materials (ceramics, glass, metals)
• Don't use brass, palladium, or plastics in a UHV system.
• Bake the system (250 °C to 400 °C) to remove water or hydrocarbons adsorbed to the walls
• Chill chamber walls to cryogenic temperatures during use
• Avoid all traces of hydrocarbons, including skin oils in a fingerprint, always use powder free Nitrile or Latex gloves

Outgassing is a significant problem for UHV systems. Outgassing can occur from two sources: surfaces and bulk materials. Outgassing from bulk materials is minimized by careful selection of materials with low vapor pressures (such as glass, stainless steel, and ceramics) for everything inside the system. Even materials which are not generally considered absorbent can outgas, including most plastics and some metals. For example, vessels lined with a highly gas-permeable material such as brass and palladium (which is a high-capacity hydrogen sponge) create special outgassing problems.

Outgassing from surfaces is a subtler problem. At extremely low pressures, more gas molecules are adsorbed on the walls than are floating in the chamber, so the total surface area inside a chamber is more important than its volume for reaching UHV. Water is a significant source of outgassing because a thin layer of water vapor rapidly adsorbs to everything whenever the chamber is opened to air. Water evaporates from surfaces too slowly to be fully removed at room temperature, but just fast enough to present a continuous level of background contamination. Removal of water and similar gases generally requires baking the UHV system at 200 to 400 °C while vacuum pumps are running. During chamber use, the walls of the chamber may be chilled using liquid nitrogen to reduce outgassing further.

Hydrogen (H) 2, Carbon Dioxide (CO2) 44, Carbon Monoxide (CO) 28 and Helium (He) 4 are the most common background gases in a well-designed, well-baked UHV system.

Typically, there is no single vacuum pump that can operate all the way from atmospheric pressure to ultra high vacuum. Instead, a series of different pumps is used, according to the appropriate pressure range for each pump. Pumps commonly used to achieve UHV include:

•Scroll pumps
•Turbomolecular pumps (especially compound and/or magnetic bearing types)
•Ion pumps
•Titanium sublimation pumps
•Non-evaporable getter (NEG) pumps
•Cryopumps

UHV pressure is measured with an cold cathode gauge or an ion gauge.

Metal seals or gaskets must be used between components in a UHV system to prevent even trace leakage. This all-metal seal can maintain pressures down to 100 pPa (~10−11 Torr).

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