VACUUM CHAMBER MANUAL

HIGH VACUUM CHAMBERS

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1. SCOPE

This guide applies to high vacuum chambers designed and operated at pressures (vacuum levels) from atmosphere to approximately 1 x 10^{-9} Torr. Many high vacuum chambers and systems may be designed to achieve a vacuum level of only 1 x 10^{-6} or 1 x 10^{-7} Torr. Nevertheless, the same basic principles of operation and maintenance apply. However, extreme care in the design, operation and maintenance of a high vacuum system is required in order to achieve vacuum levels in the 10^{-9} Torr range.

2. SAFETY

Unless otherwise specified and designed, this vacuum chamber is designed to only be used under vacuum and not positive pressure. If the vacuum chamber is used in positive pressure applications the warranty is voided and the user will place themselves, other individuals, and the equipment in an unsafe condition.

CAUTION Use care when handling the vacuum chamber. Many of the chambers are very heavy so use proper lifting equipment and safety devices.

Do not lift or handle the chamber by the chamber ports, lid or associated valves. Use the provided lifting eyes or the chamber body itself to move larger chambers.

CAUTION Before running a vacuum process, ensure the process has been sufficiently researched and tested in order to prevent unsafe or adverse conditions from occurring. Never place objects or materials in a vacuum chamber that might explode or otherwise become a hazard when exposed to vacuum conditions.

CAUTION Keep the equipment associated with the vacuum chamber in proper and safe working conditions. Ensure all electrical wiring associated with the chamber is done in accordance to standardized electrical codes.

CAUTION If using electricity in or near a metal vacuum chamber ensure the chamber is grounded.

CAUTION If the chamber is equipped with a view port, DO NOT operate the vacuum chamber if the view port material is cracked or damaged with deep scratches or gouges.

3. OVERVIEW

LACO high vacuum chambers include four main ports:

1. High vacuum port with valve (optional) to connect the high vacuum pump to the chamber.
2. Rough vacuum port with valve to connect the rough vacuum pump to the chamber.
3. Vent port with valve to admit air into the chamber after the vacuum cycle has completed.
4. Gauge port to attach a vacuum gauge.

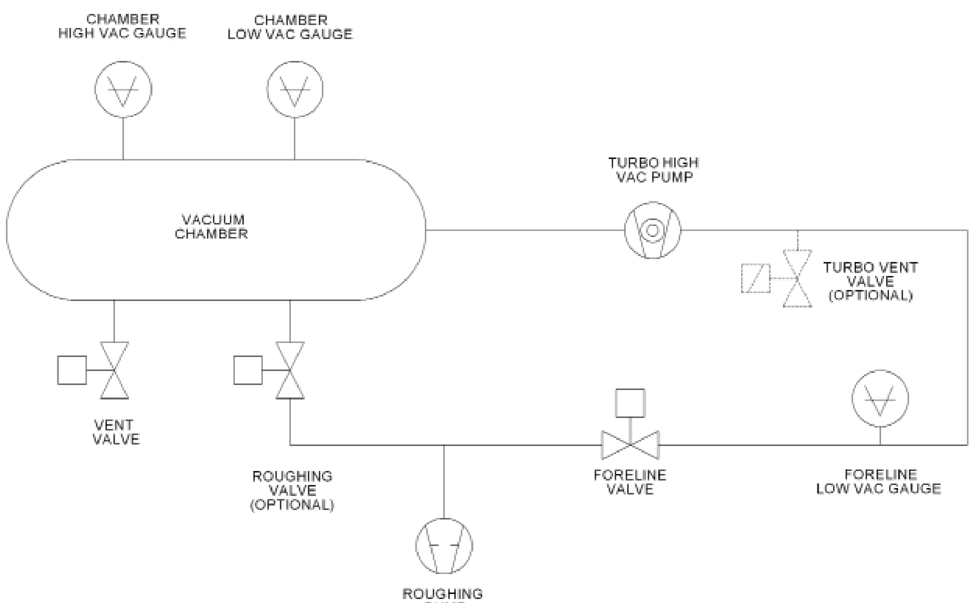
Additional ports are often included for a variety of purposes.

4. BASIC OPERATION

High vacuum systems require two independent vacuum pumps, working together to achieve high vacuum in the chamber. The roughing pump (typically a rotary vane pump) is used to initially evacuate the chamber. The high vacuum pump takes over at a specified vacuum level (called the cross over pressure) and pumps the chamber to high vacuum. In the case of a turbomolecular high vacuum pump, the roughing pump can also act as a backing pump to evacuate the exhaust (or foreline) of the turbo pump or a dedicated backing pump can be used.

Simple high vacuum systems are most often configured in one of two ways. The following configurations show typical setups using a turbo pump as the high vacuum pump.

Configuration 1: No high vacuum isolation valve.



4.1 OPERATION OF CONFIGURATION 1

Configuration 1 is commonly used when the vacuum system cycles (cycling from atmosphere to high vacuum) typically no more than once per day. In this configuration the turbo pump is turned on and off for each cycle.

1. With chamber lid or door closed, open the foreline valve to evacuate the chamber through the turbo pump. On larger vacuum chambers an optional rough port with a valve are often provided (this speeds up the rough evacuation of the chamber). In this case, both the roughing and foreline valves are opened to evacuate the chamber.

2. Start the turbo pump, allowing it to come up to speed (this typically takes 3-5 minutes) while the roughing pump evacuates the chamber.

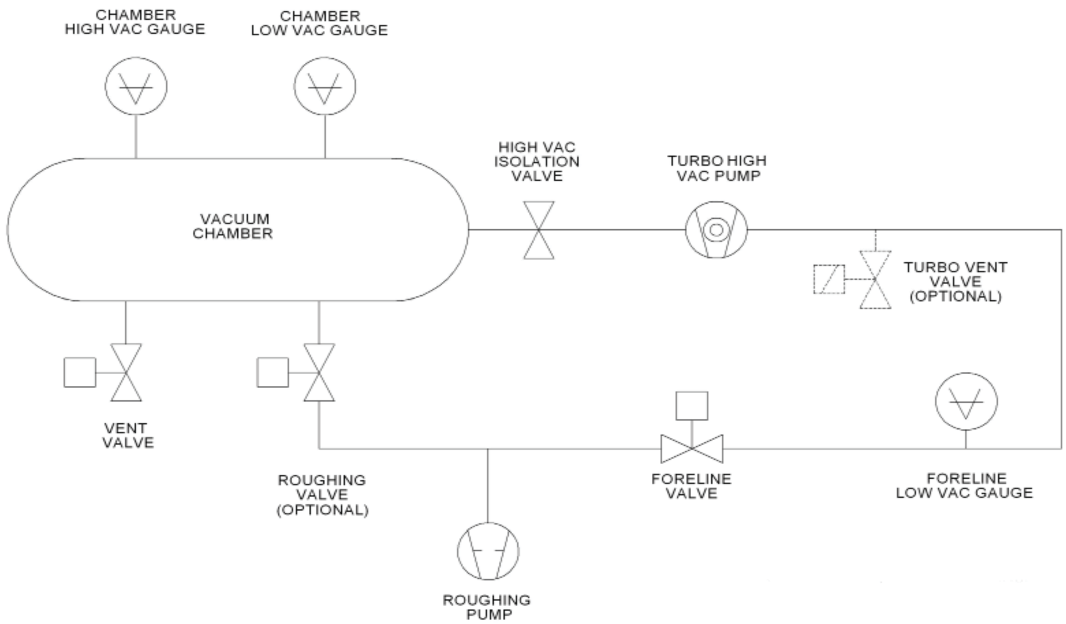
3. Once the turbo pump is at speed (chamber pressure will be less than 0.1 Torr), then close the roughing valve (if applicable) and allow the turbo pump to evacuate the chamber to the desired pressure with the foreline valve remaining open.

   NOTE Extreme care should be taken so that the turbo pump is not exposed to pressure shocks while at full speed. Never open the roughing or vent valves when the turbo pump is at full speed. The foreline valve should also remain open while the turbo pump is on.

4. Prior to venting the chamber to atmospheric pressure, close the foreline valve and turn off the turbo pump. Allow the turbo pump to slow down before opening the vent valve. Often a turbo pump vent valve (with restrictor orifice) is installed on the foreline of the turbo pump to slowly bleed air into the pump once it is turned off (this will also slowly vent the chamber). This shortens the time necessary to wait (typically to around 5 minutes depending on pump size) until the pump is spinning slow enough to then open the vent valve. Consult the turbo pump manufacturer manual for the appropriate speeds and settings.

5. Once the turbo is stopped, or spinning slow enough, open the vent valve to vent the chamber to atmospheric pressure.

Configuration 2: With high vacuum isolation valve.



4.2 OPERATION OF CONFIGURATION 2

Configuration 2 is commonly used when the vacuum system cycles (cycling from atmosphere to high vacuum) frequently (more than once per day). In this configuration the turbo pump is left on and is isolated from the chamber with a valve so that the chamber may be vented to atmospheric pressure..

1. Start up the turbo pump and insure it is operating at full speed with the foreline valve open and the high vacuum valve closed.
2. With chamber lid or door closed, close the foreline valve, then open the roughing valve to evacuate the chamber. On systems where there is a dedicated roughing pump (the pump function is not shared between backing the turbo pump and roughing the chamber), then the foreline valve should remain open.

   `**NOTE** The turbo pump will normally run with the foreline valve closed for a few minutes while the chamber is being evacuated to the crossover setpoint. If the chamber rough evacuation will be several minutes or more, then separate, dedicated backing and roughing pumps should be used.

3. Once the crossover pressure is achieved (typically less than 0.1 Torr – consult turbo pump manufacturer manual for recommended crossover pressure), close the roughing valve, open the foreline valve, then open the high vacuum valve, in that order.

4. Allow the turbo pump to evacuate the chamber to the desired pressure.

   NOTE Extreme care should be taken so that the turbo pump is not exposed to pressure shocks while at full speed. Never open the roughing or vent valves when the turbo pump is at full speed. The foreline valve should also remain open while the turbo pump is on.

5. Prior to venting the chamber to atmospheric pressure, close the high vacuum valve. Open the vent valve to vent the chamber to atmospheric pressure.

If using an oil-sealed mechanical pump as the roughing or backing pump, never turn off the vacuum pump unless the vacuum valve has first been closed (An alternate method is to close the vacuum valve and vent the vacuum line before turning of the vacuum pump.) This will minimize the chance of pump oil to be sucked into and contaminate the vacuum chamber and/or turbo pump.

5. OPERATION GUIDELINES

The most common problem associated with high vacuum systems is the inability to achieve the desired base pressure (vacuum level). A number of factors can be the cause.

5.1 IMPROPER PUMP SIZING

In a high vacuum system, the high vacuum pump primarily is pumping gases absorbed onto the walls of the chamber and other components. If the volume of the chamber to be evacuated is the only consideration in selecting the size of the high vacuum pump, then the pump will not likely achieve the desired base pressure. One must also consider gas loads from outgasing (see below) as well as other sources (such as leaks or permeation) when sizing the pump.

5.2 ENVIRONMENTAL EFFECTS

Water vapor is the primary contaminant/gas in a vacuum system. The water vapor comes from the air and will absorb on the walls of the chamber. Pumping of the layers of water vapor on a vacuum chamber is a very slow process. High humidity, low chamber temperature, high surface area inside the chamber, and dirt and contamination all contribute to higher absorption of water vapor and poor vacuum performance. In general, if vacuum levels need to be below 10^{-6} Torr, then vacuum baking of the vacuum chamber is required. The vacuum baking may only be required initially (if the chamber is operated and protected from humidity), or may be required each vacuum cycle.

5.3 CONTAMINATION / OUTGASSING

In addition to water vapor, other chemicals and materials may contribute to the gas load of a vacuum chamber. Oils and lubricants, even from fingerprints, will limit the vacuum performance. Some contaminants with low vapor pressures (such as oils) may take weeks and months to fully pump away. Prevent liquids, chemicals, oils, or any contamination from entering the vacuum chamber.

5.4 IMPROPER USE OF MATERIALS

Many materials contain chemicals, residues, or porous surfaces that will outgas under vacuum conditions. Most plastics and elastomers, for example, are not compatible with high vacuum systems. Though elastomer seals (such as Buna N and Viton) are acceptable for high vacuum systems, their use should be minimized. Minimize the use of plastics, porous materials, and materials with rough surfaces.

5.5 IMPROPER TOOLING DESIGN

A common problem in high vacuum systems is virtual leaks. Virtual leaks are introduced into a vacuum system by improper vacuum chamber or fixture design. A virtual leak is a small pocket or void that communicates with the vacuum system through a very small path. A common example of a virtual leak is a threaded screw installed into a blind, tapped hole. The dead space below the screw in the tapped hole is the pocket and the threads form the small path. The pocket of air must be evacuated through the threads each time the chamber is vented. This can significantly slow down the evacuation of the chamber. Venting the screw or eliminating the blind hole will eliminate the virtual leak.

5.6 LEAKS

Most often leaks are created in a vacuum system when a seal is broken (whether a door seal or a flange seal). If a leak is assumed, always check the item in the system that was last modified. Use a helium leak detector as a tool to locate leaks.

Table 1: DOs and DON'Ts for operating a high vacuum system

DO	DON'T
Always touch the chamber or any components that will go inside the chamber with clean, gloved hands.	Touch the inside chamber with bare hands.
Bake out the chamber to achieve a deeper vacuum.	Place plastics or porous materials in a vacuum chamber.
Clean any part prior to placing in to a vacuum chamber.	Use oils or greases inside the vacuum chamber, unless they are high vacuum compatible. Then use sparingly.
Vent the vacuum chamber with dry nitrogen to prevent water vapor from absorbing on the clean walls of the chamber.	Allow parts with virtual leaks into a vacuum chamber.
Keep the chamber under vacuum at all times, even when not in use.	Use dirty tools inside the vacuum chamber.

6. MAINTENANCE

Inspect the chamber door seal regularly to ensure no defects or wear have occurred. If cracks begin to appear in the gasket replace it immediately. See the spare parts section for ordering replacement gaskets. Do not clean your gaskets with any solvents as this will shorten the gasket life. To clean gaskets, wipe down gasket with a lint free wipe and DI water. A vacuum grease can be applied to the gasket to help enhance gasket life. Apply the grease sparingly to the gasket to achieve a smooth, thin film.

Regularly clean your chamber to keep your vacuum process running at optimum performance. A dirty chamber will adversely affect the vacuum process. The vacuum pump, chamber door seal and other vacuum components should be cleaned regularly. Clean your chamber with mild detergent and rinse with DI water, followed by wiping with Methanol. Methanol or other mild solvents can also be used clean or wipe down the inside of the chamber. Use lint free wipes to wipe out chamber.

To attain good pump-down performance, ensure the vacuum pump you are using is properly sized for your application and chamber size. If using an oil-sealed pump change the oil regularly.

7. TROUBLE-SHOOTING

The troubleshooting table below provides assistance to common vacuum problems.

Table 2: Troubleshooting

PROBLEM	CAUSE	SOLUTION
Chamber will not pump down	Leak in vacuum line	Check hose, hose connections, and clamps
	Door and gasket not sealing flat	Adjust hinge – contact LACO for assistance
	Defect in door seal	Replace door seal.
	Vent Valve or other valve left open	Close valve.
Chamber evacuates slow or will not achieve base pressure	Poor Vacuum Pump Performance	Change pump oil.
		Vacuum pump needs rebuild
	Outgassing of Product	Minimize outgassing effect, remove offending part
	Outgassing of Vacuum chamber	Clean vacuum chamber and components
	Leak in system	Inspect all components of connections. Helium Leak test chamber system, if possible. Perform rate of rise test to see if you have a leak or outgassing problems. *
	Defective Vacuum Gauge	Check operation of high vacuum gauge

*A rate of rise test can be performed by evacuating the chamber to the lowest pressure practical, then closing all valves and plotting the pressure rise over time up to pressures over 1 Torr. If the pressure rise is linear then the culprit is likely an external leak. If the pressure rise slows down at higher pressures (is non-linear), then the culprit is likely outgassing.