



Turbo Pump Basics: Installation, Operation, Start/Stop & Venting

Applications Note

GLOBAL APPLICATIONS TEAM



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I. INTRODUCTION

This document contains basic information on the installation and operation of Agilent Turbo-molecular pumps and is intended as a guideline for general use customers. Specific applications may require amendments to these instructions to ensure optimum longevity of the pump. Please contact your Agilent Sales Specialist, Manufacturer's Representative, Applications Engineer, or Customer Support Specialist for information specific to your installation.

II. TURBO-MOLECULAR PUMP MOUNTING

Agilent Turbo-molecular pumps are designed to be mounted in any orientation. Care must be taken when mounting pumps to a chamber, and use of an Inlet Screen to prevent objects from entering the pump is strongly recommended.

A. Orientation: No Limitations

Agilent Turbo-molecular pumps are designed to be mounted either vertically or horizontally. The Monolithic Rotor design delivers ruggedness, light weight, and resistance to air inrush regardless of orientation.

B. Mounting: CAUTION

Detailed instructions on the number and strength of bolts to mount a Turbo-molecular pump to a chamber are described in the operating manual for each pump. Spinning rotors contain a large amount of kinetic energy due to the mass and high rotational speed. In the event of catastrophic pump failure (contact between rotating and stationary pump components) this energy can be released suddenly.

To avoid damage to equipment and to prevent injuries to operating personnel the installation instructions given in the pump manual must be strictly followed!

C. During Operation

Avoid impacts, oscillations or movements of the Turbo-molecular pump when in operation to avoid damaging the pump's bearings.

For pumping aggressive gases, Agilent Turbo-molecular pumps are fitted with a special port to allow a steady flow of inert gas (like N₂, Ar) for pump bearing protection (see section IV D "Bearing Purge" below).

D.



Inlet Screen

All Agilent Turbo-molecular pumps are offered with an optional inlet screen to prevent the blades of the pump being damaged by debris greater than 0.7 mm diameter. The inlet screen, however, reduces the pumping speed by about 10 %.

III. STARTING A TURBO PUMP

A. Soft-Start Feature

If a Turbo-molecular pump with grease lubricated bearings sits without turning for an extended period of

time (1-12 months), the bearing grease may not be evenly distributed in the bearing races. 'Soft-Start' is a unique feature of Agilent Turbo-molecular pumps that should be Enabled for first-start-up of a pump, or when the pump has not been rotated to full speed in a few months.

Pumps which have sat for longer than 12 months MUST be returned to the factory for Re-Channeling as described below in Section II B).

The Soft-Start function is enabled from the front panel of Rack-Mount controllers, or through the T-PLUS Software control program on Navigator style controllers and its purpose is to carefully control the pump's initial ramp-up sequence, allowing time for adequate lubrication of the pump's bearings and for the lubricant to reach optimal operating conditions. Soft-Start is typically ENABLED for the FIRST ramp up following an extended downtime, then DISABLED to reduce ramp up time on subsequent start-ups. When Soft-Start is Enabled, a pump can take up to 45 minutes (depending on the pump model and gas load during ramp-up) to achieve full speed.

The Soft-Start feature can only be Enabled or Disabled when the pump is OFF and the rotor is completely stopped.

Each Agilent Turbo-molecular pump model has a matching controller, with ramp-up (including Soft-Start) routine designed specifically for that pump model. The ramp-up routine for one pump model may not be ideal for another pump model. Contact Agilent Sales, Service Support, or Applications Engineering for details on mixing controller and pump models.

B. Extended Storage: 'Re-channeling'

If a Turbo-molecular pump with grease lubricated bearings sits without turning for an extended period of time (≥ 12 months), the bearing grease may separate and will not be evenly distributed in the bearing races. Severe or catastrophic damage to the pump may occur if adequate precautions are not taken.

Customers should (where possible) exercise Turbo-molecular pumps periodically by allowing the pump to ramp-up to full speed (using the Soft-Start routine) to avoid the need for Re-channeling, a tightly controlled process for re-mixing and re-distributing the bearing lubricant which can only be done by a qualified professional at an Agilent Vacuum Products facility.

Turbo-molecular pumps not in use must be stored between -20C to 70C (0-95% Humidity, non-condensing).

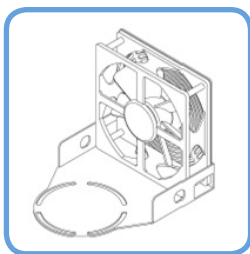
IV. NORMAL OPERATION

This section describes some basic concepts of a Turbo-molecular pump's Normal Operation, specifically selection of a foreline pump, cooling, pump monitoring, and bearing purge.

A. Backing (Foreline) Pump Selection

The selection (sizing) of a foreline pump is critical for successful operation and longevity of the pump. Agilent's Vacuum Products Catalog provides specific recommendations for the size of foreline pump to match each Turbo-molecular pump model. The recommended pump size has been calculated (with sufficient margin) to maintain the foreline pressure BELOW the maximum tolerable foreline pressure when the Turbo-molecular pump is operating at its maximum reasonable throughput.

B.



Cooling

Turbo-molecular pumps generate heat as they compress gasses, and therefore must be cooled. Most Agilent Turbo-molecular pumps are offered with an optional Air Cooling Kit (fan, mounting bracket, and cabling to power the fan from the Controller) and all Agilent turbo-molecular pumps offer the capability to use water recirculation to cool the pump.

The pump temperature should be monitored (during vacuum system testing) to ensure that the thermal shut-off limits are not exceeded. Gas load, gas type, foreline pressure, and ambient temperature all have an influence on Turbo-molecular pump operating temperature.

C. Pump Monitoring

Vacuum gauges are typically used to monitor the conditions (foreline and chamber pressures) under which a Turbo-molecular pump is operating. Many of Agilent's Rack Mount Control Units have the ability to connect to vacuum gauges and display their readings.

Useful information (on the operating conditions of the Turbo-molecular pump) can also be gained by connecting Agilent's T-PLUS control software to the pump (via the controller). T-PLUS can provide Power, Current, and Temperature readings for the Turbo-molecular pump, both during steady-state operation and during Start-Up.

D.



Bearing Purge

When a customer's process involves harsh or corrosive gases (which can damage pump bearings) or evacuating particle rich environments, Agilent recommends fitting a Bearing Purge System to the Turbo-molecular pump.

The bearing purge delivers a low pressure, low flow (10 or 20 sccm) of inert gas directly to the Turbo-molecular pump's bearings, preventing particles from entering the bearings, and corrosive gases from degrading the bearing lubricant. In Industrial

applications, it is important to use the bearing purge during the pump Shut-Down sequence to sweep particles away from the bearing during rotor deceleration.

Bearing Purge Kits are available for most Turbo-molecular pump models; specific part numbers for each model are provided in the Vacuum Products Catalog.

A 20 sccm bearing purge is also recommend for processes using Argon gas, as the thermal properties of this gas can increase rotor (and pump bearing) temperatures. The bearing purge has a side effect of removing heat from the bearing location.

E. Pump Used in Presence of Magnetic Fields

Magnetic fields induce eddy currents in the rotor of a Turbo-molecular pump that tend to oppose to its rotation. The result is increased electrical power consumption by the motor, most of which is dissipated as heat in the rotor. This effect is strongly dependent on the intensity, time function and distribution of the magnetic field. In some cases, a magnetic shield around the pump may be required. Specific details on operating a Turbo-molecular pump in the presence of magnetic fields are provided in Agilent's Vacuum Products Catalog.

V. STOPPING A TURBO PUMP

How a Turbo-molecular pump is stopped can have a critical influence on the reliability and longevity of the pump. A vent-solenoid is most commonly used to deliberately slow the pump ensuring minimum time is spent at the critical bearing frequencies. Alternately, Agilent's Auto Braking function can be engaged (on some pump/controller models) to use electrical power to slow the rotor. In all cases a well-defined pump Shutdown Procedure is recommended for systems which are periodically brought to Atmosphere.

Turbo-molecular pumps should NEVER be shut-down by opening the foreline connection while the rotor is spinning. The huge inrush of gas (from the foreline) will cause the rotor to lift (the 'Helicopter' effect) possibly exceeding the clearances between rotating and stationary parts, causing a catastrophic pump crash.

A.



Turbo Pump Venting

On 'Sealed' systems (no steady state gas load), it may take several hours for the Turbo-molecular pump to spin down. This is not recommended, since during spin-down the pump may spend an extended period of time at critical rotational frequencies.

In this case it is desirable to introduce a low flow source of inert gas (typically Nitrogen) into the vacuum system to accelerate the ramp-down, and minimize the time the pump will spend at its critical frequencies. Venting flow rates are typically on the order of 5-15 sccm and should be delivered directly to vent port of the turbo pump. Air or inert gas, free from dust or particles must be used for venting the pump. Below 100 Hz rotor speed, the pump can be vented very rapidly without damage.

- I. **FORELINE vs CHAMBER VENTING:** On some pumps, where a dedicated port for venting is not present or accessible, it may be acceptable to vent the vacuum system through the foreline of the pump, allowing the gas passing into the pump inlet to effectively slow down the rotor. A good rule-of-thumb is to allow the pump to spin down in approximately the same time it takes to ramp up to full speed (with Soft-Start DISABLED). Caution must be taken NOT to introduce particles or contamination from the foreline into the vacuum chamber.

Venting through the vacuum chamber (pump inlet) is least desirable, as this flow of gas directly impacts the Turbo-molecular pump blades, and may cause blade deflection, or rotor displacement that could lead to contact between the rotating and stationary components of the pump.

- II. **MANUAL VENT SCREW:** Agilent Turbo-molecular pumps ship with a standard Manual Vent Valve on the body of the pump (typically a knurled knob). After shutting off the Turbo-molecular pump, the vent screw can be slowly opened about $\frac{1}{2}$ to $\frac{3}{4}$ turn, admitting room air into the body of the pump. The operator will hear the deceleration of the rotor. With practice, well controlled rotor deceleration can be achieved using the Manual Vent Valve.

- III. **LOAD LOCK APPLICATIONS:** Some customers (ie. those with Load Lock applications) may wish to vent the turbo pump as fast as possible. In such cases, the maximum rotor deceleration (in Hz/sec) must be respected. The maximum allowable deceleration values for each pump are available from Agilent Vacuum Products Division Customer Service or Applications Engineering. More complex systems may require a pulsed venting sequence, for example delay→vent→vent closed→delay→vent.

IV. V3KG/V2300 CONTROLLERS: These controllers incorporate an Automatic vent procedure that (when activated) modulates the vent valve to maintain the rate of deceleration at approximately 5 Hz/sec.

V. TEMPERATURE EFFECTS: Venting the pump raises the pump surface temperature approximately 10 - 20 °C depending upon the cooling conditions. This is normal and results from friction between the fast spinning rotor and the incoming vent gas. Although the temperature increase is well tolerated by the pump materials and components, it is always advisable to allow the pump to cool prior to restarting the pump.

Note: Cooling time depends on the cooling conditions of the pump. A good rule of thumb is to allow 15-30 mins cooling time.

B. Auto Braking/Auto Stop

Agilent Controllers feature a mechanism for “electronically” slowing a rotor as an alternative to venting. Electronic braking should be used when “normal” venting will cause a rapid increase in pressure inside the Turbo-molecular pump, causing rotor deceleration beyond the recommended maximum Hz/sec rate. This typically happens when the chamber volume is minimal (circa. 1 L volume) or when a Gate Valve is positioned above the Turbo-molecular pump’s inlet, and CLOSED on pump shut-down.

Electronic braking is also recommended for applications where the pump/system cannot be vented (e.g. nuclear applications) or if the vacuum level inside the chamber needs to be maintained at a certain level (below atmospheric pressure) for the next analysis.

C. Shut-Down Sequence: Backing Pump ON

After sending a Stop command to a Turbo-pump, whether via front panel (Rack mount controllers), T-PLUS Software (Navigator controllers), or via Controller I/O command (on integrated systems), it is crucial that the backing pump of the turbo pump be allowed to remain on. The duration the pump must remain on for will be unique to each system.

VI. SUMMARY

Turbo-molecular pumps are high speed devices and care must be taken during Installation, Start-Up, and Shut-Down to maintain optimum longevity and reliability.

Soft-Start routine should be engaged for any pump that has not been exercised (ramped up to full speed) for more than a few weeks. Re-Channeling (performed at an Agilent Vacuum Products facility) must be performed on pumps that have not operated for >12 months.

Proper selection of foreline pump and maintaining adequate cooling are essential. High particulate applications, or when corrosive gases are present require the use of a bearing purge gas.

Turbo-molecular pump shut-down must be done in a manner that respects all operating limits, and the maximum deceleration rate for each pump. The foreline pump MUST be left on during initial deceleration of the pump following initiation of shut-down.