Benefits of a Turbo Pump

Applicable Products	CryoAdvance™ 50, 100	Cryostation® s200	
Document Status	Approved	**Last Updated Date**	2/22/2024

Purpose

This document is intended to present the benefits of adding a turbo pump to your vacuum control unit. Benefits discussed will be faster time to vacuum, better vacuum performance, and cleaner cooldowns to base temperature with a turbo-equipped Montana Instruments cryostat.

Background

A vacuum control unit equipped with a turbo pump allows for cleaner cooldowns and faster time to vacuum in the cryostat system. A turbomolecular pump, more simply a turbo or turbo pump, allow systems to achieve and maintain high vacuum (~10^{-3} to ~10^{-9} Torr) in conjunction with other techniques like a roughing pump (dry-scroll, diaphragm, etc.) to obtain vacuum. A system with only a roughing pump can reach near 10^{-3} Torr on its own, whereas a turbo pump system (with a backing/roughing pump) can reach near 10^{-5} Torr in the same time frame. The turbo works to achieve high vacuum by giving gas molecules momentum (in a rough vacuum environment approximately 10^{-3} Torr created by the backing pump) by colliding them with moving and static surfaces, in this case the blades and stators of the turbo. The blades direct the molecules away from the inlet side of the turbo pump towards the exhaust side, creating or maintaining a vacuum environment[1].

For a cryostat system, the addition of a turbo pump is significant as it allows the system to cryopump more efficiently. Surfaces are not as saturated with gases as they otherwise would be in a non-turbo system, allowing the system to pull vacuum to a lower pressure sooner than a system without a turbo installed. This hastens the overall cooldown process as the system is not battling against gases (the worst offender being water vapor) saturating surfaces as much. A turbo is the best way to overcome and remove bothersome water vapor and other gases, as well as providing a cleaner cooldown compared to a system without the turbo pump installed.

Applicable Theory

To experimentally determine the effect of a turbo on cryostat system performance, a turbo was installed into a Montana Instruments vacuum control unit and a cooldown was performed on a standard Montana Instruments Cryostation®. Figure 1 compares vacuum pressure over time between a standard vacuum control unit (model number VCM24) and a unit equipped with a turbo pump (model number VCM24-turbo).

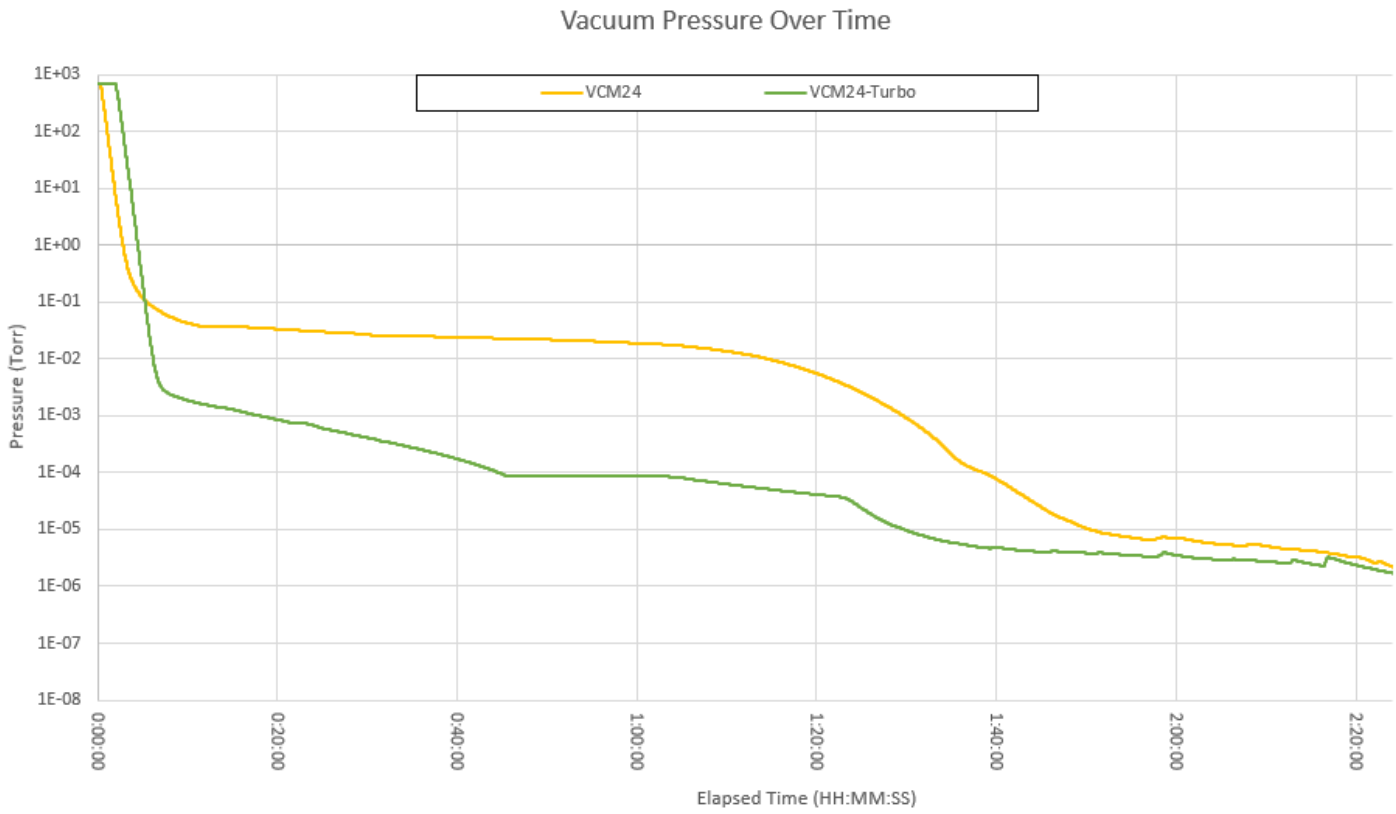

Figure 1: Comparing vacuum pressure over time between the vacuum control unit and the vacuum control unit equipped with a turbo.

As Figure 1 shows, the turbo-equipped system creates a lower pressure vacuum than the non-turbo system, as well as reaching a lower vacuum pressure in less time than the non-turbo system. While a turbo does not reach a lower overall base pressure or lower base temperature than a non-turbo system, reaching a lower vacuum pressure sooner allows for a cleaner cooldown, as previously discussed. Customers concerned about having an ultra-clean cooldown and reaching vacuum sooner and closer to room temperature should opt for a turbo pump-equipped cryostat system. Other factors to consider regarding condensing of molecules and getting clean cooldowns are:

- Lab environment and area climate - a cryostat in a dry, arid environment will inherently have less molecules in the air that can potentially condense in or on the sample space compared to a more humid environment and climate.

- Storage of the cryostat system-if a cryostat has been sitting unused for some time, it is likely the first cooldown will have very poor performance in both vacuum and temperature. If your cryostat is going to be unused for long periods of time, it is recommended to keep the system under vacuum at room temperature, if possible. If the system cannot be kept under vacuum, store the system with sample chamber lid and windows secured to prevent excess dust and contaminates from being deposited in the sample chamber.

To alleviate the issues mentioned above, Montana Instruments recommends purging the system multiple times with nitrogen to remove contaminates from the chamber before system use, if the system has gone unused for a long period of time, or if system performance (vacuum or temperature) seems to be suffering. An additional way to remove contaminates from the system is to complete a system bakeout. Heating the system up to 325K can help pull condensed contaminates (often water vapor) from surfaces, resulting in cleaner future cooldowns (please refer to your system manual for more details on the baking out of a cryostat system). Following these recommendations and adding a turbo pump can help ensure the best possible performance from your Montana Instruments cryostat system.

Summary

A cryostat system equipped with a turbo pump can achieve better vacuum pressure in a shorter amount of time than a system without a turbo installed. A turbo can also help provide a cleaner overall cooldown by allowing less condensing of water vapor and other gases on windows and on the sample. To discuss a Montana Instruments turbo-equipped cryostat, contact a sales engineer.

References

[1] https://www.leybold.com/en-us/knowledge/vacuum-fundamentals/vacuum-generation/how-does-a-turbomolecular-pump-work

[2] All other data and information internal to Montana Instruments.