

VACUUM SYSTEM PROCEDURES

General Guidelines:

There are three high-performance vacuum systems in the Space Propulsion Laboratory. This document describes their operating procedures:

ASTROVAC:	Page 2
1.6 × 1.5 m cylindrical chamber. Evacuated by two Cryopumps (~7500 ls ⁻¹ , Xe). Bakeable with included heaters and controller. Pumps all gases, EXCEPT HELIUM.	
MINIVAC:	Page 10
50 cm long × 20 cm DIA cylindrical chamber. Evacuated by two turbo molecular pumps (140 ls ⁻¹ , N ₂).	
SPUTNIK:	Page 13
30 cm spherical chamber. Evacuated by a single high compression ratio turbo molecular pump (70 ls ⁻¹ , N ₂). Gate isolation valve to ASTROVAC for enhanced pumping.	

The main purpose of this document is to serve as a procedural **checklist**. All personnel with installation and maintenance responsibilities should become familiar with the contents of the manuals of the pumps, high vacuum valves and vacuum gauge instrumentation.

It is extremely important to keep the vacuum systems free of contaminants. By following these simple guidelines, operation should remain straightforward and trouble-free:

- Always use clean, plastic gloves when working inside the chambers or when assembling and disassembling vacuum ports. Use shoe covers when climbing into ASTROVAC.
- Use adequate covers for the pump inlets (Cryopumps in ASTROVAC and Turbopumps in MINIVAC) when installing equipment (Remember to remove covers before operation).
- Use clean tools and avoid leaving them behind when closing the chamber since they could fall into the pump inlets and produce a catastrophic failure.
- Before closing, inspect and clean the chamber, if necessary, with fab-wipes and adequate solvents. In particular, the user should verify the absence of foreign objects inside the Cryopump valve cavities in ASTROVAC.
- Keep an overall clean working environment in the lab room to minimize the amount to particles that could enter the vacuum systems when opened.
- Chambers should be kept under vacuum when not in use.

Notes about Varian Multi-Gauges:

Varian Multi-Gauge controllers are used in all systems to monitor the chamber pressure. It is constantly referenced in this document to switch to TC1, TC2, TC3, CC1 and CC2. To do so cycle the different transducers by pressing CHAN on the control box until the appropriate LED indicators light up. Cold cathode pressure readings are by default adjusted to N₂. If different gases are pumped use the corresponding gas correction factor (see manual).

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ASTROVAC

Warning: Energize the chamber heat **ONLY** when the chamber is under vacuum. Dangerous pressure build up may otherwise result.

Warning: Do not pressurize the chamber. Large forces will result which may be dangerous especially when opening the door. Always vent the chamber to atmosphere before opening the door.

Cryopump Start-up:

NOTE: If the pumps have been inactive for 2 weeks or more, or if they have been exposed to atmospheric conditions, or their performance has decreased with time, then a full regeneration is required. Go to the Cryopump Regeneration section in this document to regenerate and start-up the Cryopumps.

Determine system status:

- Wall breakers are ON (except for the 480 V box).
- Cryopumps are OFF and WARM (room temperature).
- Air pressure is ON.
- ALL valves are closed.
- Water flows through cooling lines to the compressors (1.5 – 2 gpm).
- Front panel cooling fan is ON.

Energize the Mechanical Roughing pump:

- MECHANICAL PUMP switch ON.
- Observe oil level at proper height in sight glass.
- Monitor pressure on Multi-Gauge TC1 (should read below 10^{-2} Torr.)

Energize the CT10 Cryopump:

- CT10 Regen Valve ON.
- Evacuate until Multi-Gauge TC1 indicates below 10^{-2} Torr.
- CRYO PUMP CT10 FRONT switch ON (compressor and pump start).
- CT10 Regen Valve OFF.
- Monitor cool-down until temperature (dial gauge under pump body) reads < 20 K.

Energize the OB400 Cryopump:

- OB400 Regen Valve ON.
- CRYO PUMP OB400 REAR switch ON (compressor starts).
- On the OB400 On-Board Controller:
 - Press CONTROL.
 - Press NEXT until ROUGH V CLOSED displays.
 - Press 1 (one) on keypad to open the valve.
 - Evacuate until Multi-Gauge TC1 indicates below 10^{-2} Torr.
 - Press 0 (zero) on keypad to close the valve.
 - Press NEXT until CRYO OFF displays.

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- Press 1 (one) to start pump.
- Press MONITOR. Display reads: CRYO ON and second stage temperature.
- OB400 Regen Valve OFF.
- Monitor cool-down until second stage temperature reads 10-15 K.

If water moisture is condensing on the outside of a Cryopump vacuum vessel, evacuation of the pump is necessary:

Moisture on the CT10 Cryopump:

- Verify: ALL valves are closed.
- Verify: MECHANICAL PUMP switch ON.
- CT10 Regen Valve ON.
- Evacuate until TC1 indicates below 10^{-2} Torr.
- CT10 Regen Valve OFF.
- Continue to monitor the Cryopump temperature.
- If condensation occurs again, repeat procedure.
- If the problem persists, a leak might be present. Shut down the Cryopump and inspect for leaks.

Moisture on the OB400 Cryopump:

- Verify: ALL valves are closed.
- Verify: MECHANICAL PUMP switch ON.
- OB400 Regen Valve ON.
- On the OB400 On-Board Controller:
 - Press CONTROL.
 - Press NEXT until CRYO ON displays.
 - Press 0 (zero) on keypad to stop the pump.
 - Press NEXT until ROUGH V CLOSED displays.
 - Press 1 (one) on keypad to open the valve.
 - Evacuate until Multi-Gauge TC1 indicates below 10^{-2} Torr.
 - Press 0 (zero) on keypad to close the valve.
 - Press NEXT until CRYO OFF displays.
 - Press 1 (one) to restart the pump.
 - Press MONITOR. Display reads: CRYO ON and second stage temperature.
- OB400 Regen Valve OFF.
- Continue to monitor the Cryopump temperature.
- If condensation occurs again, repeat procedure.
- If the problem persists, a leak might be present. Shut down the Cryopump and inspect for leaks.

Caution: Extended rough pumping of the Cryopumps is not recommended because the array charcoal may become contaminated by pump oil.

Monitor the progress of the Cryopumps cool down. Cool down can take up to 3 hours. If 5 hours or more have passed and the temperature is not decreasing a failure may have occurred, shut down the pumps and refer the user's manual.

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Evacuate the Chamber:

Determine system status:

- Cryopumps are ON and COLD.
- Air pressure is ON.
- ALL valves are closed.
- Front panel cooling fan is ON.
- Chamber is leak-free (refer to most recent leak detector test).

Closing the Vacuum System:

- Close the main door, *slowly*.
- The door flange must sit gently and evenly on the chamber flange.
- Protect the mating sealing surface of the O-ring seal from scratches, dents and dirt.
- Tighten the four chamber clamps. **Note:** Extra tightening is required on the top two.

Energize the Mechanical Roughing pump:

- MECHANICAL PUMP switch ON.
- Observe oil level at proper height in sight glass.
- Monitor pressure on Multi-Gauge TC1 (should read below 10^{-2} Torr.)

Pump down:

- Roughing Valve ON.
 - Main door gap should close down slowly due to suction.
 - Some oil smoke will be exhausted through the room vent pipes.
 - If excessive smoke is observed:
 - Pump oil-mist eliminator may have failed (see manual).
 - Roughing pump operating at full capacity due to a large leak in the vacuum system or improper closing of the main door. Roughing valve must be turned OFF and chamber must be inspected.
- Monitor chamber pressure on Multi-Gauge TC2:
 - The Chamber will take from 45 minutes or longer to pump down to the 10^{-3} Torr range depending on the outgassing rate of the chamber walls. If pump out time is longer than 3 hours chamber bake out may be required.

Switch to Cryopumps:

- Roughing Valve OFF.
- CT10 FRONT CRYO VALVE switch ON (wait 10 seconds).
- OB400 REAR CRYO VALVE switch ON.
- Monitor pressure on Multi-Gauge TC2: Pressure should remain in the 10^{-3} Torr range.
- Monitor pressure on Multi-Gauge CC1: Activate cold-cathode by pressing EMIS.
- MECHANICAL PUMP switch OFF.

Note: It is recommended to close CT10 FRONT CRYO VALVE and OB400 REAR CRYO VALVE whenever high capacity pumping is not required (i.e., overnight or between experimental runs). Remember to **deactivate** CC1 by pressing EMIS until OFF is displayed whenever the cryo valves are closed.

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Venting the Chamber:

Determine system status:

- Cryopumps are ON and COLD.
- Air pressure is ON.
- Mechanical Pump front switch OFF.
- Chamber is under vacuum.
- Verify: Cold-cathode gauge is OFF (press EMIS in CC1 until OFF displays).
- **ALL** valves are closed.

Venting:

- Clamps should be on, but lightly tightened.
- Chamber heat is OFF (If venting from bakeout, wait until chamber cools down).
- Chamber Vent Valve ON.
 - The inrush of air should be heard. The venting of the chamber will be complete when the inrush stops and TC2 reads about 760 Torr.

Shutting the Vacuum System Down:

NOTE: Shutting down the Cryopumps is recommended if the system is not to be used for a period of one week or more.

Determine system status:

- Cryopumps are ON and COLD.
- Air pressure is ON.
- ALL valves are closed.
- Chamber heat is OFF.
- MECHANICAL PUMP switch OFF.
- Chamber is under vacuum.

Shutdown of the CT10 Cryopump:

- De-energize the CRYO PUMP CT10 FRONT switch.

Shutdown of the OB400 Cryopump:

- On the OB400 On-Board Controller:
 - Press CONTROL.
 - Press NEXT until CRYO ON displays.
 - Press 0 (zero) on keypad to stop the pump.
- De-energize the CRYO PUMP OB400 REAR switch.

If chamber is to remain under vacuum (recommended for storage) then:

- De-energize ALL wall breakers.
- Close water cooling lines.
- Shut-down front panel cooling fan.

Otherwise, perform chamber vent (see above).

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Chamber Bake Out Operation:

NOTE: this procedure should be carried out with the Cryopumps OFF. To do so, follow the Evacuate the Chamber instructions but DO NOT start up the Cryopumps and DO NOT switch to Cryopump operation.

Determine system status:

- Cryopumps are OFF (see note above).
- Air pressure is ON.
- Chamber is under vacuum.

Bake out:

- MECHANICAL PUMP switch ON.
- Roughing Valve switch ON.
- Connect HEAT PLUG into wall outlet.
- Energize 480 V wall breaker.
- Energize HEATER switch.
- Set temperature controller to 302 F (150 C) (see manual).

Caution: Continuously monitor the Chamber bake out process. De-energize the heater control if smoke or excessive hot spots occur on the chamber or if the chamber temperature is not controlled at the set point.

- Continue to heat and evacuate the chamber until the vacuum pressure read out on TC2 is below 5×10^{-3} Torr.
- De-energize the heater control.
- De-energize the 480 V wall breaker.
- Disconnect HEAT PLUG from wall outlet.
- Do not vent chamber until cooled down.

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Cryopump Regeneration:

Determine system status:

- Wall breakers are ON (except for the 480 V box).
- Air pressure is ON.
- ALL valves are closed.
- Water flows through cooling lines to the compressors (1.5 – 2 gpm).
- Front panel cooling fan is ON.
- Open main valve on N₂ cylinder and set the regulator 2nd stage pressure to 40 psi.
Note: Verify that the N₂ cylinder holds enough gas (> 800 psi regulator 1st stage).

Energize the Mechanical Roughing pump:

- MECHANICAL PUMP switch ON.
- Observe oil level at proper height in sight glass.
- Monitor pressure on Multi-Gauge TC1 (should read below 10⁻² Torr.)

CT10 Cryopump Regeneration:

- Verify: pump is at room temperature (if not, let the pump warm up overnight).
- Regeneration cycle:
 - CT10 Regen Valve ON.
 - Evacuate for 5 minutes, record the pressure (P_{5 min}) value displayed on TC1. In addition, record the time to reach a pressure equal to P_{5 min} in the previous cycle.
 - CT10 Regen Valve OFF.
 - CT10 Purge Valve ON.
Note: The pump relief valve will open after the vacuum vessel is pressurized, discharging N₂ plus previously trapped gases to the atmosphere. If hazardous or flammable elements were pumped during previous operation then adequate venting measures from the relief valve should be provided (i.e., cold trap or venting duct).
 - After 5 minutes: CT10 Purge Valve OFF.
 - Repeat cycle.
- Perform at least 5 cycles. To verify the effectiveness of the procedure, a considerable decrease in the time to reach a given pressure (P_{5 min} of previous cycles) should be noted. Also, the value of P_{5 min} for a given cycle should be lower than for previous cycles.
- After last cycle: CT10 Regen Valve ON.
- Evacuate until Multi-Gauge TC1 indicates below 10⁻² Torr.
- CT10 FRONT CRYO VALVE switch ON (compressor and pump start).
- CT10 Regen Valve OFF.
- Monitor cool-down until temperature (dial gauge under pump body) reads < 20 K.

If water moisture is condensing on the outside of the CT10 Cryopump vacuum vessel, evacuation of the pump is necessary. Refer to page 3 of this document.

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OB400 Cryopump Regeneration:

Note: This pump is able to perform an automated regeneration routine from the pump controller. Refer to the user's manual for the automated procedure. The following manual regeneration procedure is recommended for personnel not familiar with the pump control.

- Verify: pump is at room temperature (if not, let the pump warm up overnight).
- OB400 Regen Valve ON.
- CRYO PUMP OB400 REAR switch ON (compressor starts).
- Regeneration cycle:
 - On the OB400 On-Board Controller:
 - Press NEXT until ROUGH V CLOSED displays.
 - Press 1 (one) on keypad to open the valve.
 - Evacuate for 5 minutes, record the pressure ($P_{5 \text{ min}}$) value displayed on TC1. In addition, record the time to reach a pressure equal to $P_{5 \text{ min}}$ in the previous cycle.
 - Press 0 (zero) on keypad to close the valve.
 - Press NEXT until PURGE V CLOSED displays.
 - Press 1 (one) on keypad to open the valve.

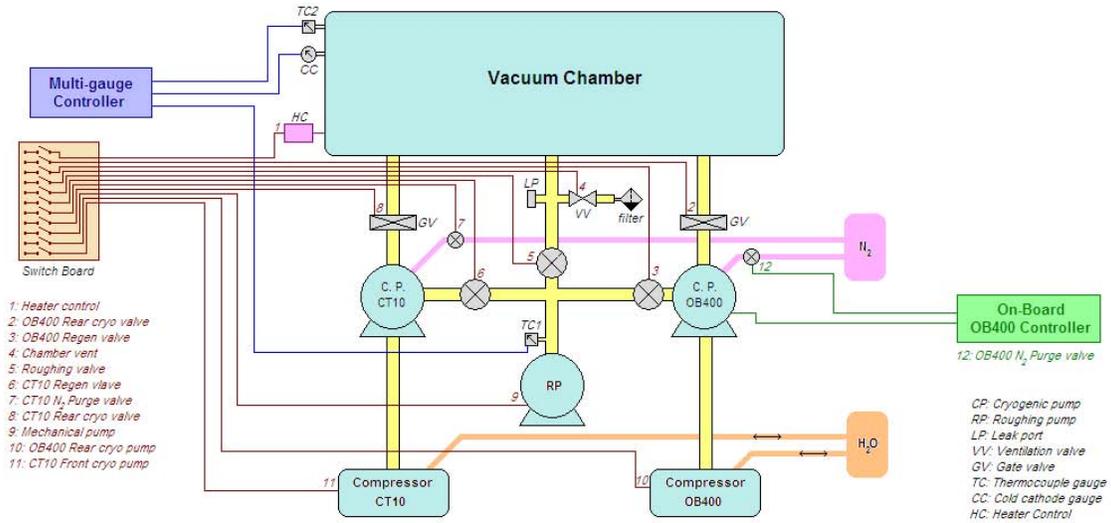
Note: The pump relief valve will open after the vacuum vessel is pressurized, discharging N_2 plus previously trapped gases to the atmosphere. If hazardous or flammable elements were pumped during previous operation then adequate venting measures from the relief valve should be provided (i.e., cold trap or venting duct).
 - After 5 minutes: Press 0 (zero) on keypad to close the valve.
 - Repeat cycle.
- Perform at least 5 cycles. To verify the effectiveness of the procedure, a considerable decrease in the time to reach a given pressure ($P_{5 \text{ min}}$ of previous cycles) should be noted. Also, the value of $P_{5 \text{ min}}$ for a given cycle should be lower than for previous cycles.
- After last cycle, on the OB400 On-Board Controller:
 - Press CONTROL.
 - Press NEXT until ROUGH V CLOSED displays.
 - Press 1 (one) on keypad to open the valve.
 - Evacuate until Multi-Gauge TC1 reads below 10^{-2} Torr.
 - Press 0 (zero) on keypad to close the valve.
 - Press NEXT until CRYO OFF displays.
 - Press 1 (one) to start pump.
 - Press MONITOR. Display reads: CRYO ON and second stage temperature.
- OB400 Regen Valve OFF.
- Monitor cool-down until second stage temperature reads 10-15 K.

If water moisture is condensing on the outside of the OB400 Cryopump vacuum vessel, evacuation of the pump is necessary. Refer to page 3 of this document.

Monitor the progress of the Cryopumps cool down. Cool down can take up to 3 hours. If 5 hours or more have passed and the temperature is not decreasing a failure may have occurred, shut down the pumps and refer the user's manual.

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ASTROVAC Block Diagram



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MINIVAC

Evacuate the Chamber:

Determine system status:

- Power outlet strip ON.
- Air pressure is ON (check regulator).
- Multi-gauge is ON.
- Turbopumps are STOPPED.
- Turbopump controllers display: READY FOR LOCAL SOFT START
- Chamber door (ISO200 flange) is removed.
Note: if the chamber door is closed, go directly to Pump Down.
- Vent switch UP (GREEN).
- Chamber is leak-free (refer to most recent leak detector test).

Closing the Vacuum System:

- Make sure that ISO200 blank (door) and chamber flanges are clean.
Note: For some experiments the ISO200 blank is substituted by a flange reducer ISO200 to QF50. In that case make sure the QF50 is clean and installed with adequate O-ring.
- Inspect O-ring for integrity and position it over the ISO200 flange groove.
- Carefully hold the flange-O-ring assembly and close the vacuum system. Make sure to hold the assembly in place with at least one hand.
- With the other hand, place two locking clamps (top and bottom) and hand tighten.
- Use an appropriate tool to tighten clamps with adequate torque. DO NOT over-tight.
- Place and tight with adequate torque the remainder six clamps. DO NOT over-tight.

Pump down:

- Verify: Vent switch UP (GREEN).
- **Note: failure to determine the correct switch position may result in damage to Turbopumps.**
- Turbopump 1 controller: press START/STOP button.
- Turbopump 2 controller: press START/STOP button.
Note: Roughing pump, cooling fans and isolation valves are automatically engaged.
- BOTH Turbopumps display starting sequence.
- Verify NORMAL OPERATION at 75 KRPM.
- Check pressure in Multi-Gauge TC2: pressure should drop to 1×10^{-3} Torr.
- Wait 10 to 15 minutes, then switch to BA and/or CC, press EMIS to start selected gauge.
Note: Use of the BA (Bayant-Alpert) ionization gauge is recommended only when pressure levels are 1×10^{-5} Torr or lower.

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Shutting Down the Vacuum System:

Determine system status:

- Power outlet strip ON.
- Air pressure is ON.
- Multi-gauge is ON.
- Chamber is under vacuum.
- Turbopump 1 and Turbopump 2 controllers display: NORMAL OPERATION 75 KRPM.
- Vent switch UP (GREEN).

Turbopump shutdown:

- Switch to BA: Verify gauge is OFF, if not press EMIS to de-energize gauge.
- Switch to CC: Verify gauge is OFF, if not press EMIS to de-energize gauge.
- Turbopump 1 controller: press START/STOP button.
- Turbopump 2 controller: press START/STOP button.
- BOTH Turbopumps are disengaged.
Note: Verify text message in controllers: READY FOR LOCAL SOFT START
- If venting is required wait at least 10 minutes for compressor slow down.

Venting and opening the chamber:

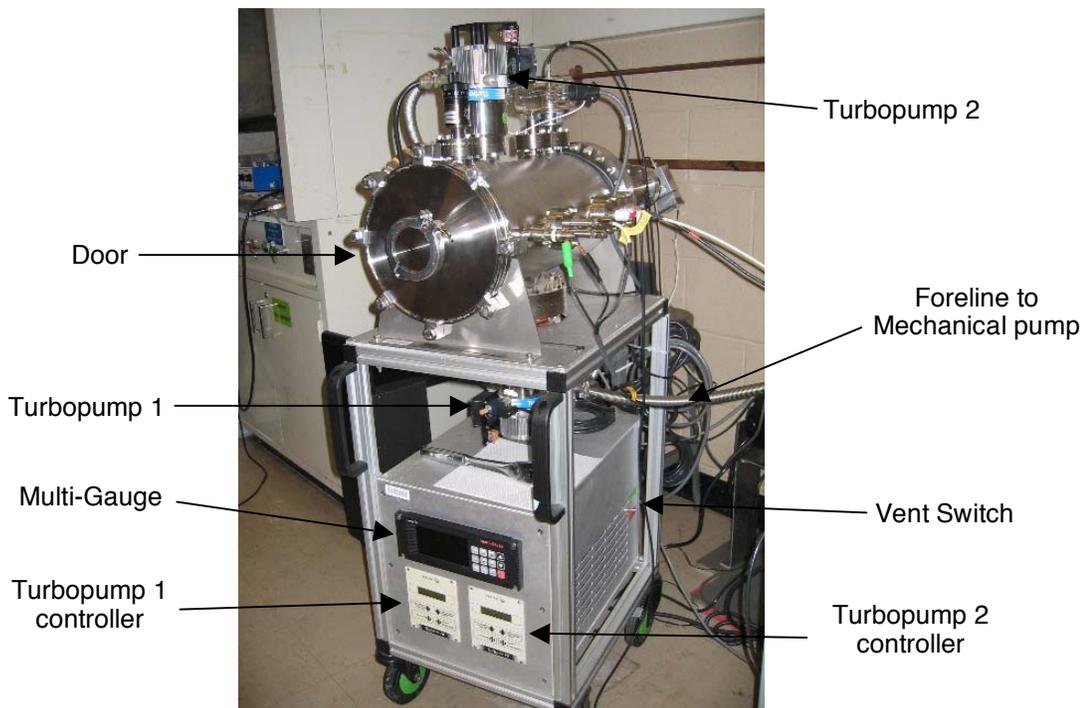
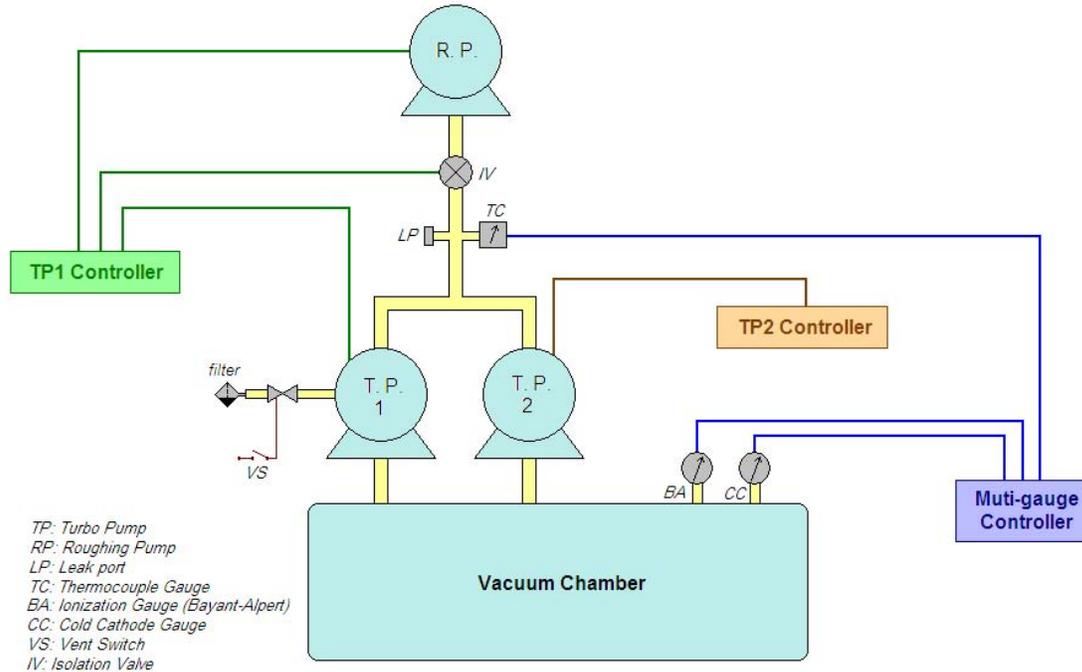
- Vent switch DOWN (RED).
- Monitor pressure in TC2 until atmospheric conditions reached.
- Use appropriate tool to remove door clamps, except top and bottom.
- With one hand, hold the door in place while removing the final two clamps.
- Carefully remove door.
Note: Make sure to get a grip on the O-ring, which should be removed at the same time as the rest of the flange.
- Place flange and O-ring assembly on a clean, flat surface.

It is recommended to keep the chamber under vacuum whenever possible, i.e. when under storage.

It is highly recommended to keep the chamber closed whenever possible and only open it when everything is ready for equipment installation.

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MINIVAC Block Diagram



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SPUTNIK

NOTE: A multichannel plate and phosphor screen are permanently mounted on one of the chamber flanges. Exposing these components to atmospheric conditions will limit their lifetime. It is important to keep Sputnik under vacuum and vent only when adding or removing experimental components.

Evacuate the Chamber:

Determine system status:

- Air pressure is ON.
- Multi-gauge in ASTROVAC panel is ON (Mechanical Pump wall breaker must be ON).
- Turbopump is STOPPED.
- Turbopump controller display: READY FOR LOCAL SOFT START.
- Chamber door is closed (do not over-tight knob).
- SPUTNIK VENT VALVE switch OFF (switch located next to TP controller).
- SPUTNIK GATE VALVE switch OFF (switch located on ASTROVAC panel).
- Chamber is leak-free (refer to most recent leak detector test).

Pump down:

- Turbopump controller: press START/STOP button.
Note: Roughing pump, cooling fan and isolation valve are automatically engaged.
- Turbopump displays starting sequence.
- Verify NORMAL OPERATION at 75 KRPM.
- Check pressure in Multi-Gauge TC3: pressure should drop below 2×10^{-3} Torr.
- Switch Multi-Gauge to CC2, press EMIS to activate gauge.
Note: This gauge is accurate for pressures $> 1 \times 10^{-8}$ Torr.

Pump down through ASTROVAC:

- ASTROVAC chamber is ENGAGED and UNDER VACUUM.
Note: Follow instructions in this document to verify ASTROVAC's condition.
- SPUTNIK is engaged and under vacuum (see **Pump down** section above).
- ASTROVAC Cryo-valve switches ON.
- Verify Multi-Gauge CC1 pressure reads below 1×10^{-6} Torr (ASTROVAC side).
- Verify Mutti-Gauge CC2 pressure reads below 5×10^{-5} Torr (SPUTNIK side).
- Verify air pressure to gate valve (65 psi in regulator).
- SPUTNIK GATE VALVE switch ON.

Shutting Down the Vacuum System:

Determine system status:

- Air pressure is ON.
- Multi-gauge is ON.

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- Chamber is under vacuum.
- Turbopump controller displays: NORMAL OPERATION 75 KRPM.
- SPUTNIK GATE VALVE switch OFF.
- Note: Verify air pressure to gate valve (65 psi in regulator) if SPUTNIK GATE VALVE switch was ON.

Turbopump shutdown:

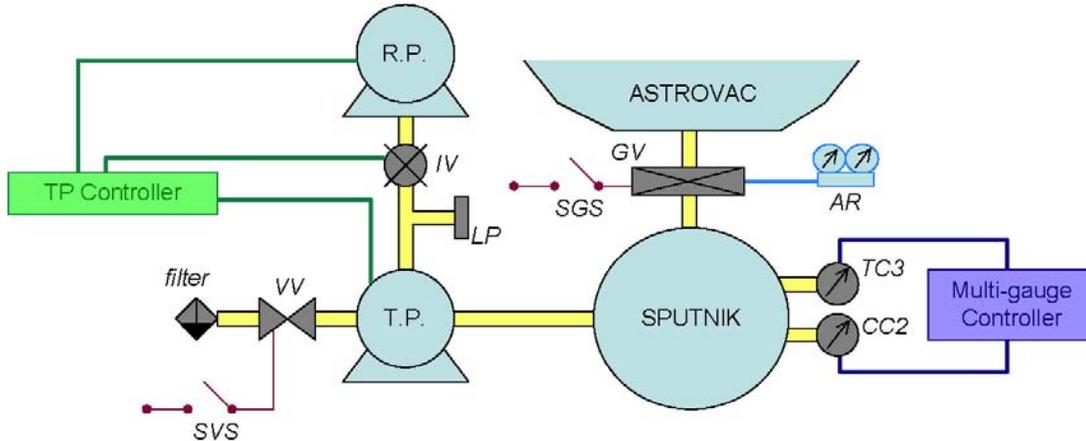
- Switch to CC2: Verify gauge is OFF, if not press EMIS to de-energize gauge.
- Turbopump controller: press START/STOP button.
- Turbopump system is disengaged.
Note: Verify text message in controller: READY FOR LOCAL SOFT START.
- If venting is required wait at least 10 minutes for compressor slow down, otherwise leave vacuum system in current configuration.

Venting and opening the chamber:

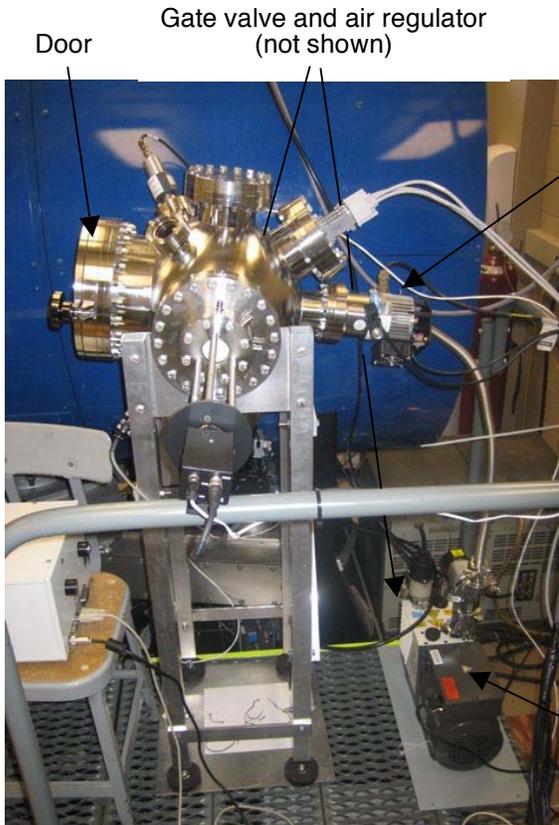
- SPUTNIK VENT VALVE switch ON (switch located next to TP controller).
- Monitor pressure in TC3 until atmospheric conditions reached.
- Open door.
- After installing/removing components, **close door and evacuate the chamber.**

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SPUTNIK Block Diagram



TP: Turbo Pump	IV: Isolation Valve	SGS: Sputnik Gate Switch	TC3: Thermocouple Gauge
RP: Roughing Pump	SVS: Sputnik Vent Switch	GV: Gate Valve	CC2: Cold Cathode Gauge
LP: Leak Port	VV: Vent Valve	AR: Air Regulator	



Sputnik Gate Valve Switch (on ASTROVAC panel)



T.P. Controller and Vent Switch (rack mounted)

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