

HOW LONG WILL 100ml (OF WATER) LAST ?

We assume the following:

Volume = 100ml

Pressure = 100psi

Nozzle = 30microns

Turbo pumping speed = maximum ~1400 l/s for N₂ – we guess ~1000 l/s for water

(Note: only below ~7.5E-4 Torr most turbo pumps operate at their maximum pump capacity)

Assume that the gas expands into 4E-4 Torr (0.0532Pa) pressure and that this pressure is stable.

This implies that the pump removes at most 1000 l/s of 4E-4 Torr pressure (water) gas.

In this pressure regime the amount of gas produced by a substance is given by:

$PV=nRT$. $R=8.3144621 \text{ J/(K*mol)}$, $T=373 \text{ K}$, $n=100*p/(\text{molar mass})$ (for water this is $100\text{g}/(18 \text{ g/mol}) = 5.5 \text{ mol}$),
 $P=0.0532 \text{ Pa}$. With these values we get $V=320,623 \text{ m}^3 = 3.21\text{E}8 \text{ l}$.

Divide V by the pump speed to get 321,000 s.

Divide by 3600 s to get hours:

Duration minimum = 89.16 hrs (Water).

Divide by 24 hrs to get days:

Duration minimum = 3.7 days (Water).

To get the pump time for your liquid, find the number of moles m in the liquid reservoir and multiply this number by $m/5.5$.

PUMP DOWN OF THE DRY LIQUID-TO-GAS MANIFOLD: Start-up Phase

Preparation !!!

In case you need to evacuate the >>tank<< make sure you have the valve $V_{\text{evac-tank}}$ open during the pump down of the chamber. **If you forgot to evacuate during the pump down phase you need to make sure that the “hidden bypass” and the bypass between the chamber and the 2nd stage is closed; open $V_{\text{evac-tank}}$ very slowly.**

Get the Liquid-to-Gas Manifold ready

1. Close V_{drain}
2. Close C_{aux}
3. Close and lock V_{transfer}
4. Close and lock $V_{\text{gas-manifold}}$
5. Close $C_{\text{reservoir-drain}}$
6. Close C_{aux}
7. Close V_{bypass}
8. Close V_{protect}
9. Open V_{blocking}
10. Open $V_{\text{evac-line}}$

Start “chem-lab” diaphragm pump in controller rack

11. Open $V_{\text{three-way}}$ to pump
12. Pump for 1 minute
13. Open V_{nozzle}
14. Pump for 1 minute and check Pressure Gauge (should go down)
15. Close $V_{\text{three-way}}$

Make sure the chamber fore-vacuum is running (especially scroll at 2nd stage)

16. Open V_{bypass} slowly only when the manifold and the reservoirs are dry !
17. Open V_{protect}
18. Let it pump for 10 minutes

START/STOP HEATING

FIRST: INSIDE THE CHAMBER

Use heat controller on Controller Rack

Heat the gas line first

set desired temperature to 120deg C: **DO NOT GO HIGHER IN TEMPERATURE !!!**

- turn on controller unit (switch in the back)
- select thermocouple and temperature units (1.: press “↵” for 3 sec. , press “↶” till you get “Inpt”, press “▲” or “▼” till you get “J”, only if “J” is flashing hit “↵”. 2.: Press “↶” till you get “tpun”, press “▲” or “▼” till you get “C”, only if “C” is flashing hit “↵”.)
- enable PID mode (press “↶” till you get “ctrl”, press “▲” or “▼” till you get “PID”; only if “PID” is flashing hit “↵”)
- set desired temperature (press “↵”, press “▲” or “▼” and then confirm with “↵”)
- turn on the heater controller (flick the switch labeled “heater controller on” up; check if fans are running)
- start PID controller (press “↶” till you get “r-S”, press “▲” or “▼” till you get “run”, only if “run” is flashing hit “↵”)
- set digital trimmer to restrict max. current (set dip switch to “10”)

Heat the nozzle next

set desired temperature to 125deg C: **DO NOT GO HIGHER IN TEMPERATURE !!!**

=> see instructions above

To stop heating:

- stop PID controller (press “↶” till you get “r-S”, press “▲” or “▼” till you get “stop”, if flashing hit “↵”)
- set digital trimmer to restrict min. current (set dip switch to “00”)

See next page for the heating outside the chamber =>

START/STOP HEATING - continue

SECOND: OUTSIDE THE CHAMBER

Use heat controllers next to Gas Manifold

Heat the gas line first

set desired temperature to 125deg C: **DO NOT GO HIGHER IN TEMPERATURE !!!**

- turn on the unit (press the “reset” button on GFCI plug)
- **watch out: Unit immediately starts running (goes directly to 100deg C) – act fast to stop it**
- select the heating mode (press “■” and then “▲” or “▼” till you hit “CON”)
- select your temperature (press “▲” or “▼”, change flashing value with “▲” or “▼”, stores value after 3 seconds automatically)

Heat the reservoir next

Keep it cold for the transfer of the liquid; you cannot and should not transfer liquid into the hot reservoir (safety issue !). Set to desired temperature after transfer (170deg C max). It is recommended

to go up in steps like 50, 80, 100, 120, 150, 170deg C...

=> see instructions above

To stop heating:

- put temperature to “20” (press “▲” or “▼”, change blinking value with “▲” or “▼”, stores value after 3 seconds automatically)
- turn off the unit (press the “test” button on GFCI plug)

MAKE A LIQUID-TO-GAS JET

Prepare the Chamber

1. Close all chamber bypasses
2. Set Vacuum Gauge controller to appropriate ranges
(Jet Dump: 1E-7, Chamber: 1E-7, 2nd Stage: 1E-6, Source: 1E-4)

Prepare the Liquid-to-Gas Manifold

3. Reservoir Heater should be cold (set it to 20deg C); remove sleeve & cool it down with a “water bucket” if needed;. **Note: you cannot and should not transfer liquid into the hot reservoir (safety issue !).**
4. Close V_{nozzle}
5. Close V_{protect}
6. Close V_{blocking}
7. Close $V_{\text{three-way}}$
8. Close and lock V_{evac}
9. Close V_{seed}

Prepare the Transfer Arm of the Manifold

10. Close V_{transfer}
11. Close C_{aux}
12. Close $C_{\text{supply-drain}}$
13. Open V_{drain}
14. **Wear your Personal Protective Equipment (Gloves, Glasses etc.):** Fill liquid into small metal funnel slowly to avoid bubbles which can clog the filling mechanism; stop when liquid reaches desired level in glass indicator funnel.
15. Close V_{drain}

Transfer the Liquid

16. Open V_{transfer} slowly and watch the level in the glass indicator funnel drop to desired level
17. Close and lock V_{transfer}

See next page =>

continue: MAKE A LIQUID-TO-GAS JET

Make a (cold) jet

18. Open V_{blocking}
19. Open V_{nozzle} slowly (2 to 3 seconds)

Flush out the gasoline (especially when seeding):

20. Close V_{blocking}
21. Open $V_{\text{evac-line}}$
22. Open $V_{\text{three-way}}$ to exhaust for 3 seconds
23. Open $V_{\text{three-way}}$ to the forepump and pump for 3 seconds (not longer to avoid water pollution of the pump !)
24. Close $V_{\text{three-way}}$
25. Close $V_{\text{evac-line}}$
26. Open V_{blocking}
27. Start Reservoir Heater (set to desired temperatures; 170deg C max. It is recommended to go up in steps like 50, 80, 100, 120, 150, 170deg C)
28. Watch the vacuum gauges at the controller rack

STOP AND START JET IN VACUUM CHAMBER

Stop the Jet

1. Close V_{blocking}
2. Open $V_{\text{evac-line}}$
3. Open $V_{\text{three-way}}$ to exhaust slowly (should take 3 seconds)
4. Open $V_{\text{three-way}}$ to diaphragm pump and pump for 10 seconds (not longer since condensables are bad for the diaphragm pump) , then close $V_{\text{three-way}}$ again
5. Do NEVER pump wet reservoir or gas lines via the bypass to the second stage (it will pollute and damage the scroll forepump).

Restart the Jet

1. Close $V_{\text{three-ways}}$
2. Close $V_{\text{evac-line}}$
3. Open V_{blocking}

SEED JET WITH NOBLE GAS: USE OF THE OPTIONAL GAS SUPPLY SYSTEM

Prepare the Gas Supply System

1. **The reservoir should be empty and dry and cold**
2. Connect the diaphragm pump to gas supply system
3. Close V_{blocking} and V_{transfer}
4. Open C_{drain} and connect gas supply system to reservoir
5. Connect the gas supply system to the regulator of the gas bottle
6. Close V_{exhaust}
7. Open V_{seed} , any valves in front of the gas regulator, and the regulator itself to pump to the main valve of the bottle (which should be closed)
8. Open V_{pump} and pump for 5 minutes

Make a seeded Jet

9. Close V_{seed} , V_{pump} , and the regulator (keep any valve in front of the regulator open)
10. see **MAKE A LIQUID-TO-GAS JET**
11. **Note:** It is recommended to start with a low reservoir temperature after the liquid transfer like 50deg C and observe the vacuum gauges
12. To avoid the liquid being pushed through the nozzle apply He buffer gas with a pressure that is higher than the seed gas via $C_{\text{dry-out}}$:
Open $V_{\text{dry-out}}$ to dial in the pressure while $V_{\text{evac-line}}$ and V_{nozzle} are open after this section has been pumped out; note the ion gauges need to be preset for this jet. Now open V_{blocking} and close $V_{\text{evac-line}}$.
13. Open the gas bottle and dial in a pressure of ~30 to 50 psi. Then open V_{seed} and watch the gauges. Wait for the He to get out (~10 to 15 minutes)
14. Increase temperature of the liquid and pressure of the gas in an alternating way (20 to 40deg C & 20 psi steps)
15. For a water jet of 170deg C at the reservoir the Ar pressure is supposedly ~120 psi
16. Feel the Knee with your finger (**caution:** warm to hot): You likely will feel a temperature gradient which can be moved to the left and right with increasing the temperature of the reservoir and increasing the gas pressure

Stop the seeded Jet

17. Close V_{seed} and the gas bottle
18. See **STOP AND START JET IN CHAMBER** or **STOP ENTIRE LIQUID-TO-GAS JET OPERATION OR MAKE A REFILL**
19. Open C_{exhaust}
20. Open V_{exhaust} slowly to drain the gas (should take 2 to 3 seconds)
21. Close V_{exhaust}
22. Open V_{pump} and pump for 1 minute
23. Close the gas regulator and V_{pump}

STOP ENTIRE LIQUID-TO-GAS JET OPERATION OR MAKE A REFILL

Stop Jet in Chamber

1. Close V_{seed}
2. Close V_{blocking}
3. Open $V_{\text{evac-line}}$
4. Open $V_{\text{three-way}}$ to exhaust slowly (should take 5 seconds)
5. Open $V_{\text{three-way}}$ to pump and pump for 15 seconds, then close $V_{\text{three-way}}$ again
6. Close V_{nozzle}

Re-transfer Liquid back to Supply Reservoir

7. Close V_{blocking}
8. Close V_{drain}
9. While the Reservoir and the gas line is hot slowly open V_{transfer} and monitor the liquid level in the glass funnel. Close V_{transfer} when the level stopped rising and no more bubbles make it to the surface.

If your Chemical is toxic:

10. Do not re-transfer the liquid but open $V_{\text{evac-line}}$ and open $V_{\text{three-way}}$ to exhaust
11. Monitor with the ion-gauges and the COLTRIMS spectrometer if the jet is fading. You can close $V_{\text{three-way}}$ and check if the source chamber is falling or rising after a while; if it is still rising there is still liquid – if it is stable or falling you can now pump on it.
12. You may want to heat up the reservoir if it safe to accelerate the process. With 100 deg C it can take 2h for ~100ml.

Drain (and refill) the Reservoir

13. Stop the reservoir heater, i.e. set the heater to 20degC (not higher !) and monitor the cool-down process. Wait for the temperate to go down to <30deg C. You may want to use a bucket with water to cool down the reservoir after carefully removing the heater sleeve (**caution:** hot on the inside).
14. In case you want to refill the reservoir close V_{nozzle} , open V_{blocking} and $V_{\text{evac-line}}$ and open $V_{\text{three-way}}$ to the pump and pump for 20 seconds, then close $V_{\text{three-way}}$, $V_{\text{evac-line}}$ and V_{blocking} and transfer more liquid by opening V_{transfer}

See next page =>

continue: STOP ENTIRE LIQUID-TO-GAS JET OPERATION OR MAKE A REFILL

In case you DO NOT want to refill:

- Step 1: Clean the gas lines

15. Keep Heaters of outside and inside gaslines on
16. Close V_{blocking}
17. Open $V_{\text{evac-line}}$
18. Open $V_{\text{three-way to forepump}}$
19. Pump out as long as you can (>1day if possible)

- Step 2: Pump out the Reservoir

20. Make sure V_{nozzle} is closed
21. Wear your PPE (Gloves, Glasses, etc.): Open $C_{\text{reservoir-drain}}$ and drain the liquid into a beaker
22. Open $C_{\text{dry-out}}$ and attach dry gas with reasonable flow which you can control by opening $V_{\text{dry-out}}$
23. Open $V_{\text{evac-line}}$
24. Open V_{blocking}
25. Close $V_{\text{three-way}}$ to the pump just a little bit to give some gas ballast; watch for liquid coming out of the pump exhaust
26. Let it run for 2 to 12 hours
27. Now detach dry gas and close $V_{\text{dry-out}}$, $C_{\text{dry-out}}$ and $C_{\text{reservoir-drain}}$. You can now pump out the reservoir by opening $V_{\text{three-way}}$ for at least 3 minutes. Optional: Close $V_{\text{three-way}}$ afterwards, open V_{protect} and V_{bypass} to pump with scroll.

CLEAN-UP PROCESS

Clean out the Supply Vessel

1. Close V_{transfer}
2. Wear your PPE (Gloves, Glasses, etc.): Open $C_{\text{supply-drain}}$
3. Open V_{drain} and empty liquid into a beaker
4. Attach a dry gas to $C_{\text{supply-drain}}$ and dial in a decent flow by opening $V_{\text{dry-out}}$
5. Let it run for 2 to 12 hours

Regenerate the Forepump(s)

In case you polluted the forepumps with any condensable gases open the gas ballasts or detach forepump and let it pump a small amount of (dry) air, i.e. you need to restrict the flow with either a small pin hole in a Kwik-Flange plastic cap or a screw with a washer in the (red water) hose or similar.