Cryocooler Parts Cleaning

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# Goals

The ultimate goal to develop alternative suppliers of compressed gas lines and fittings to remedy the slow/unreliable delivery experienced when obtaining Polycold parts from Brooks Automation. A bonus is the substantially lower procurements cost (factors of 3 to 10 times).

The principal uncertainty to be addressed is the cleanliness of the lines. We need to remove contaminants very thoroughly to prevent them from cryopumping in the capillary tube in the cold head.

The cleaning procedures and cleanliness monitoring methods can also be employed to refurbish contaminated lines.

We will also require the development of an alternate source of refrigerant gas. As yet this document only covers the cleaning procedures and assessment methods.

# Equipment needed

* Ultrasonic cleaner, large enough to contain hoses!
* Small water pump
* Tap water
* De-ionized water
* Adapters from water hose to KF25.
* Dry N2 cylinder
* Miscellaneous bellows hoses and KF25 couplers to get from oven to cylinder and pumps.
* KF25 to high pressure gas line adapters (2 per hose)
* LN2 trap
* Vacuum valve, KF25 to KF25
* Oven (not vacuum) that is large enough to accommodate hoses to be baked.
* Hot air gun for warming up trap.

# Cleanliness Assessment Method(s)

The Polycold compressor does include a getter for recovering oil from the compressed gas lines, which may remove other contaminants to some extent. So while we could identify contaminants with a Residual Gas Analyzer, this must be borrowed from Palomar. Furthermore it is complicated to operate and is still reliant on understanding what the baseline measurement looks like from a sufficiently clean system.

The final assessment for what constitutes “sufficiently clean” will be the measurement of the cooling power versus cold-head temperature to show that the cold head is working as described in the data sheet and that this performance remains stable. A contaminated system may begin well but performance will degrade more quickly than expected. Since the oil adsorber never works with 100% efficiency we expect all systems to degrade over time and to need periodic maintenance but we hope this will be only necessary every few years. Experience so far suggests that a five year maintenance interval is possible.

For now, let’s try placing the parts under test in the large vacuum oven and baking at 150C. This temperature is chosen to be well above the boiling point of water while being well below the 204 C (400F) maximum for Viton seals. The seals (on the Aeroquip fittings) are actually neoprene which is good to 212F. If they are outside of the oven then the temp you specify should be fine.

While baking at 150C, evacuate the lines or fittings under test, with an LN2 cooled trap in series with the pump. Valve off the parts under test and vent the trap to inspect after 1 hour (initial test). Repeat this process several times until the condensate is opposite the inlet port drops below the background condensation that occurs when the pump is vented.

When done, backfill with dry Nitrogen (not air) to 1 atmosphere overpressure (i.e. 2 atmospheres absolute). If pumping on a long line, it is convenient to place the backfill connection at the far end since this configuration allows flushing through the system with dry N2, while it is heated. This can be executed as a slow bleed at the input or fill, evacuate, refill, etc. The latter may be most effective initially.

# Cleaning Procedures

## Wash

For very dirty (e.g. oil contaminated lines) we will use the ultrasonic cleaner, but first we need to fill the lines with water-detergent mix that has been preheated by the ultrasonic cleaner.

1. Rig up a connection from a small water pump or a KF25 flange.
2. Attach KF25 adapters to all high-pressure gas fittings to hold them open. *Be careful to point the fixture away from personnel (yourself) and to wear eye protection as the lines may be pre-charged with compressed gas. Vent to fume hood.*
3. Place plumbing to be cleaned in the ultrasonic cleaner.
4. Connect the pump to push water from the ultrasonic cleaner through the plumbing to be cleaned. Direct the outlet to return the water to the cleaner.
   1. Collecting or filtering the initial outlet water could be useful to determine whether the line was badly contaminated.
5. Once the recirculation has been established activate the ultrasonic cleaner for 10 minues or so (TBD)

## Rinse

1. Switch to pumping clean water through the hose, while still running ultrasound, until water exiting will not foam when shaken in a container.
2. Remove hose from ultrasonic cleaner and wash off detergent from exterior.
3. Flush interior with deionized water (once).
4. Blow clean air through hose to flush out water as best you can. A lot will remain.

## Dry

1. Move wet hose to large oven.
2. Connect inlet to dry N2 cylinder.
3. While bleeding dry N2 slowly through the line, heat to 110 C to boil off water. Keep connectors outside the oven since they are only rated to 95 C. Leave outlet open until hot (and thus dry).
4. Once dry, shut of dry N2 flow and begin pumping line through a valve to cold trap. Don't fill trap yet.
5. With hose still in oven (but connectors outside), close off valve to trap; refill with dry N2; shut off dry gas supply; pump; repeat a few times. This should flush out remaining water vapor.

## Bake

1. Pump out line and trap.
2. Fill trap with LN2
3. Continue pumping for an hour.
4. Vent lines and trap pump with ***dry*** N2; inspect trap. Smell residual condesnation on trap to monitor for organics. Is any film left behind after water evaporates. (Use hot air blower to hasten warm up of trap.)
5. Repeat the previous four steps a few times to show that material collected by trap is dropping. Stop when material collected in trap becomes invisible against condensation which collects as soon as the trap is removed.
6. Pressurize line to plus one atmosphere and disconnect at high pressure fitting so the line remains pressurized.

## Charge with refrigerant

* Procedure TBD.