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Inlet design for water vapour isotopologue measurements

The inlet for vapour measurements at the Geophysical Insitute, University of Bergen, operated within the FARLAB national infrastructure laboratory, is designed with the following principles in mind:

1. Minimize artifacts from tubing material
2. Minimize chance of condensation and memory in tubing
3. Obtain a high-resolution signal of ambient vapour variations
4. Prevent pollution of instrument from aerosols
5. Minimize background humidity during calibrations

In more detail:

1. Minimize artifacts from tubing material:

Artifacts are minimized by using material that does not have fractionating wall-effects. Synflex tubing has been shown to be unsuitable for isotope measurements, as it is fractionating, and creates an artificial d-excess signal (Tremoy et al., 2012). Similarly, we have seen that even short pieces of rubber tubing can have fractionating effects with very large memory. PTFE may be acceptable, but stainless steel (or copper) are the preferred tubing materials. We use diameters of 3/8 or 1/4 inches with Swagelok compression fittings.

2. Minimize chance of condensation and memory in tubing:

We reduce the buildup of water on the wall of the tubing and the chance of condensation by heating the tubing with a heat cable to temperatures between 50-70C. We have had very good results with tubing that is pre-packed with a heating cable and foam insulation (Thermon Inc). However, it is easy to build a package of the stainless steel tubing, a heat cable, wrap both with aluminium tape to distribute the heat, and cover with foam tubing, and a final layer of tape for water proofing. Make sure that the heat cable/thermostat is properly fused to prevent fires.

3. Obtain high-resolution signal:

We obtain a high-resolution signal by the two measures above, and by increasing the flow through the inlet system with a small pump (KNF N022.18). The pumps we use provide 5-10 slpm of flow, and can be regulated by a hand valve ahead of the pump (Swagelok SS-1RS4). The Picarro vaporizer is connected with a T-piece and a check valve (Swagelok 6L-CW4S4) to prevent flow out of the analyzer) and 1/8 inch stainless steel tubing (also heated). From switching tests between dry air and ambient air, we can achieve a time resolution of up to 30s with 6m inlet tubing for stable isotope signals. The 1/8 tubing should be kept as short as possible.

4. Prevent pollution of instrument from aerosols, insects, and precipitation

The inlet is constructed as a downward-facing tube end, terminated by an in-line particulate filter (Swagelok SS-4FW-140) to prevent large particles and insects from entering the tubing. Above the tube end, a 30cm stainless steel bowl (Ikea) prevents precipitation from entering the tube mouth. We protect the Picarro analyzer against aerosol pollution with a PTFE filter (Millex-FG, 0.20 µm, hydrophobic PTFE, 50 mm, Merck Millipore) on the inlet line that is periodically exchanged, depending on the proximity of pollution sources.

5. Minimize background humidity during calibrations

The Picarro calibration unit SDM is designed for operation with a drying unit, such as Drierite. However, Drierite does not remove all moisture from ambient air, in particular during warm and moist environments. In addition, the drying patron degrades over time and needs replacement, potentially compromising calibrations. We have modified the SDM such that it can be operated with synthetic air delivered from a standard gas bottle. A two-stage regulator with max 3 bar at the second stage is attached to the gas bottle. A flow meter with needle valve is placed next in line from the regulator to obtain a precise flow of 250 sccm at ambient pressure (second-stage gauge at 1 bar). A solenoid valve (12-24V) then allows to electrically control the flow to the mixing unit (where liquid injection from SDM goes into the vapourizer). The electrical connections of the solenoid valve are placed at the location of the connectors of the small pump inside the SDM (we used the connector from the power LED of the SDM for that purpose). In effect, the SDM only delivers the liquid, and the airflow is entirely provided by the gas bottle, but activated by the SDM.

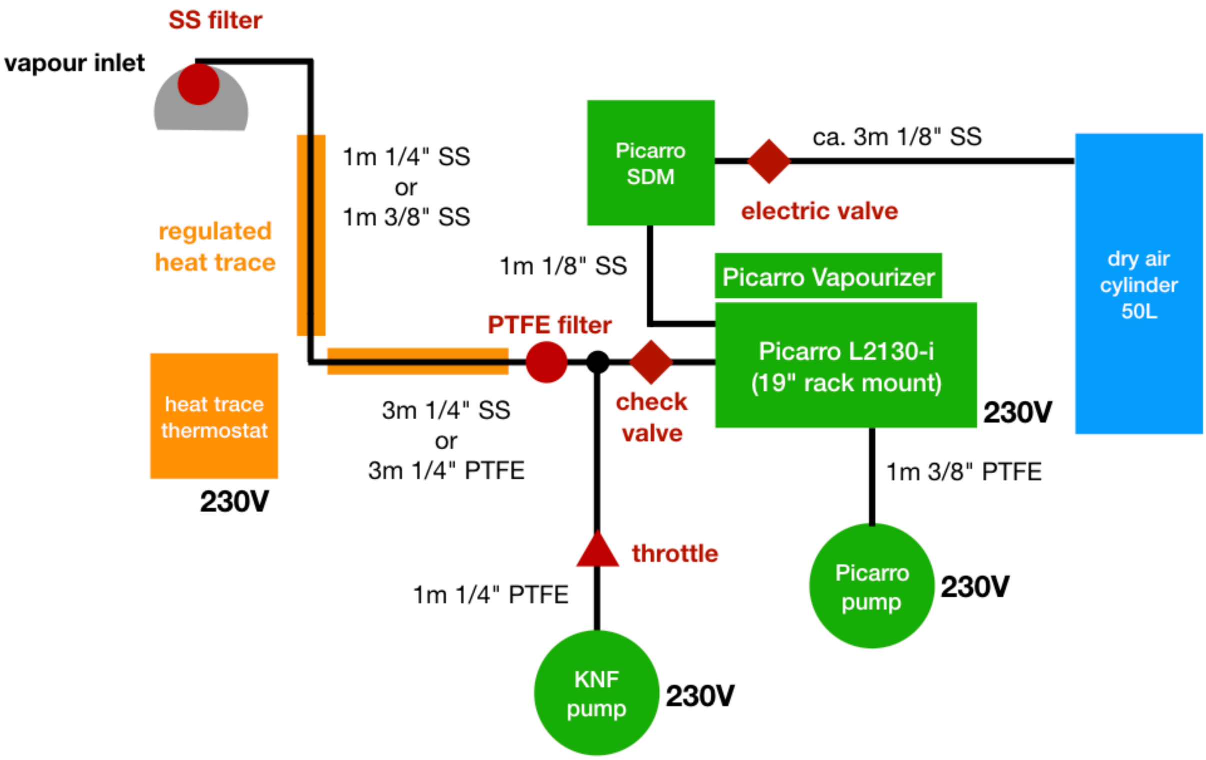

Figure 1: Schematic drawing of inlet setup used during the Iceland-Greenland-Seas Project cruise on R/V Alliance during March 2018, designed identically to the setup at the Geophysical Institute at University of Bergen. The setup has also been used on the Icebreaker KV Svalbard in August 2018, and the at Alpine Research station in Finse, Norway from Dec 2018 to Feb 2019 (all with FARLAB participation).