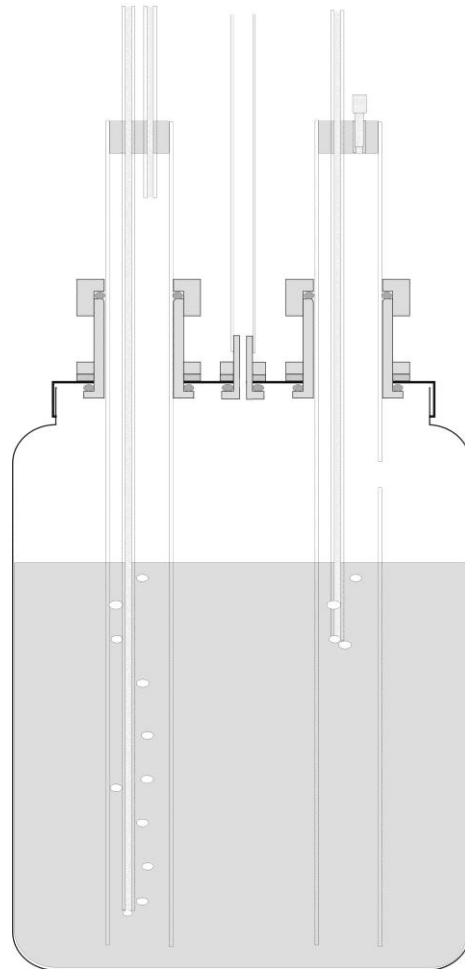


Probble

Simple gas humidifier and overpressure control/safeguard



User Manual, April 2012, NorECs AS

Features and typical uses: A Probble is a water-filled PET plastic container with gas flow connections that primarily allows you to humidify the gas while maintaining a small constant overpressure suitable to safely drive a small flow of gas through an apparatus like a laboratory fuel cell chamber or annealing furnace tube. Secondly, it provides safety overpressure release in case the following apparatus becomes closed. Thirdly and optionally it

allows separate overpressure regulation and flow visualisation of return gas, useful for verification of apparatus function and gas-tightness. In the case of use with fuel cells or other dual chamber applications, two Probbles allow individual adjustment of overpressures and thus can help monitor and minimise effects of sealing leakage.

Note: Probble operates with small overpressures (the column of a few cm of water only). It is thus meant for small flows, typically up to 50 – 100 ml/min, depending on gas line and gas, and for gas pathways without considerable obstruction. Typical uses are annealing furnaces, ProboStat and other measurement cells or SOFC button test cells.

Notice on safety: The Probble *must* be preceded by a needle valve and/or flowmeter that regulate the gas flow. It is *not* intended that flow regulating valves are placed after the Probble. Each Probble is preassembled ready for use. If delivered in a pair, they may be marked for instance Blue for Oxidising gases and Red for Reducing or Fuel gases, but they are otherwise identical.

Fill and keep water close to the Max level: Before use, fill the Probble with pure – preferably distilled or deionised water – to the Max level. Refill when the water level decreases and in any case before it reaches the Min level.

Overpressure and final outlet connection: If working with flammable gases or in other ways gases that should not be let into room air, connect the simple centre stub in the lid to hood or ventilation using e.g. a PVC hose (enclosed). Be sure that this outlet path cannot be closed or obstructed.

Gas line connections and operation: The Probble has two bubbler tubes (PMMA plexiglass) with openings for 1/8” PTFE gas tubing. The first has two top openings. Insert one of the enclosed PTFE thin tubes and feed it *almost* to the end of the plexiglass tube, see figures. Connect it to your flow-regulated supply of gas (e.g. a NorECs FCMix). Insert another PTFE tube into the other top opening of the same plexiglass tube, but let this one stop just below the opening, see figures. Connect the outlet of this tube to your process application (e.g. a NorECs ProboStat). When gas runs normally, it bubbles up from the long PTFE tube and proceeds out via the other one to the process application. If the onward flow is closed or obstructed the gas

soon starts bubbling off the surrounding longer plexiglass tube and out through the lid stub (preventing dangerous overpressure to build up.)

The second bubbler plexiglass tube has also two top connection holes (one is plugged by default). You may optionally use this to monitor the return gas from the process application: Insert a third PTFE tube e.g. one centimetre into the water (see figures) and connect your process application return gas to this. Note that the depth into the water of this PTFE tube should be much shorter than the long one in the first bubbler. The gas will bubble through the water showing you that gas flows and that the process application is roughly gas tight. The gas eventually escapes through the small hole in the second bubbler plexiglass tube and out into the common chamber of the Probble and out through the lid stub.

Gas pressures may be adjusted - within limits - by adjusting the insertion length of the PTFE tubes or by loosening the caps holding the plexiglass tubes to the lid, moving tubes up or down, and retightening. Before tightening, ensure the rubber gasket is pressed all the way down.

Humidity levels: The water vapour content in the gas after bubbling through the Probble will be close to the saturation pressure of water vapour over pure water at the temperature at hand (normally room temperature). The theoretical pressure can be found in Handbook tables or calculated by thermo-chemical software. The effectiveness of the bubbler will vary with flow, depth, temperature, bubble size etc. You may expect humidification of 95-100% of theoretical. Thus, the accuracy of the obtained pH_2O is not very high. As a first approximation of all the above factors, we suggest that 0.03 bar (0.03 atm, or 3 %) H_2O is used as a reasonable statement of pH_2O in the wetted gas. The precision of this may be increased by measuring the room temperature and looking up in the tables. Moreover, calibration or check with a humidity meter can be worthwhile, but such instruments are often not very accurate themselves.

Reduced humidification and other remedies against condensation: The humidification level being effectively somewhat below 100% has the advantage of avoiding condensation down the gas line. There may still be reasons to reduce the humidity in the gases further. This may be desired to tests applications with drier gases, or it may be necessary to avoid condensation with cells (e.g. fuel cells) that produce water internally. Heating materials that dehydrate or produce water by reaction (e.g, reduction of NiO by H_2) may also give increased water vapour levels in the output. In order to reduce the water level of the input gas, one may shorten the insertion length of the first PTFE tube, if necessary to above the water level.

The gas then obtains a more partial humidification. The Probble may alternatively be immersed in a chilled thermostatted bath. This will give a smaller and more constant level of water vapour, and reduced chance for condensation later in the gas line. One may also bypass the bubbler by a T-connection, only utilising it for overpressure control and safety.

If condensation in gas lines becomes a problem, avoid having cold-spots like cooling water lines near the gas lines. Also, do not cool ProboStats, fuel cells, or other devices too much – they are best run well above room temperature.

If fuel cells produce too much water by load or leakage, one may apply natural or active heating of cold parts, and return gas lines may be heated using e.g. heating tape. It may be an idea to insert an unheated container in the line to collect condensed water before clogging the gas passage.

Connect to Swagelok tube fittings: The PTFE tubing to and from the Probble can be connected in standard Swagelok 1/8" tube fittings. Use the standard metal ferrules that come with the Swagelok fittings. When making Swagelok connections, be sure that you know the procedures. This can be learnt in Swagelok documentation, and is briefly repeated here: When making a *new* connection, insert and keep the tube all the way in, and fasten the nut with your fingers, being sure the two ferrules are in place. From finger-tight, tighten ¾ turn (for 1/8" tubing) by using two wrenches. When re-connecting a *previously connected* Swagelok tube connection, the ferrules are already in place and have deformed the tube. In this case, only tighten lightly by the two wrenches, using maximum only the force of two fingers.

Materials specification list:

O-rings:

- 25x3: Nitrile rubber, 70 shore
- 94,92x2,62: Nitrile rubber, 70 shore
- 12x1: Viton, 70 shore

Jar: PET

Jar lid: PP

Rigid "lexiglass" tubes: PMMA

Flexible 1/8" tubes: PTFE

Ventilation hose: PVC

Plug for double feedthrough caps: PTFE