



## **Groundwater Sampling for SF<sub>6</sub> / CFCs using stainless steel bottles**

### **General remarks**

Sampling for dissolved gases requires resolution of the following potential problems:

1. Avoid gas exchange with the atmosphere during sampling  
Solution: Use tight connections between well and sampler
2. Avoid air contamination by inclusion of air bubbles  
Solution: Flush sampler and tubing well, remove any remaining air bubbles
3. Avoid loss of dissolved gases by degassing (formation of a gas phase)  
Solution: Keep sampling system under sufficient pressure to suppress degassing
4. Avoid leakage of gas in or out of the sample during transport and storage  
Solution: Use absolutely gas tight containers.

### **Well selection and preparation**

Not all wells or pumps are suitable for gas tracer sampling, because of the requirements of closure against air or other gas phases and of sufficient pressure to prevent degassing. Closed boreholes are highly desirable, open wells or springs are problematic, because they allow gas exchange. Ideal are artesian wells with sufficient pressure or wells pumped by a submersible pump. Sucking pumps should be avoided, they most likely induce degassing. Pressure tanks often contain a pressurized gas phase, which may exchange with the water and induce uncorrectable gas fractionations. If pressure or storage tanks are present, the water should be taken *before* it enters the tanks. Sampling after chemical treatment or filtering of the water should also be avoided if possible.

Before sampling, the well should be sufficiently flushed (pump out at least once the volume of the borehole). During flushing, temperature and electrical conductivity should be checked to see if the values stabilise. After flushing of the well, a tight connection to the sampler has to be established (see below).

## **Connection of sampler to well, pressure regulation**

The sample containers are stainless steel bottles with a valve on either end. A short, removable copper tube can be attached to one side before sampling, for connection with the well. This tube (or directly the thread on the valve) is connected to the pump, tap or other point of water withdrawal through flexible plastic tubing. Ideally, a tap near the well head is used. Often, several hoses need to be connected in order to reduce the diameter to the size of the connecting tube. We usually deliver a piece of tubing that fits tightly on the tube. We recommend to use this piece as the last part in the connection. In order to withstand water pressure, we use inner braided PVC tubing, and in order to allow detection of bubbles, we prefer transparent tubing. All connections should be secured with hose clamps.

Sometimes, air is sucked in at connections of the tubing, particularly if the diameter of the tubing increases in flow direction. Try to avoid such configurations (always go from large to small diameter) and tighten all fittings to avoid leakage. Slight leakage out of the tubing may be tolerable.

The complete tubing has to be checked for bubbles. Especially at connections. Bubbles can be removed by squeezing and bending the hoses or knocking against the tubing. During the whole sampling procedure, it is recommended to hold the sampler nearly upright, such that air bubbles can rise along with the water flow and are flushed out of the system.

If bubbles form due to degassing of the water, an increase of pressure can often help to suppress degassing. If the pressure can be regulated, it may be increased once the sampler is completely filled with water. At high pressures, the stability of the connections can be checked easily by temporarily closing a valve. The pressure should also be regulated such as to avoid any sound (rush) in the tap or connections, as it may indicate turbulence or degassing. If the pressure is low or if it is impossible to avoid bubbles, you may take the sample anyway but mark it accordingly.

## **Filling and closing the samplers**

For the initial filling of the bottle, the pressure should not be too high, in order to avoid degassing due to spraying or turbulence after the inlet valve. Keep the bottle upright and wait until it is filled from bottom to top. Once the sampler is filled, the pressure may be increased. The bottle should be well flushed, at the very least one entire filling should be replaced. After rinsing, the sample is isolated by quickly closing both valves (the sequence of closing is not critical if the sampler is in upright position). The valves provide a sufficiently gas tight closure of the bottles.

## **Sample identification and additional data**

To identify the samples, you may put stickers or tape on the sample cylinders. Please do not write directly on them. Additional information should be written down in a field book.

For each sample, note at least the sample identification, location, well name, and date of sampling in your field book. To interpret the data, we need some additional data, such as temperature and salinity (electrical conductivity) of the water, altitude of the well, altitude of the presumed recharge area, and if possible mean annual temperature in the recharge area. At least the water temperature and the approximate elevation at the sampling site should be known. We strongly recommend to measure temperature and electrical conductivity of the water during sampling. Especially a good knowledge of the water temperature is critical for the interpretation of SF<sub>6</sub> and CFC concentrations, because of their strongly temperature dependent solubilities.

## **Packing and transport**

The containers are best packed in aluminum cases, in which we usually ship them. They should be packed such that they cannot move during transport. Especially, precautions should be taken to avoid inadvertent opening of the valves.

## **The most important points step by step:**

**Pump long enough to flush the borehole completely.**

**Find a suitable tap or other outlet of the well/pump for connection.**

**Avoid pressure tanks, sucking pumps, and any contact with air or gas phases.**

**Connect the samplers by a tight combination of tubing.**

**Check if the connections withstand the pressure when the outlet is closed.**

**Flush the tubing, remove bubbles in the hoses.**

**Fill the bottles gently, then flush them well.**

**Close both valves quickly.**

**Identify the samples (name, location, date).**

**If possible note temperature, conductivity and altitude of the well.**

**Protect the valves from inadvertent opening.**