Technical note TNE-01

Retro-diffusion

Contamination of a gas stream with high purity gases can occur in many ways. For example, atmospheric components will enter a process stream if a leak or diffusion occur through the pipe material. This will happen even if the internal pressure is higher than the atmospheric pressure. This effect is called retro-diffusion.

Example: A process stream with argon has a pressure of 10 bar. The argon contains 5 ppm oxygen as impurity. The partial pressure of argon in this stream is 10 bar. The partial pressure of oxygen is 0.00005 bar.

$$\frac{10 \times 5}{1.000.000} = 0{,}00005 \text{ bar}$$

The composition of gases in the atmosphere is shown in Table 1.
The atmospheric pressure is 1 atm, which is about 1 bar.

The partial pressure of oxygen is 0.21 bar in air, while the partial pressure inside the pipe is 0.00005 bar, which comes from the 5 ppm impurities. The difference in the partial pressure between air and the process flow is very significant. It can be seen in Figure 1 that we have a system in imbalance that will try to reach equilibrium. The partial pressures "P O_2 atm" and "P O_2 intern" are only separated from each other by the pipe wall. Should a leak occur, oxygen from the surroundings will flow into the process stream and cause contamination. If oxygen is an unwanted contaminant for the application, problems may occur. The same principle applies to other gases, including moisture, see Figure 1 and Table 2.

Diffusion through the pipe wall can also take place if the pipe material allows diffusion. Table 2 demonstrates the level of contamination that will be present in 1 meter long pipes made of different materials. Other values apply to other gases. Acid-resistant steel is recommended as copper is a soft metal. The copper joints will eventually start to leak due to vibrations, handling etc.

For example, an assay system made of Teflon hoses will allow components such as oxygen and moisture to migrate through the pipe walls and accumulate in the system, especially when not in use. Oxygen and moisture are normally critical contaminants for gas analyzers.

Gas	Atmospheric composition	Partial pressure
Nitrogen	78 %	PN_2 = 0,78 bar
Oxygen	21 %	PO_2 = 0,21 bar
Argon	1 %	PAr = 0,01 bar

Table 1: The partial pressure in the atmosphere of the three most common gases in air.

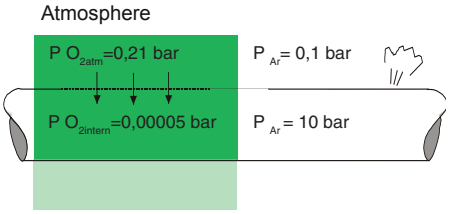

Figure 1: 1 meter pipe, diameter 2 x 4 mm, flow 5 liters/h, 10 bar Ar.

Material	Contamination with O_2
Acid-resistant steel, Copper	0 ppm
Mylar	0,02 ppm
Nylon 6	0,05 ppm
Kel-F	0,6 ppm
Perbunan	5,3 ppm
Neoprene	6,9 ppm
Polyethylene	11 ppm
Teflon (PTFE)	13 ppm
Polyvinyl	27 ppm
Rubber	40 ppm

Table 2