Table 4 — Driving Forces for Atmospheric Diffusion

Gas Constituent	Concentration of Gases *Inside* Hose ppm A	Concentration of Gases *Outside* Hosse (Air composition) ppm B	Approx. Driving Force for gases to diffuse out of hose to atm ppm A–B	Result
Argon	950,000	9000	941,000	Argon diffuses *out* of hose
Helium	50,000	5	50,000	Helium diffuses *out* of hose
Nitrogen	100	780,000	–779,900	Nitrogen diffuses *in* to hose
Oxygen	20	209,000	–209,000	Oxygen diffuses *in* to hose
Moisture	10	20,300	–20,300	Moisture diffuses *in* to hose

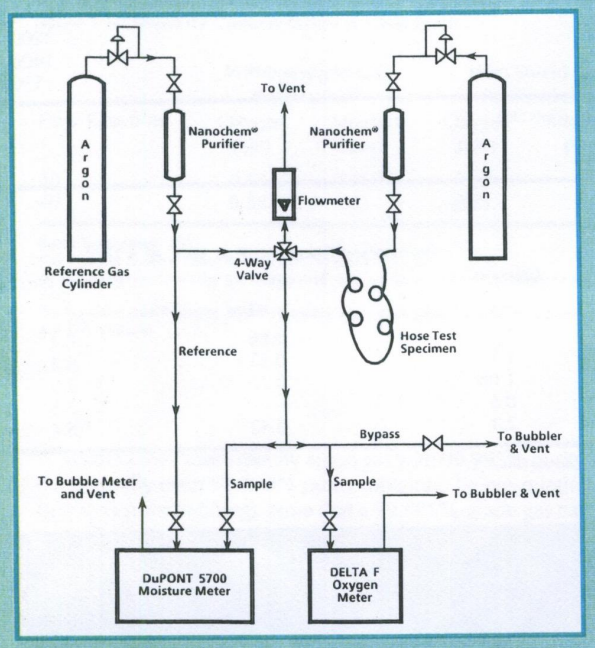

Fig. 4 — Measurement of atmospheric oxygen and moisture permeation through plastic/rubber hoses.

7. *Additives in the polymer.* In general, addition of plasticizers to increase flexibility to the hose (during manufacture) will increase the permeability of the plastic. Addition of inorganic fillers will usually decrease the permeability.

8. *Degree of crystallinity/density of polymer.* Density is a measure of the free volume between the molecules of the polymer. In general, the higher the density, the lower the permeability. The crystalline structure of the polymer is usually less permeable compared to the amorphous form. Crystallinity and density are strongly related. The higher the crystallinity, the higher the density of the polymer. But, more density increases stiffness, giving a less flexible hose. Table 3 shows the effect of crystallinity and density for permeation of oxygen, nitrogen and carbon dioxide through polyethylene and polypropylene (Ref. 8).

Glove Box Applications

Butyl rubber has much less moisture and oxygen permeation than Neoprene rubber (Table 2). So, Butyl rubber gloves should be used for welding applications in a glove box or inert atmosphere chamber and neoprene gloves should be avoided.

Table 5 — Experimental Data, Permeation of Atmospheric Oxygen and Moisture through Weld Hoses

Polymer	Atmospheric Permeation for 8-ft length of hose Oxygen[(a)] ppm	Moisture[(a)] ppm
"Rubber" (Goodyear Conair)	0.77	9.4
PVC (Linde 40V77)	0.12	5.5
Teflon	0.82	0.56

Flow Rate = 20 ft³/h, Temperature = 20°C (room air-conditioned)
(a) Impurities in test gas and piping manifold removed by gas purification. Indicated impurity levels are due to atmospheric permeation alone.

Glove boxes can be made of Plexiglas and, occasionally, Lexan. Although Plexiglas and Lexan have negligible oxygen permeation (Table 2), the moisture permeation rates are very high. Consequently, glove boxes should preferably be made of metal, with only the windows/viewing ports made of Plexiglas or, preferably, Lexan. Choosing Plexiglas over Lexan would still imply almost 300% more permeation (Table 2). It would be even better to have the windows made of glass, instead of plastic.

Many users measure only the oxygen content of glove boxes, which is often 10 ppm or less. Nevertheless, because of the very high moisture permeation constants of Plexiglas and Lexan (viewing windows), Neoprene and Butyl rubber (gloves and seals), the box's moisture content can be easily 50–250 ppm.

Permeation of Nitrogen — Welding of Titanium

Because of its reactive nature, titanium metal is often welded in glove boxes under an argon atmosphere. One should thoroughly shield the weld with purified shielding and trailing gas, even when welding inside a glove box — with its permeating moisture through its Plexiglas, Lexan and rubber components.

Also, nitrogen in argon can reduce ductility in titanium welds from the formation of titanium nitrides. However, the concentration of nitrogen in argon or helium in gas cylinders is usually small enough that there isn't a major effect on weld quality. The permeation of nitrogen is usually only a quarter the permeation of oxygen in many plastics. Since oxygen permeation is usually too small in most cases, permeation of atmospheric nitrogen into glove boxes is not likely to be high enough to affect weld quality.

Driving Forces for Permeation

Permeation (*i.e.*, diffusion) is a function of the partial pressure of each individual component of the gas mixture, *not* a function of the total pressure of the gas mixture.

Consider a hose carrying a blend of 95% argon/5% helium