Highest ← PERMEATION → Lowest

Neoprene Rubber	Butyl Rubber	PVC Tygon	PE (high density) Polypropylene Teflon PTFE	Kel-F Saran	Metal

Fig. 2 — Degrees of permeability.

Table 1 — Impurity Concentration at Weld Torch

	Without Shield Gas Purification[(a)]		*With* Shield Gas Purification[(b)]	
Flow Rate ft³/h	Oxygen ppm	Moisture ppm	Oxygen ppm	Moisture ppm
20	0.53	40	0.39	20
40	0.55	22	0.31	11

Room Temperature: 25°C
Gas Cylinder Quality: Oxygen − 0.1 ppm, Moisture − 4 ppm.
(a) Impurities contributed by gas cylinder, piping manifold and 30-ft PVC tubing to weld torch.
(b) Impurities contributed by 30-ft PVC tubing alone (from permeation of atmospheric oxygen and moisture).

Most GTAW users specify argon gas with 99.995% purity, and occasionally even 99.998% purity (obtained by pre-purging gas cylinders prior to filling). Note that a 99.995%-grade gas can still contain up to 50 parts per million (ppm) of total impurities, and 99.998% up to 20 ppm. In many critical welding applications, such levels may be high enough to cause defects or premature corrosion. An off-spec or dirty cylinder could contain much higher levels of impurities.

Piping Systems

Many large fabricators and repair shops use a centralized supply of liquid argon. While argon from this tank is very pure (less than 2–5 ppm total impurities), such low levels are usually attainable only at the immediate outlet of the tank. The gas then travels through a piping network (manifold system) anywhere from several hundred feet to a few miles long, and just about every component in that network can be a source of leaks. Impurities trapped in piping joints, such as Ts, where there is not continuous flow, may continue to desorb into the rest of the piping manifold for days or even months. In most cases, the quality of the gas at the weld torch is significantly poorer than at the liquid bulk supply.

Plastic and Nonmetallic Components

Hoses and plastic tubing are commonly used to obtain flexible joints, such as when connecting a gas cylinder to a power source or to deliver gas from the power source to the weld torch. Such nonmetallic joints can significantly degrade gas quality. Atmospheric moisture and oxygen — at the molecular level — can diffuse through the solid walls of plastic parts and thereby contaminate the gas stream flowing within the plastic tubing or component (such as valve seats, O-rings, etc.). Called atmospheric permeation, the resulting contamination may be aggravated by leakage through poorly crimped hose connections and loose or damaged fittings, resulting in a much higher level of contaminants at the weld torch.

Purification

To determine the precise effects of atmospheric permeation, tests and test welds described were performed at a weld shop in the Research Center of Hercules Inc., Wilmington, Del. Relatively clean argon gas containing only 0.1 ppm oxygen and 4 ppm moisture was allowed to flow at 20 ft³/h (6 m³/h) through the weld shop manifold, a Miller Synchrowave 300 power source and a Linde HW-18 weld torch. The shop manifold consisted of about 75 ft (22.5 m) of ½–1 in. (12.7–25.4 mm) inside diameter carbon steel piping.

Typical of such manifold installations, the quality of argon at the outlet of the weld torch had deteriorated to 0.5 ppm oxygen and 40 ppm moisture. In passing through the manifold, piping, power supply unit, connecting hoses and the weld torch, the moisture content of the gas had increased tenfold — from 4 to 40 ppm.

A NANOCHEM® resin-based gas purifier was installed at the outlet of the welding power source (Fig. 1), and the moisture concentration at the weld torch was immediately reduced to 20 ppm. Since the moisture concentration was measured to be less than 0.05 ppm at the immediate outlet of the gas purifier and no leaks were found in the tubing and other components, permeation of atmospheric moisture through the PVC hose to the torch was suspected.

Atmospheric permeation was confirmed by increasing the gas flow rate while keeping the operating pressure constant. Because the amount of permeating impurities stays constant regardless of gas flow rate, a higher flow rate diluted the permeating contaminants in the gas. When the flow rate was doubled from 20 to 40 ft³/h (12 m³/h), the permeate (moisture) concentration was roughly halved (Table 1).

Permeability Factors

All gases, such as oxygen, moisture, carbon dioxide and nitrogen, can diffuse through the walls of just about all rubber and plastic hoses, tubing and other components. Permeation is absent only in all-metal all-welded pipes. If the piping manifold is not welded, permeation can occur at pipe-thread connections, which are usually sealed with a plastic, such as Teflon tape. Table 2 lists permeability coefficients for several known plastics that might be used in gas delivery systems (Ref. 2–7). SI units of permeability have been used. The higher the permeation coefficient, the higher the amounts of the diffusing contaminant and the worse the quality of the ensuing gas. For critical gas purity requirements in welding, a permeation coefficient less than 100 can be considered acceptable; permeation coefficient below 10 would be excellent.

Rubber hoses are often used in welding applications because of their strength and flexibility, but most have high permeation