Monitoring Moisture Content in Medical Gases

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When we go to the hospital or order oxygen for home healthcare, most of us go on faith that the gas is safe. Few, if any, patients worry about gas contaminants, like moisture, which can lead to corrosion within the gas delivery system and the formation of harmful bacteria in the gas delivery lines. Yet, because of its inherent stickiness and ubiquity in the air, moisture is one of the hardest molecules to measure and to control. Fortunately, gas suppliers strongly adhere to government standards for moisture and other contaminants when it comes to medical gases, which are regulated as a drug. In the United States, standards are set by the United States Pharmacopeia (USP), a non–governmental, official public standards–setting authority for prescription and over–the–counter medicines and other healthcare products manufactured or sold in the US. In Europe, standards are set by The European Pharmacopoeia (Ph Eur).

Medical gases are, by definition, gases that are manufactured, packaged, and distributed for administration to patients in anesthesia, therapy, or diagnosis. They include oxygen, nitrous oxide, nitrogen, carbon dioxide, helium, medical air, and instrument air. Since these medical gases are the most frequently administered "drugs" in home healthcare, nursing facilities, medical clinics, and hospitals, their concentration, quality, purity, and pressure settings are closely monitored. Accuracy and reliability are absolute requirements when delivering, handling, storing, and dispensing the gases.

Accupoint 2 microprocessor-based moisture transmitter
Photo: MEECO, Inc.

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Compressed gas cylinders are versatile in many settings and allow relatively easy transport and delivery. But, for healthcare institutions where large volumes of gases are consumed, medical gas pipeline systems are more convenient and economical. Such systems contribute to cleanliness, simplify gas handling procedures, minimize points of contamination, and reduce risks to personnel. Bulk systems also allow for continuous and uninterrupted supply of the gases and precise control of usage.

Owing to water's abundance in the atmosphere and its affinity to condense on the interior surface of a gas cylinder or container, it is the most persistent contaminant in gas applications. For example, moisture seepage can occur during delivery of a medical gas to the storage tank. Since air drawn into the compressor intake is never completely free of water vapor, water is always present in a compressed air or medical air pipeline system. Dryers and desiccants can remove some, but not all of the moisture. Moisture analysis of medical gases at delivery junctures and critical locations is therefore necessary to keep contamination under control.

In most industrialized countries, medical gases are classified as prescription drugs because their usage is considered unsafe unless under the supervision of a licensed practitioner or by properly-instructed emergency personnel. While carbon dioxide USP and nitrous oxide USP can contain up to 200 ppm (parts-per-million) of moisture according to the US Federal Drug Administration, trace moisture requirements are more stringent in Europe. There, no more than 60 ppm of moisture can be present in medical grade air, oxygen, and nitrogen, and in cylinders of nitrous oxide and carbon dioxide.

The European Pharmacopoeia also specifies electrolytic technology as the approved method for trace moisture analysis. Based on Faraday's Law, an electrolytic moisture analyzer (Figure 1) serves as an absolute and fundamental standard, with renowned stability and accuracy. Using electrolysis, the water molecule is dissociated into hydrogen and oxygen molecules, creating a current directly proportional to the amount of water present.

The electrolytic cell consists of a hollow glass tube with two electrodes helically wound and partially embedded on the tube's inside surface. A thin, hygroscopic film of phosphorous pentoxide (P_2O_5) covers the electrodes. This delicate assembly, called the element, is surrounded by a protective metal body and is supported within the cell body to allow gas flow through its cavity. Since the opening through the body around the element is sealed, the gas can only flow through the glass tube.

When a sample gas enters the cell at a known flow rate, the P_2O_5 film adsorbs all the moisture molecules present in the gas. A voltage applied across the electrode terminals then electrolyzes the moisture in the film. Upon reaching equilibrium, the rate at which moisture molecules enter the cell will be equal to the rate at which molecules are electrolyzed.

Since each electrolyzed water molecule displaces two electrons from the anode to the cathode, the electrolysis current is a measure of the electrical charge displaced per second. The moisture concentration can then be calculated using the current, the elementary charge of an electron, and total flow rate of the gas passing through the cell. For example, at 100 sccm, 1 ppm of moisture corresponds with a current of 13.14 μA.

The electrolytic cell can be used together with a regulator to manually adjust the gas flow or with a mass flow controller for more precise control of the gas flow rate. The latter increases the cost of a moisture analyzer, but can be combined with software, an LCD display, multi-scale output options, and additional user-friendly features. Analyzers are

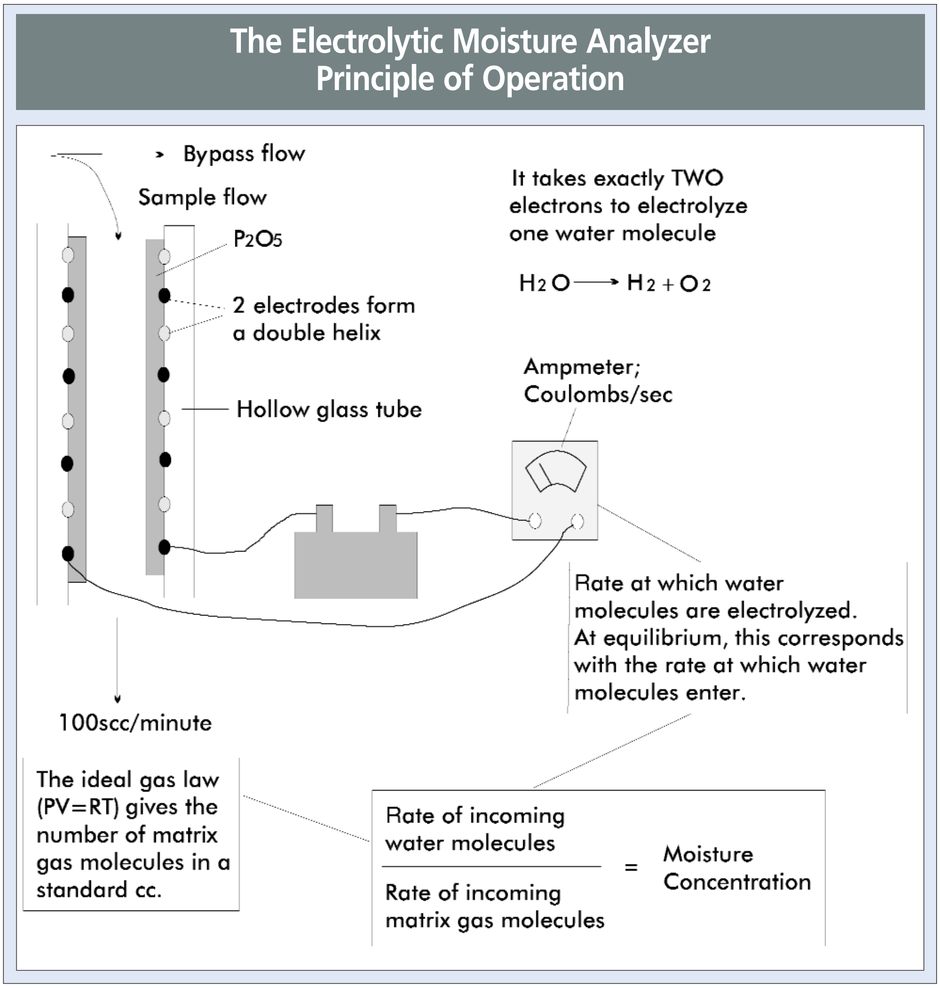

Figure 1 Source: MEECO

designed to fit into standard rack mounts with other equipment. An analyzer can also be modified with a pressure regulator to handle high inlet pressures (> 100 psig). In low-pressure applications, control valves that replace the regulator can accommodate inlet pressures below 100 psig, for example.

Electrolytic moisture analyzers have long served the medical gas industry and are widely employed by major European gas suppliers, including AGA Linde, Air Products, Air Liquide, and Praxair. Among the leading suppliers of this technology in Europe, the Antipodes, Latin America, and elsewhere, MEECO, Inc. has manufactured its highly refined electrolytic cells for over 60 years. We work closely with our medical gas customers to insure that our packaging, software interface, and outputs conform to their evolving needs. The one consistent feature is our electrolytic cell, giving our customers and their end-users assurance that the medical gas they supply and rely on is indeed safe.

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