7500 Boone Avenue North
Minneapolis MN 55428 USA
763-493-6370 FAX: 763-493-6358

TECHNICAL BULLETIN

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SUBJECT: "WHICH HEAD SPACE ANALYZER IS BEST FOR ME?"

Every oxygen analyzer has an oxygen sensor as its core technology. No matter how plain or fancy an instrument is it will always be limited by its basic sensor capabilities and limitations. Three basic oxygen sensor technologies are used in nearly all of the oxygen analyzers on the market today. They are:

- Paramagnetic
- Electrochemical (also known as polargraphic, coulometric, or galvanic)
- Zirconium Oxide

Each of these basic sensors has their own pluses and minuses. Let's explore them further.

1) Paramagnetic

The oldest of the three, this technology is based on the weak magnetic characteristics of the O_2 molecule. When placed in a magnetic field, oxygen can be detected by using balanced dumbbells. Their deflection from a null point depends on the amount of oxygen present. This technique was important in the 1920's and 1930's because better methods of detecting oxygen had not been developed yet. Its chief negative was its susceptibility to vibration, due to its delicately balanced moving parts, its non-rugged nature, and its resulting unreliability and frequent break down. The most popular supplier of paramagnetic instruments in the 1970's was Beckman Instruments, who no longer make these units.

2) Electrochemical (polargraphic)

Sensors were developed in the 1950's and 1960's that were able to detect oxygen and create a current or voltage through a chemical reaction. These sensors were a big improvement over paramagnetics because they were much cheaper, and not sensitive to vibration. They had to be protected from direct contact with the oxygen gas however, so a membrane was inserted between the oxygen sample and the sensor. The oxygen must diffuse through the barrier membrane, go into and electrolyte liquid solution, and then react with the sensor's electrode. The chief drawbacks are the time to get and answer, typically 20 seconds to one minute per test, (due to the diffusion rate through the barrier), and the maintenance required to replace frequent broken membranes and evaporated electrolytes. Electrochemical units are typically cheaper, but suffer from slow response time, drifty results from room temperature changes affecting the membrane diffusion rate, and frequent membrane and electrolyte maintenance issues.

3) Zirconium Oxide (ZO_2)

In the 1970's, it became commercially possible to manufacture zirconium ceramics with such precision that they could reliably be used to sense oxygen. When heated in a small, self-contained oven to a high temperature, zirconium oxide ceramics detect oxygen very

sensitively and reliably. Zirconium sensors are better than the other technologies because they are extremely fast (2 sec.), require very small sample size (2 cc), are very sensitive to oxygen, are very rugged, have no moving parts, and do not rely on membranes or electrolytes. Their only drawbacks are their higher cost and their potential for cracking if liquid should be injected into them.

To recap, these are the important points to consider:

Sensor Type	Advantages	Disadvantages
Paramagnetic	First modern day O_2 detector, developed in the 1920s.	Delicate; unreliable; sensitive to vibration; old technology; requires large sample size.
Electrochemical (polarographic, coulometric, galvanic)	Less expensive, not vibration sensitive.	Slow; drifty due to room temperature fluctuations; frequent costly membrane and electrolyte maintenance.
Zirconium Oxide	Very fast (2 sec), small sample size (2 cc), very rugged.	More expensive, can be damaged if liquid is injected into sensor (MOCON supplies a superior liquid filter to prevent this).
Other: Infrared	Very good for measuring CO_2 gas	Cannot detect oxygen.

The vast majority of head space analyzers sold to the food, pharmaceutical, and medical packaging industries today are of the zirconium oxide sensor variety, due to the major advantages listed above.

MOCON has been manufacturing electrochemical sensors for our barrier film permeation testing instruments for over 25 years, so we know this technology extremely well. All of our oxygen head space analyzers, however, use zirconium sensors because they are the best for that particular application. We have been supplying zirconium systems for over 15 years.

We welcome the chance to share our experiences with you, and to tell you why we fell we are the best vendor of zirconium oxide oxygen head space analyzers for your investment. Our systems are entirely made in the U.S.A.