

Beverage



Introduction

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What you can measure, you can control

The quality, taste and shelf-life of beverages can be seriously affected by the presence or absence of O₂, CO₂ and other gases. Monitoring and analysis are therefore conducted throughout the processing, up to and including the packaged beverage.

This manual gives an overview of **Orbisphere** measuring systems and their applications in the beverage industry. Our equipment is installed by major breweries and soft drink manufacturers all over the globe.

Their experience and needs are the key consideration in **Orbisphere's** on-going research and development program of innovative methods, devices and accessories serving an industry where efficiency and product quality are of prime importance.

Orbisphere produces highly selective analyzers for oxygen, hydrogen and ozone, as well as a range of versatile instruments for measuring carbon dioxide, nitrogen and other gases found in industrial processes.

Although brewing is a highly traditional industry, using century-old skills, stringent new regulations and changing world markets mean certain parameters must be met to assure desired flavor, color and shelf-life.

Orbisphere analyzers provide the quality and performance not only to measure with precision and reliability, but to stand up to the most demanding applications with a minimum of maintenance.

Today, through precise measurement and analysis, even the smallest breweries - using the most traditional brewing methods - can assure the highest quality, capacity and efficiency of their production facilities.



Electrochemical Sensors for O₂, O₃ or H₂

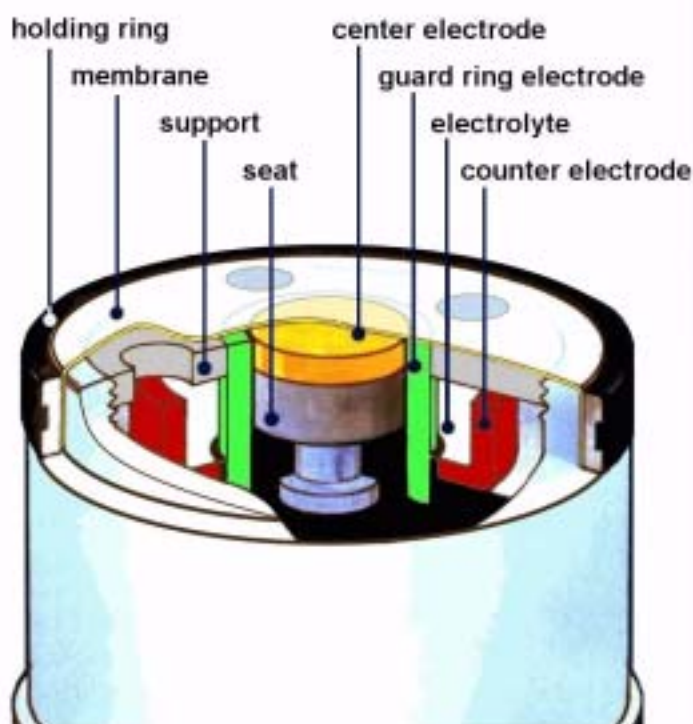
An Electrochemical (EC) Sensor in its simplest form, consists of a working and a counter electrode immersed in an electrolyte solution and covered with a waterproof, yet gas permeable membrane.

By applying a reference voltage to the counter electrode a current will flow in proportion to the gas diffusing through the membrane to the working electrode. This current represents the partial pressure or fugacity of the sample.

The **Orbisphere** sensor has a third electrode called a guard ring electrode, having the same potential as the working electrode, thus eliminating interfering gases present in the electrolyte.

As a result only gas penetrating through the membrane directly above the working electrode is measured, producing a very short response time.

The guard ring electrode, as well as many other state-of-the-art features, ensures that reliable, accurate and robust **Orbisphere** sensors meet the most demanding needs of the beverage industry - especially in those sectors where environments are harsh.



Electrochemical Sensors for O₂, O₃ or H₂

Orbisphere electrochemical oxygen, hydrogen and ozone sensors provide a wide range of valuable benefits:

High sensitivity and absolute zero

In the oxygen sensor, the 99.999% pure gold cathode is set in a ceramic valve seat with a predetermined high spring load. This forms a perfect seal which eliminates residual current.

The factory tested residual signal is < 0.3 ppb, making zero setting unnecessary; even when extension cables of up to 500 meters are used.

No risk of interference by additives or carbon dioxide

The guard ring electrode surrounds the measuring electrode, thus electrolyzing all impurities that could interfere with the measurement.

Pressure resistant

All stainless steel construction of the sensor assures resistance up to 100 bars of static pressure and pressure shocks up to 7 bars.

Fast stabilization and low drift

The "deep drawing" membrane mounting method creates a wrinkle-free and perfectly taut, yet unstretched, membrane over an electrolyte layer of only a few microns.

This ensures fast stabilization and low drift even at very high applied pressures.

Resists daily hot caustic cleaning

Rugged sensor construction, coupled with mechanical expansion compensation enables use over a temperature range of 0° to 100°C.

Detachable sensor cable

The detachable, waterproof sensor cable ensures ease of installation and maintenance.

Sensors are supplied with a support to facilitate service.



Thermal Conductivity Sensors for CO₂ or N₂

Thermal Conductivity (TC) Sensors are based on a membrane covered, thin-film integrated circuit.

Gas passes to the measuring section by diffusion only. The 1 mm² membrane is heated to about 70°C above ambient temperature. The specific thermal conductivity of the gas surrounding the membrane, causes thermal energy to be dissipated from the "hot" membrane.

The cooling of the membrane is measured, or in the case of temperature stabilization, the electrical power needed to keep the excess temperature constant. Two additional resistors measure and compensate for the effect of the ambient temperature.

The thermal conductivity sensor is too fragile to be used unprotected in liquids. Therefore, it is installed in a sensor holder with a very small dead volume and covered by a second membrane.

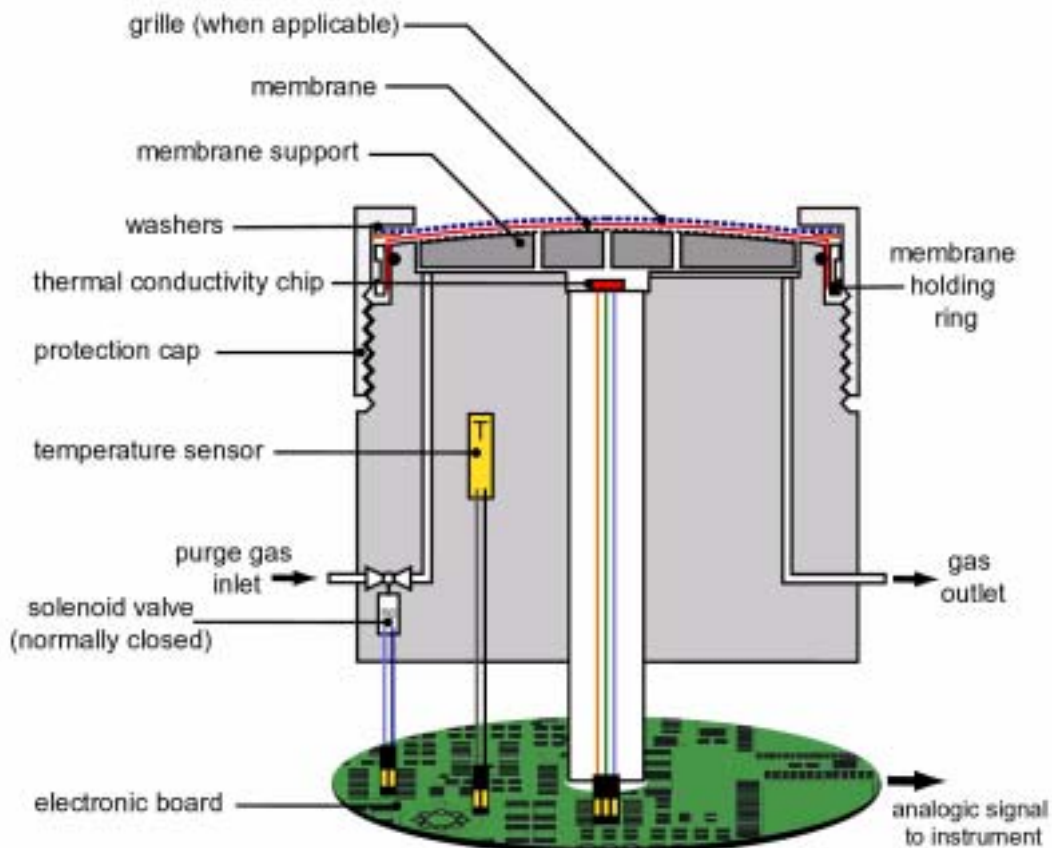
This membrane acts as a barrier to liquid, but allows gas to diffuse to the sensor. The rate of diffusion, for a specific membrane, depends on

the time lapse of the measurement cycle and the concentration of the gas to be measured. Since the time lapse has been defined by the purge and measuring cycle, only the concentration of the gas to be measured remains to be determined.

The purge gas has two functions. The first is to evacuate the sample from the sensor so a new cycle can begin. Thus it is not necessary to wait for equilibrium - resulting in a very fast response

The second function is to make the system insensitive to interfering gasses. The purge gas should ideally be a gas present in the sample, (one that is not to be measured or that would interfere with the measurement). For example, if CO₂ is measured in a beverage and we purge with N₂, then each time we purge, the N₂ signal is offset. In other words, the system is made insensitive to N₂.

Another advantage of this method is the total elimination of drift as the zero point is recalibrated every 17 seconds.



Thermal Conductivity Sensors for CO₂ or N₂

Orbisphere TC sensors offer a number of important benefits.

High sensitivity with absolute zero

During the purge mode, the zero setting is reset in every cycle to eliminate zero drift. Extension cables up to 100 meters in length can be used without influencing the results.

Low drift and fast stabilization

The "deep drawing" membrane-mounting method together with the Protection Cap produce a constant dead volume for fast and reproducible measurements. This ensures rapid stabilization and low drift even at very high applied pressures.

No interference by other gases

Interference by another dissolved gas can be eliminated by purging with that gas.

High pressure resistance

The all stainless steel construction of the sensor resists up to 20 bars static pressure, as well as shocks up to 7 bars.

Sensors resist daily hot cleaning

Rugged sensor construction together with a purge during CIP enable use of the sensor over a temperature range of 0° to 100°C.

Detachable sensor cable

The detachable, waterproof sensor cable ensures ease of installation and maintenance.



Sensor Membrane Selection

Membrane selection

Choice of membrane is often determined by sensor location.

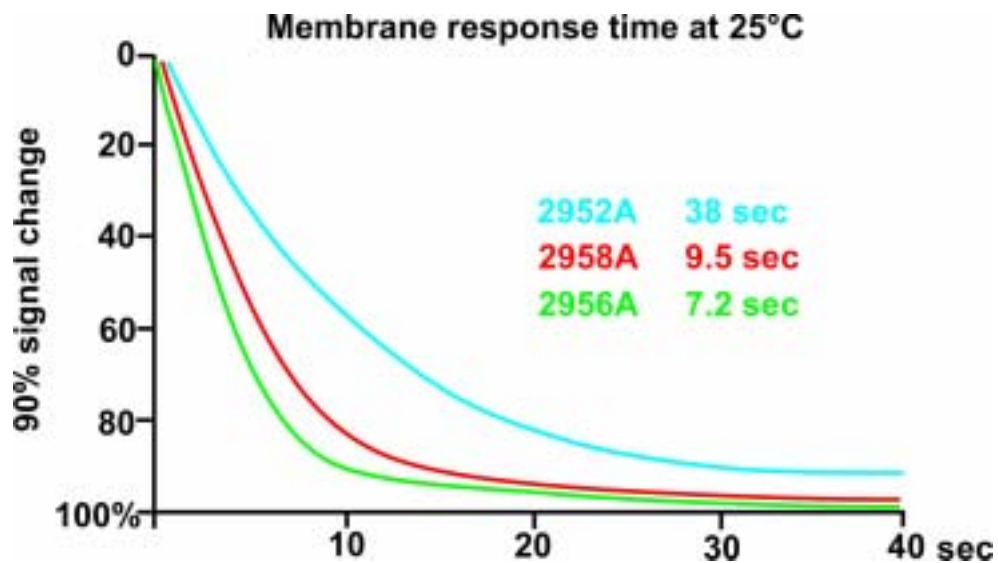
For most in-line measurements, model **2952A** membrane is adequate, as it resists mechanical pressure shocks caused by abruptly closed valves.

Its response time, flow requirements, and lower detectable limit are more than sufficient for all clear beer applications.

For off-line measurements, model **2958A** is recommended for its faster response.

For measurements in the gas phase, the model **2956A** is recommended for its high permeability.

Membrane model **29552A** and model **2995A** are ideal for measurements in hot and cold wort, because they resist temperature extremes and suspended particles.



Analyzers and Indicating Instruments

Series 510/410 analyzers

The **Orbisphere** 510/410 series analyzers offer a precise and powerful process monitoring capability.

Designed to complement **Orbisphere's** high quality oxygen, hydrogen and ozone electrochemical sensors, these instruments provide accurate, repeatable trace level measurements and an impressive level of data management.

Features of the 510 analyzers include:

- High level of measurement accuracy and rapid response time meaning reliable and effective process monitoring
- Easy to use, intuitive software navigation is simple to use for line operators and flexible enough to meet the needs of technical personnel
- The color touch-screen, housed in a stainless steel enclosure conforming to IP65, defines a robust unit built to handle the industrial environment
- Data storage of up to 10,000 measurements, the last 1,000 operator actions and details of the last 50 calibrations

- Internal diagnostics simplify troubleshooting and issue reminders for maintenance and calibration
- Software password protection offering five levels of controlled access
- Adjustable alarms and outputs provide assurance that any out-of-specification events are registered
- Suitable for sampling dissolved concentrations from ppb to super-saturation, and gaseous concentrations from ppm to percent level

Features of the 410 analyzer are the same as for the 510 analyzer, with the following exceptions:

- The touch-screen is only available in monochrome
- Data storage of up to 1,000 measurements, the last 1,000 operator actions and details of the last 10 calibrations

Instrument versions

The series 510 analyzers are available in panel mount (illustrated below), wall mount and portable, versions.

The series 410 analyzers are available in panel mount and wall mount versions.



Analyzers and Indicating Instruments

Series 3650 Analyzer

The 3650 Micro O₂ Logger is a robust, waterproof, portable oxygen analyzer. It can identify and store up to 240 oxygen and temperature measurements for statistical control or a printout.

Many of the features are similar to the Series 3600 analyzer, such as:

- Possibility to configure the instrument for dissolved or gaseous oxygen.
- Automatic range selection.
- Choice of membranes to optimize system performance.
- Automatic calibration in air using built-in temperature and barometric pressure sensors.

The Micro Logger does not use potentiometers; all settings are entirely digitally controlled. System configuration, such as membrane selection, options and data retrieval are handled with Microsoft® Windows™ through the full duplex RS 232 digital serial link.

The Micro Logger will run for 40 hours on two dry cells or on rechargeable batteries. They can be replaced at any time without loss of settings or measuring data.

The waterproof battery compartment prevents possible leakage of electrolyte into the instrument.

Instrument versions

The series 3650 instrument is available in three versions (depending on measurement units required), each having similar performance features:

- Model 3650/111
- Model 3650/112
- Model 3650/113



Analyzers and Indicating Instruments

Series 3610 and Series 3620/21 Analyzers

The Series **3610** and Series **3620/21** Analyzers are virtually identical, and differ only in the number of sensor inputs.

The series **3610** Analyzer receives one TC sensor for hydrogen, carbon dioxide or nitrogen. The Series **3620** Analyzer receives two TC sensors and the Series **3621** a combination of one TC sensor and one EC oxygen sensor.

The basic elements of the system are the Microprocessor-controlled Analyzer, the Thermal Conductivity Sensor(s) and a purge gas supply with regulator. If one of these elements does not function properly, the whole system is affected.

The Analyzer measures the thermal conductivity signal and converts it into a digital signal for processing. The analyzer also controls the purging and measuring mode of the sensor and supplies analog or digital outputs for process control or data processing.

Instrument versions

The microprocessor controlled single or dual channel instrument is available in seven basic versions:

- Model **3610/4xx** instrument measuring CO₂.
- Model **3610/5xx** instrument measuring N₂.
- Model **3620/44xx** instrument measuring 2 x CO₂.
- Model **3620/54xx** instrument measuring N₂ and CO₂.
- Model **3620/55xx** instrument measuring 2 x N₂.
- Model **3621/41xx** instrument measuring CO₂ and O₂.
- Model **3621/51xx** instrument measuring N₂ and O₂.

Both the **3610** and **3620/21** instruments have a HOLD input. This freezes the current output signal when the filler stops, to avoid over carbonization caused by no flow.



Analyzers and Indicating Instruments

3624 ProBrix Plus Analyzer

This instrument is ideal for use in soft drink manufacturing plants.

It makes in-line measurements just before the filler, ensuring ultimate product quality. It measures actual carbon dioxide levels, and dissolved oxygen levels in the sample and in addition, provides accurate brix levels.

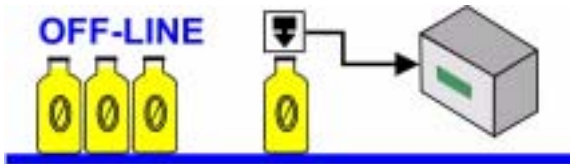
Sophisticated software is provided to give constant and easy to read measurement displays, as well as a complete statistical analysis of all measurements taken.



Sampling Methods

In general, there are three sampling methods used to make measurements.

The OFF-LINE method, used mainly by *Quality Assurance Departments* to determine whether the final product meets various specifications.



A disadvantage of this method is, that by the time the measurement is made in the laboratory, a multitude of bottles or cans could be out of specification, resulting in expensive recycling.



For the same reason, in *Production*, off-line sampling should be made next to the filling machine (*Quality Control Just In Time*). The measuring equipment, however, must be much more robust than that used in the laboratory.

The IN-LINE method offers many advantages such as an alarm to the control room, which is actuated seconds after a problem occurs.



In-line measurements can also show up a trend, such as pump seal wear, seal leaks due to vibration, and filter leaks. In-line measurements can, in fact, help improve plant efficiency.

The ON-LINE method is mainly used if there are no robust sensors that can be directly installed in the production line.



For on-line measurements, the sample is taken from the production line and fed through a flow chamber with a sensor installed and then disposed of.

Disadvantages of this method are a considerable waste of product and the risk of sample contamination.

Accessories

Off-line and On-line Accessories

- **Flow Chamber** model **32005**, with needle valve flow control for carbonated liquids.
- **Flow Chamber** model **29507** for liquids with suspended particles, such as wort or fruit juice.



- **Model 32550 External Temperature Sensor** (Off-line) for use with TC sensors.
When measurements are made in bottles or cans with the Beverage Package Sampler, the temperature of the liquid increases fairly fast, because the complete sampling system is generally at room temperature and the sample is around 1° to 2°C.
The error caused by this temperature difference can be compensated for by putting the External Temperature Sensor as close to the measuring sensor as possible.
A Junction Box is connected between the sensor and the instrument; no other modifications are required.

- **Beverage Package Sampler** model **29971** for sampling bottled wine, without removing the cork.
- **Beverage Package Sampler** model **29972** for cans and crown-corked bottles.



Accessories

In-line accessories

- Model **32003 Insertion And Retraction Valve** for Varivent housing. This valve permits insertion or removal of the sensor at any time without interrupting the process.



- Model **32551 External Temperature Sensor** (In-line) for use with TC sensors. When making in-line measurements a temperature error can occur as a result of the thermal mass of the sensor. This is because only a small portion of the sensor touches the sample while a large portion is in contact with the air. The External Temperature Sensor has a very small mass and can be mounted directly into the model 29501 sensor socket. The temperature sensor is connected to a junction box located between the sensor and the instrument; no other modifications are required.

- Model **29501 Sensor Socket** for welding to stainless steel pipes. This socket permits removal of the sensor before a CIP or during an interruption of the process.
- Model **32605 Purge Backup Unit** for Thermal Conductivity Sensors.

If the power is switched off in a factory during the weekend, the purge gas for the TC sensor is automatically switched off (the solenoid valve closes when there is no power). This could cause an accumulation of humidity in the sensor and it would take about two hours before it would work properly again.

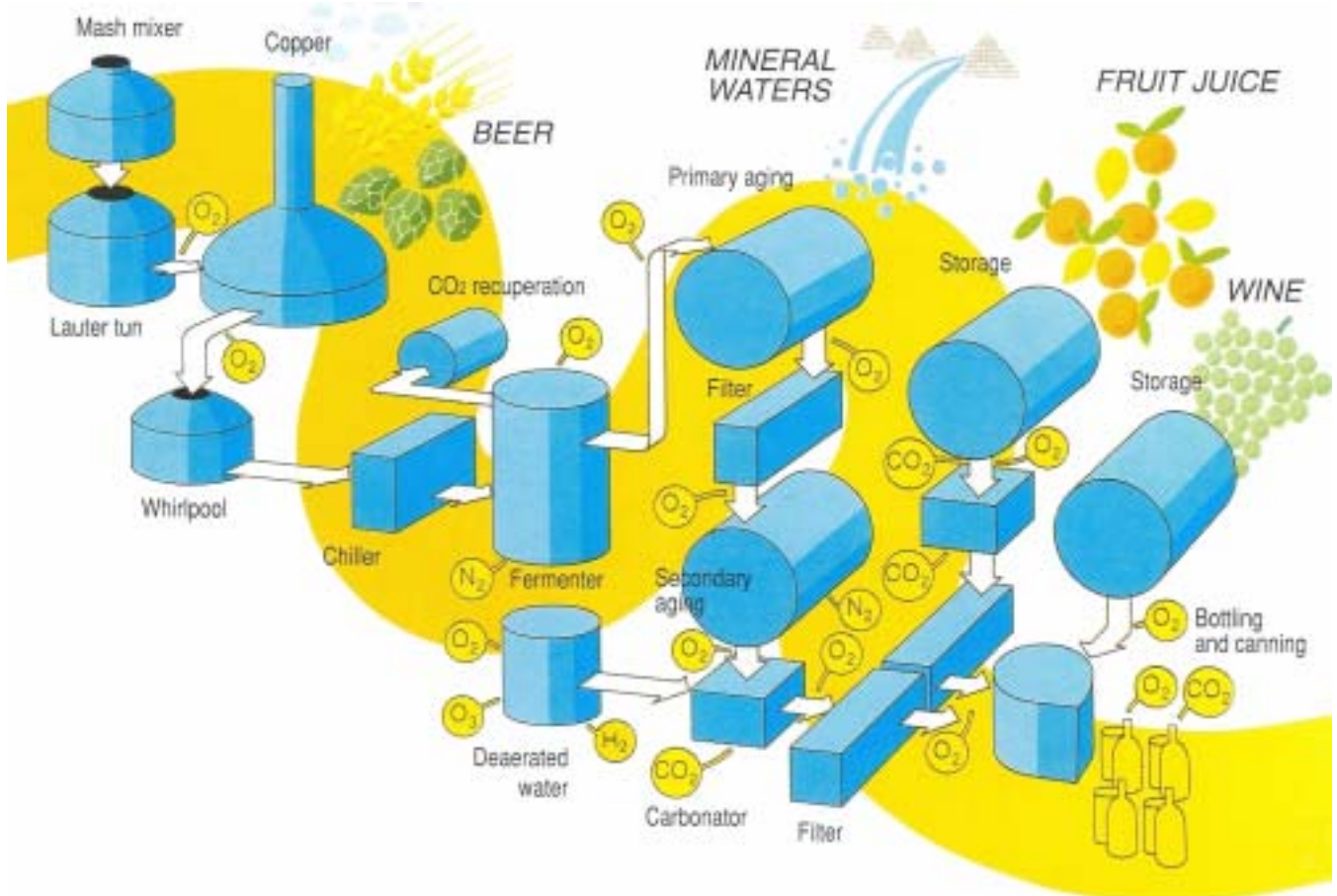


The purge backup unit is battery powered and operates the purge gas for four days. It can be connected between the sensor and the instrument without modifications. When the power is again turned on, the batteries automatically recharge.

Applications

There are at least as many sampling, or measuring points, as there are production steps in the brewing of beer or in the processing of soft drinks and other beverages.

In the following section, you will see how **Orbisphere** instruments can be employed to monitor and control complex processes precisely, helping to improve both plant efficiency and product quality.



Applications

Mashing and Lautering

At this early stage, oxygen uptake has a direct influence on the turbidity, color and quality of bitterness.

Unless precautions are taken, oxygen values as high as 100 ppm will occur.

Normally, measurements are taken by a sensor which is mounted in the wall of the lauter tun, or by suspending the sensor.

For this application, membrane model **2952A** is recommended.

Copper

The wort is boiled in the wort copper with vigorous agitation for about 90 minutes.

Since oxygen has a direct influence on the haziness of beer, the copper needs to be flushed with oxygen-free vapors to prevent air pick-up.

The positioning of the sensor will depend on the boiling process, but it can often be installed at the bottom of the wort copper, just before the valve to avoid large temperature variations.

Values of 0.5 ppm are possible. Membrane model **2995A** is recommended.

Fermentation

In brewing beer, oxygen is essential to the fermentation. An excess or deficiency of oxygen is detrimental to the gravity, clarity, color and taste of the final product.

The effects of oxygen are partly biological, because of its role in yeast metabolism and partly chemical, because it reacts with the many sensitive organic substances that make up the composition of beer.

An excellent closed loop system for automatic wort aeration can be composed of the **Series 410/510 Analyzer**, the sensor installed in-line and the 4-20mA isolated current output connected to a self tuning controller.

To avoid micro bubbles, oxygen or air should be distributed in the wort in counterflow through a "frit" or a candle.

Gravity profiles (as a function of the degree of fermentation) can also be determined by measuring CO₂ instead of gravity, since there is a direct relationship between the two parameters.



Applications

Carbon dioxide recovery

The oxygen concentration in plant CO₂ can significantly affect the dissolved oxygen level in the final product.

For this reason, measurement and control of oxygen are required to maintain a quality product without wasting large amounts of CO₂.

Filtration

During the filtration process, yeast, solids and bacteria are retained while the beer passes through the filter sheets.

New techniques, based on measurement and control of oxygen levels, permit filtration without pre- or post-runs and with insignificant oxygen uptake. Membrane model **2952A** is recommended.

Water deaeration

Deaerated water is used throughout the beverage industry to reduce oxygen levels in filters, tanks and lines.

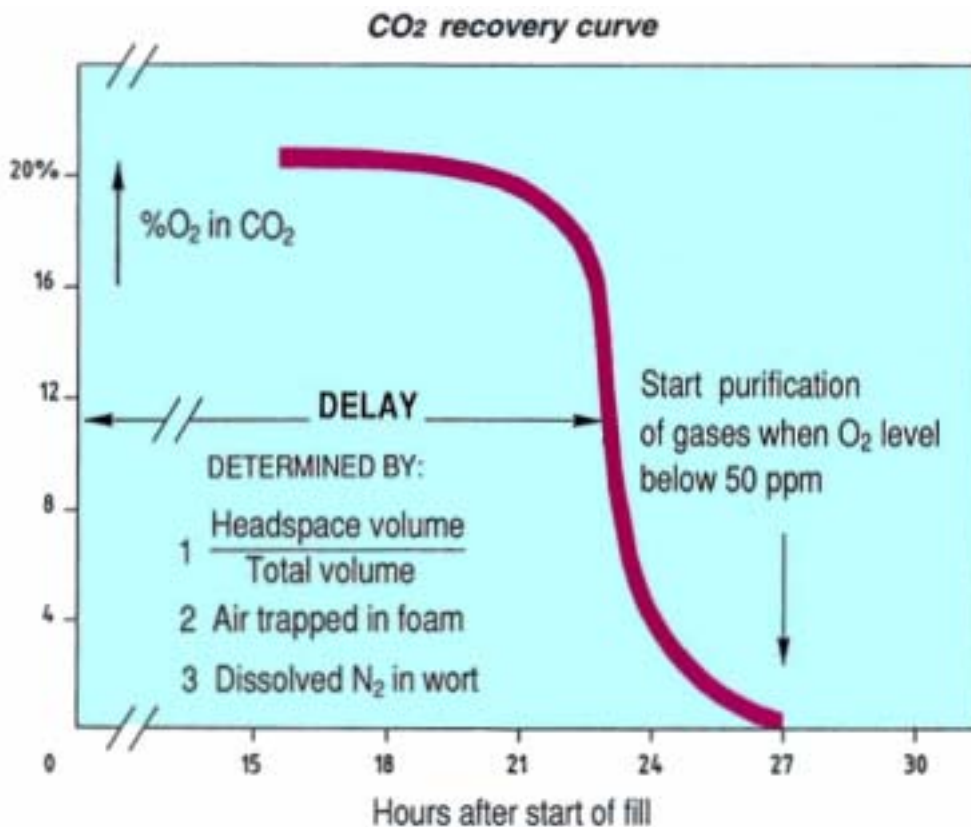
In high-gravity brewing, deaerated water requires close monitoring as small amounts of dissolved oxygen will substantially increase the oxygen level in the final product.

The sensor can be installed directly in the deaerator cascade system. Oxygen values of 10 ppb are not uncommon.

Also, since ozone is used more and more for sterilization or to remove metals from deaerated water, it should be monitored. For both oxygen and ozone measurements, membrane model **2956A** is recommended.

Note :

New catalytic oxygen removal systems use hydrogen injection to bind the oxygen and hydrogen molecules to form deaerated water.



Applications

Carbonation

During secondary aging the beer matures and develops its full flavor. At the end of the storage period, the beer contains between 0.35% and 0.45% CO₂. Since the finished product should contain 0.5% CO₂, the additional amount is added in the filter room.

Carbonation is usually done automatically in a closed loop. A high quality injector and static mixer are essential to ensure that the CO₂ dissolves correctly, to avoid over-carbonation and reduce loss of CO₂ during filling.

In some countries, nitrogen is injected in a similar way to give beer a more stable foam - often referred to as a "head" - when it is poured into a glass.

An excess of nitrogen in cans of beer could cause them to explode during pasteurization. Also, for lightly or non-carbonated soft drinks, nitrogen is injected to ensure that the can remains rigid. Due to its relatively low solubility, the nitrogen remains in the headspace.

Bottling and canning

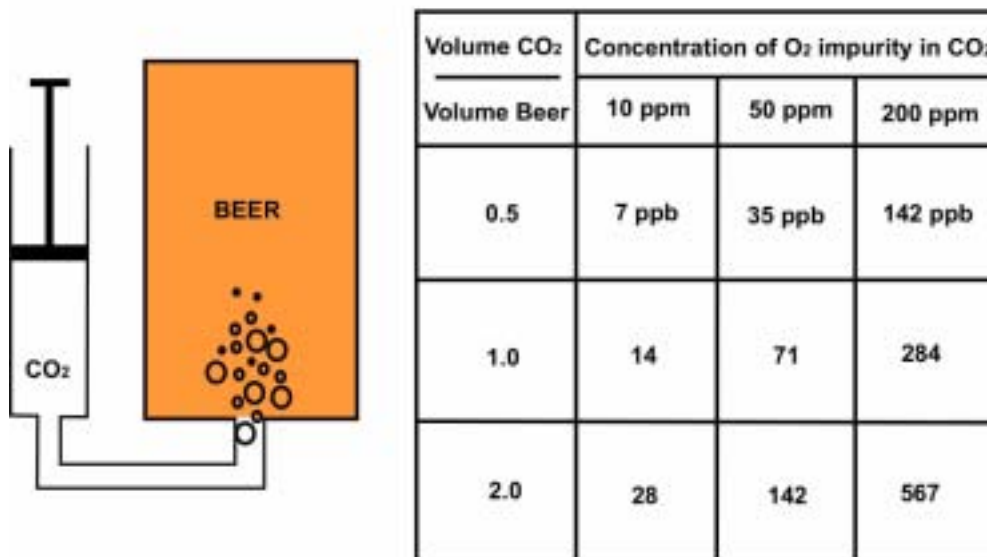
Measurements of dissolved or gaseous oxygen in bottles and cans should be made directly after filling and before pasteurization. This is because a high migration of oxygen from the liquid to the gas phase takes place within an hour after filling. Measurements made in pasteurized bottles have little value, because about 30% of the oxygen content disappears through heat-catalyzed oxidation.

Model **2740** Headspace Analyzer can be used for both headspace and liquid measurements in bottles and cans. The system measures oxygen, temperature and pressure; it also calculates the headspace volume and the CO₂ content.

The most important parameters in the final quality control are O₂, CO₂ and headspace volume.

Because of its speed of response, the system is also ideal for measurements next to the filling machine. This monitoring helps reduce bottle or can rejects in the event of technical problems ("*Quality control just in time*"). In canned soft drinks with high oxygen levels, corrosion of the can could cause hydrogen evolution, which could eventually cause the can to explode.

Method of dissolving minimum quantity of CO₂ at elevated pressure



Applications

High-gravity brewing

High-gravity brewing is becoming more common today because of its important economic and technical advantages. These include:

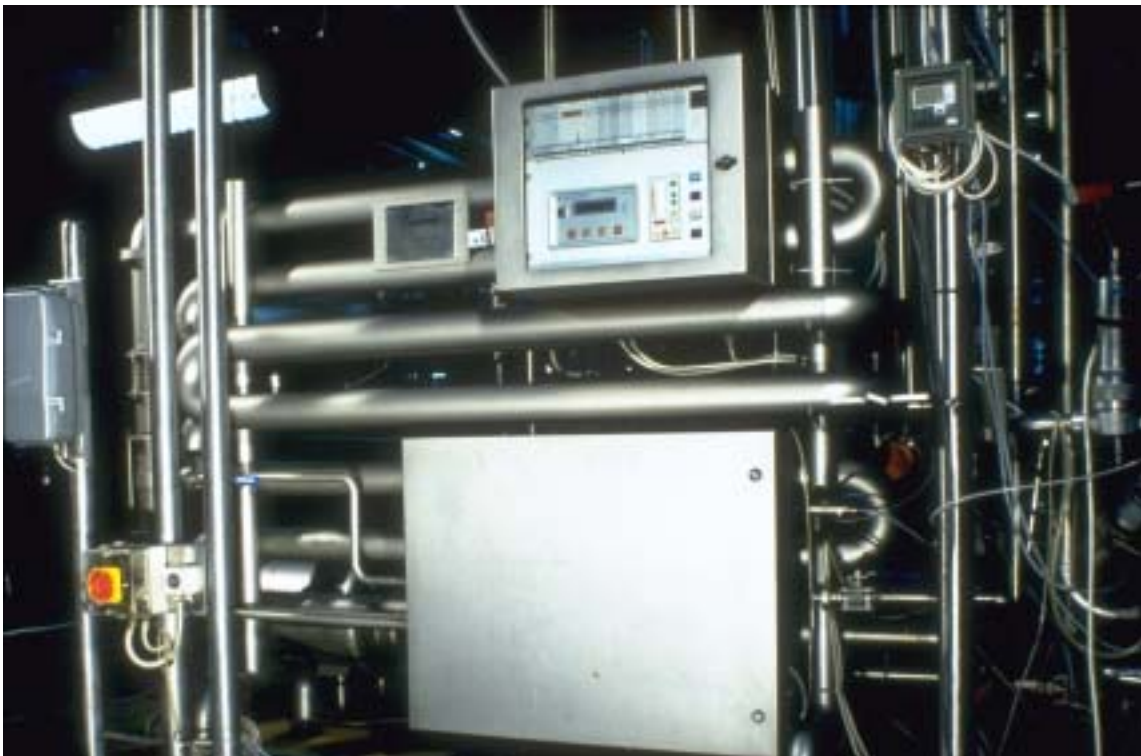
- Increased capacity of about 30% without major investment.
- Possibility to produce various blends from one original type of beer.
- Beer is more stable and has a more uniform taste.
- The original extract or alcohol level is controlled at the time of blending.

High-gravity beer is usually brewed as normal premium beer and subsequently adjusted to the desired degree of original extract with the addition of sugar or corn syrup to the brew kettle.

The upper limits of high-gravity worts are as high as 18% Brix.

In many breweries, blending of high-gravity beer with deaerated dilution water is now routinely controlled by accurately maintaining the ethanol concentration within $\pm 0.02\%$ alcohol. Such control is particularly important when excise duties are collected on the beer's alcohol content.

Illustrated below is a high-gravity measuring loop with CO₂, density and alcohol sensors.



Applications

Blending of soft drinks

The classic blending of soft drinks is often based on the three-vessel-principle. Deaeration, carbonation and blending are carried out separately for optimum results in each step of the process (the overlapping of individual effects is eliminated).

Illustrated below is a three-vessel-type blender with an **Orbisphere** 3610 analyzer installed.

For **deaeration** of the beverage water, a maintenance-free liquid ring vacuum pump is often used to generate a vacuum in the first vessel. At the same time, a maximum water surface is created through atomization via a special nozzle assembly. The combination of these two procedures ensures that the dissolved gases are almost completely driven out of the beverage water. Removal of oxygen, in particular, ensures constant beverage quality.

Since oxidation losses are reduced to a minimum, the machine provides beverages with controlled taste and odor; there is also an economical use of raw materials.

Carbonization is done with specially designed high-pressure injectors. Precisely computed cross-sections, flow ratios and pressure ratios in the nozzle chamber ensure optimum solution of the CO₂ gas in the water; the gas is finely dispersed as minute bubbles; hence it dissolves efficiently. The carbonized water is stored in a CO₂ saturation container. This process is necessary to create an equilibrium in the newly created solution.

Blending of the carbonized water with the ingredients (for example, ready-made syrup) to create the desired beverage is carried out with a piston dosing pump.

The influence of changes in pressure, temperature or viscosity of the individual beverage ingredients are somewhat compensated for by the dual dosing pump. The final blended beverage is then collected in another vessel under slight overpressure. Here it stabilizes until it reaches the point where it can be gently conveyed to the filling machine.



Glossary of terms

Alcohol:

Primarily ethyl alcohol (ethanol) but other volatile alcohol compounds are included in the reference method.

Can rigidification:

Addition of nitrogen to the beverage to compensate for the thin walls of the cans.

CO₂ recovery:

Time when CO₂ collection starts, this operation is time dependent due to wort temperature or pitching rate of the yeast.

Conversion factors for CO₂:

10 g/kg = 5 v/v = 1%

Deaeration:

Mechanical or chemical way to remove gas from water.

Diluent:

Deaerated water used for high gravity brewing or blending of soft drinks.

Foam stability:

Addition of nitrogen to beer to obtain a nicer and more stable "head".

Frit:

Finely perforated ceramic or metal disk used to bring air or CO₂ into solution.

Gravity:

Measurement of gravity profile:

During fermentation, an alternative solution is the measurement of CO₂.

"Just in time":

Quality control of the most important parameters immediately after filling.

Liquor:

Water used in the brewery.

Mashing:

Operation to convert malt into an infusion; oxygen uptake can be important during raking and sparging.

Pitching:

Addition of yeast during fermentation.

Racking:

Filling casks, kegs or storage tanks with beer.

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