A Novel Method for Measuring Oxygen in Processing Applications
ICBC September 15, 2011

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Beverage Sales Manager
Haffmans NA

Pentair Haffmans
Agenda

• Pentair and Pentair-Haffmans background

• Optical oxygen technology

• Why and where to measure oxygen

• What is TPO and new differentiated technology

• Optical oxygen management Tools Overview

• Conclusion
Pentair welcomes Clean Process Technologies!

As of May 12, the companies under Clean Process Technologies (CPT) – Filtrix, Haffmans, Nijhuis, Pentair Components & Services, Pentair Process Technology, Südmo and X-Flow – became part of Pentair’s Filtration Solutions global business unit.

Pentair is a global diversified industrial company headquartered in Minneapolis. With revenues of about $3 billion, Pentair employs approximately 14,500 people worldwide.
<table>
<thead>
<tr>
<th><strong>Pentair Südmo</strong></th>
<th><strong>Pentair Haffmans</strong></th>
<th><strong>Pentair X-Flow</strong></th>
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</thead>
<tbody>
<tr>
<td>Pentair Südmo offers an extensive range of sanitary and aseptic valves and fittings, complete manifolds, design review and superior customer service for the food, dairy, beverage, pharmaceutical and consumer products industries.</td>
<td>Pentair Haffmans develops and supplies quality control equipment and total CO2 and O2 management systems for the brewing and beverage industries.</td>
<td>Pentair X-Flow develops, manufactures and supplies membranes for municipal and industrial applications, including potable water, process water, wastewater treatment, water for re-use and desalination.</td>
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<td>Pentair Filtrix develops and manufactures innovative point-of-use and point-of-entry water purification products based on membrane and activated carbon technologies.</td>
<td>Pentair Nijhuis develops, manufactures and supplies centrifugal high performance pumps, and pumping systems for the water, wastewater, fire fighting, steel, paper, chemical, marine, and dredging industries.</td>
<td>Pentair Process Technology engineers and supplies Beer Membrane Filtration technology and state-of-the-art breweries.</td>
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</table>
Pentair Haffmans has 60 years of experience in providing CO₂ and O₂ management, quality control equipment and green CO₂ recovery systems.

**Headquarters** - Venlo, The Netherlands

**Major Industries Served**
- Brewing
- Beverage
- Wineries & Distilleries

Did you know that …

… Pentair Haffmans can recover CO₂ in breweries and beverage plants, distilleries, wastewater treatment plants, and in biogas plants … and that the recovered green CO₂ is food-grade and suitable for use.
Pentair Haffmans technologies are applied in more and more markets!

- Breweries
- Soft drink
- Wine & Cider

Mineral water
Desalination
Bio-ethanol / Distilleries
To determine the O₂ content, an O₂ sensor (sensor spot) is put in contact with the medium to be measured. For a short time the sensor spot is intensely illuminated by a light source. Depending on the O₂ content in the medium the sensor spot will give a light signal.

A photo detector measures this light signal and from the signal the O₂ content is calculated. The sensor spot experiences wear with use and will need to be replaced. The frequency depends on the number of times that the O₂ content is measured by illuminating the sensor spot.
**Optical O₂ Measurement Principle**

- Optical O₂ sensor
- Based on the quenching of luminescence caused by collision between molecular oxygen and luminescent dye molecules in exited state
- The measurement is temperature compensated
Optical $O_2$ response time

Response time

- Haffmans
- Traditional $O_2$ measurement

$O_2$ value (ppm)

$T_0$, $T_{90}$, $T_{99}$

time (s)
O₂ Measurement – Why?

• Maintain quality during storage
• Shelf Life assured
• Guarantee content of nutritional components
• Prevent corrosion inside cans
• Enrich with O₂

Improved Sensory and Functional properties

Savings on flavorings and ingredients
O₂ Measurement – Why?

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Improved Sensory and Functional properties

Savings on flavorings and ingredients
O₂ Measurement – Where?

• Deaeration
• Storage
• Filtration
• Filling
• Finished product
• Wastewater treatment

Laboratory & Analysis
In Process -> Improve efficiency
What is TPO?

TPO = Total Package Oxygen

A measurement of all $O_2$ within a packaged container, including:

- $O_2$ in the headspace (HS) – HSO and
- Dissolved Oxygen (DO)
Traditional method for measuring TPO

Preparations

• Acclimatize the sample to 20 °C (68 °F)
• Shake for 5 minutes to equilibrium of all gasses
• 3-5 minutes pause time

DO measurement

• Beverage sample is forwarded to DO Meter

TPO calculation

• DO x HS x Temperature factor (Z-factor method)
Traditional method for measuring TPO

- Transport
- Acclimatization
- Shake
- Pause
- DO
- HS Volume

Beverage sample to O₂ meter
Traditional method for measuring TPO

- Time: Sample preparation takes more than 10-15 minutes
- Sampling: Risk of O$_2$ contamination
- Origin of O$_2$: Not possible to discriminate the origin of O$_2$
  - HS or
  - DO
- Indirect method
Differentiated measurement

HS

HSO

DO

Liquid

Oxidation
Novel method for measuring TPO

- No sample preparation required
- Sample remains in the package
  - less chance of $O_2$ contamination
  - able to measure beverages with pulp or fibers
- Origin of $O_2$: Differentiated measurement of
  - $O_2$ in HS and
  - DO
- Direct method
Novel method for measuring TPO

Product remains in the package
Novel method for measuring Total Package Oxygen.
Comparing traditional & novel methods

Comparison TPO measurement
(novel method versus traditional method)

TPO [ppb]

samples

TPO measurements executed with Inpack TPO/CO$_2$ meter
Inpack TPO/CO₂ Meter, type c-TPO

- Differentiated measurement
  - DO
  - HSO
- Fully automated
- Operator independent
- No sample preparation required
- Beverage remains in package

- Optical O₂ Measurement
  - Reduced maintenance
  - Long stability
  - Quick response
  - No O₂ consumption
Portable O$_2$ MEASUREMENT
Portable $O_2$ Measurement

$O_2$ Gehaltmeter, o-DGM

Type o-DGM
Portable $O_2$ Measurement

$O_2$ GEHALTEMETER, RANGE OF USE

$O_2$ content of carbonated beverages
- in tanks
- in pipelines
- in kegs (pre-mix)
- on dispensing systems
- in bottle and cans (in combination with ISD)
Portable $O_2$ Measurement

$O_2$, TECHNICAL DATA $O_2$-MEASUREMENT

$O_2$ MEASUREMENT

- Measuring Range: 0.0-2,000 ppb
- Accuracy: 1 ppb +/- 2% meas. value
- Detect. limit: 1 ppb
- Response time (T99.9): < 1 minute
- Temperature range: -2 to 40 °C
Portable O₂ Measurement

O₂, USP O₂-MEASUREMENT

• Approved new optical O₂ meas. technology
• Excellent long term stability (no calibration required)
• High accuracy
• Quick response
• No electrolyte that needs to be replaced
• Small sensor size
• No O₂ consumption
In-line O$_2$ Measurement
In-line $\text{O}_2$ Measurement

IN-LINE $\text{O}_2$ GEHALTEMETER

Sensor

Transmitter

TYPE OGM
**OGM, TECHNICAL DATA**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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<tbody>
<tr>
<td>O₂ Range</td>
<td>0 – 2,000 ppb</td>
</tr>
<tr>
<td>Accuracy O₂ Measurement</td>
<td>1 ppb (+2% of measured value)</td>
</tr>
<tr>
<td>Measuring frequency</td>
<td>10 s (adjustable from 2-999 s)</td>
</tr>
<tr>
<td>Process connection</td>
<td>Varivent</td>
</tr>
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Optical $O_2$ Management Tools

- Sensor
- Transmitter
- Portable $O_2/CO_2$
- Inpack & Laboratory

Optical technology
## Optical O₂ Management Tools

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<tr>
<th></th>
<th>Lab / package</th>
<th>At-line</th>
<th>In-line</th>
</tr>
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<tbody>
<tr>
<td>O₂</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
<tr>
<td>Combined O₂/CO₂</td>
<td><img src="image4.png" alt="Image" /></td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
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• Results of novel and traditional methods are in agreement with a comparable standard deviation
• Added value by differentiated $O_2$ measurement
• Easy to pinpoint source of $O_2$ in a package
• Added confidence with knowing sources of $O_2$
• Assurance of ensuring product quality/shelf life
Novel TPO Measurement

A sustainable solution keeps this party going!