MBAA – MEASURING DISSOLVED OXYGEN IN A BREWERY

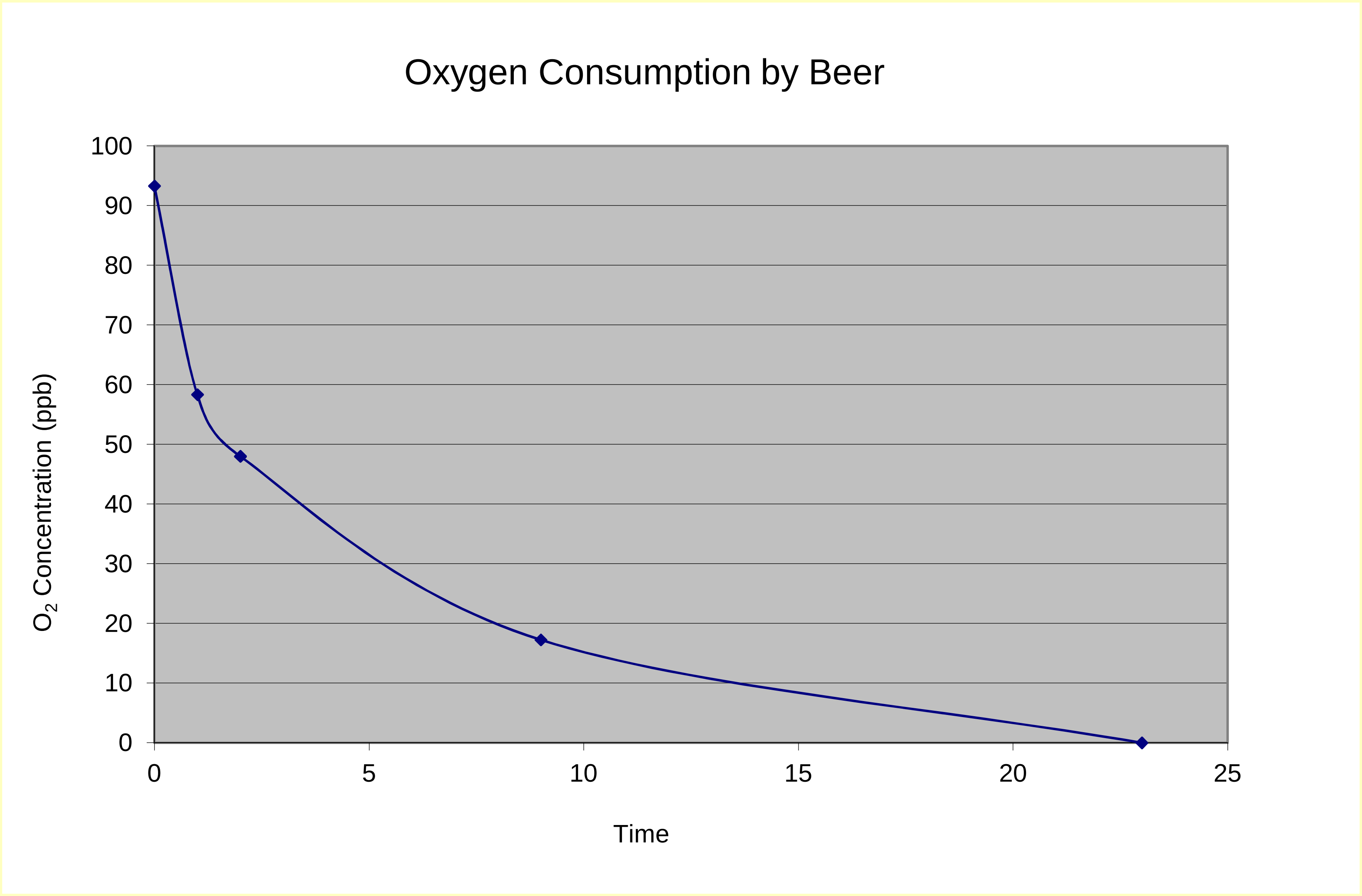
Northern California Section

February 2013

AGENDA

- Why measure O_2?
- Oxygen measurement technologies
- Wort O_2
- Process Beer O_2
- Package Air
- Package O_2

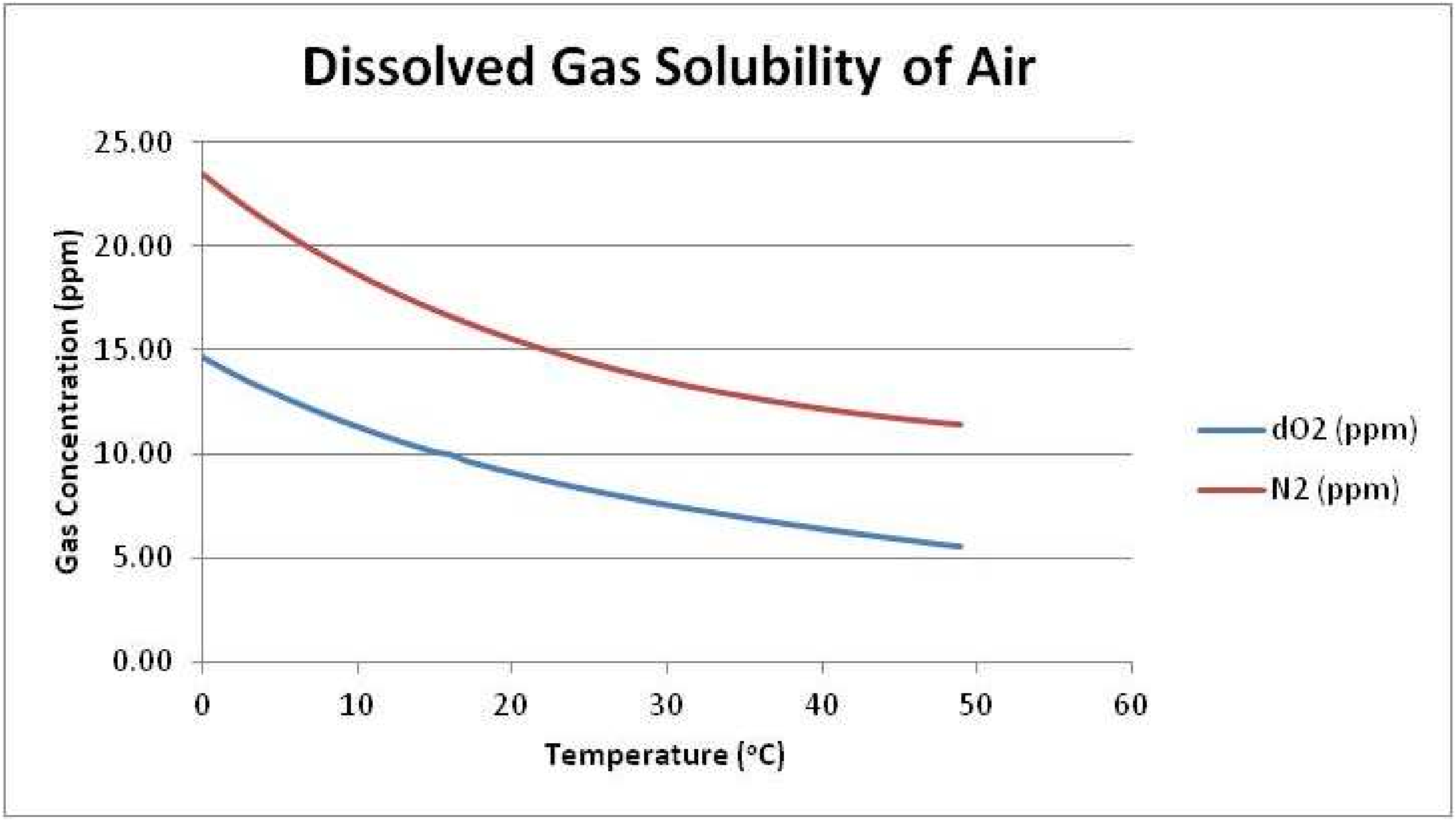
WHY MEASURE O_2?



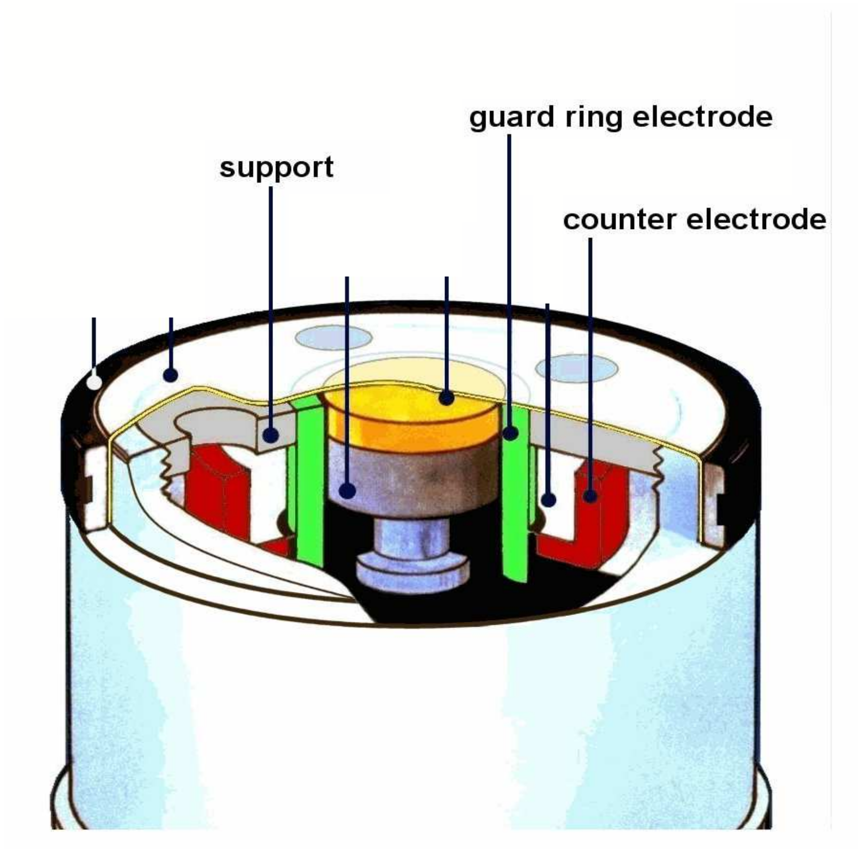
DISSOLVED O_2 THEORY

- O_2 sensors measure the partial pressure of O_2 gas
  - Partial pressure is proportional to the % dissolved O_2 concentration
- An O_2 solubility factor is applied
  - Henry's Law constant ($f_i = k_{dt}\, x_i$)
- Instrument displays a weight/volume unit
  - mg/L - ppm or µg/L - ppb

SOLUBILITY OF AIR DERIVED N_2 AND O_2

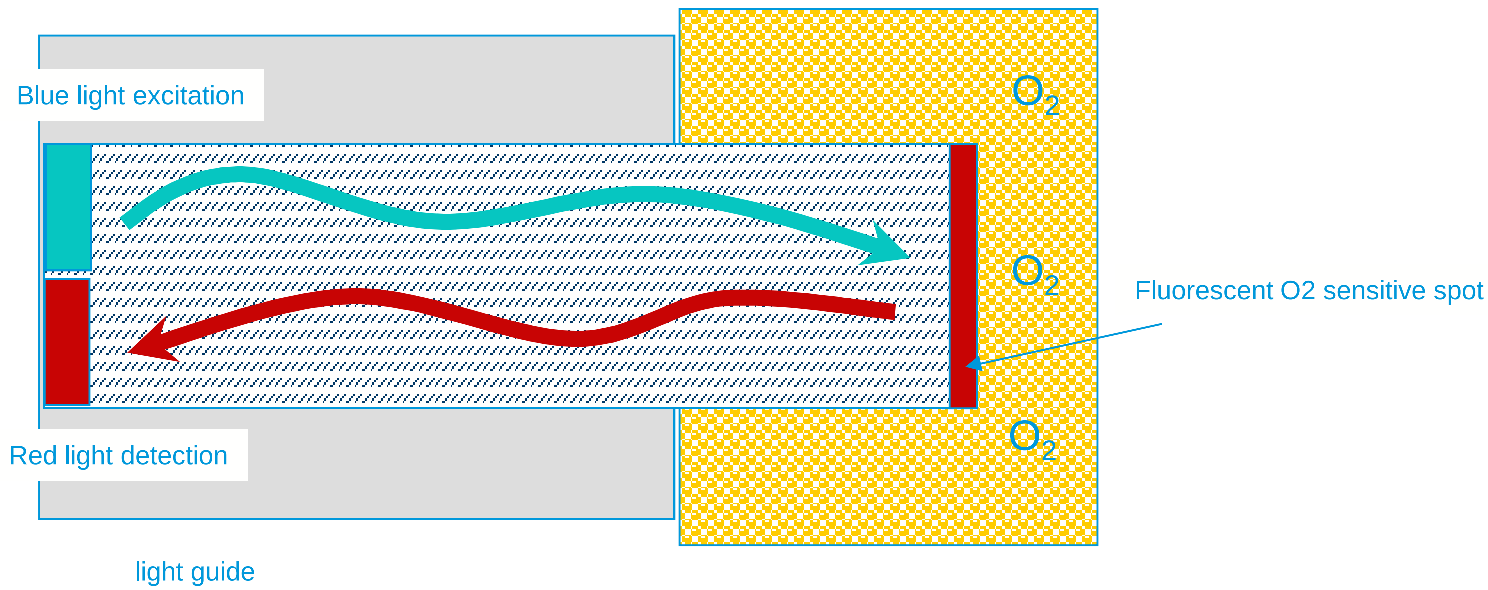


ELECTROCHEMICAL O_2



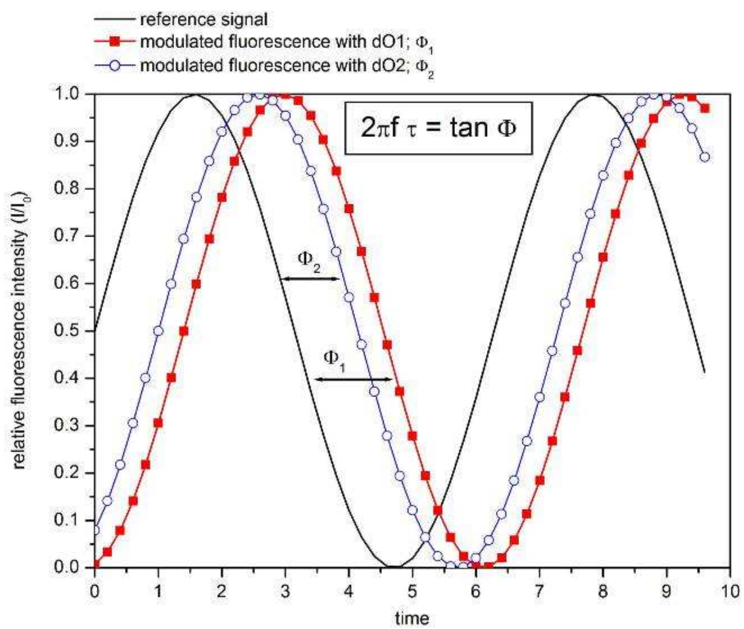
- Clark-type electrode
- Membrane covered
- Contains electrolyte
- Voltage is applied to the electrodes
- Oxygen migrates across a gas-permeable membrane
- Current measured is proportional to the O_2 content of the sample
- EC sensors convert O_2 to OH^-

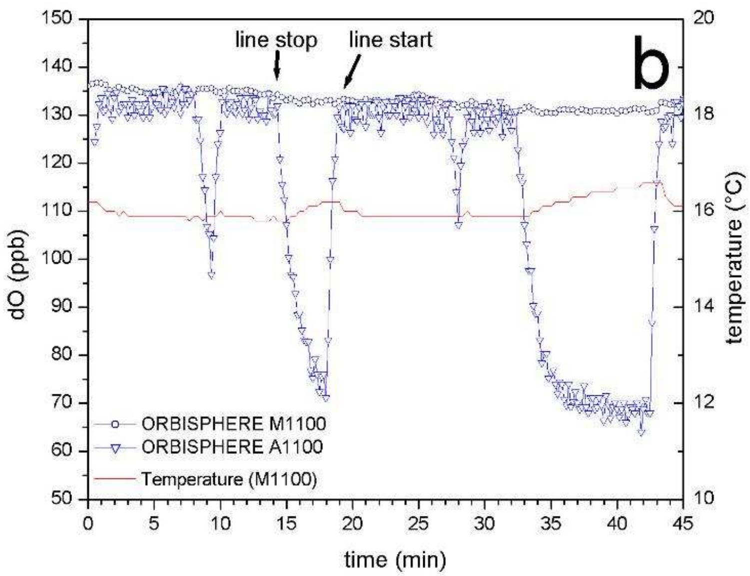
OPTICAL PRINCIPLE



- O_2 quenches the fluorescent activity
- O_2 is not consumed by the sensor

OPTICAL SIGNAL STABILITY





- Measuring signal phase shift results in low sensor drift
- Signal is unaffected by flow or pressure

EC SENSOR PROS & CONS

Pros

- High dynamic range
  - 0 to 200 ppm
- Can be used with wort and beer

Cons

- Sensor requires “warm-up”
- Downward drift over time
- Quarterly maintenance
- Complicated maintenance

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OPTICAL PROS & CONS

Pros

- Fast response time
- Low drift
- Minimal maintenance
- Less beer usage

Cons

- Beer dynamic range
  - 0.0008 to 2.00 ppm
- Wort dynamic range
  - 0.1 ppm to 30+ ppm
- Cold CIP interference
  - ClO_2, Cl_2, and Para-acetic acid

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WORT O_2

- Why measure wort dO_2?
  - O_2 affects yeast viability and vitality
  - Both too high and too low O_2 levels can lead to off flavors
- Where to measure?
  - As far as possible from an injection point
  - Inline or portable
  - Before yeast addition

AGING AND FILTRATION O_2

- Why measure process O_2?
  - Air leaks into the process via venturi effects
- Where to measure?
  - In process after
    - Pumps
    - Valves
    - Filters
    - Centrifigues
  - Fermentation vessel
  - BBT
  - Base of filler
  - Inline or portable

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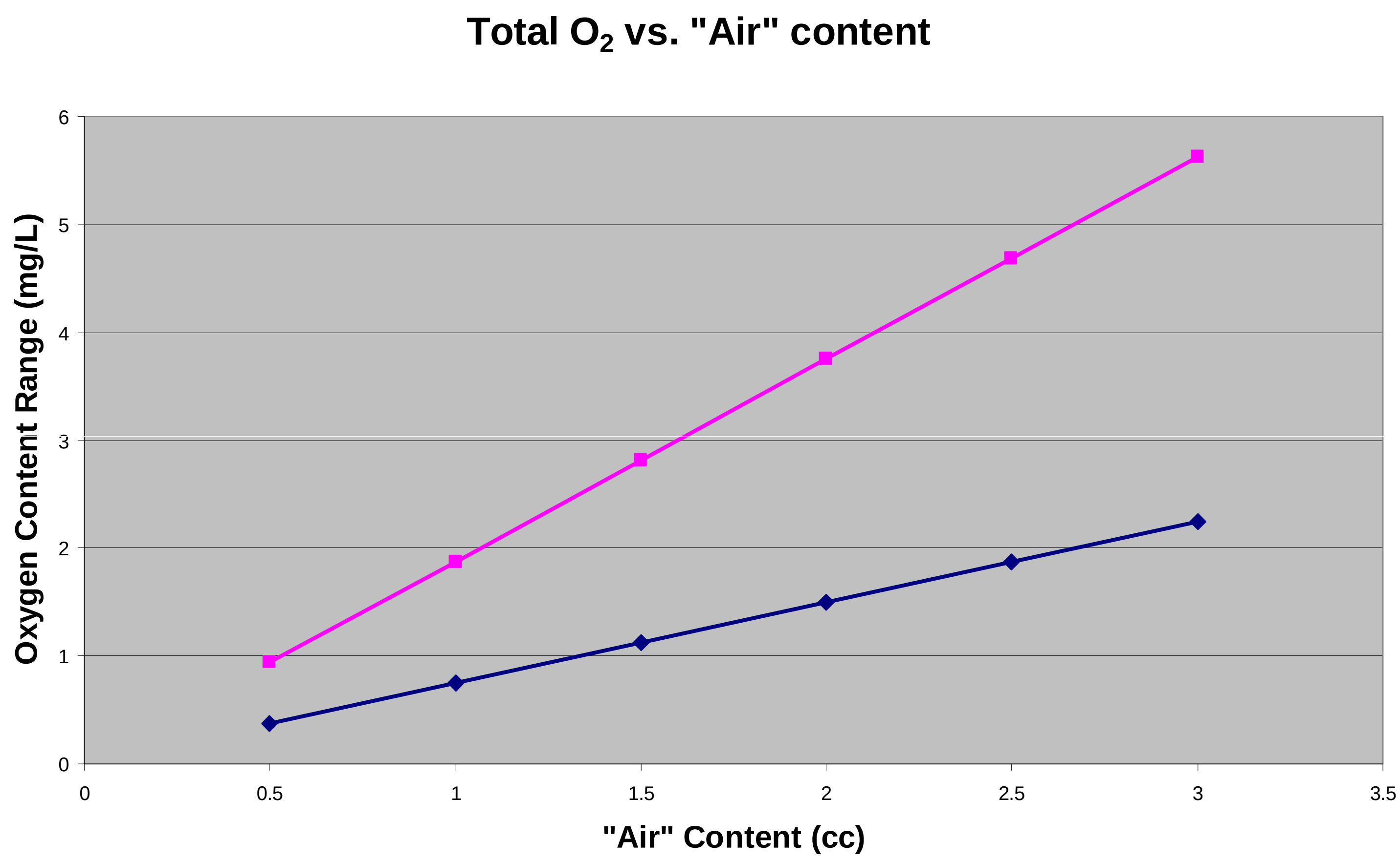
“AIR” MEASUREMENTS

- Caustic shake out method
  - Volume of unknown gas is called “air”
  - How much of the “air” is O_2 ?
- Headspace “Air” - Daltons Law
  - 80% N_2 & 20% O_2
- Liquid “Air” - Henry’s Law
  - 60% N_2 & 40% O_2

THEORETICAL LIMITS FOR AIR AS TOTAL PACKAGE O_2



PACKAGE O_2

- Why measure package O_2?
  - Fillers can be a huge source of O_2 contamination
  - Validate crown integrity
- Where to measure?
  - Shaken packages
  - Unshaken packages

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WHAT IS TOTAL PACKAGE OXYGEN (TPO)?

- Total Package Oxygen
- TPO = liquid O_2 + HS O_2
  - Liquid O_2 = dO_2
  - Headspace O_2 = pO_2
- TPO = dO_2 + pO_2

AIR VS TPO

Location	# of Samples	Total Package O_2	"Air" Content
Random	10	83 ± 32 ppb	0.25 cc ± 0.05 cc
Valve A	10	102 ± 106 ppb	0.25 cc ± 0.10 cc
Valve B	10	799 ± 205 ppb	0.35 cc ± 0.15 cc
Valve C	10	84 ± 26 ppb	0.25 cc ± 0.05 cc

TPO MEASUREMENTS

- Why Measure TPO
  - Normalized value
  - Accounts for variations in headspace volume
  - Can be used for statistical process control

- What affects TPO
  - dO_2 and or HSO_2
  - Headspace volume
  - Liquid volume
  - Temperature

FINAL THOUGHTS

- Inline measurements give continuous feedback
- Oxygen control is important for prolonging shelf stability
- Oxidative effect of oxygen pickup is cumulative
- TPO is the best method for quantifying package O_2 pickup

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- Follow my blog on dissolved gases and other brewing topics:
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