Gusmer Enterprises, Inc.®

Niche Applications for ORP Monitoring in the Brewing and Seltzer Market

Agenda

- Gusmer & Hamilton Overview
- Hamilton EasyFerm Plus ORP Arc sensor
- ArcAir Software and Connectivity
- What is ORP?
- Sampling points in the beverage space
- Applications and what can be gained
- Q & A – Type questions in the Q/A box

Service with Knowledge® since 1924

Founded in 1918

Management and Ownership currently in 3rd generation

FERMENTATION & FILTRATION PRODUCTS AND SERVICES for FOOD, BEVERAGE & BIOTECH/PHARMACEUTICAL APPLICATIONS

Manufactured and Resale Products

15 Direct Technical Sales Representatives

4 Product Managers &
3 Application Specialists

16 Research &
Development Scientists

Direct Sales Resources Spread Throughout the US.

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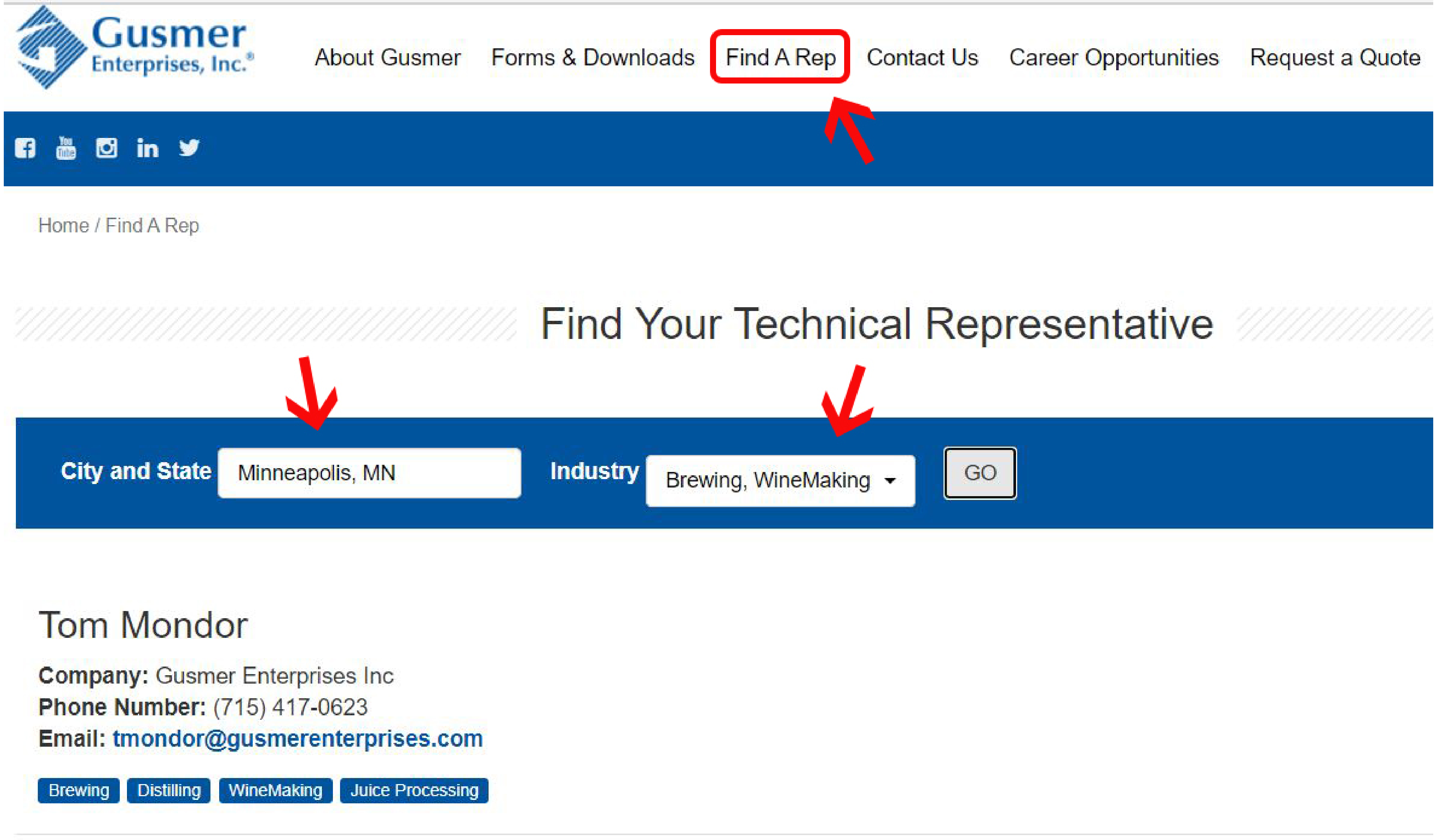

Hamilton Overview

- The Hamilton Company has been manufacturing precision measurement devices for over 60 years
- Partnership between Gusmer and Hamilton was established in 2014
- Gusmer is Hamilton’s sole distributor for the beverage industry

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Easyferm Plus ORP Arc

- Integrated Transmitter

- VP8 Connector for RS-485 (MODBUS) or 4-20 mA communication
  Bluetooth Adapter available
- Measurement Range: -1500 mV to +1500 mV
- Data logging over time using ArcAir PC software

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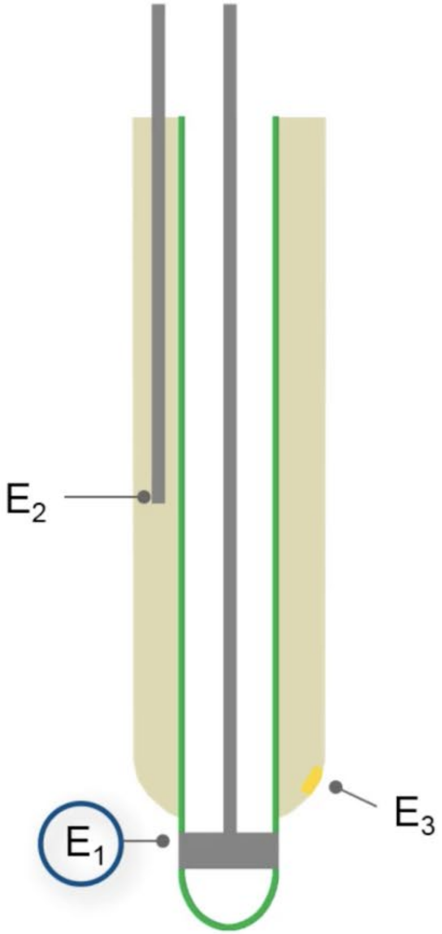
ORP Measurement

The sum of potentials



The ORP electrode potential is the sum of 3 potentials

E_1 = Platinum wire and process

E_2 = Reference electrode and electrolyte

E_3 = Junction between the electrolyte and the process

$$E_T = E_1 + E_2 + E_3$$

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Calibration

- +271 and +475 standards
- Accuracy of +/- 5 mV
- 2 year shelf life
- Unique bottle reservoir avoids cross contamination and dispenses only what is needed for calibration
- Quick and convenient calibration using ArcAir software

Sensor Housings

- Tri-clamp and Varivent fixed place housings
- Angled options available
    - ORP Sensors must be installed at a minimum angle of 15 degrees

ArcAir

Available on PC (Windows) and Mobile Devices (Apple/Android)

Monitor up to 30 sensors simultaneously

Communicate with sensors and record data over time to a PC

Convenient sensor calibration, configuration, and troubleshooting

GMP Compatible reporting, event tracking, and traceability

HAMILTON arc Air

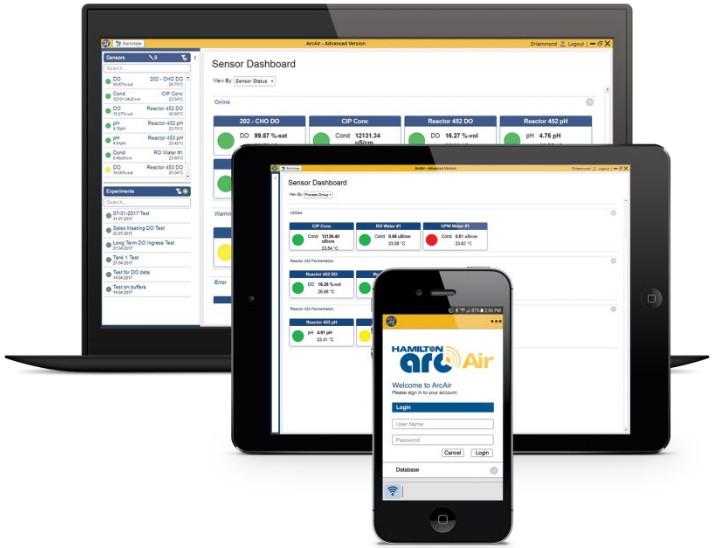
READY FOR COMPLIANCE Part 11

ArcAir

Quick status indicator

- Good
- Warnings
- Errors

Operating indicators



DO — Reactor 453 DO

9.91%-sat — 24.26°C

Warnings: 2 — Errors:

Sensor Health

Quality Indicator	30 %
Operating Hours	3210.43 h
Max. Measurement Temperature	110 °C
Operating Hours Above Max. Measurement Temperature	0 h
Max. Temperature	130 °C
Operating Hours Above Max. Temperature	0 h
Number of SIP Cycles	0
Number of CIP Cycles	0
Number of Autoclavings	0

Warnings and Errors

Calibration Warnings	DO: Calibration recommended, DO: Last calibration was not successful

81 – 100%	Excellent
61 – 80%	Good
46 – 60%	Acceptable
36 – 45%	Poor
< 35%	Replace

HAMILTON arc Air

Basic

- App and PC
- Lite functionality
- Sensor calibration and configuration
- Automatic documentation of each configuration and calibration

Warning text strings

DO: Calibration recommended,
DO: Last calibration was not successful

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ORP: Not a New Concept

- Water Quality
- Waste Water
- Bioprocessing
- Wineries

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ORP: What is it?

Oxidation/Reduction (Redox) Reactions

- Oxidation Reduction reactions occur in and around us continually
- The energetics that drive life and processes around us

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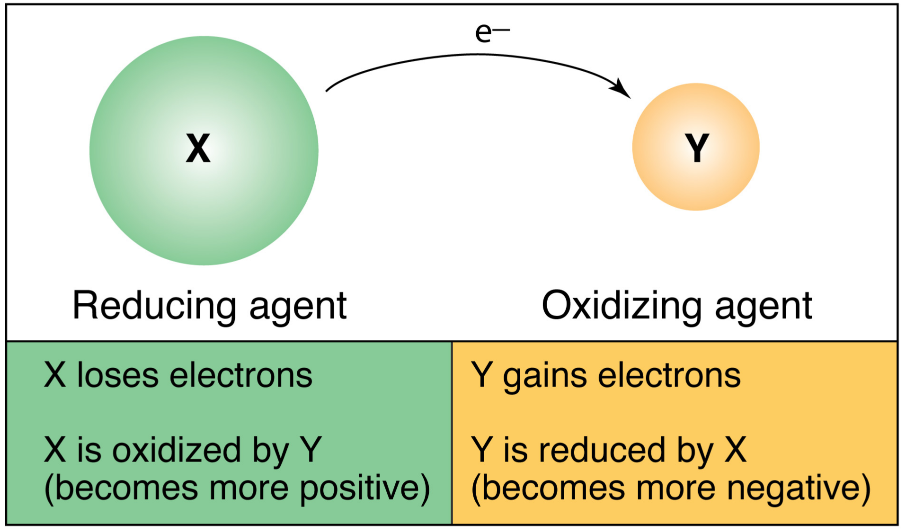
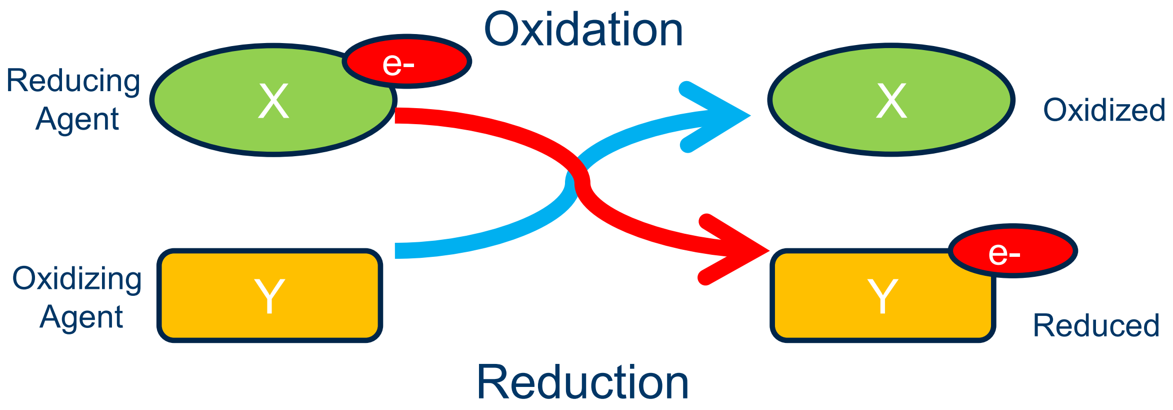
ORP: What is it?

- Measure of the tendency of a substance to Oxidize or Reduce another Substance.



http://www.kgs.ku.edu/Hydro/GWtutor/Plume_Busters/remediate_refs/redox_chemistry.htm



OIL RIG
Oxidation Is Losing electrons
Reduction is Gaining electrons

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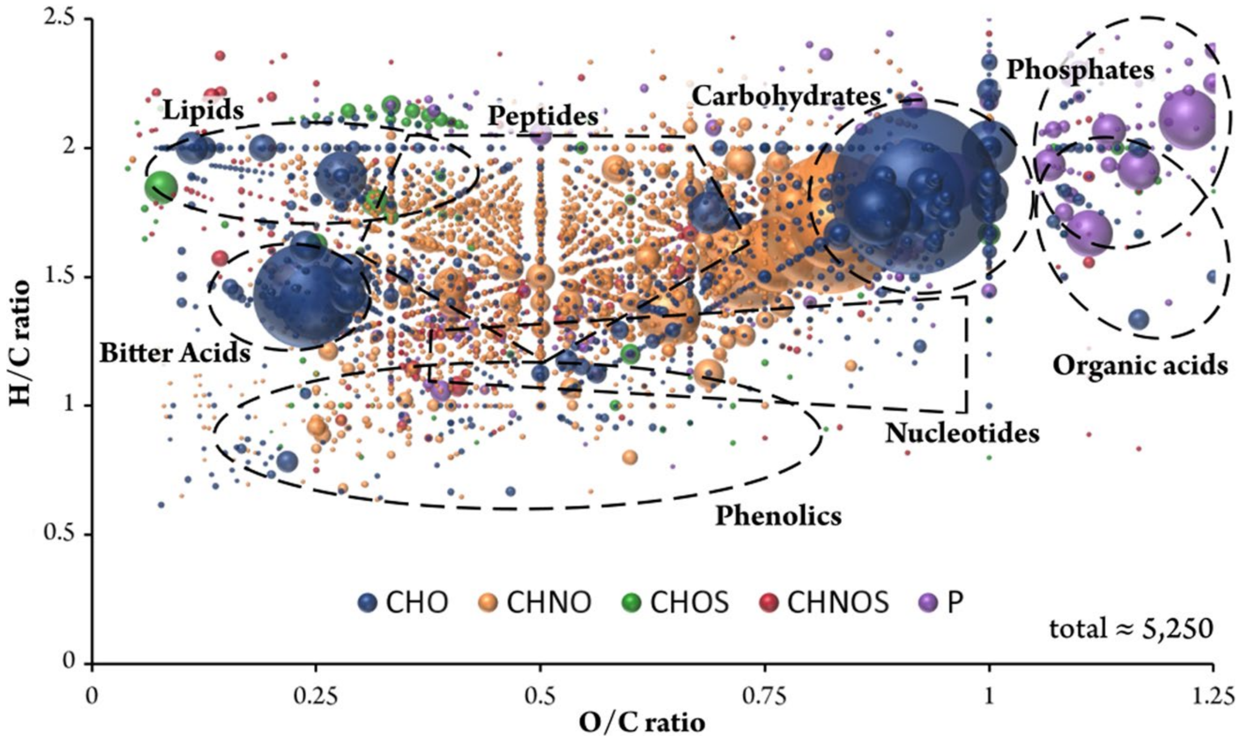
Common Redox Potentials

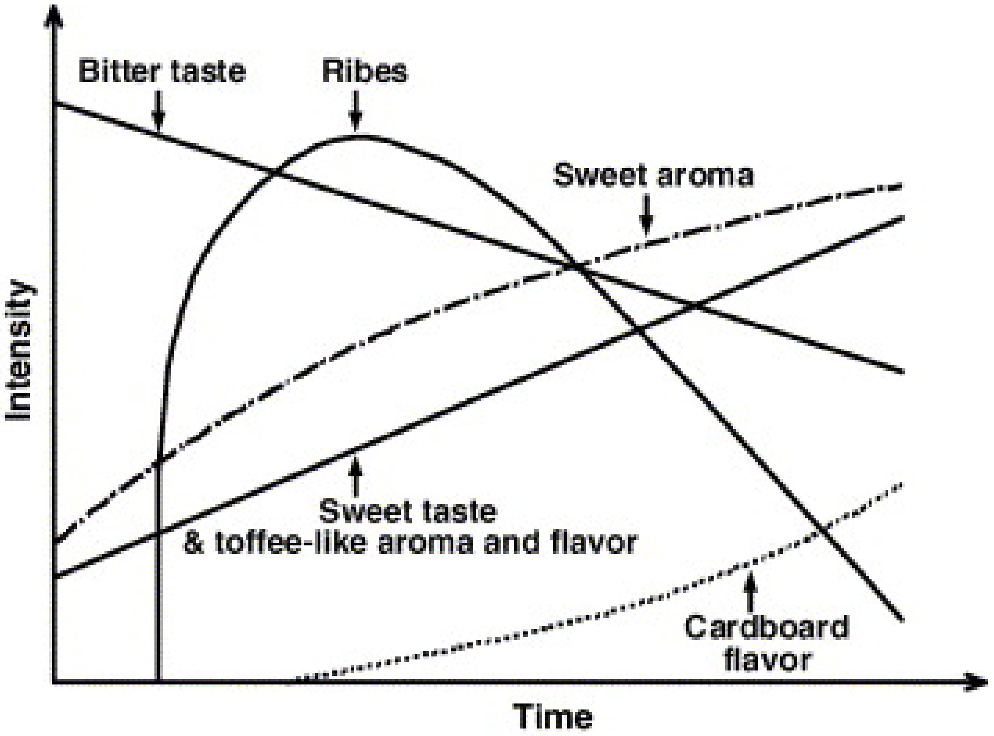
Standard Potentials at 25°C

Half Reaction	Potential
$F_2 + 2e^- \rightarrow 2F^-$	+2.87 V
$O_3 + 2H^+ + 2e^- \rightarrow O_2 + H_2O$	+2.07 V
$S_2O_8^{2-} + 2e^- \rightarrow 2SO_4^{2-}$	+2.05 V
$PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 + 2H_2O$	+1.69 V
$Au^+ + e^- \rightarrow Au$	+1.69 V
$Pb^{4+} + 2e^- \rightarrow Pb^{2+}$	+1.67 V
$2\ HClO + 2H^+ + 2e^- \rightarrow Cl_2 + 2H_2O$	+1.63 V
$Ce^{4+} + e^- \rightarrow Ce^{3+}$	+1.61 V
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$	+1.51 V
$Au^{3+} + 3e^- \rightarrow Au$	+1.40 V
$Cl_2 + 2e^- \rightarrow 2Cl^-$	+1.36 V
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$	+1.33 V
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$	+1.23 V
$MnO_2 + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2H_2O$	+1.21 V
$Pt^{2+} + 2e^- \rightarrow Pt$	+1.20 V
$Br_2 + 2e^- \rightarrow 2Br^-$	+1.09 V
$2Hg^{2+} + 2e^- \rightarrow Hg_2^{2+}$	+0.92 V
$ClO^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^-$	+0.89 V
$Ag^+ + e^- \rightarrow Ag$	+0.80 V
$Hg_2^{2+} + 2e^- \rightarrow 2Hg$	+0.79 V

Half Reaction	Potential
$2H^+ + 2e^- \rightarrow H_2$	**0.000 V**
$Fe^{3+} + 3e^- \rightarrow Fe$	−0.04 V
$Pb^{2+} + 2e^- \rightarrow Pb$	−0.13 V
$Sn^{2+} + 2e^- \rightarrow Sn$	−0.14 V
$Ni^{2+} + 2e^- \rightarrow Ni$	−0.23 V
$V^{3+} + e^- \rightarrow V^{2+}$	−0.26 V
$Co^{2+} + 2e^- \rightarrow Co$	−0.28 V
$In^{3+} + 3e^- \rightarrow In$	−0.34 V
$PbSO_4 + 2e^- \rightarrow Pb + SO_4^{2-}$	−0.36 V
$Cd^{2+} + 2e^- \rightarrow Cd$	−0.40 V
$Cr^{3+} + e^- \rightarrow Cr^{2+}$	−0.41 V
$Fe^{2+} + 2e^- \rightarrow Fe$	−0.44 V
$Zn^{2+} + 2e^- \rightarrow Zn$	−0.76 V
$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$	−0.83 V
$Cr^{2+} + 2e^- \rightarrow Cr$	−0.91 V
$Mn^{2+} + 2e^- \rightarrow Mn$	−1.18 V
$V^{2+} + 2e^- \rightarrow V$	−1.19 V
$ZnS + 2e^- \rightarrow Zn + S^{2-}$	−1.44 V
$Al^{3+} + 3e^- \rightarrow Al$	−1.66 V
$Mg^{2+} + 2e^- \rightarrow Mg$	−2.36 V

Beer Chemistry is Complex





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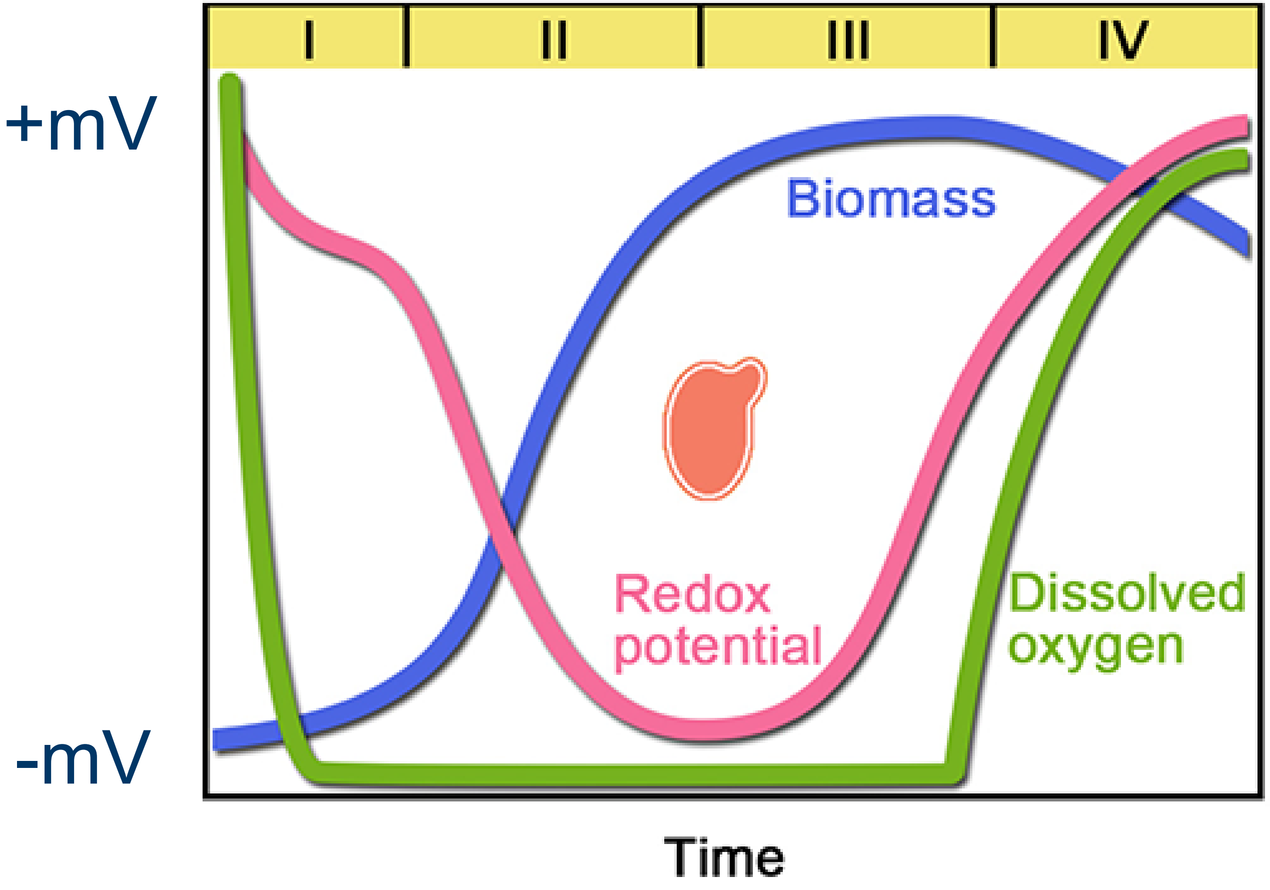
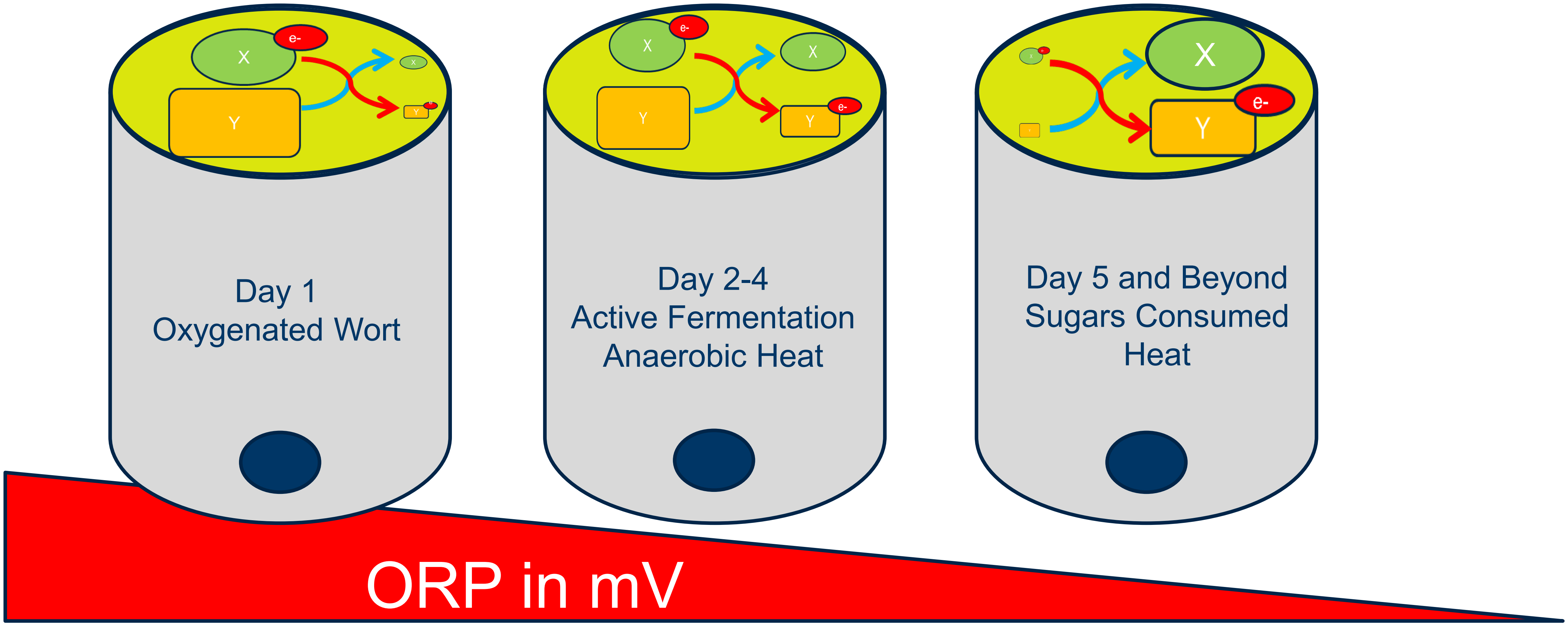
Vanderhaegen et al. (2006)Food Chemistry Volume 95, Issue 3, April 2006, Pages 357-381

ORP as a Function of Fermentation



Liu, Qin and Lin (2017). Fermentation and Redox Potential, Fermentation Processes, Angela Faustino Jozala, IntechOpen, DOI: 10.5772/64640. Available from: https://www.intechopen.com/books/fermentation-processes/fermentation-and-redox-potential

ORP as a Function of Fermentation



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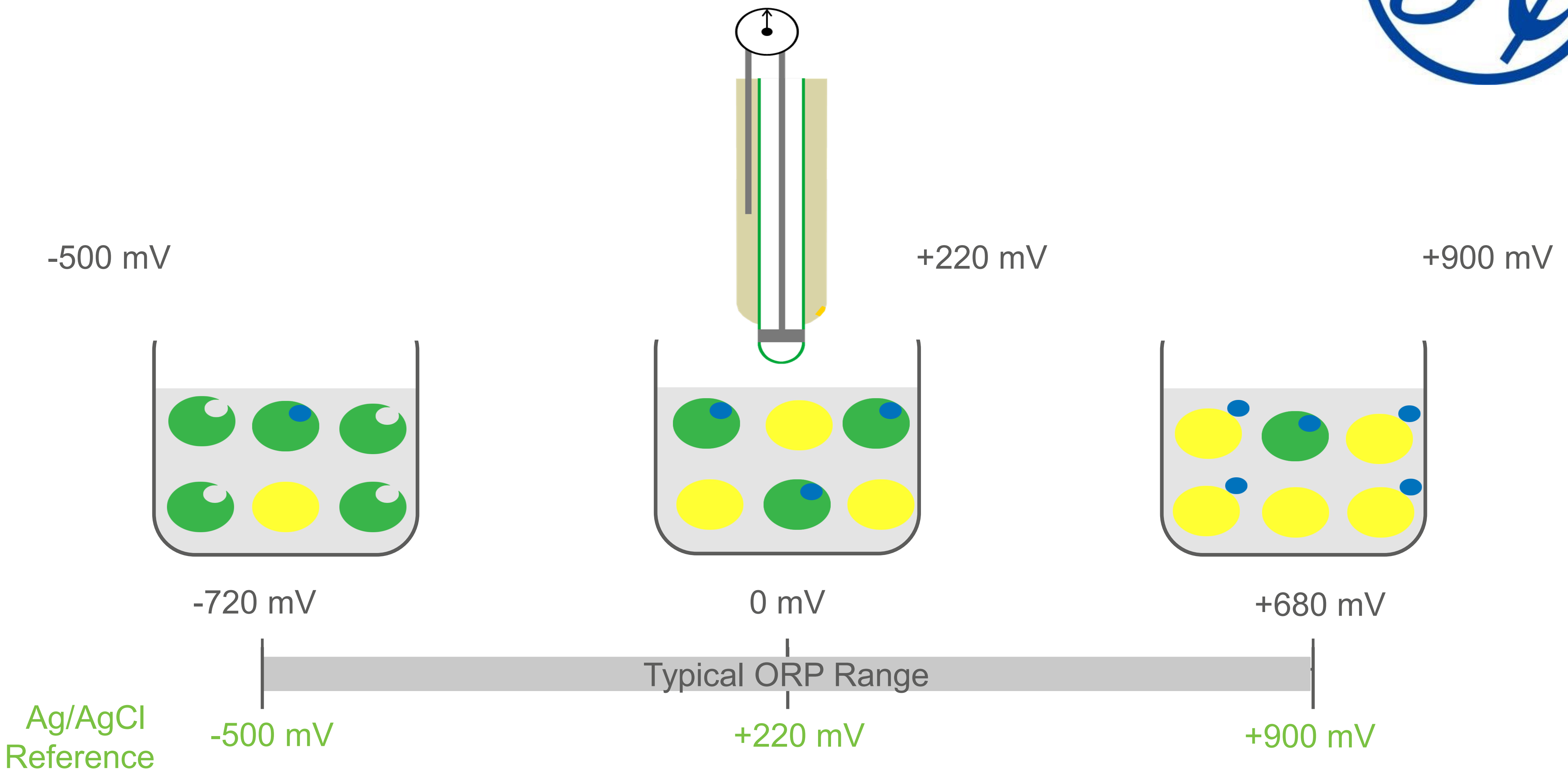
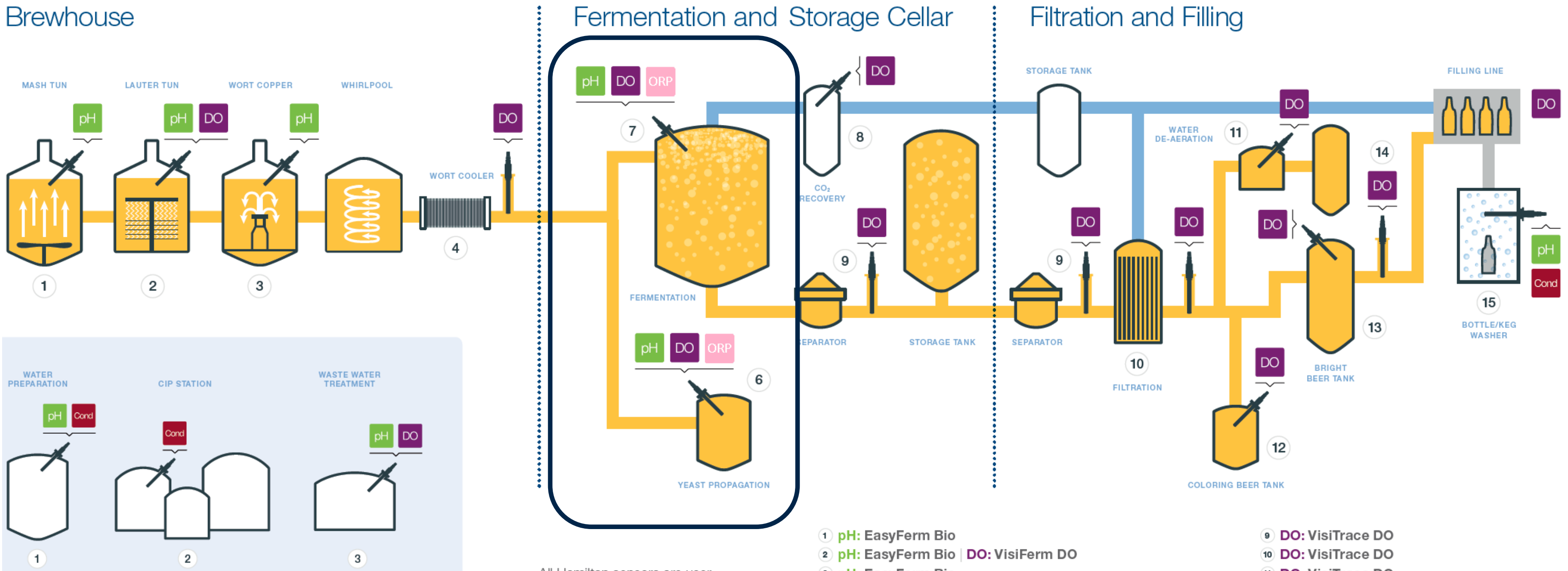
Measuring ORP



Application Points



1 **pH:** Polilyte Plus | **Cond:** Conducell 4USF
2 **Cond:** Conducell 4USF
3 **pH:** Polilyte Plus | **DO:** VisiFerm DO

All Hamilton sensors are user friendly and easy to integrate into existing process control systems. Sensors, housings and buffers are compliant with the existing regulations.

1 **pH:** EasyFerm Bio
2 **pH:** EasyFerm Bio | **DO:** VisiFerm DO
3 **pH:** EasyFerm Bio
4 **DO:** VisiFerm DO
6 **pH:** EasyFerm Bio | **DO:** VisiFerm DO | **ORP:** EasyFerm Plus ORP
7 **pH:** EasyFerm Bio | **DO:** VisiFerm DO | **ORP:** EasyFerm Plus ORP
8 **DO:** VisiTrace DO
9 **DO:** VisiTrace DO
10 **DO:** VisiTrace DO
11 **DO:** VisiTrace DO
12 **DO:** VisiTrace DO
13 **DO:** VisiTrace DO
14 **DO:** VisiTrace DO
15 **pH:** Polilyte Plus | **Cond:** Conducell 4USF

Applications in Brewing

(23) Neuberg, O., and Reinfurth, E., *Ibid.*, 89, 365 (1918).
(24) Robison, R., and Morgan, W. T. J., *Biochem. J.*, 22, 1277 (1928).
(25) Warburg, O., "Über den Stoffwechsel der Tumoren," Berlin, 1926.
(26) Warburg, O., "Über die katalytischen Wirkungen der lebendigen Substanz," Berlin, 1928.
(27) Warburg, O., and Christian, W., *Biochem. Z.*, 254, 438 (1932).

Received April 27, 1935.

Application of Oxidation-Reduction Potential to Brewing Control

The theory of the oxidation-reduction systems and their potentials has recently been applied to brewing control work and the preliminary results appear to justify a more intense study.

Certain factors influencing the flavor and keeping quality of beer, which have been little understood, may thereby find an explanation. Outstanding are the influence of aëration during the various stages of the brewing process, the propagation of microorganisms, and the effect of oxidizing and reducing reactions on beer flavor.

The oxidation-reduction potential is generally expressed by the symbol, rH (the negative logarithm of the pressure of the reducing hydrogen present in the solution). The oxidizing power of a solution is the greater the higher its potential, and the reducing power is greater the lower its potential. An electrometric and a colorimetric method are available for the determination of rH, providing means for a methodical study of the oxidation factor wherever it occurs during the entire brewing process. Its application is described in the study of aëration, of the so-called light-taste, and of yeast turbidities.

F. P. SIEBEL, JR., AND E. SINGRUEN[1]
Siebel Institute of Technology, Chicago, Ill.

During the past five decades the brewing industry has more and more turned to science for assistance in the solution of its practical problems. The advancements in physical, colloidal, and biochemistry, in particular, have contributed a great deal to the better understanding of purely empirical experience and rule-of-thumb methods. In many cases brewing scientists have traced the causes of frequent disturbances and, based on this knowledge, have been successful in devising means to remedy faulty conditions and eliminate them for the future.

The application of the theory of hydrogen-ion concentration to malting and brewing has become a well-known, comparatively simple, and effective method for controlling processing methods. Numerous other problems of physicochemical character, however, have remained unsolved. It is only during the past year that European brewing scientists have put another modern theory—that of the oxidation-reduction systems—to work, to study into some of the heretofore least understood factors influencing the flavor and the keeping quality of the beer. These include all oxidation and reduction reactions which take place during beer production. Outstanding in this respect are the influence of aëration, the propagation of microörganisms, and the effect of oxidation and reduction on the beer flavor.

Other industries are already making practical use of the oxidation-reduction potential. In the dairy industry the degree and, to a certain extent, the nature of milk infections are determined by means of suitable oxidation-reduction indicators; it is also claimed that the suitability of milk for certain types of cheese can be predicted by this method.

[1] Present address, 542 Arlington Place, Chicago, Ill.

French wineries recognize the effect of the oxygen in the air on the wine aroma and are now investigating the oxidation-reduction potential as a possible means of controlling aëration. It also finds application in sewage treatment and in the study of the biological condition of soils.

De Clerck in France (*1*) and Mendlik in Holland (*2*) were the first to study the merits of the oxidation-reduction potential for brewing control work. Although their investigations are still in the experimental stage, the preliminary results appear to be deserving of attention.

Theory of Oxidation-Reduction Systems

Under oxidation, originally all those reactions were classified in which oxygen combined with another substance to form a new compound. In the meantime, however, a better understanding of intermolecular arrangement has taught us that atoms consist of an inner, positively charged nucleus (protons) around which particles with negative charges (electrons) revolve. Atoms which lose an electron in the course of a chemical reaction gain a positive charge.

For instance, an increase in valence constitutes a gain of a positive charge—in other words, an oxidation. Since no electron can exist by itself, it will be bound by another substance which is thereby reduced. It is evident, therefore, that neither oxidation nor reduction can take place alone but that both reactions always are concurrent and consist in the transfer of electrons from the oxidized to the reduced substance. If we consider the gain of a positive electric charge as oxidation, although no oxygen may be involved at all in the reaction, and the gain of a negative electric charge as reduction, the modern definition of oxidation would be "loss of electrons."

Ind. Eng. Chem. 1935, 27, 9, 1042–1045
Publication Date:September 1, 1935
https://doi.org/10.1021/ie50309a018

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Applications in Brewing and Seltzer

ORP as been overlooked in beer production

DO, pH and Temperature Control

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Niche Applications in Beer and Seltzer

- Core Brand Consistency and Optimization
- Research & Development
- Yeast Propagation and Biomass Production
- Improved Attenuation
- Reductive Character Control (Seltzer)
    - H2S (hydrogen sulfide)

Yeast Wrangler

CHRISTIAN GRESSER
Regensburg | Nöbdenitz

Gusmer Enterprises, Inc.®

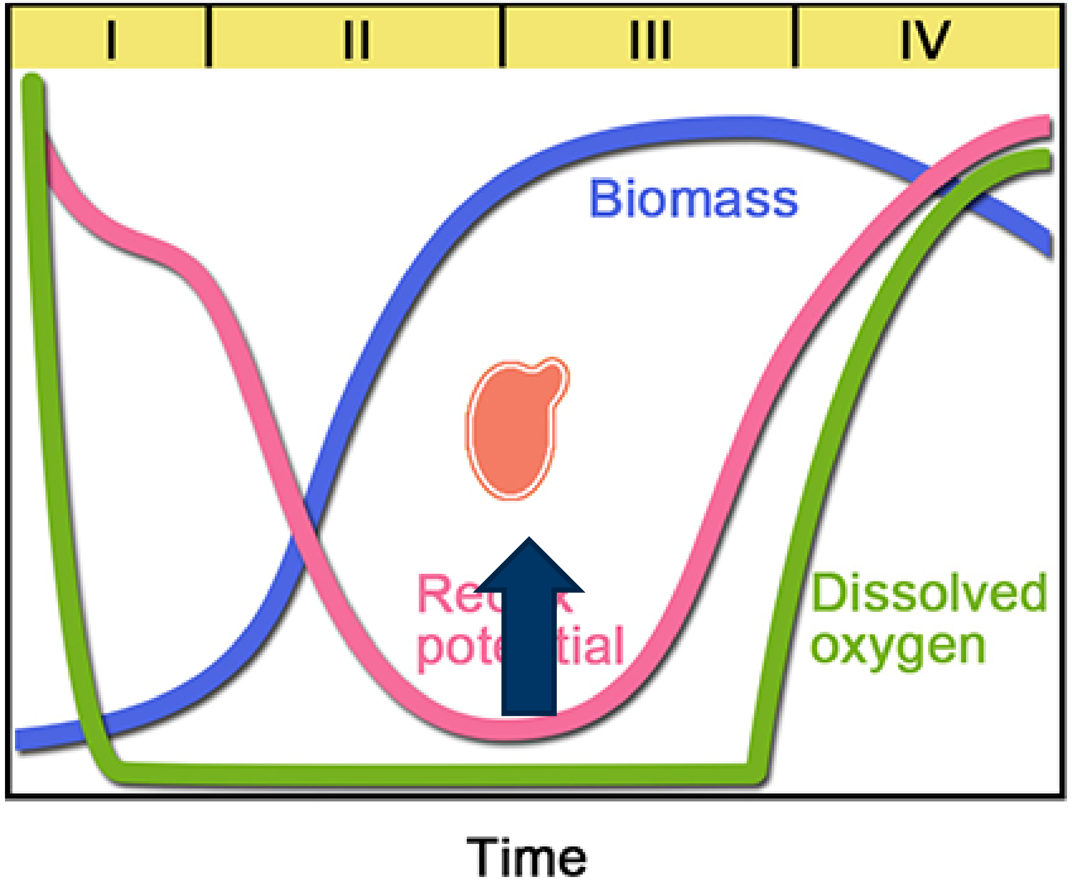
Niche Applications in Beer and Seltzer

- High Gravity and Very High Gravity Beer/Seltzer (14°P and up)
  - Beneficial Ester production
  - Flavor Stability
  - Economies of Scale
    - Brand Diversification
    - Improved Efficiencies
    - Labor, Waste/Effluent, Energy, Cleaning per unit of product

PureMalt
CRAFTED
Over 800 years of craft...

DENWEL

Why Implement of ORP?



Real Time Monitoring of ORP

Real Time intervention
- Microoxygenation
- Nutrient Additions
  - Increase biomass production
  - Control off-flavors
  - Improve wort/must attenuation

Liu, Qin and Lin (2017). Fermentation and Redox Potential, Fermentation Processes, Angela Faustino Jozala, IntechOpen, DOI: 10.5772/64640. Available from: https://www.intechopen.com/books/fermentation-processes/fermentation-and-redox-potential

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City and State: Minneapolis, MN

Industry: Brewing, WineMaking

GO

Tom Mondor

Company: Gusmer Enterprises Inc
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Email: tmondor@gusmerenterprises.com

Brewing | Distilling | WineMaking | Juice Processing

Thank You!