

January
2014

Instrument Assessment Report

Hamilton Portable Dissolved Oxygen Meter



Executive Summary

Hamilton have developed a portable oxygen meter "Beverly" that relies on luminescence quenching by oxygen. This report assesses Beverly as a possible asset for brewers for dissolved oxygen measurement in beer and wort; the latter for control of fermentation. Beverly is shown to be user-friendly and reliable. Beverly was demonstrably effective in at-line dissolved oxygen measurement over the range that would most commonly be required in breweries.

Background

Hamilton are a supplier of oxygen probes and ancillary technologies to beverage industries including breweries. Their oxygen probe technology utilises luminescence quenching by oxygen rather than electrochemical detection of the more established technology. Previously Campden BRI have assessed Hamilton's in-line oxygen probes favourably. Hamilton are now marketing "Beverly", which is a portable dissolved oxygen meter suitable for off-line or at-line use. This report is an assessment of Beverly as a possible asset to brewers for measurement of oxygen in beer and to control oxygen in wort prior to fermentation.

Scope of Work / Methods

- Hamilton supplied a "Beverly" portable oxygen meter to Campden BRI for technology assessment.
- The instrument was two point calibrated with air and nitrogen.
- A keg of commercial standard strength lager was sourced (internationally the



most important beer style in volume terms).

- A lager wort was brewed in the Campden BRI Pilot Brewery and standard analysis was performed upon it.
- The beer was filled into a bright beer tank and the dissolved oxygen level was altered by recirculation around a gas control rig (based on hydrophobic membrane technology). Oxygen was added to the beer by gas exchange with compressed air at 1 bar gauge pressure. Oxygen could also be removed by application of vacuum. Several different oxygen concentrations were tested. For beer relevant oxygen levels are in the range 0 to 2000 ppb so these were the concentrations tested. For the wort, the relevant range is 0 to oxygen saturation therefore much higher concentrations were tested.
- For each test the Beverly was compared with a reference electrochemical oxygen meter (also portable). Note that the reference instrument was intended to be a comparison with an alternative technology, there was no suggestion that the reference instrument output was "the correct value". The two units were fitted at-line (each to a sample port in the main) side by side. The beer or wort was gas-adjusted before the instruments were exposed to the sample so that "time zero" was first contact with the sample.

Results and Comments

Observations on Using the Hamilton Meter

The user interface was extremely simple to use. Campden BRI personnel were able to perform the trials confidently with almost no demonstration from Hamilton personnel.

It was found that the operator must supervise the measurement carefully to ensure that there is not gas breakout (bubble formation) in the flow through the meter (in the case of carbonated beverage such as the beer sample). In these trials this effect was eliminated by controlling the back-pressure valve (flow control valve on the meter).

The instrument supplied was a prototype that did not have the rugged construction that the commercial instrument will have. However, the functionality, software and firmware (user interface) and the mechanical equipment for sample handling and measurement were the same therefore the unit was suitable for the assessment. The final version will have the following specifications:

- Measuring range 4 ppb to 25 ppb dissolved oxygen. This will cover all the brewers' needs unless they have a yeast that has a very high oxygen requirement (approaching oxygen saturation), which is rare.
- Protection classification IP67. So the instrument would not suffer damage from say a water hose.
- Temperature 0-80°C and pressure 0-10 bar. So therefore the instrument will operate in conditions as extreme as the hot side of a flash pasteuriser.

Calibration of the instrument was extremely simple. A small flow of oxygen free gas (nitrogen was employed by Campden BRI) of at least 500 ml/min for the zero point and air for the air saturation point.



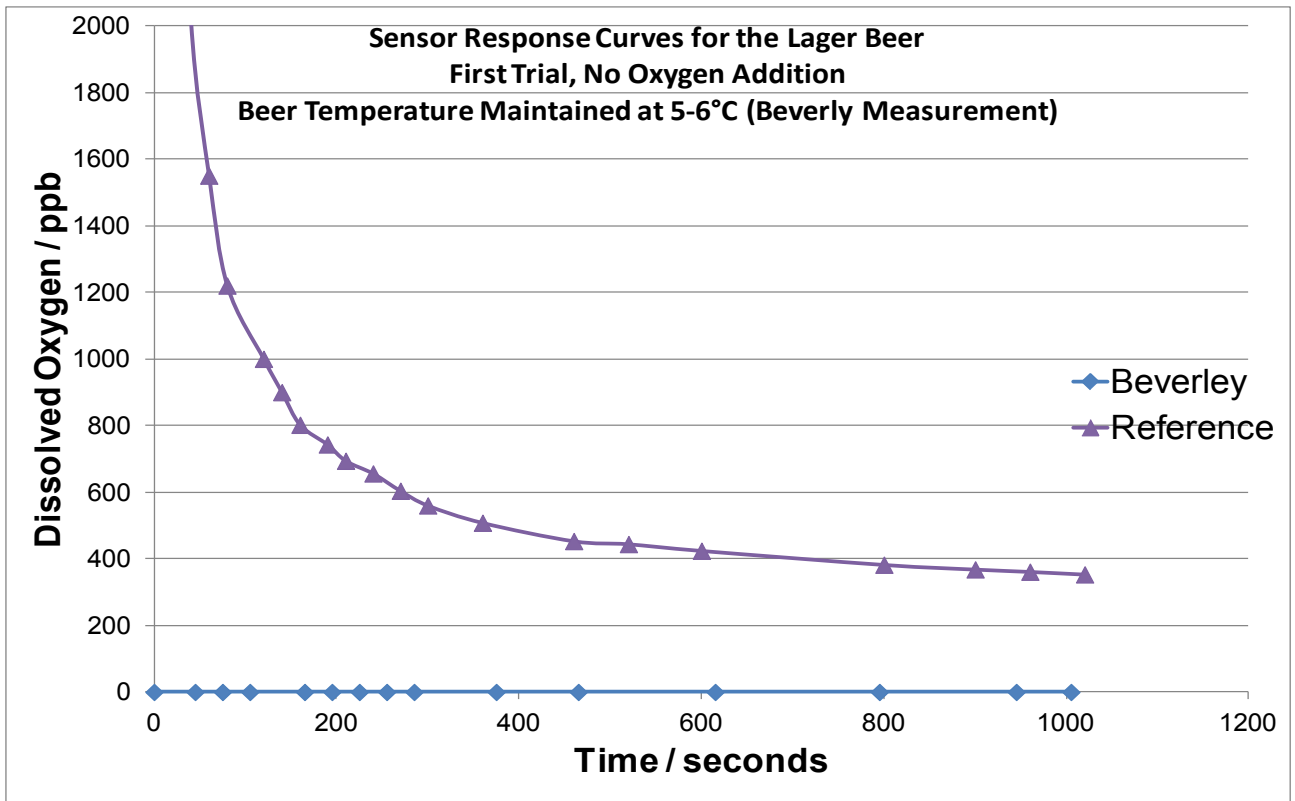


Figure 1: Dissolved Oxygen Measurement Results

Modern breweries are able to achieve very low values for in-pack oxygen and hence Beverly's inability to resolve any dissolved oxygen. The reference electrochemical instrument attained 353 ppb, which would be a high value for a modern large brewery, but as will be seen below the instrument was measuring too high values. In the plot above the axis was rescaled because the reference instrument recorded an extremely high value before equilibrium was attained.

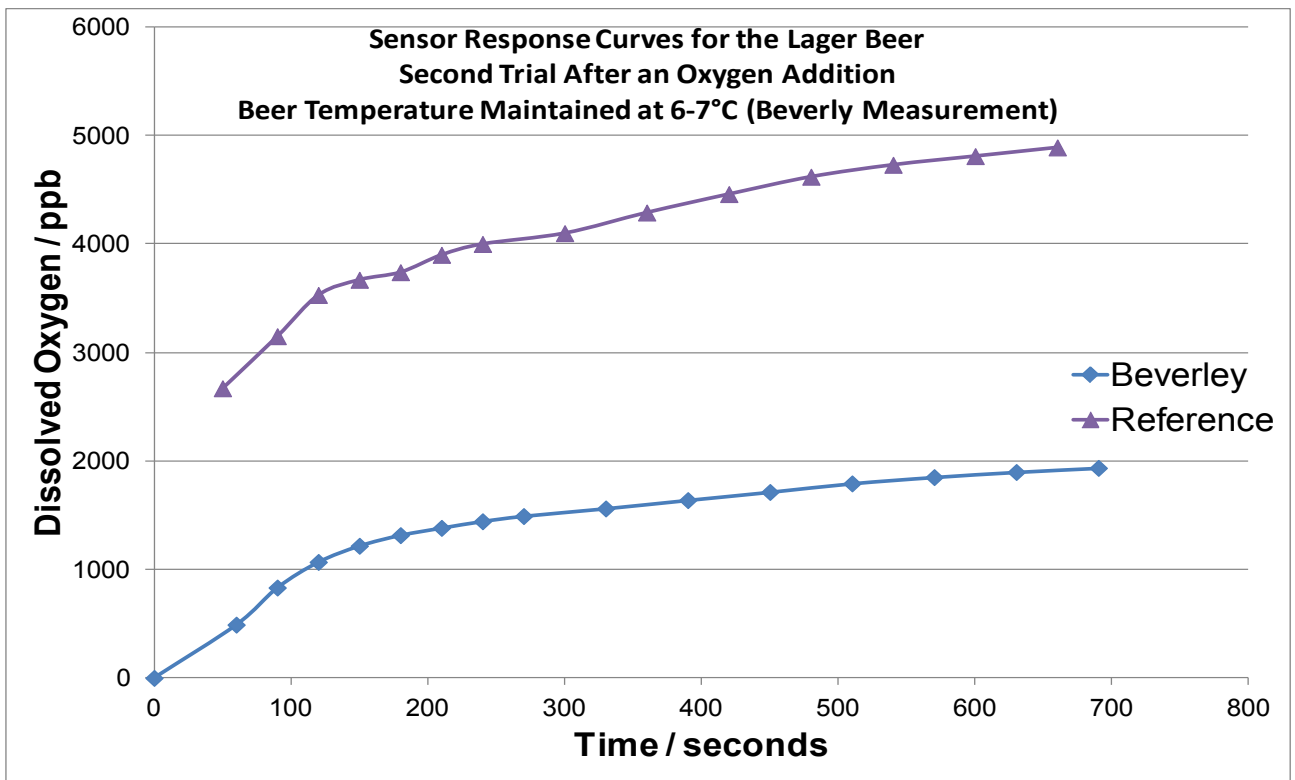


Figure 2

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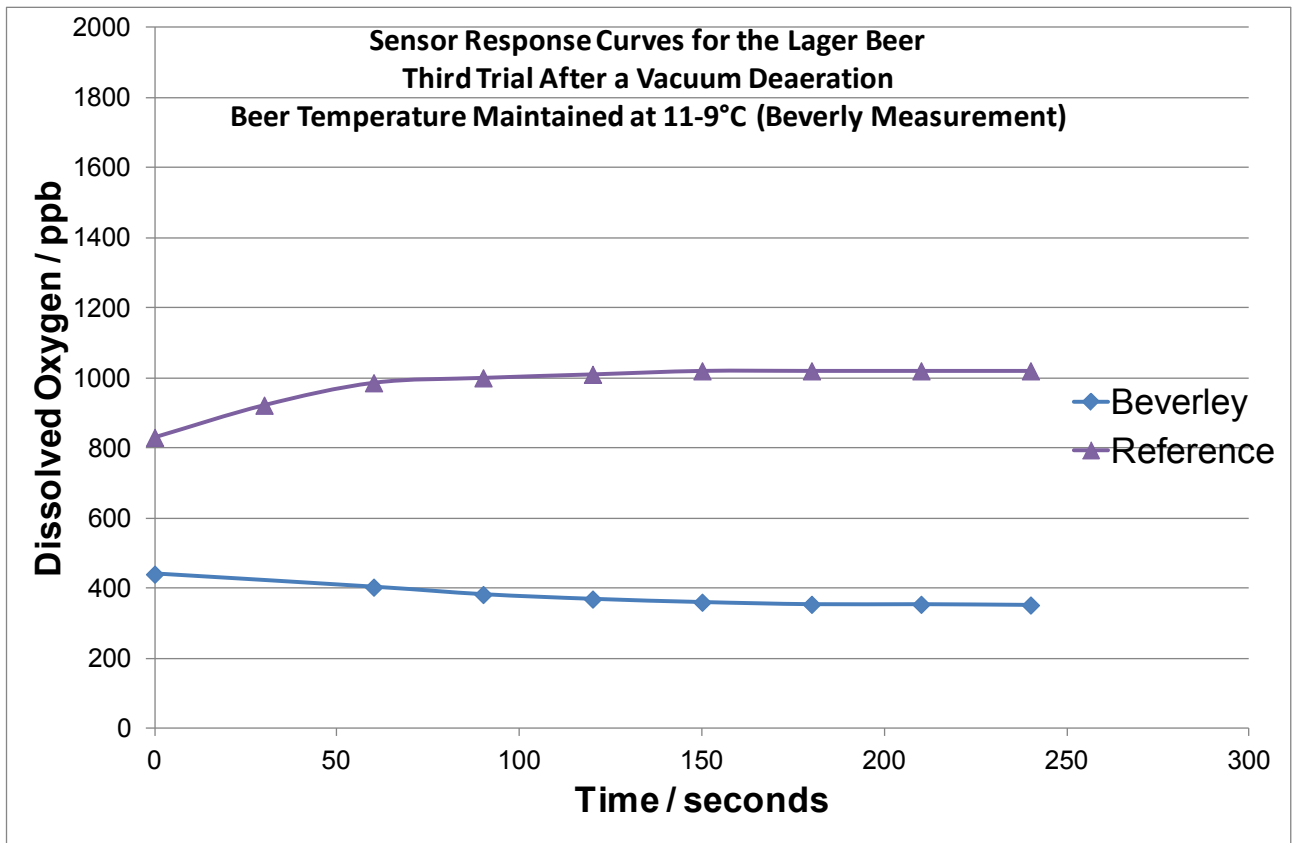


Figure 3

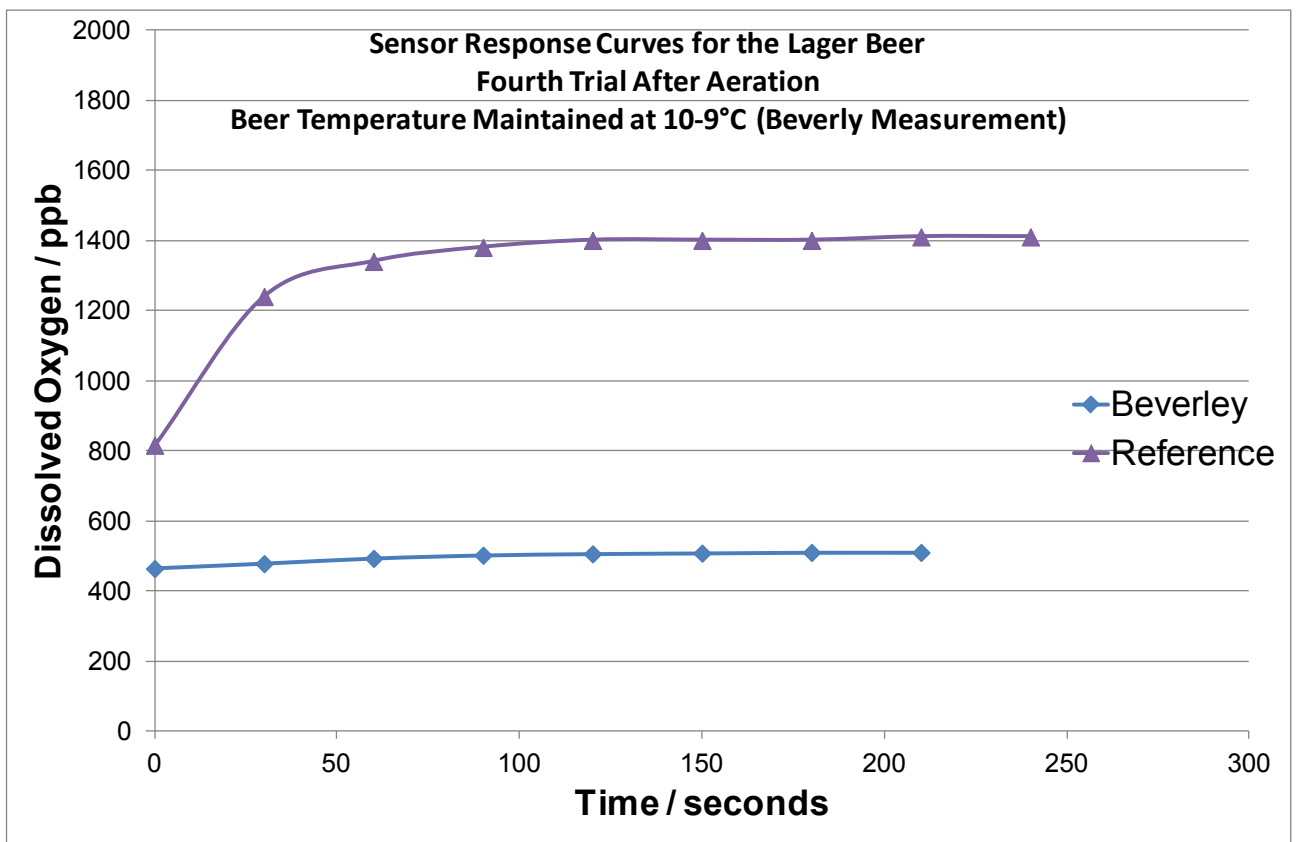


Figure 4



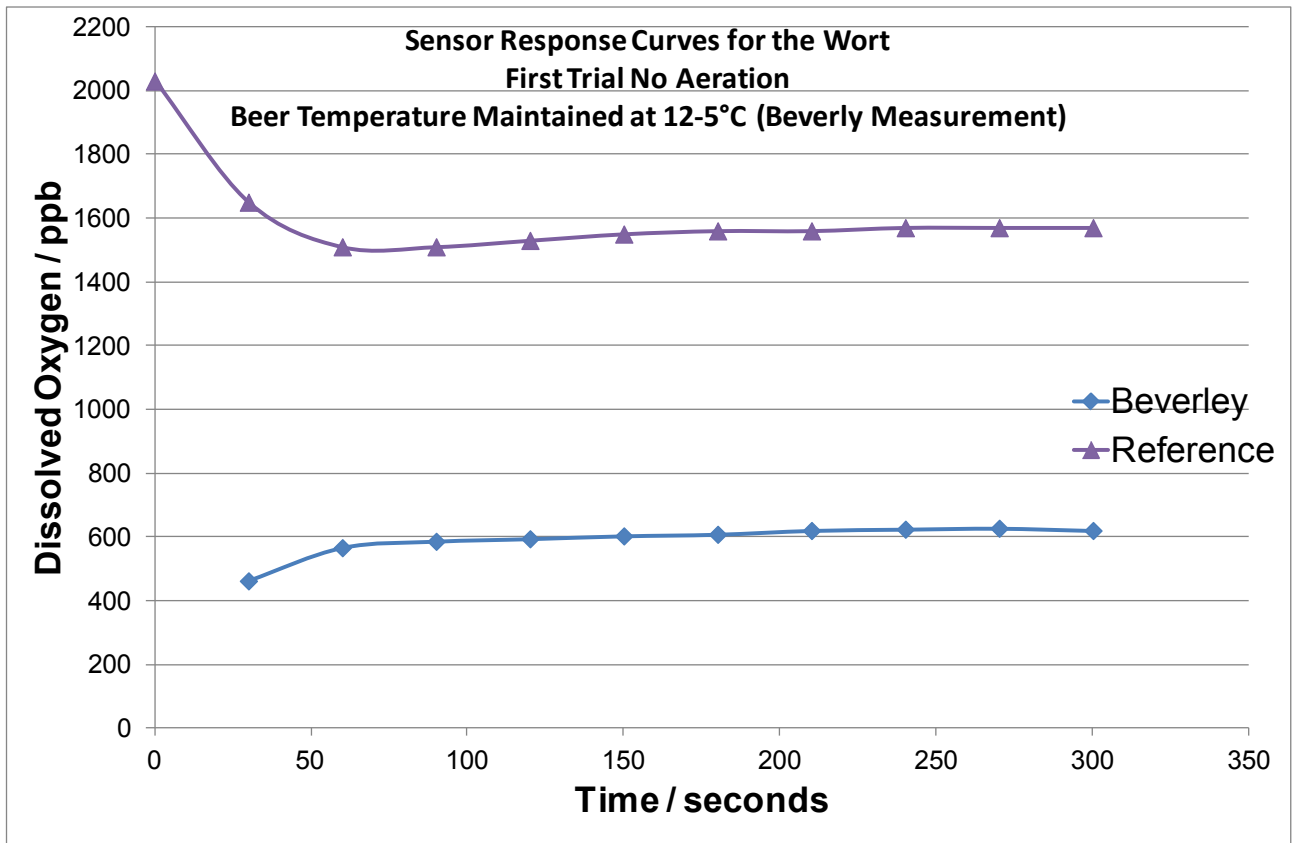


Figure 5

The final stages of wort production are performed at high temperature (more than 90°C including a boiling phase) hence dissolved oxygen figures were low initially.

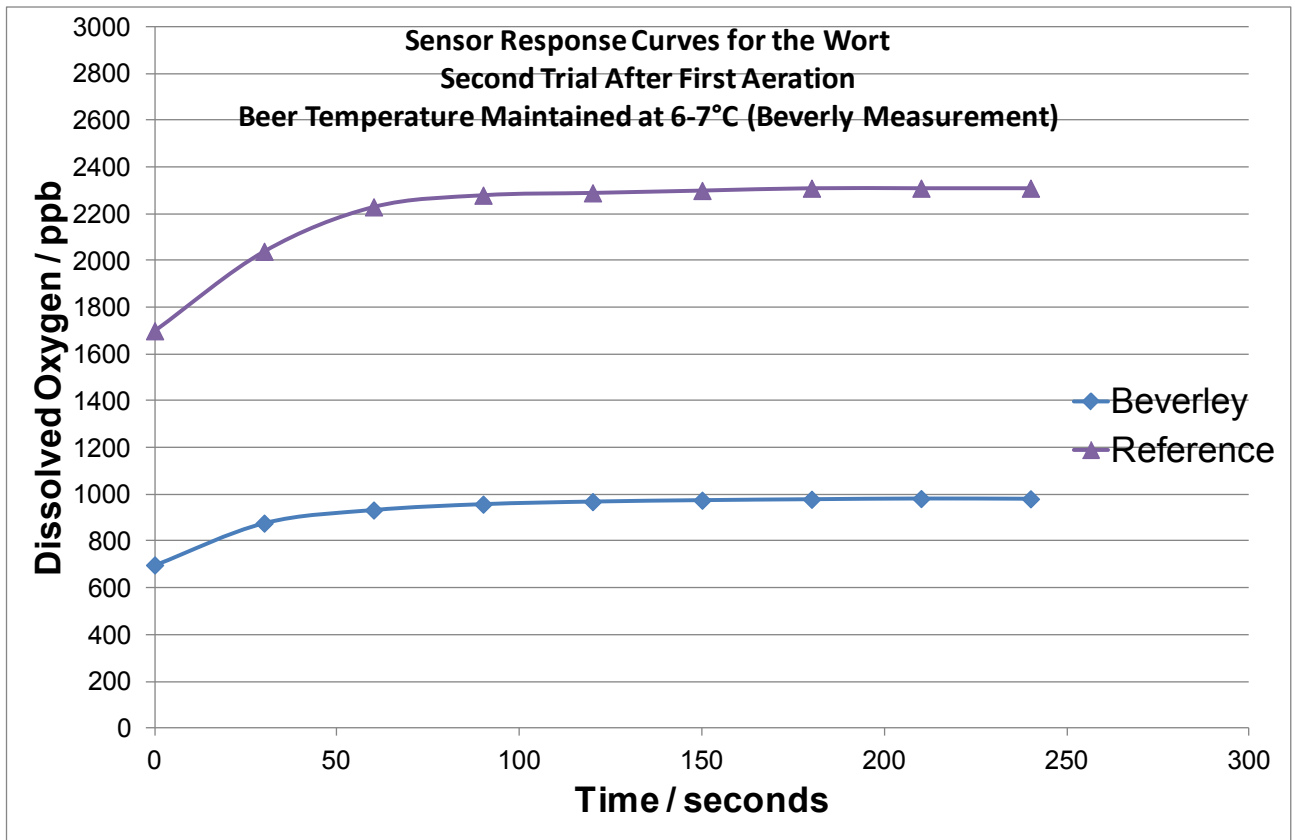


Figure 6

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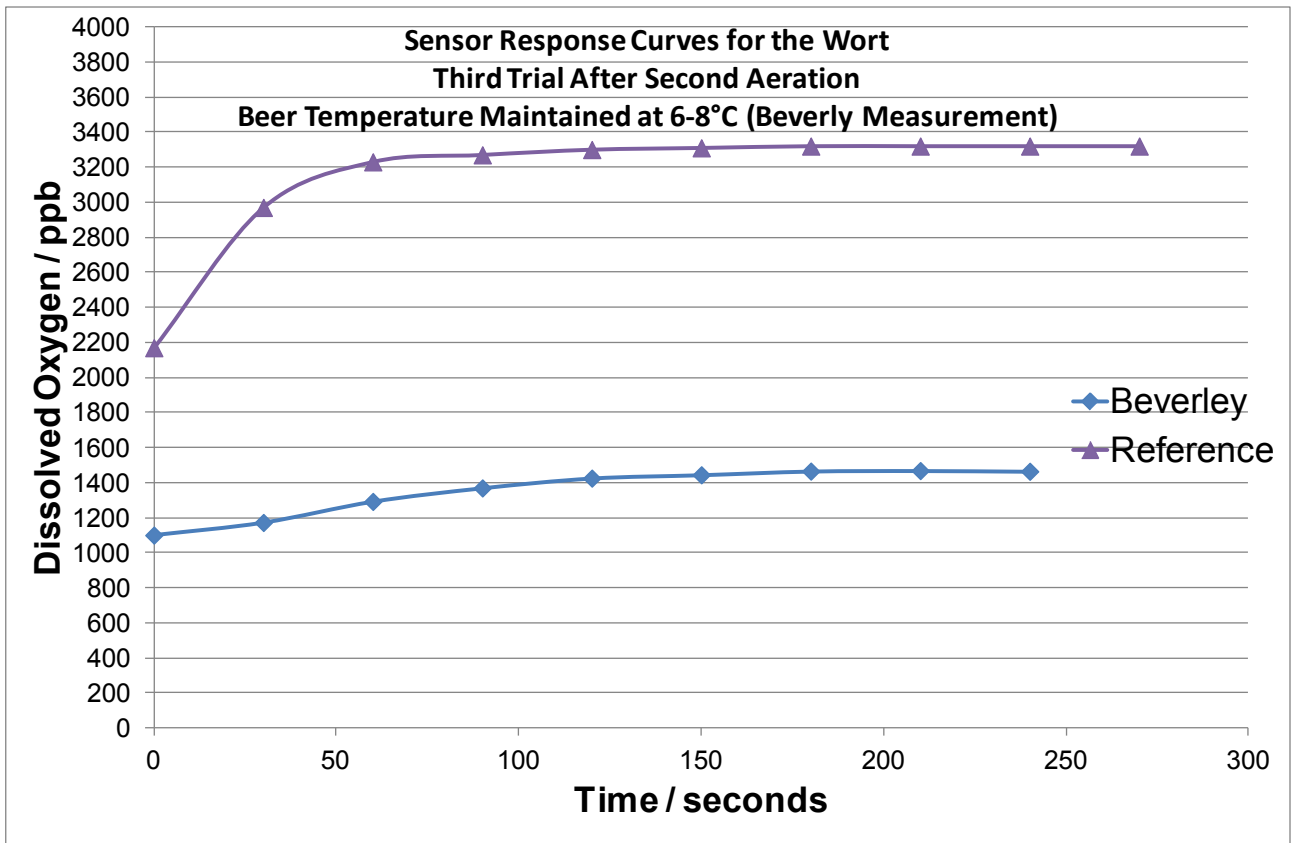


Figure 7

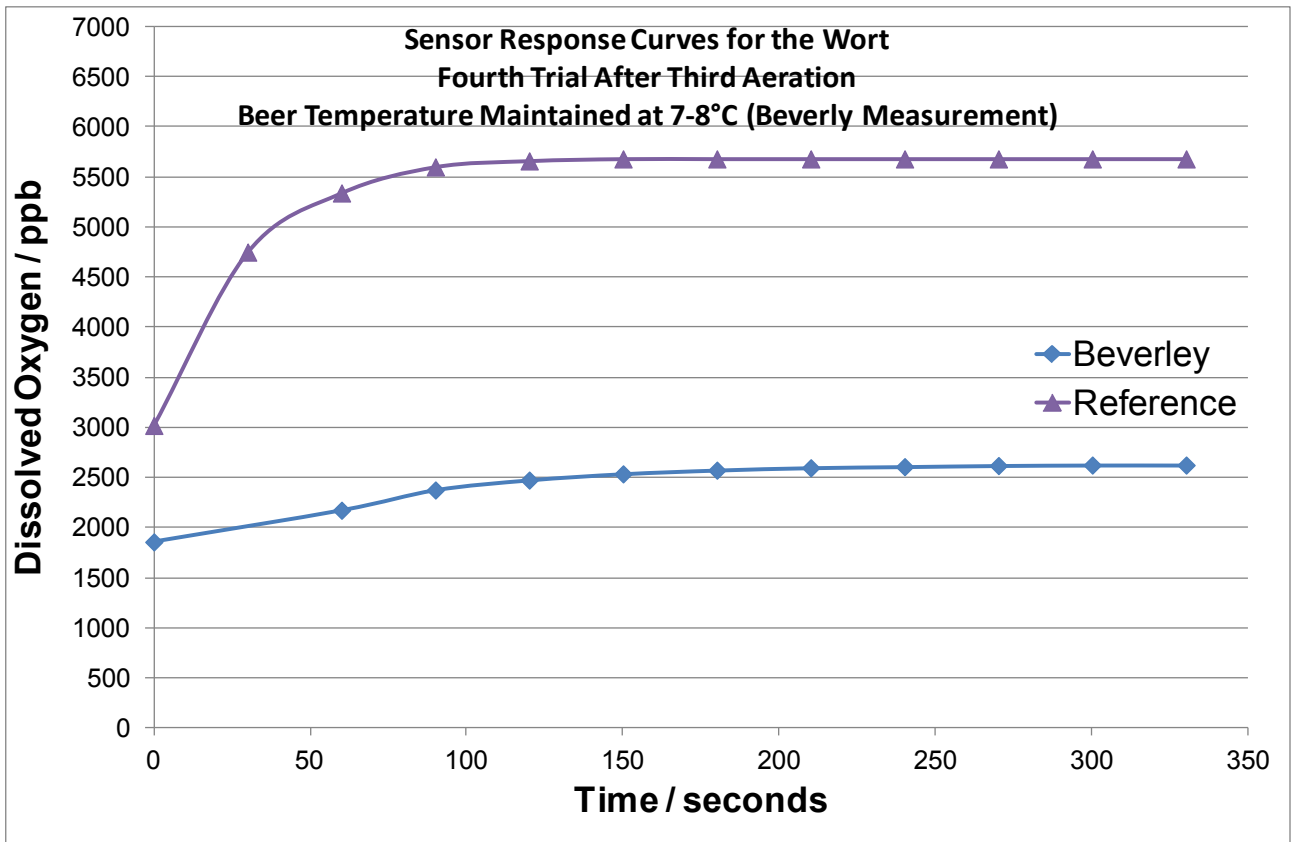


Figure 8



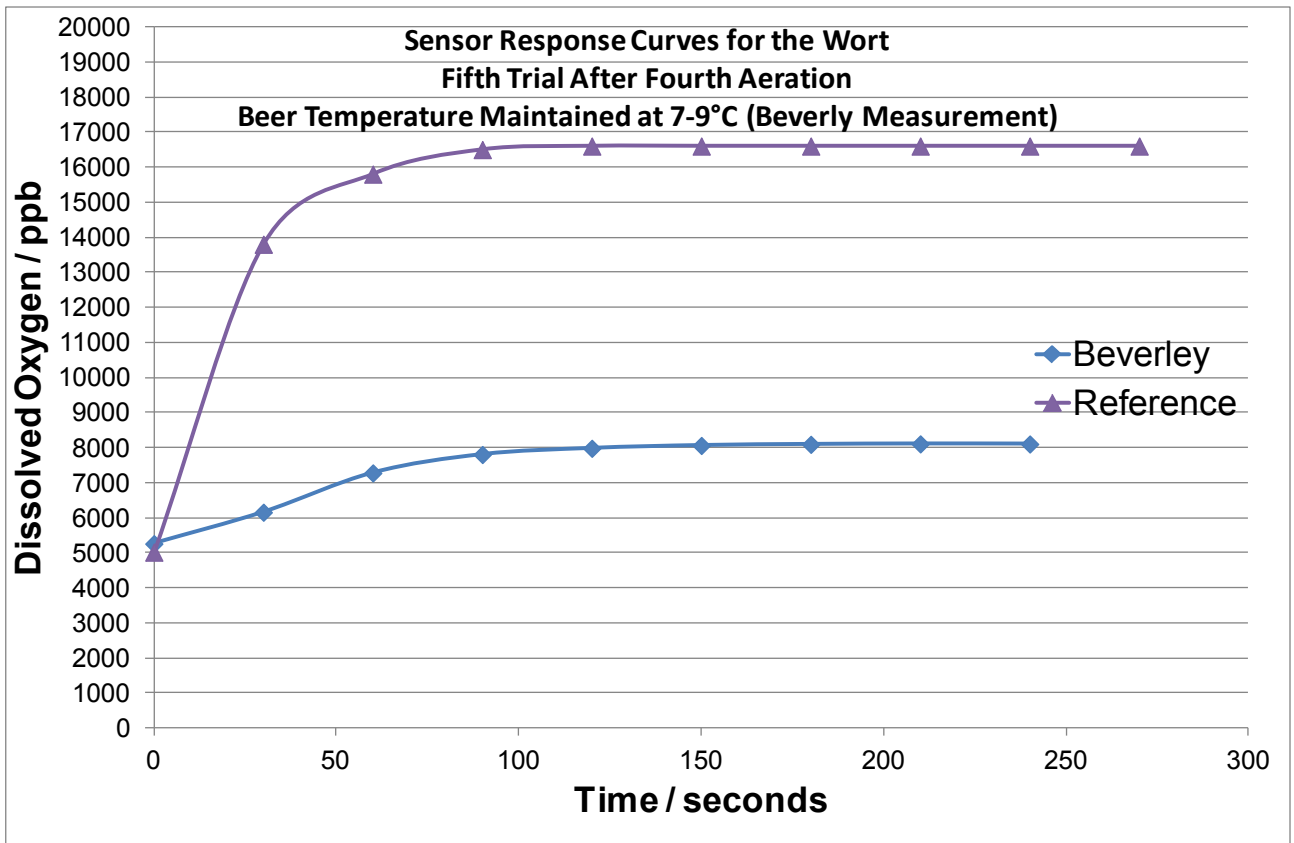


Figure 9

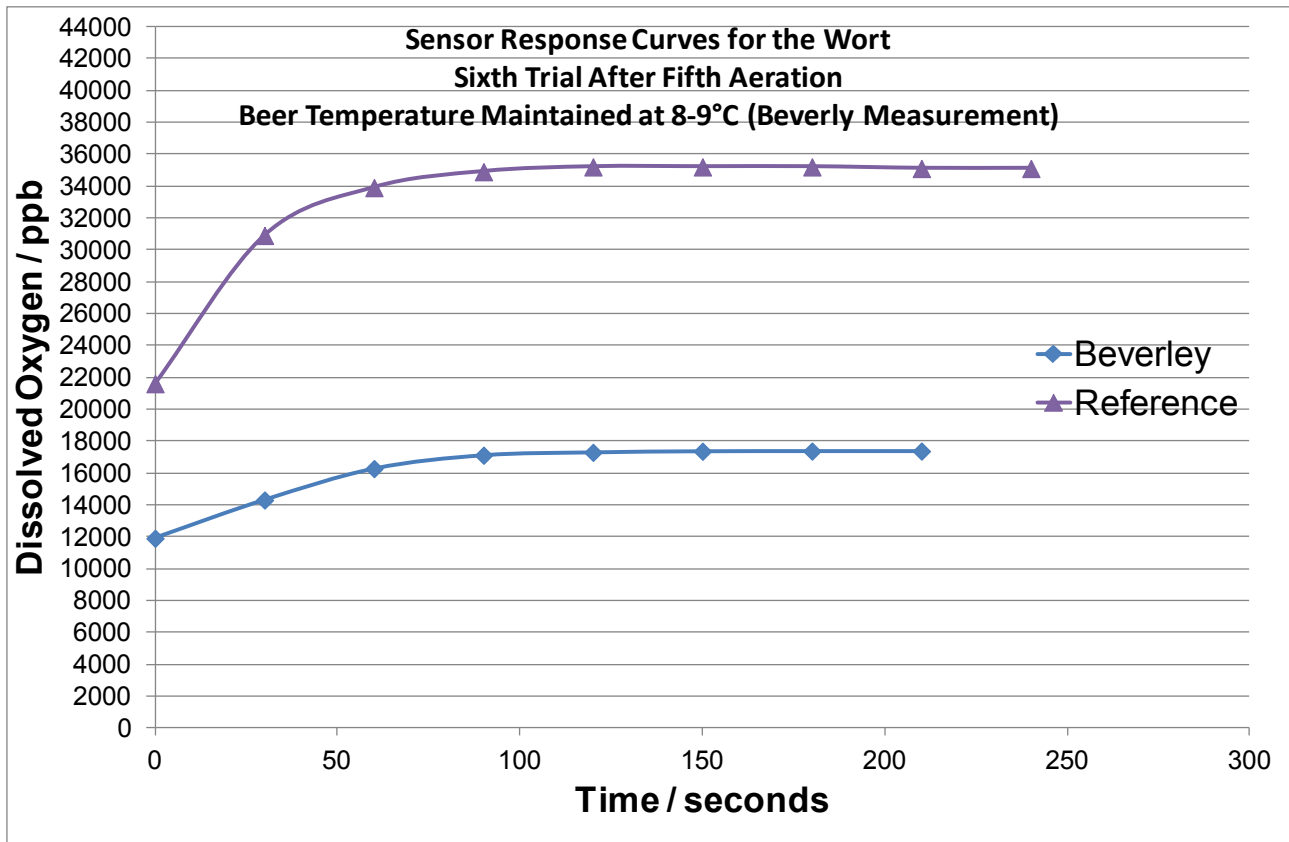


Figure 10

It is clear from the results that the reference electrochemical instrument was supplying much higher values than Beverley. It is also clear that the results from Beverley are more credible than the reference instrument. The result for the beer without aeration (first plot) appeared to generate an unusually high value from the reference instrument. Even more compellingly, the final plot showed wort where



aeration was for such a duration that near oxygen saturation would have been achieved. With 1 bar gauge air this would have been around 16000 ppb as indicated by Beverly. It would not have been the 35000 ppb as indicated by the reference instrument.

The data above allows an assessment of the response time, which in this report refers to the time taken to achieve approximately the final equilibrium measured value. The response time for both the reference unit and Beverly was usually in the two to three minute range.

Conclusions

- The Beverly portable oxygen meter is simple to use and is compatible with brewery personnel, product streams and the production environment.
- The instrument produced superior results to an electrochemical instrument with which it was compared. It is not known whether this represented superior performance and reliability of the luminescent technology compared to electrochemical or whether the electrochemical instrument was performing badly for another reason. No disadvantages of the luminescent technology were identified.

Recommendations

The Beverly portable oxygen meter is suitable for brewery operation.



APPENDIX

Analysis of the Campden BRI Lager Wort



Analysis Report Form 1723 - 13

Gary Freeman
Bri (Engineering & Pilot Plants)
Campden Bri
Centenary Hall
Coopers Hill Road
RH1 4HY

Campden BRI Nutfield
(Engineering & Pilot Plants)
Order Number: not supplied
Date Received: 25 Nov 13
SDG ID: 188528

Parameter	Method No.	Result	Units
pH	AM/029	5.29	
Bitterness	AM/003	36	BU
Colour	AM/029	15	EBC
FAN	AM/017	169	mg/l
Fermentability	AM/013	73	%
PG	AM/013	43.81	
Total Soluble Nitrogen	AM/002	801.0	mg/l



Signed:

Ian Slaiding
Analytical Laboratory Manager

Date: 04 Dec 13
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Campden BRI (Nutfield)
Centenary Hall
Coopers Hill Road, Nutfield
Surrey RH1 4HY
United Kingdom

Tel. +44 (0) 1737 822 272
Fax. +44 (0) 1737 822 747

Email: enquire@campdenbri.co.uk
Web: www.campdenbri.co.uk

Campden BRI (Nutfield)
Registered Number 2690377
Registered Office:
Station Road, Chipping Campden
Gloucestershire, GL55 6LD