

Application Note

The quality control of beer by measuring specific gravity and refractive index

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| Industry | Food & beverage |
| Instrument | Density/Specific gravity meter, Refractometer |
| Measurement method | Resonant frequency oscillation, Detection of critical angle of optical refraction |
| Standards | GB/T 4928 |

1. Scope

This application note shows an example of measuring quality control items for beer using a combination of density/specific gravity meter and refractometer. Each item was calculated from specific gravity and refractive index (Refer to "7. Notes") measured by the combined system including the optional KEM RA connection kit.

- Alcohol concentration
- Real extract
- Apparent extract
- Original extract
- Apparent fermentation
- Real fermentation

2. Post-measurement procedure

After the sample in the measurement cell is drained, rinse the cell with pure water and ethanol in that order. The cell should then be dried by purging it with dry air.

3. Apparatus

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|-----------|--------------------------------|
| Equipment | Density/Specific gravity meter |
| Option | RA Connecting kit |

4. Reagents

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|------------------------------|------------|
| Rinse liquid 1 (for washing) | Pure water |
| Rinse liquid 2 (for washing) | Ethanol |

5. Procedure

- Calibration -

- 1) In the dry state of the cell, perform the calibration by air.
- 2) Introduce pure water into the cell and then perform the calibration with pure water.
- 3) Introduce ethanol into the cell, then purge with dry air.

- Preparation -

- 1) The sample is degassed by natural filtration twice, using a paper filter (No.5C; Advantec Toyo, Tokyo, Japan).
- 2) Collect the filtrate in a sample bottle.

- Measurement -

- 1) Introduce the pretreated sample into the cell after the cell is dry.
- 2) Measure the specific gravity and refractive index.
- 3) Rinse the cell with pure water, and then ethanol, purge the cell with dry air.

6. Example

—Parameter—

The measurement parameters are set by the customer (see the table below).

| <Density/Specific gravity meter> | | <Refractometer> | |
|----------------------------------|---------------|-----------------|---------|
| Set temperature | 20.00°C | Set temperature | 20.00°C |
| Stability sense | 1 | Stability sense | 0 |
| Limit time | 600(s) | Wait time | 0(s) |
| Viscosity correction | OFF | Limit time | 50(s) |
| Calibration material | air and water | | |

(The measurement parameters are examples for using KEM's Density/Specific gravity meter and Refractometer. They may vary depending on the model.)

—Measurement results—

Table 1 shows the results of specific gravity and refractive index measurements for the three types of beer samples, and calculation results for each control item.

Table 1 Measurement results

| Beer | Density (g/cm ³) | Specific gravity (20/20°C) | Refractive index (nD) | Ref* | Alcohol Conc. (wt%) | Alcohol Conc. (vol%) | Real extract (wt%) | Original extract (°P) | Apparent extract (°P) | Real fermen- tation (%) | Apparent fermen- tation(%) |
|------|---------------------------------|----------------------------------|-----------------------------|--------|---------------------------|----------------------------|--------------------------|-----------------------------|-----------------------------|----------------------------------|----------------------------------|
| A | 1.00593 | 1.00774 | 1.34112 | 35.727 | 3.89 | 4.96 | 3.76 | 11.32 | 1.98 | 68.1 | 82.5 |
| B | 1.00368 | 1.00548 | 1.33754 | 26.298 | 1.98 | 2.52 | 2.35 | 6.31 | 1.41 | 63.5 | 77.7 |
| C | 1.00624 | 1.00805 | 1.34347 | 41.925 | 5.47 | 6.97 | 4.53 | 14.96 | 2.06 | 71.4 | 86.2 |

*For more information about Ref, refer to "7. Notes".

7. Notes

The alcohol concentration (wt%) was calculated based on the Berglund, Ellington and Rasmussen regression equation. The other control items were calculated based on the formula described in the BCOJ (Brewery Convention of Japan) Beer Analysis Method. The calculation formulas are shown below.

- Alcohol concentration (wt%) $AI = 0.323 - 277.4 \times (SG-1) + 0.2691 \times (Ref-14.5)$
- Alcohol concentration (vol%) $AI' = AI \times d / 0.78924$
- Real extract (wt%) $Er = 0.251 + 129.8 \times (SG-1) + 0.1179 \times (Ref-14.5)$
- Original extract (°P) $P = 100 \times (2.0665 \times AI + Er) / (100 + 1.0665 \times AI)$
- Apparent extract (°P) $Ea = -460.234 + 662.649 \times SG - 202.414 \times SG^2$
- Real fermentation (%) $Fr = 100 \times 2.0665 \times AI / (2.0665 \times AI + Er)$
- Apparent fermentation (%) $Fa = 100 \times (P - Ea) / P$

| | |
|-----------------------|---|
| SG | Specific gravity of beer (20/20°C) |
| d(g/cm ³) | Density of beer at 20°C |
| Ref | Eintauch-refraktometer (Refractometer readings with a special scale) |

Ref is converted from the refractive index nD by the formula below.

(1) Case of nD ≤ 1.34274

$$\text{Ref} = 32.2421 + 2637.3 \times (\text{nD} - 1.3398) + 2386.57 \times (\text{nD} - 1.3398)^2 - 357849 \times (\text{nD} - 1.3398)^3$$

(2) Case of nD > 1.34274

$$\text{Ref} = 69.7677 + 2740.29 \times (\text{nD} - 1.3538) + 4356.06 \times (\text{nD} - 1.3538)^2$$

8. References

- Jean De Clerck: *Textbook of Brewing*, vol. 2 (1958)
- BCOJ Beer Analysis Method (Rev. Ed.), *Brewery Convention of Japan*, (2013)
- V. BERGLUND,W . EMLINGTON & K. O. RASMUSSEN: über die Verwendung des Zeißschen Refraktometers bei der Malzanalyse, *Wochenschrift far Brauerei*, 51, 233 (1934)
- Official Methods of A. O. A. C., 12th Edition, *Assoc. Official Anal. Chem.* (1975)