Method 9.4 – Boiler, boiler feed water and effluent: total dissolved solids (TDS)

1. Rationale

The method is applicable to boiler water, boiler feed water and effluent and measures the total dissolved solids (TDS) in the sample.

2. Principle

The total dissolved solids in boiler water is determined by either one of two methods. In the first method a sample of water is dried completely and the mass of the residue determined. The second method uses conductivity. Specialised TDS conductivity meters are available which are calibrated directly in TDS units. If a general purpose conductivity meter is used it must be standardised against the drying method. While the drying method gives more reliable results, the conductivity method is much faster. However, conductivity is sensitive to temperature and the necessary corrections must be applied if the meter itself is not able to do temperature compensation.

The total dissolved solids in boiler feed water and effluent is only determined using the drying method.

3. Apparatus

3.1 **Analytical balance** readable to 0.0001 g

3.2 **Evaporating dish**: 200 mm ϕ

3.3 **Oven** operating at 105°C

3.4 **Conical flask**: 250 cm^3

3.5 **Pipette** (graduated): 100 cm^3

3.6 **Beakers**: 250 cm^3

3.7 **Watch glass**: 60 mm ϕ

3.8 **Volumetric flask**: 1 000 cm^3

3.9 **Measuring cylinder**: 500 cm^3

3.10 **Glass beads**

3.11 **Boiling water bath**

3.12 **Funnel**: 100 mm ϕ stemless

3.13 **Desiccator** with self indicating silica gel

3.14 **pH meter**

3.15 Thermometer (optional)

3.16 Filter paper: Whatman No 5 or equivalent, 55 mm ϕ

4. Reagents

4.1 Acetic acid (30 %)

Concentrated acetic acid (also called glacial acetic acid) (CH_3COOH) is a corrosive acid and contact with the skin, eyes and through inhalation should be avoided. Only open acetic acid bottles in a fume cupboard while wearing safety glasses and gloves.

Measure 500 cm^3 distilled water into a 1 000 cm^3 volumetric flask. Add 300 cm^3 glacial acetic acid. The dilution is exothermic and the solution will heat. Cool and make to the mark with distilled water.

4.2 pH Buffer solutions: pH 4 and 7

5. Procedure

5.1 TDS by drying

Add a few glass beads to the evaporator dish and weigh accurately to 0.0001 g. Filter the required volumes as indicated in Table 1 of the sample through a fluted filter paper supported in a funnel which rests directly on a beaker. Pipette the required aliquots as indicated in Table 1 into the evaporating dish. Place the evaporating dish on the boiling water bath until the water has evaporated. Dry the residue in an oven for the required time as indicated in Table 1 at 105°C. Cool the dish in a desiccator and reweigh.

Table 1: Required conditions for different types of samples

Sample	Volume to be filtered (cm^3)	Aliquot to be pipetted (cm^3)	Time for drying (hours)
Boiler water	150	100	1
Boiler feed water	250	200	1
Effluent	120	100	2

5.2 TDS by conductivity (boiler water only)

5.2.1 Calibration of instruments

Following the manufacturer's directions, calibrate the pH meter using the 4.00 and 7.00 pH buffer solutions (compensated for a temperature different from 20 or 25°C) while stirring at a constant rate.

Check the conductivity meter with a standard TDS or conductivity solution on a daily basis. If the reading does not correspond to the solution specification (μS/cm) the instrument must either be calibrated or a cell constant must be calculated and applied to the final reading (as demonstrated in 6.2).

5.2.2 TDS measurement

Transfer 100 cm^3 of boiler water into a 250 cm^3 beaker. Measure the pH while stirring and adjust the pH to 7.0 ± 0.2 by adding the 30% acetic acid solution dropwise.

Rinse the conductivity meter with a portion of the sample and measure the conductivity of a fresh portion of the sample. If the conductivity meter does not have temperature compensation, measure the temperature of the solution.

5.2.3 Standardisation of the conductivity meter

If a TDS specific conductivity meter is used no standardisation is necessary.

If a general purpose conductivity meter is used it must be standardised against the TDS by drying method. Measure the TDS by drying of a standard sample. Also measure the conductivity of the sample using the procedure in 5.2.2. Measure the temperature and apply the temperature correction if the meter is not equipped with temperature compensation as demonstrated in 6.3. Calculate the conversion factor.

6. Calculations

6.1 TDS by drying

$$\text{TDS (mg/litre)} = (M_2 - M_1) \times 1000 \times \frac{1000}{\text{aliquot (cm}^3)}$$

where M_1 ≡ mass of the empty dish (g)
M_2 ≡ mass of the dried dish and residue (g)

6.2 Conductivity cell constant

Measure the conductivity of a standard solution with a known specific conductivity. If the solution temperature is not 20°C and the meter is not equipped with temperature compensation, apply the equation below to the specific conductivity of the standard solution to obtain the theoretical conductivity of the standard solution before calculating the cell constant.

$$\text{Conductivity at T } (\mu\text{S/cm}) = \text{Conductivity at } 20°\text{C} \times [1 + 0.021 \times (T - 20)]$$

where T ≡ Temperature (°C)

$$\text{Cell constant (/cm)} = \frac{\text{theoretical conductivity } (m\text{S/cm})}{\text{conductivity reading } (m\text{S})}$$

The conductivity reading of a sample must be multiplied by the cell constant.

6.3 TDS by conductivity

If a TDS conductivity meter is used read the TDS (mg/litre) directly from the meter.

If a general conductivity meter is used determine a conversion factor as described in 5.2.3. The temperature adjustment must be made to the conductivity reading according to the equation below.

$$\text{Conductivity at } 20°\text{C } (\mu\text{S}) = \frac{\text{conductivity at T } (m\text{S})}{[1 + 0.021 \times (T - 20)]}$$

where T ≡ Temperature (°C)

Calculate the conversion factor using the equation below.

$$\text{Conversion factor} = \frac{\text{TDS by drying (mg/litre)}}{\text{Conductivity } (m\text{S})}$$

Apply the conversion factor to the conductivity reading (corrected for temperature) of the sample to obtain the TDS in mg/litre.

7. Example

7.1 TDS by drying

Mass of the empty dish	=	15.4327 g
Mass of the dried dish and residue	=	15.4958 g

TDS = 631 mg/litre

7.2 TDS by conductivity

Assume that a general purpose conductivity meter is used.

Specified conductivity of a standard solution	=	328 µS/cm at 20°C
Conductivity reading of the standard solution	=	318 µS at 20°C

Cell constant	=	1.03 /cm
TDS of a standard sample by drying	=	631 mg/litre
Conductivity of the standard sample	=	258 µS
Apply the cell constant	=	266 µS/cm
Conversion factor	=	2.45 mg × cm/(litre × µS)
Conductivity of the sample	=	301 µS
Apply the cell constant	=	310 µS/cm
Multiply by the conversion factor	=	760 mg/litre

8. References

SASTA (1985). *Laboratory Manual for South African Sugar Factories*. 3rd Edition: 350 - 351.