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**Method for determination of boron
in flue gas**

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal for establishment of Japanese Industrial Standard submitted by Japan Environmental Management Association for Industry (JEMAI) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

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Method for determination of boron in flue gas

1 Scope

This Japanese Industrial Standard specifies the method for determination of concentration of boron contained in exhaust which is generated by combustion of coal, waste, biomass, etc. and discharged to gas flue, chimney, duct, etc. (hereafter referred to as “flue gas”), by collecting and analysing particulate and gaseous boron respectively, and then by totalling their results. The particulate boron is a general term for boron and its compound contained in the particulate matter collected by the filter of 99.5 % or over in collection efficiency to the particle of 0.3 μm , and the gaseous boron is a general term for boron and its compound which pass through the filter.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

- JIS K 0050 *General rules for chemical analysis*
- JIS K 0095 *Methods for sampling of flue gas*
- JIS K 0116 *General rules for atomic emission spectrometry*
- JIS K 0133 *General rules for high frequency plasma mass spectrometry*
- JIS K 0557 *Water used for industrial water and wastewater analysis*
- JIS K 8150 *Sodium chloride (Reagent)*
- JIS K 8180 *Hydrochloric acid (Reagent)*
- JIS K 8230 *Hydrogen peroxide (Reagent)*
- JIS K 8541 *Nitric acid (Reagent)*
- JIS K 8576 *Sodium hydroxide (Reagent)*
- JIS K 8625 *Sodium carbonate (Reagent)*
- JIS K 8819 *Hydrofluoric acid (Reagent)*
- JIS K 8863 *Boric acid (Reagent)*
- JIS K 9901 *Highly purified nitric acid*
- JIS P 3801 *Filter paper (for chemical analysis)*
- JIS Z 8808 *Methods of measuring dust concentration in flue gas*

3 Principle of analytical method

The particulate boron in flue gas is determined, after it is collected in the sampling equipment using filter paper, by using inductively coupled plasma atomic emission spectrophotometry (hereafter referred to as “ICP emission spectrometry”) or inductively

coupled plasma mass spectrometry (hereafter referred to as “ICP mass spectrometry”). The gaseous boron in flue gas is determined, after the flue gas is absorbed in the absorbing solution, by using the ICP emission spectrometry or ICP mass spectrometry. The concentrations of particulate boron and gaseous boron are totalled and the concentration of boron in flue gas is obtained. The individual minimum limit value of determination for both particulate boron and gaseous boron shall be 0.05 mg/m³ in the case of ICP emission spectrometry and be 0.001 mg/m³ in the case of ICP mass spectrometry by taking the amount of gas sampling as 120 L.

NOTE : The unit of mg/m³ declared in this Standard is the mass concentration under the standard conditions (273.15 K, 101.32 kPa).

4 General matters

The general matters shall be as follows.

- a) The general matters common to the method for gas sampling shall be in accordance with **JIS K 0095** and **JIS Z 8808**.
- b) The general matters common to the chemical analysis shall be in accordance with **JIS K 0050**.
- c) The general matters common to the ICP emission spectrometry shall be in accordance with **JIS K 0116**.
- d) The general matters common to the ICP mass spectrometry shall be in accordance with **JIS K 0133**.
- e) Water to be used for the preparation and analysis of sample solution shall be A3 water specified in clause 4 of **JIS K 0557** or at least equivalent to it in quality. However, it shall be water prepared by using a distiller of silica glass or metal.

5 Sampling method for particulate boron

5.1 General

The sample gas is usually taken at least twice at the same sampling position at intervals of shorter length and analysed respectively.

5.2 Measuring position

The measuring position shall be in accordance with 4.1 of **JIS Z 8808**.

5.3 Measuring point

The measuring point shall be in accordance with 4.3 of **JIS Z 8808**.

5.4 Sampling equipment

The normal type sampling equipment specified in 8.1 (1) of **JIS Z 8808** or the balance type of sampling equipment specified in (2) shall be used. However, for the filter paper, the filter paper containing alumina shall not be used because of adsorbing gaseous boron and the filter paper of silica fibre shall be used. The sampling equipment is classified into type 1 and type 2 by the position of the dust collector, and for type 1, the dust collector is placed inside the duct and for type 2, the dust collector is placed outside the duct.

5.5 Sampling operation

The sampling operation shall be as follows.

a) Preparation of sampling

- 1) **Calculation of suction flow rate for isokinetic sampling** In the case of using the normal type sampling equipment, it shall be obtained according to the calculation formula specified **9.3.1** of **JIS Z 8808**.
- 2) **Preparation of dust collector** The preparation of the dust collector shall be in accordance with **9.3.2** of **JIS Z 8808**.

b) Sampling

The sampling shall be in accordance with **9.4** of **JIS Z 8808**.

- c) **Measurement of suction gas amount** The measurement of the suction gas amount shall be in accordance with **9.5** of **JIS Z 8808**.

5.6 Amount of gas sampling

The amount of gas sampling under the standard conditions (273.15 K, 101.32 kPa) shall be calculated as the dry gas amount (V_{SD}) or the wet gas amount (V_{SW}) according to the following formulae.

a) In the case of obtaining dry gas amount

1) In the case of using wet gas meter

$$V_{SD} = V \times \frac{273.15}{273.15 + t} \times \frac{P_a + P_m - P_v}{101.32} + 22.4l(a + b) \quad \dots\dots\dots (1)$$

2) In the case of using dry gas meter

$$V_{SD} = V \times \frac{273.15}{273.15 + t} \times \frac{P_a + P_m}{101.32} + 22.4l(a + b) \quad \dots\dots\dots (2)$$

b) In the case of obtaining wet gas amount

1) In the case of using wet gas meter

$$V_{SW} = V \times \frac{273.15}{273.15 + t} \times \frac{P_a + P_m - P_v}{101.32} + 22.4l(a + b + c) \quad \dots\dots\dots (3)$$

2) In the case of using dry gas meter

$$V_{SW} = V \times \frac{273.15}{273.15 + t} \times \frac{P_a + P_m}{101.32} + 22.4l(a + b + c) \quad \dots\dots\dots (4)$$

where, V_{SD} : dry gas amount (L)

V_{SW} : wet gas amount (L)

V : gas amount measured by gas meter (L)

t : temperature at gas meter (°C)

P_a : atmospheric pressure (kPa)

$P_m^{1)}$: gauge pressure at gas meter (kPa)

$P_v^{2)}$: saturated vapour pressure of water at t °C (kPa)

$a^{1)}$: gas for the analytical object collected in absorbing solution (mol)

$b^{1)}$: the other gas than that for the analytical object collected in absorbing solution (mol)

$c^{1)}$: amount of water obtained according to clause 6 of **JIS Z 8808** (mol)

273.15 : absolute temperature corresponding to 0 °C (K)

101.32 : pressure corresponding to one atmospheric pressure (kPa)

22.41 : volume of 1 mol of gas at standard condition (L)

Notes ¹⁾ There are many cases where neglect is allowed.

²⁾ See table 1.

6 Sampling method for gaseous boron

6.1 General

The sample gas is usually taken at least twice at the same sampling position at intervals of shorter length and analysed respectively.

6.2 Measuring position

The measuring position shall be in accordance with 5.2.

6.3 Measuring point

The measuring point shall be in accordance with 5.3.

Moreover, when gaseous boron and particulate boron are separately measured, the adjacent measuring point is used. When the adjacent measuring point can not be provided because gas flue, chimney, duct, etc. are small, after it is confirmed that the composition of exhaust gas and the temperature of exhaust gas are stable, the respective samples of gaseous boron and particulate boron are successively taken at the same measuring point.

6.4 Sampling equipment

The sampling equipment to be used shall be as specified in clause 6 of **JIS K 0095** and as follows. The example of construction of sampling equipment is shown in figure 1.