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Continuous analyzers for oxygen in flue gas

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Descriptors : exhaust gases, air pollution, oxygen, determination of content, instrumental methods of analysis

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law.

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Continuous analyzers for oxygen in flue gas

1 Scope This Japanese Industrial Standard specifies the magnetic system (magnetic wind type and magnetic force type) utilizing paramagnetic property of oxygen and the electrochemical system (zirconia type and electrode type) utilizing electrochemical oxidation-reduction reaction among the continuous analyzers (hereafter referred to as “analyzers”), to measure continuously by oxygen in flue gas for the purpose of combustion control and also the analyzers to measure continuously oxygen in flue gas for the purposes of reference oxygen concentration conversion and calculation for the amount of flue gas in public nuisance instrumentation.

Remarks 1. The normative references are as follows.

- JIS C 1302 *Insulation resistance testers (battery operated)*
- JIS K 0055 *General rules for calibration method of gas analyzer*
- JIS K 0095 *Methods for sampling of flue gas*
- JIS K 0213 *Technical terms for analytical chemistry (electrochemistry division)*
- JIS K 1107 *High purity nitrogen*
- JIS Z 8103 *Glossary of terms used in instrumentation*

- 2. The units and numerical values given in { } in this Standard are based on the traditional unit system and are appended for informative reference.
- 3. As the analyzer of measuring principle other than these, there is an analyzer based on the catalyst combustion type, and it is shown in Information 1. The Orsat method as one of the analysis methods for oxygen in flue gas is shown in Information 2.

2 Common matters Common matters of the gas sampling methods shall be in accordance with JIS K 0095. Common matters of the calibration methods of analyzers shall be in accordance with JIS K 0055.

Information The safety handling method of high pressure gas shall be in accordance with the High Pressure Gas Control Law (published on June 7, 1951) (refer to guide book for high pressure gas control handling in environmental atmosphere continuous analysis prepared in October, 1973, by Safety Countermeasure Committee for Environmental Atmosphere).

3 Definitions For the purposes of this Standard, the following definitions and the definitions given in JIS K 0213 and JIS Z 8103 apply.

- (1) **zero gas** The gas to be used for calibration of the minimum scale value of analyzer.

- (2) **span gas** The gas to be used for calibration of the maximum scale value of analyzer.
- (3) **calibration gas** The gas to be used for calibration of analyzer. The generic term of zero gas, span gas, scale setting gas, etc.
- (4) **zero drift** The variation of indicating value to the minimum scale of analyzer in a certain period.
- (5) **span drift** The variation of indicating value corresponding to scale span of analyzer in a certain period.
- (6) **interference component** The coexisting component interfering the measurement.
- (7) **set flow rate** The flow rate of sample gas, calibration gas, etc. set for the analyzer.
- (8) **dumbbell** The bar of which both ends are attached with material having extremely small magnetic susceptibility in comparison with oxygen such as quartz.
- (9) **zirconia** The element of zirconium oxide to conduct oxygen ion corresponding to oxygen concentration (partial pressure).
- (10) **portable type** The analyzer with a purpose of travelling measurement, which is small and light in weight, having characteristic of short warming-up time.
- (11) **stationary type** The analyzer of which gas sampling point is fixed and which has a purpose to measure continuously for a long period and has characteristic superior in stability.

4 Measuring system

4.1 Magnetic system The magnetic system which is to obtain continuously the oxygen concentration by utilizing the attraction force generated at the time of magnetization of oxygen molecule that is paramagnetic material in the magnetic field, shall be divided into the magnetic wind type and the magnetic force type.

Remarks : This system is applicable in the case where the influences of gas (nitrogen monoxide) having a large volumetric susceptibility are negligible.

- (1) **Magnetic wind type** In this type, the intensity of magnetic wind to be generated by loss of magnetic property due to heating of a part of oxygen molecules attracted in the magnetic field shall be detected by hot wire element.
- (2) **Magnetic force type** This type is divided into dumbbell type and pressure detecting type, and shall be as follows:
 - (a) **Dumbbell type** In the dumbbell type, the deflection amount of dumbbell to be generated by the difference of magnetization intensity between the dumbbell and the oxygen in the sample gas shall be detected.
 - (b) **Pressure detecting type** In the pressure detecting type, the discontinuous attraction force acting to oxygen molecule in a magnetic field interrupting periodically shall be detected as the back-pressure changing amount of auxiliary gas flowing into the magnetic field at a definite flow rate.

4.2 Electrochemical system In the electrochemical system, the oxygen concentration shall be obtained continuously by utilizing electrochemical oxidation-reduction reaction and this system shall be divided into zirconia type and electrode type.

- (1) **Zirconia type** In this type, the electromotive force to be generated between the electrodes by setting electrodes at both ends of zirconia element heated at a high temperature and by flowing sample gas to one electrode and air to another electrode, shall be detected.

Remarks : This type is applicable to the case where the influences of inflammable gas (carbon monoxide, methane, etc.) reacting with oxygen at a high temperature or of gas (sulfur dioxide, and the like) corroding zirconia element are negligible or able to be removed.

- (2) **Electrode type** In this type, the electrolytic current to be generated at the time of reduction of oxygen diffuse-absorbed in electrolytic bath through gas permeable diaphragm on the solid electrode surface shall be detected. In this type, there are a constant potential electrolysis type giving reduction potential from outside, a polarograph type and a galvanic cell type constituting galvanic cell.

Remarks : This type is applicable to the case where the influences of gas (sulfur dioxide, carbon dioxide, etc.) causing oxidation-reduction reaction are negligible or removable.

5 Performances The analyzers shall satisfy the following requirements :

- (1) **Measuring range** The measuring scale range of this analyzer shall, as a rule, be 0 to 5 % O₂, 0 to 10 % O₂, and 0 to 25 % O₂, and the measuring range shall be selected by 1 to 3 ranges from these.
- (2) **Repeatability (Reproducibility)** The deviations in the test of 7 (2) shall be within ± 2 % of the maximum scale value for each measuring range.
- (3) **Fluctuation of indication** The fluctuation of indication in the test of 7 (3) shall be not more than 2 % of the maximum scale value for each measuring range.
- (4) **Zero drift** The maximum deviation in the test of 7 (4) shall be within the range of ± 2 % of the maximum scale value for each measuring range per 24h, however, for portable type, it shall be per 4 h.
- (5) **Span drift** The drift in the test of 7 (5) shall be within the range of ± 2 % of the maximum scale value for each measuring range per 24 h, however, for portable type, it shall be per 4 h.
- (6) **Linearity (Indication error)** The indication error in the test of 7 (6) shall be within the range of ± 5 % of the maximum scale value for each measuring range.
- (7) **Response time** The response time in the test of 7 (7) shall be within 4 min. However, that of an analyzer for public nuisance measurement shall be matched with the response time of other analyzer (analyzer for sulfur dioxide in flue gas or analyzer for nitrogen oxide in flue gas).
- (8) **Influence of interfering components** The total sum of influence values of interfering

components in the test of 7 (8) shall be not more than 5 % of the maximum scale value for each measuring range.

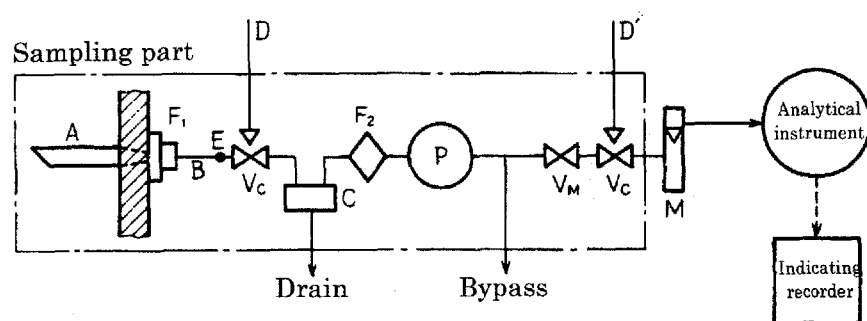
- (9) **Stability to change of environmental temperature** When the environmental temperature shifts by 5 °C from an arbitrary temperature in the service temperature range of 10 (8) in the test of 7 (9), the analyzer shall still satisfy the requirements of 5 (4) and 5 (5). Further, the test results according to 7 (9) are applicable to the temperatures other than that at which the test is executed [provided that it's in the range of using temperature of 10 (8)].
- (10) **Stability to change in flow-rate of sample gas** The change of indication due to fluctuation of ± 5 % of set flow-rate in the test of 7 (10) shall be within the range of ± 2 % of the maximum scale value for each measuring range. However, it is not applicable to the analyzer not specified with set flow-rate.
- (11) **Stability to voltage fluctuation** The results in the test of 7 (11) shall be within the range of ± 1 % of the maximum scale value for each measuring range.
- (12) **Withstand voltage** In the case of an analyzer using commercial power source, abnormalities shall not be caused in the test of 7 (12).
- (13) **Insulation resistance** In the case of an analyzer using commercial power source, the insulation resistance shall be not less than 2 M Ω in the test of 7 (13).
- (14) **Transmission output** Where the analyzer for public nuisance measurement requires the transmission output other than that for the recorder, the transmission output shall be DC 0 to 1 V or 1 to 5 V (in either cases, the internal resistance, 500 Ω max.) or DC 4 to 20 mA which are in linear proportional relation with oxygen concentration.

6 Construction of Analyzers

6.1 General construction The analyzer in the case of measuring under the near dry gas condition, hereafter referred to as the "dry gas base", shall consist of a sampling part, analytical instrument, indicating recorder, etc. as shown in Fig. 1-1 and Fig. 1-2 for example. In Fig. 1-1, the sampling part and indicating recorder are shared with other analyzer for example with sulfur dioxide analyzer, and nitrogen oxide analyzer in some cases.

Further, for the analyzer in the case of measuring under the wet gas condition, hereafter referred to as the "wet gas base", the construction examples are shown in Fig. 1-3 and Fig. 1-4.

Further, the indicated value of analyzer of wet gas base shall, as required, be converted to dry gas base.



where A : Sampling tube
 B : Conduit
 C : Dehumidifier
 D, D' : Calibration gas introducing inlet
 E : Sample introducing inlet
 F₁ : Coarse filter
 F₂ : Microfilter
 M : Flowmeter
 P : Pump
 V_C : Directional control valve
 V_M : Throttle valve

Fig. 1-1 Example of construction of analyzer (An example of dry sampling)

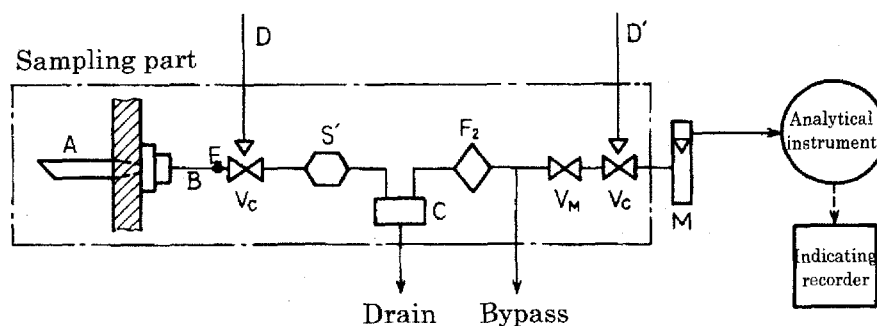


Fig. 1-2 Example of construction of analyzer (An example of wet sampling)

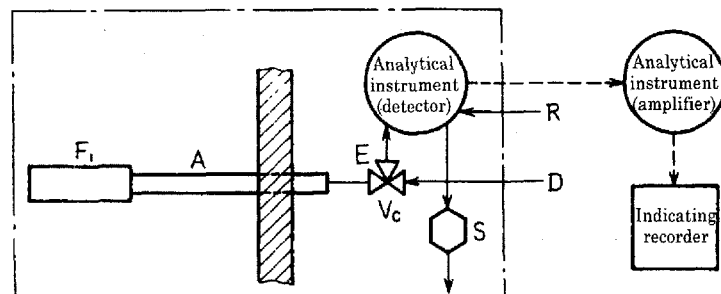
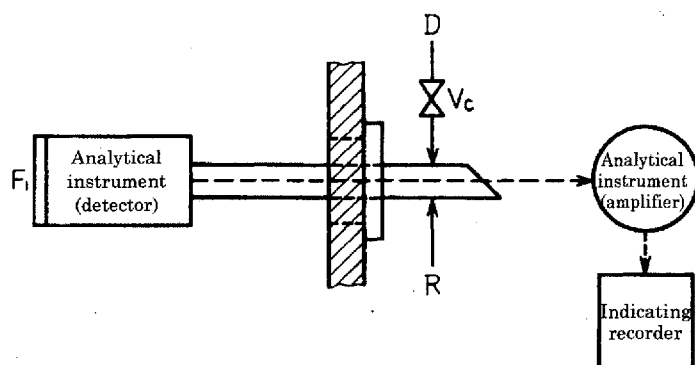


Fig. 1-3 Example of construction of analyzer (An example of direct connecting type)



- | | |
|---|--------------------------------------|
| where A : Sampling tube | $\dot{M}$: Flowmeter |
| B : Conduit | R : Comparison gas introducing inlet |
| C : Dehumidifier | S : Aspirator |
| D, D' : Calibration gas introducing inlet | S' : Aspirator (water jet) |
| E : Sample introducing inlet | V_C : Directional control valve |
| F_1 : Coarse filter | V_M : Throttle valve |
| F_2 : Microfilter | |

Fig. 1-4 Example of construction of analyzer (An example of direct inserting type)

6.2 Sampling part The sampling part is a part to remove dust in the sample gas and to supply the sample gas continuously at a constant rate to the analytical instrument while keeping the amount of moisture content constant as required, and it consists of a sampling tube, coarse filter, conduit, dehumidifier, microfilter, suction pump or sample gas suction apparatus such as aspirator, flowmeter, directional control valve, throttle valve, calibration gas introducing inlet, etc. and shall be as follows.

Further, in the case of measuring oxygen, carbon dioxide, carbon monoxide, etc. for the purpose of combustion control and the like, the part made of other material than those specified in the following may be used.

- (1) **Sampling tube** The sampling tube is a tube for sampling the gas which is attached to the flue wall or the like, and that made of stainless steel, ceramics, quartz, etc. shall be used.
- (2) **Coarse filter** The coarse filter shall be used to remove dust in the sample gas at a temperature for the moisture content not to condensate. For the filter element, stainless steel net, ceramics, carborundum, etc. shall be used.
- (3) **Conduit** The conduit is a tube to introduce the sample gas to the sample introducing inlet from the coarse filter, and shall, as a rule, be made of tetrafluoroethylene resin, and further it shall be insulated or heated so as not to keep the moisture content from condensing, as required.
- (4) **Dehumidifier** The dehumidifier is an apparatus to remove the moisture content in the sample gas or reaction gas by a method such as condensation, and the type of air cooling, electron cooling, or the like shall be used.