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**Automated measuring systems
and analyzers for nitrogen oxides
in flue gas**

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. Consequently **JIS B 7982 : 1995** is replaced with **JIS B 7982 : 2002**.

This revision is made based on **ISO 10849 : 1996** *Stationary source emissions—Determination of the mass concentration of nitrogen oxides—Performance characteristics of automated measuring systems* in order to make Japanese Industrial Standard conform to International Standard.

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In the event of any doubts arising as to the contents,
the original JIS is to be the final authority.

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Automated measuring systems and analyzers for nitrogen oxides in flue gas

Introduction This Japanese Industrial Standard has been prepared based on the first edition of **ISO 10849 Stationary source emissions—Determination of the mass concentration of nitrogen oxides—Performance characteristics of automated measuring systems** published in 1996 without any modification in technical contents with respect to the corresponding parts and the following items are added from **JIS B 7982 : 1995**.

a) nitrogen oxides b) ozone source gas and c) sample gas of clause 3 Definitions, clause 4 Performance of measuring instrument, 5.1 General construction, 5.5 Indicating recorder, clause 6 Marking, clause 7 Instruction manual, Annex 1 (normative) Controlled potential electrolysis system analyser, Annex 2 (normative) Type and measuring range of measuring instruments and clause 2 of Annex 4 (normative) Performance test of measuring instruments.

In addition, the detailed explanatory contents were added to each item of 5.2 Composition, 5.3 Sampling unit of extractive method and 5.4 Analyser. Furthermore, the portions with underlines of dots or sidelines are the matters which are not specified in the corresponding International Standard.

1 Scope This Standard specifies automated measuring systems (hereafter referred to as “measuring systems”) and automated measuring instruments (hereafter referred to as “measuring instruments”) which are used to continuously measure the concentration of nitrogen monoxide, nitrogen dioxide or nitrogen oxides in flue gas in the stationary sources, using the extractive method. However, this Standard does not apply to the measurement of dinitrogen monoxide (N₂O).

The classification of measuring principle is as follows:

- a) Chemiluminescence system
- b) Infrared absorption system
- c) Ultraviolet absorption system
- d) Differential optical absorption spectrometry (DOAS)

Remarks 1 Analysers based on the measuring principles other than those mentioned above include analysers based on controlled potential electrolysis system, which is described in Annex 1 (normative).

2 The type and measuring range of measuring instruments are described in Annex 2 (normative), the facilities for measurement and measuring range in Annex 7 (informative), and the supplementary performance of measuring system in Annex 8 (informative).

3 Since the measuring systems and measuring instruments for nitrogen oxides in accordance with the non-extractive method are described in **JIS B 7992**, all of the contents in **ISO 10849** correspond by using this Standard together with it.

- 4 The International Standard corresponding to this Standard is as follows.

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21**.

ISO 10849 : 1996 *Stationary source emissions—Determination of the mass concentration of nitrogen oxides—Performance characteristics of automated measuring systems (MOD)*

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

JIS C 1302 *Insulation resistance testers*

JIS K 0001 *Reference material—Standard gas—Nitrogen monoxide*

JIS K 0003 *Reference material—Standard gas—Carbon dioxide*

JIS K 0004 *Reference material—Standard gas—Sulfur dioxide*

JIS K 0104 *Methods for determination of nitrogen oxides in flue gas*

JIS K 0151 *Non-dispersive infrared gas analyzer*

3 Definitions For the purposes of this Standard, the following definitions shall apply.

- a) **nitrogen oxides** The total quantity of nitrogen monoxide and nitrogen dioxide.
- b) **ozone source gas** Oxygen or gas containing oxygen for generating ozone (dry air, argon-diluted oxygen or the like).
- c) **sample gas** The gas which has been pretreated by passing through the primary filter, dehumidifier or the like to be introduced into an analyser.
- d) **stationary source emissions** Those gases that have been emitted by a stationary plant or process and are transported to a chimney for dispersion into the atmosphere.
- e) **chimney** Stack or final exit duct on a stationary process used for the dispersion of residual process gases.
- f) **analyser** An analyzing unit in a measuring instrument.
- g) **automated measuring system** A complete system that may be attached to a chimney to continuously measure and record the mass concentration of the measuring object passing through the chimney.
- h) **calibration** To mark out a scale of measuring instrument using calibration gas before beginning any measurement.

- i) **calibration curve** Curve describing the relation between the concentration of calibration gas and the indicated value of analyser.
- j) **calibration gas** Standard gas used for marking out a scale of measuring instrument. A generic term for zero gas, span gas, intermediate point gas, etc.
- k) **comparative measurements** Measurements that are performed in the same chimney in the same sampling plane for the same period of time by the comparative method.
- l) **comparative method** Method for comparing the measurement performed by measuring instruments installed at the site for measurement with that by measuring systems or chemical analysis methods of which performance was confirmed.
- m) **standard deviation** A measure of the working accuracy determined by performing statistical analysis of results obtained from sufficient number of comparative measurements.
- n) **mass concentration** Concentration of a substance in flue gas expressed in mg/m^3 .
- o) **volume concentration** Concentration of a substance in flue gas expressed in volppm.

In addition, the conversion between volume concentration in volppm and mass concentration in mg/m^3 is performed according to the following relation.

$\text{NO} \quad 1 \text{ volppm} = 1.34 \text{ mg/m}^3$

$\text{NO}_2 \quad 1 \text{ volppm} = 2.05 \text{ mg/m}^3$

(under conditions of pressure of 101.32 kPa, temperature of 273.15 K and dry gas)

4 Performance of measuring instrument When performing the test in accordance with the performance test of Annex 4 (normative), measuring instruments shall meet the following performance.

Table 1 Performance of measuring instrument

Item	Performance	Test method
Repeatability	± 2 % of the maximum scale value	2.2 a) of Annex 4
Zero drift	± 2 % of the maximum scale value	2.2 b) of Annex 4
Span drift	± 2 % of the maximum scale value	2.2 c) of Annex 4
Indication error	± 2 % of the maximum scale value	2.2 d) of Annex 4
Response time	2 min or less	2.2 e) of Annex 4
Effect of interfering substances	5 % or less (chemiluminescence system)	2.2 f) of Annex 4
	5 % or less of the maximum scale value (other systems)	
Stability against flow rate change of sample gas	± 2 % of the maximum scale value	2.2 g) of Annex 4
Stability against voltage fluctuation	± 1 % of the maximum scale value	2.2 h) of Annex 4
Withstand voltage	No anomalous behavior	2.2 i) of Annex 4
Insulation resistance	5 M Ω or more	2.2 j) of Annex 4

5 Construction

5.1 General construction The construction of measuring instrument shall conform to each of the following.

- Its shape shall be correct, and the assembling and finish of each part shall be superior and solid.
- There shall be no apprehension to generate any dangerous condition under usual operation, and it works safely and smoothly.
- Each device shall be constructed so as not to easily malfunction mechanically or electrically and not to create any dangerous situation.
- It shall be constructed so as not to admit water condensation which may result in malfunction of the measuring instrument.
- Parts which contact any heating device, such as a light source or heater, shall not deform or change functionally owing to heat.
- When performing maintenance or checking, it shall have a construction which lends itself to easy operation with no danger.

5.2 Composition The composition shall be classified into the following two types.

- Extractive method** The method in which the sample gas is extracted from the flue gas by a suction pump, provided continuously to the analyser by removing moisture or by keeping it at a fixed amount as necessary.

As shown in Fig. 1 and Fig. 2, the extractive method shall be composed of a sampling unit, analyser, indicating recorder, etc.

An example of composition of automated measuring instruments for nitrogen monoxide/nitrogen oxides is shown in Fig. 1, and an example of composition of automated measuring instruments for nitrogen monoxide in Fig. 2.

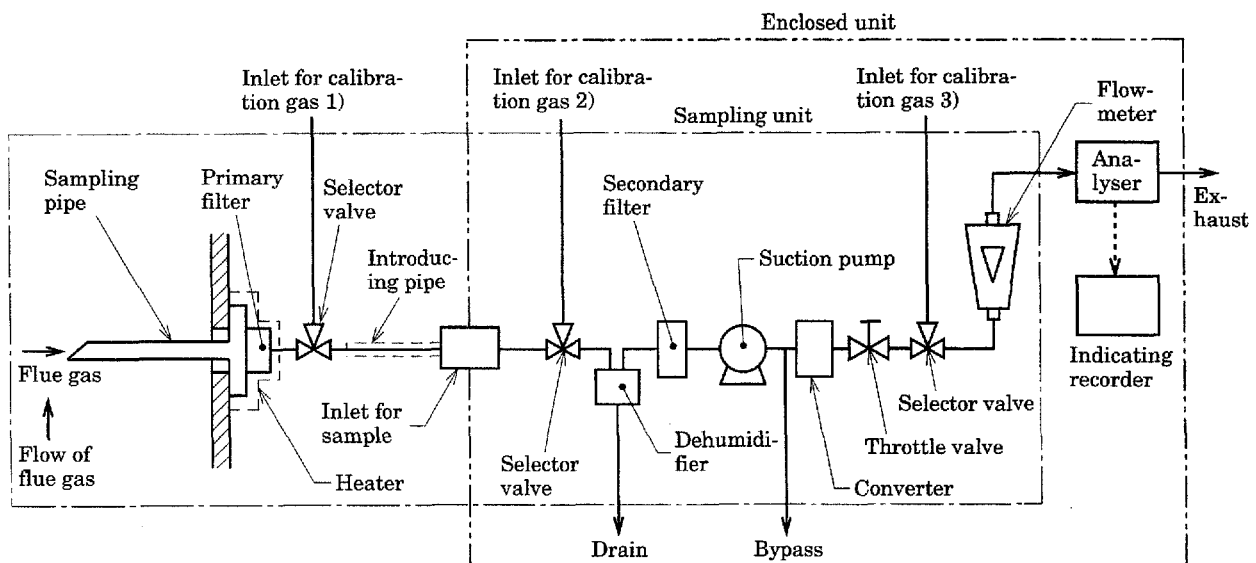


Fig. 1 Example of extractive method for measuring nitrogen oxides

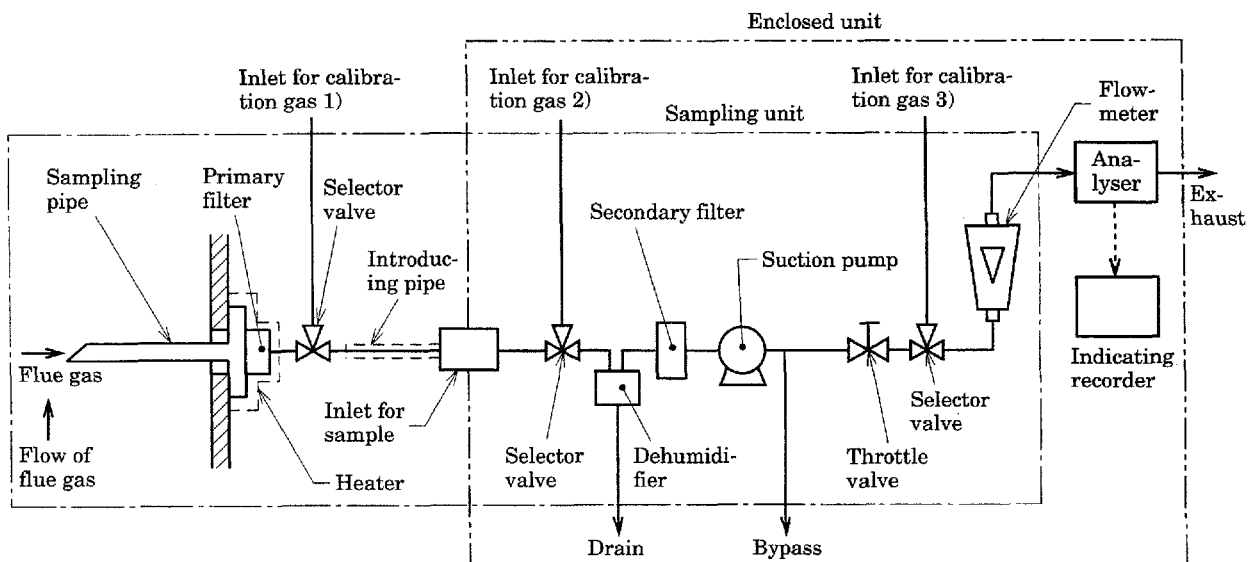


Fig. 2 Example of extractive method for measuring nitrogen monoxide

The inlets for calibration gas shall be located at three positions as shown in the figure, and shall be used appropriately, selectively, so as to serve the purpose.

- 1) Calibration of measuring systems
- 2) Calibration of measuring instruments
- 3) Calibration of analysers

- b) **Diluting method of sample gas** The method in which the sample gas extracted from the flue gas is provided continuously to the analyser after the dew point is lowered by diluting it with gas which does not have effects on nitrogen oxides. This method is shown in Annex 5 (normative).

5.3 Sampling unit of extractive method This sampling unit shall have functions to remove dust in the flue gas and to remove moisture or to keep moisture at a constant amount as required, and shall provide a constant amount of required sample gas continuously into the analyser while the loss of object components is controlled to be as small as possible. It shall be composed of a sampling pipe, primary filter, introducing pipe, dehumidifier, secondary filter, suction pump, flowmeter, selector valve, throttle valve, inlet for calibration gas, etc.

- a) **Sampling pipe** The pipe for collecting sample gas which is attached to the wall of gas flue. It is made of tetrafluoroethylene resin, stainless steel, ceramics, quartz or borosilicated glass. For materials used for sampling pipe, select in consideration of the following.
- 1) Tetrafluoroethylene resin is usable in the case where the temperature of sample gas is up to 220 °C.
 - 2) Stainless steel, ceramics, borosilicated glass, etc. are usable also in the case where the temperature of sample gas is 250 °C or higher. Stainless steel has a possibility of making the ratio of nitrogen monoxide and nitrogen dioxide change. Therefore, when it is necessary to measure nitrogen monoxide and nitrogen dioxide individually, ceramics or borosilicated glass is required to be used. In order to sample gas without making the concentration in flue gas change, the cooling may be applied.
- b) **Primary filter** This filter is for removing dust from the flue gas and shall be used at a temperature which does not allow moisture or acid to be condensed. It shall be made of silica glass fibre, stainless steel nets, sintered metal, porous ceramics or the like.
- c) **Introducing pipe** This is for introducing flue gas from the primary filter to the inlet for sample. It shall be made of tetrafluoroethylene resin, stainless steel or the like.
- In addition, the introducing pipe from the primary filter to the dehumidifier shall be heated, as necessary, so that moisture or acid may not be condensed.
- d) **Dehumidifier** This is a device to remove moisture in the flue gas. The air cooling, electronic cooling method or the like, or the gas phase dehumidifying method based on selective permeation of steam through a semipermeable membrane or the like shall be used.
- e) **Secondary filter** This filter is for removing fine dust in the sample gas, and materials such as fused quartz wool, glass wool, sintered ceramics, stainless steel, tetrafluoroethylene fibre shall be used.
- f) **Suction pump** This is a pump for sucking-in the sample gas or the like, and as to the system in contact with gas, the corrosion resistant material, for example rigid vinyl chloride, fluororubber, polytetrafluoroethylene resin or the like shall be used.

- g) **Flowmeter and throttle valve** These are for setting the flow rate, and their materials shall have corrosion resistance.
- h) **Selector valve** A manual valve or electromagnetic valve shall be used, and its material shall have corrosion resistance.
- i) **Converter** The converter is for converting nitrogen dioxide in flue gas into nitrogen monoxide, and is required when measuring nitrogen dioxide with a nitrogen monoxide measuring instrument. Test methods, etc. are described in Annex 6.

5.4 Analyser

5.4.1 Analyser by DOAS (differential optical absorption spectrometry) This analyser measures the concentration from the difference of absorption signal between the peak of absorption and the end in a wavelength region with absorption of the object component. The typical measuring wavelength is near 215 nm to 226 nm for nitrogen monoxide, 330 nm to 550 nm for nitrogen dioxide.

5.4.2 Analyser by chemiluminescence system This analyser measures the intensity of luminescence based on the principle that nitrogen monoxide in a photochemically excited state which is produced when making nitrogen monoxide react with ozone emits light.

It shall be composed of a flow-rate controlling section, reaction tank, photometric section, ozone generator, etc. as given in Fig. 3.

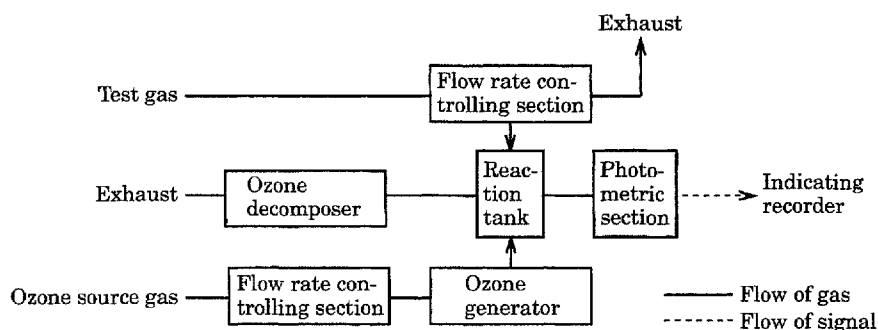


Fig. 3 An example of composition of chemiluminescence analyser

- a) **Flow rate controlling section** The flow rate controlling section of the sample gas and ozone source gas shall consist of the resistance tube, pressure adjuster and needle valve for specified flow rate control, and float type variable area flowmeter and pressure gauge for monitoring of flow rate, etc.
- b) **Reaction tank** The reaction tank is the section where the sample gas and the gas containing ozone are introduced, mixed and contacted with each other to generate chemiluminescence, and is classified into the reduced pressure type and ordinary pressure type according to the inner pressure conditions.
- c) **Photometric section** The photometric section is the section where the chemiluminescence of nitrogen monoxide and ozone are received, and are converted into signals of required magnitude for indicating recorder, and shall consist of

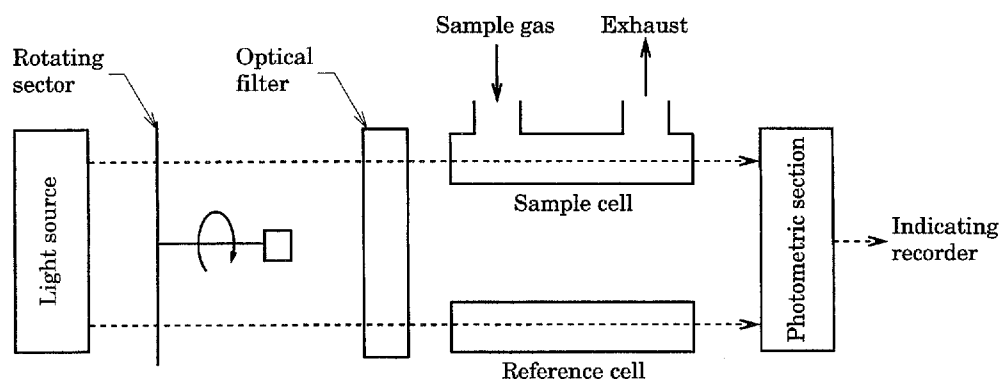
the optical filter, photomultiplier or semiconductor photoelectric conversion elements, amplification circuit, etc.

- d) **Ozone generator** The ozone generator is that, in which the oxygen in the supplied ozone source gas is converted into ozone, and shall use silent discharge, ultraviolet irradiation, etc.
- e) **Ozone decomposer** The ozone decomposer shall be that capable of decomposing the ozone in the exhaust gas discharged from the reaction tank into oxygen by means of catalytic thermal cracking or the like.

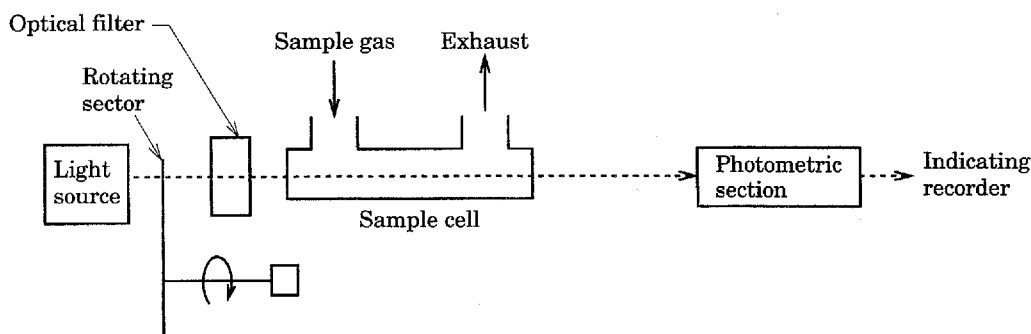
5.4.3 Analyser by infrared absorption system (infrared gas analyser) This analyser measures infrared absorption based on the principle that infrared absorption spectrum of nitrogen monoxide molecule appears at wave number with centre at $1\,876\text{ cm}^{-1}$ ($5.3\text{ }\mu\text{m}$).

The infrared gas analyser unit shall be in accordance with **JIS K 0151**.

The infrared gas analyzing unit shall be the wave length non-dispersion, positive filter system, and be composed of the light source, rotating sector, optical filter, sample cell, comparison cell, photometric section, etc. as given in Figs. 4 a) and b).



a) Double beam type



b) Single beam type

Fig. 4 Examples of composition of infrared gas analyser

- a) **Light source** Generally, a resistor such as nichrome wire or silicon carbide heated by passing electric current shall be used.

- b) **Rotating sector** This sector is for modulating optically the beams passing through the sample cell and reference cell by intermittent interruption at a constant period. The interrupting method shall be either alternating interruption or simultaneous interruption of which frequency is from 1 Hz to 20 Hz.
- c) **Optical filter** This filter shall be either gas filter or solid filter, or the combination of them, having functions to absorb and eliminate the infrared rays in absorption wavelength range of interference substances contained in the sample gas.
- d) **Sample cell** This cell shall be constructed so that the sample gas passes continuously and the cell window shall be made of materials capable of passing infrared rays such as calcium fluoride plate (CaF_2 plate).
- e) **Comparison cell** This cell has the same form as the sample cell, and it shall be filled with nitrogen gas or the like.
- f) **Photometric section** This section shall have the function to convert the absorption of infrared into electric signals of intensity required for indication recording. It shall consist of a photoelectric conversion unit and an amplifying circuit and the like.

5.4.4 Analyser by ultraviolet absorption system This analyser measures ultraviolet absorption based on the principle that ultraviolet absorption spectrum of nitrogen monoxide molecule appears near at 226 nm.

The ultraviolet absorption analyser shall be composed of the light source, sample cell, spectroscope, photometric section, etc. as shown in Fig. 5.

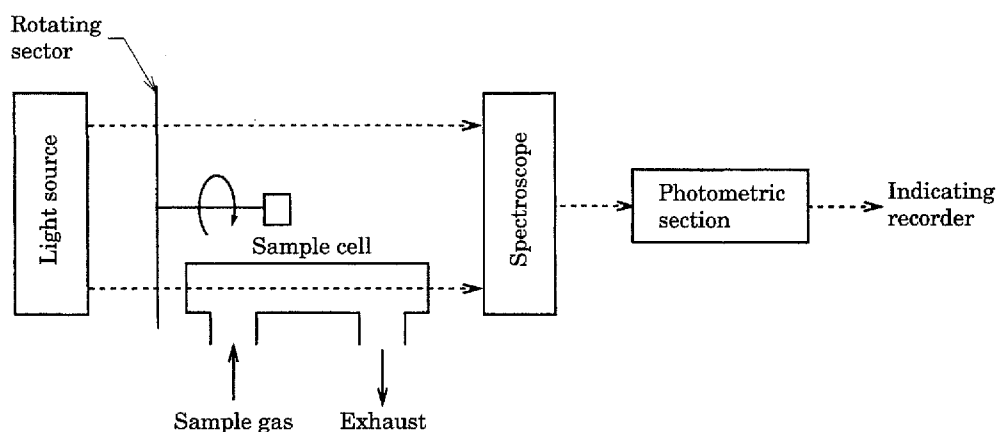


Fig. 5 An example of composition of ultraviolet absorption analyser

- a) **Light source** A deuterium lamp or medium-pressure mercury lamp shall be used.
- b) **Sample cell** This cell shall be constructed so that the sample gas passes continuously, and the cell window shall be made of materials such as quartz glass plate capable of passing ultraviolet rays and visible light.
- c) **Spectroscope** A spectroscope by which ultraviolet rays or visible monochromatic light is obtained with a prism, diffraction grating spectroscope or the like shall be used.

- d) **Photometric section** This section shall have the function to convert the absorption of ultraviolet rays into electric signals of intensity required for indication recording, and shall consist of phototube, photomultiplier or photoelectric conversion elements of semiconductor sensitive enough to detect ultraviolet rays and amplification circuit, etc.
- e) **Rotating sector** This sector is for modulating optically the beams passing through the sample cell and not passing through the reference cell by intermittent interruption at a constant period.

5.5 Indicating recorder In general, the concentration of nitrogen oxides shall be indicated and recorded on a uniform scale. If a digital display is used, the units of measurement shall be printed.

6 Marking The measuring instrument shall be marked with the following information on conspicuous places by an indelible method.

- a) Name and type name specified by the manufacturer
- b) Components to be measured
- c) Concentration range for measurement
- d) Working temperature range
- e) Type of electric power source and capacity
- f) Manufacturer's name or abbreviation
- g) Year and month of manufacture
- h) Serial number

Remarks : These information need not necessarily be marked in one place.

7 Instruction manual The instruction manual shall mention at least the following items.

- a) Site for installation
- b) Allowable ranges of sample gas temperature, its flow rate, its dust concentration, and interfering substances
- c) Pretreatment method of sample gas
- d) Piping and wiring
- e) Time for warming up
- f) Method of use
 - 1) Preparation of measurement and calibration
 - 2) Measuring procedures
 - 3) Dealing when measurement is stopped

- g) Maintenance and checking
 - 1) Guide for routine checking
 - 2) Guide for periodical checking
 - 3) Cleaning of flow channel
 - 4) Countermeasures to be taken at the time of troubles

Related standards :

- JIS K 0055 *General rules for calibration method of gas analyzer*
- JIS K 0095 *Methods for sampling of flue gas*
- JIS K 0211 *Technical terms for analytical chemistry (General part)*
- JIS K 0212 *Technical terms for analytical chemistry (optical part)*
- JIS K 0213 *Technical terms for analytical chemistry (Electrochemistry division)*
- JIS K 0215 *Technical terms for analytical chemistry (analytical instrument part)*
- JIS Z 8103 *Glossary of terms used in measurement*
- ISO 6879 : 1995 *Air quality—Performance characteristics and related concepts for air quality measuring methods*
- ISO 7996 : 1985 *Ambient air—Determination of the mass concentration of nitrogen oxides—Chemiluminescence method*
- ISO 9096 : 1992 *Stationary source emissions—Determination of concentration and mass flow rate of particulate material in gas-carrying ducts—Manual gravimetric method*
- ISO 9169 : 1994 *Air quality—Determination of performance characteristics of measurement methods*
- ISO 10396 : 1993 *Stationary source emissions—Sampling for the automated determination of gas concentrations*