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**Automated measuring systems
and analyzers for sulfur dioxide
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 7981 : 1996** is replaced with **JIS B 7981 : 2002**.

This revision has been made based on **ISO 7935 : 1992** *Stationary source emissions—Determination of the mass concentration of sulfur dioxide—Performance characteristics of automated measuring methods* 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 sulfur dioxide in flue gas

Introduction This Japanese Industrial Standard has been prepared based on the first edition of **ISO 7935** *Stationary source emissions—Determination of the mass concentration of sulfur dioxide—Performance characteristics of automated measuring methods* published in 1992 and the following items are added and altered.

- 1) **Added contents** a) sample gas b) dispersion type c) non-dispersion type of clause 3 Definitions, clause 4 Performance of measuring instrument, 5.1 General construction, 5.5 Indicating recorder, clause 6 Markings, clause 7 Instruction manual, Annex 1 (normative) Controlled potential electrolysis system analyzer, Annex 2 (normative) Type and measuring range of measuring instrument, clause 2 Performance test of measuring instrument of Annex 4 (normative), Annex 5 (informative) Flame photometric detecting analyzer
- 2) **Changes** Measuring system response time Annex 3 (normative)

In addition, portions with dotted underlines or continuous 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 sulfur dioxide in flue gas in the stationary sources, using the extractive method.

The classification of measuring principle is as follows:

- a) Conductometric analysis
- b) Infrared absorption analysis
- c) Ultraviolet absorption analysis
- d) Ultraviolet fluorescence analysis
- e) Interferometry

Remarks 1 Analyzers based on the measuring principles other than those mentioned above include analyzers based on controlled potential electrolysis system, which is described in Annex 1 (normative), and flame photometric detecting system, which is described in the Annex 4 (informative).

2 The type and measuring range of measuring instruments are described in Annex 2 (normative), and the facilities for measurement and measuring range in Annex 6 (informative).

3 Since the measuring systems and instruments for sulfur dioxide in accordance with the non-extractive method are described in **JIS B 7991**, all of the contents in **ISO 7935** corresponds 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 7935 : 1992 *Stationary source emissions—Determination of the mass concentration of sulfur dioxide—Performance characteristics of automated measuring methods (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 0003 *Reference material—Standard gas—Carbon dioxide*

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

JIS K 0055 *General rules for calibration method of gas analyzer*

JIS K 0103 *Methods for determination of sulfur oxides in flue gas*

JIS K 0151 *Non-dispersive infrared gas analyzer*

ISO 7934 *Stationary source emissions—Determination of the mass concentration of sulfur dioxide—Hydrogen peroxide / barium perchlorate / Thorin method*

ISO 10396 *Stationary source emissions—Sampling for the automated determination of gas concentrations*

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

- a) **sample gas** The gas which has been pretreated by passing through the primary filter, dehumidifier or the like to be introduced into an analyzer.
- b) **dispersive type** A type of measuring instruments that has an optical system making wavelength dispersion with a prism or diffraction grating.
- c) **non-dispersive type** A type of measuring instruments which employs either an optical filter or a detector with wavelength selectivity, instead of an optical system making wavelength dispersion with a prism or diffraction grating.
- d) **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.
- e) **analyzer** Analytical part in an automated measuring system.
- f) **calibration gas** Standard gas used for marking out a scale of measuring instrument. A general term for zero gas, span gas, intermediate point gas, etc.

- g) **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.
- h) **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.
- i) **chemical analysis method** Test method specified in JIS K 0103 or ISO 7934 for manual sampling and analysis of flue gas.
- j) **integral performance, S_A** A measure of the working accuracy determined by performing statistical analysis (standard deviation, etc.) of results obtained from sufficient number of comparative measurements.
- k) **chimney** Stack or final exit duct on a stationary process used for the dispersion of residual process gases.
- l) **stationary source emissions** Those gases that have been emitted by a stationary plant or processes and are transported to a chimney for dispersion into the atmosphere.
- m) **mass concentration** Concentration of a substance in flue gas expressed in mg/m^3 or g/m^3 .
- n) **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 g/m^3 is performed according to the following relation.

$$\text{SO}_2 \quad 1 \text{ volppm} = 0.00286 \text{ g/m}^3$$

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

4 Performance of measuring instrument When performing the test in accordance with the performance test in clause 2 of Annex 4 (normative), the measuring instrument 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	15 min or less (conductometric analysis) 4 min or less (infrared absorption analysis) 4 min or less (ultraviolet absorption analysis) 4 min or less (ultraviolet fluorescence analysis) 4 min or less (interferometry)	2.2 e) of Annex 4
Effect of interfering substances	5 % or less of the maximum scale value	2.2 f) of Annex 4
Stability against flow rate change of sample gas	± 2 % of the maximum scale value	2.2 g) of Annex 4
Stability against voltage fluctuation	± 2 % 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 inspection, 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, passed through the introducing pipe kept warm, passed through

the sample pre-treatment apparatus, and provided continuously to the analyzer. As shown in Fig. 1, this method shall be composed of a sampling unit, analyzer, indicating recorder, etc.

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

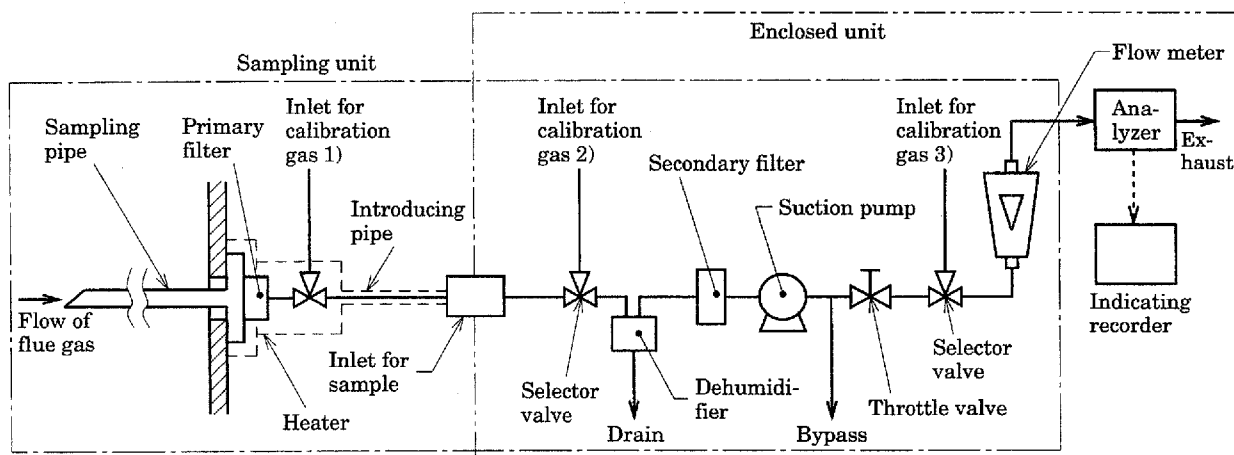


Fig. 1 Example of extractive method

- 1) Calibration of measuring systems
 - 2) Calibration of measuring instruments
 - 3) Calibration of analyzers
- b) **Diluting method of sample gas** The method in which the dew point of extracted gas is lowered by diluting the extracted sample gas with a large amount of instrumentation air or dilution gas, and the sample gas is provided continuously to the analyzer without heating and keeping warm (see **ISO 10396**).

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 analyzer 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, which is attached to the wall of gas flue, is for collecting sample gas. It shall be made of stainless steel, ceramics or quartz.
- 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 fiber or stainless steel nets.
- c) **Introducing pipe** This pipe is for introducing the flue gas from the primary filter to the inlet for sample. It is generally made of tetrafluoroethylene resin. In order to prevent the measurement error due to decrease of sulfur dioxide on the way of suction path, the sample introducing pipe shall be heated at the temperature of sulfuric acid dew point of sample gas or over.

- 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 from the sample gas, and materials such as silica fiber, tetrafluoroethylene resin shall be used.
- f) **Suction pump** This is a pump for sucking-in the sample gas, and a diaphragm type is generally used. The site contacting gas shall be made of corrosion resistant material, for example, rigid polyvinyl chloride.
- g) **Flowmeter** The corrosion resistance shall be taken into consideration. A float-type variable area flowmeter or the like is used.
- h) **Selector valve** A manual valve or electromagnetic valve shall be used, and its materials shall have corrosion resistance.
- i) **Throttle valve** A needle valve or the like shall be used, and their materials shall have corrosion resistance.

5.4 Analyzer

5.4.1 Conductometric analyzer As shown in Fig. 2, the conductometric analyzer is composed of a reference electrode, gas absorbing device, measurement electrode, sending pump for liquid absorbent, liquid absorbent tank, amplifier, and waste liquid tank. In this analysis method, a total amount of sulfur oxides is measured, so care shall be taken.

Remarks : It shall be composed so as not to generate a thermal difference between the inside liquid absorbent in the reference electrode and that in the measurement electrode.

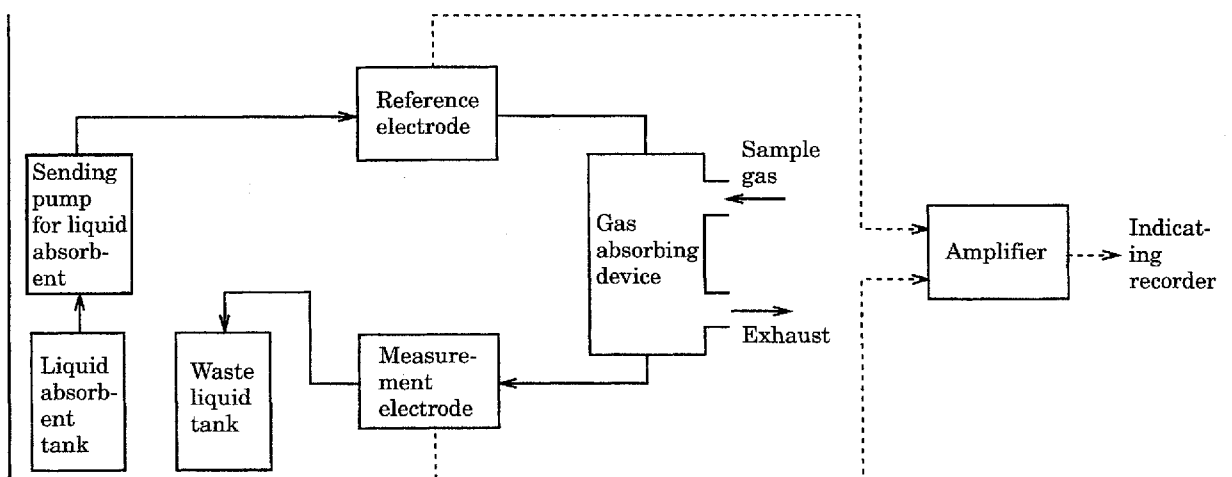


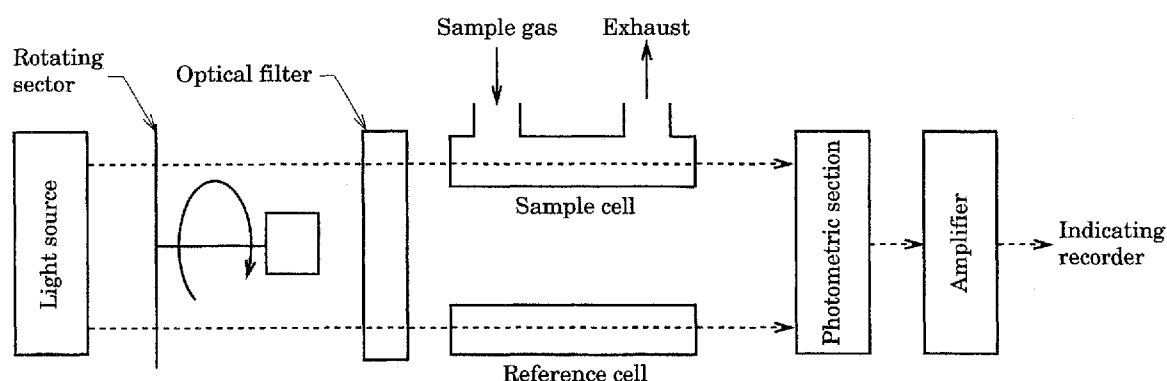
Fig. 2 Example of composition of conductometric analyzer

- a) **Reference electrode** This is an electrode for detecting the conductivity of liquid absorbent prior to aeration of the sample gas. It shall be made of corrosion resistant material against liquid absorbent, which does not cause deterioration of the liquid absorbent.

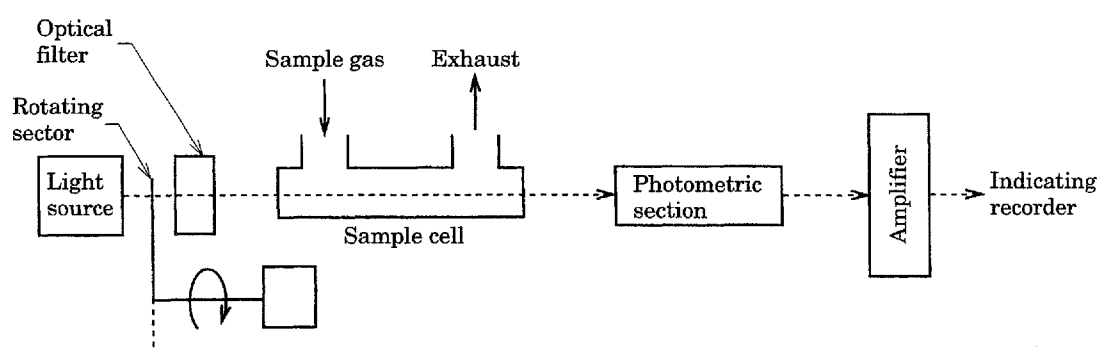
- b) **Gas absorbing device** This device is for introducing liquid absorbent and sample gas at the set flow rate and for trapping the sulfur dioxide in the sample gas into the liquid absorbent. It shall be made of corrosion resistant material against liquid absorbent, which does not cause deterioration of the liquid absorbent.
- c) **Measurement electrode** This is an electrode for measuring the conductivity of the liquid absorbent after trapping the sulfur dioxide in the sample gas. It shall be made of corrosion resistant material against liquid absorbent, which does not cause deterioration of the liquid absorbent.
- d) **Sending pump for liquid absorbent** This pump is for sending liquid absorbent at constant rate from the liquid absorbent tank to the gas absorbing device. The part contacting with the liquid shall be made of corrosion resistant material against liquid absorbent, which does not cause deterioration of the liquid absorbent.
- e) **Liquid absorbent tank** The material shall be corrosion resistant against liquid absorbent, which does not cause deterioration of the liquid absorbent.
- f) **Liquid absorbent** Hydrogen peroxide solution, acidified with sulfuric acid, of concentration specified in the instruction manual.

5.4.2 Infrared gas analyzer The infrared gas analyzer shall comply with **JIS K 0151**.

This infrared gas analyzer is a non-dispersion wavelength, positive filter type, and as shown in Fig. 3 a) and Fig. 3 b) it is composed of a light source, rotating sector, optical filter, sample cell, reference cell, photometric section, amplifier, etc.



a) Double light beam type



b) Single light beam type

Fig. 3 Example of composition of infrared gas analyzer

- 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 those, having functions to absorb and eliminate the infrared 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 windows at both ends shall be made of materials capable of passing infrared rays.
- e) **Reference cell** This cell has the same form as the sample cell, and it shall be filled with argon or nitrogen gas.
- 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.

5.4.3 Ultraviolet absorption analyzer As shown in Fig. 4 a) and Fig. 4 b), this analyzer shall be composed of a light source, spectroscopy or optical filter, sample cell, photometric section, and amplifier.

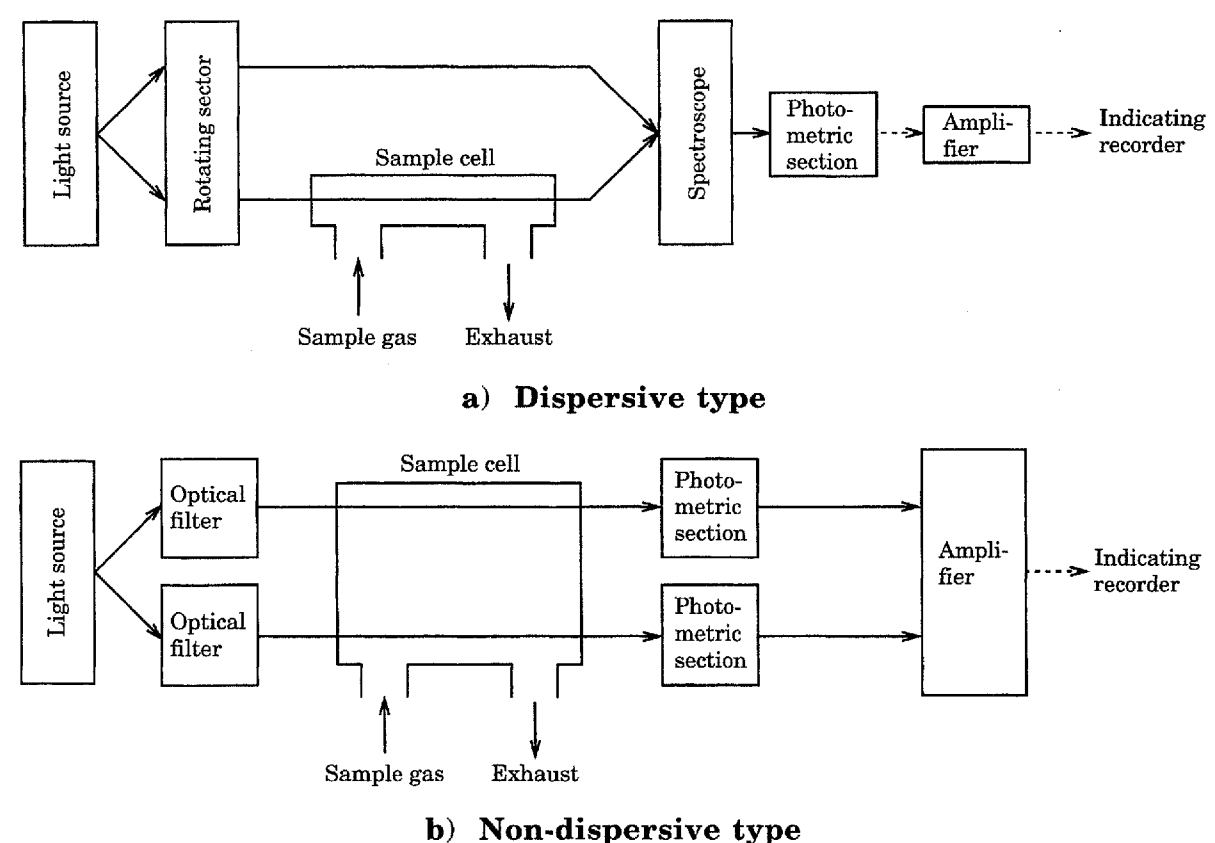


Fig. 4 Example of composition of ultraviolet absorption analyzer

- a) **Light source** A deuterium lamp or medium-pressure mercury lamp shall be used.
- b) **Spectroscope** A spectroscopy by which ultraviolet rays or visible monochromatic light is obtained with a prism, diffraction grating spectroscopy or the like shall be used.
- c) **Optical filter** Use a filter by which ultraviolet rays or visible light of specific wavelength is obtained, making use of either the absorption of specific wavelengths or optical interference by thin multilayer film.
- 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 ultraviolet rays and visible light such as quartz glass plate.
- e) **Photometric section** This section converts the absorption of ultraviolet rays into electric signals. A phototube, photomultiplier, or semiconductor detector sensitive enough to detect ultraviolet rays shall be employed.

5.4.4 Ultraviolet fluorescence analyzer As shown in Fig. 5, this analyzer is composed of a fluorescence chamber, light source device, photometric section, amplifier, etc.