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Methods for sampling of flue gas

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(building services)

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K 0095 : 1999

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. Consequently **JIS K 0095 : 1994** is replaced with **JIS K 0095 : 1999**.

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Methods for sampling of flue gas

Introduction This Japanese Industrial Standard has been prepared based on the first edition of **ISO 10396 Stationary source emissions—Sampling for the automated determination of gas concentrations** published in 1993. Some items and contents are added while part of the items and contents of the said International Standard is not adopted. Shown below are main differences thereof.

Items added; components of target gas, terms used, flue gas sampling hole, equipment (fitting metal, catching part, air-liquid separating part, safety trap, vacuum gauge, sample gas distributing tube and collecting tube) and sampling for chemical analysis (manual measurement).

Contents added; material, duct (dimensions and material), air cooling/dehumidifying of duct, water vapour removal procedure and maintenance/checking method.

Items/contents not adopted; normative references, collecting particle size of primary filtering material, material (heat resisting temperature of some materials), collecting particle size of secondary filtering material, operating temperature of suction pump, sample gas piping to analyzer, calibration method, advance check of concentration, flow speed and temperature of gas and apparatus for non-absorbing/collecting method.

The portions with sidelines and dotted underlines indicate the matters not provided in the original International Standard.

1 Scope This Standard specifies methods for absorbing and non-absorbing sampling of flue gas to analyze specific gaseous components exhausted into flues, chimneys, and ducts (hereafter referred to as “duct”).

2 Normative references The following standards contain provisions which, through reference in this Standard, constitute provisions of this Standard. The normative references without the indication of the year of coming into effect (or the year of publication) apply limiting only to the most recent edition (including the amendments).

JIS B 2238 *General rules for steel pipe flanges*

JIS B 2239 *General rules for cast iron pipe flanges*

JIS G 3452 *Carbon steel pipes for ordinary piping*

JIS G 3459 *Stainless steel pipes*

JIS G 4303 *Stainless steel bars*

JIS K 0050 *General rules for chemical analysis*

JIS K 0211 *Technical terms for analytical chemistry (general part)*

JIS Z 8808 *Methods of measuring dust concentration in flue gas*

3 Definitions For the main terms used in this Standard, the definitions in **JIS K 0211** apply, and the rest of the terms are as follows:

- a) **flue gas** Gas exhausted into a duct when fuel or other materials are burned or when various kinds of manufacturing processes are carried out, in factories and workshops.
- b) **sample gas** The flue gas to be subjected to analysis which has been collected with a collecting tube and passed through filtering material.
- c) **sampling point** The point where flue gas is sampled in a duct, and which is the end of the collecting tube inserted into the duct.
- d) **sampling hole** The hole bored through duct wall for inserting a collecting tube.
- e) **collecting tube** The tube inserted into a sampling hole for sampling flue gas.
- f) **filtering material** Material for eliminating dust and mist when flue gas is sampled.
- g) **introducing tube** The tube connecting a collecting tube and catching part or pretreatment part when flue gas is sampled.
- h) **catching part** When flue gas is chemically analyzed, the part where sample gas is caught directly into a vessel or is absorbed into absorbing liquid.
- i) **pretreatment part** When flue gas is continuously analyzed, the part where sample gas is dehumidified or where other treatments are carried out prior to introducing it into an analyzer.
- j) **condensable material** Moisture that is considered in the sample conditioning equipment.
- k) **corrosiveness** The tendency of an enclosed gas stream to attack sampling equipment components or other exposed surfaces under sampling conditions.
- l) **highly reactive source** An enclosed gas stream that contains unstable components or devices that could react to form other chemical components as conditions change.
- m) **gaseous concentrations** The mass of a particular gas per unit volume (mg/m^3) of dry gas in the flue gas, indicated by the volume ratio (ppm) of dry gas.
- n) **wet gas** A gas that is at or below the saturation point and may contain droplets of water.
- o) **chemical analysis** Generic term for manual analysis for sample gas collected in an absorbing bottle or catching container such as titrimetry, absorptiometry, gas chromatography, ion chromatography, which does not include continuous analysis.
- p) **continuous analysis** An analysis performed by an automatic measuring instrument (hereafter referred to as "measuring instrument").
- q) **completeness of sample** The elimination of leaks or physical and chemical reactions in the sample gas between the sampling hole and the catching part or the measuring instrument.

4 Principle Methods for collecting sample gas are given below.

- a) **Sample gas absorbing/collecting method** This method has two different ways of analysis. One is to carry out chemical analysis after absorbing and collecting sample gas at catching part. The other is to measure using a continuous analyzer after removing water vapour in sample gas. For both ways, it is necessary to remove interfering components in sample gas and carry the target component for analysis up to the catching part or analyzer.
- b) **Sample gas non-absorbing/collecting method** This is a field sampling method and also has two different ways of analysis. One is to carry out measurement exposing the continuous analyzer to gas flow, while protecting its detecting part with primary filtering material, without collecting sample gas. The other is to measure the concentration of target component using quantitative fluctuations of infrared and ultraviolet rays which are radiated into a duct.

Remarks : Measured values of both a) and b) are given in terms of wet gas conversion.

5 Sampling position, sampling point and sampling hole for sample gas

5.1 Sampling position Sampling position shall be as follows:

- a) Sampling position to be selected shall be the place where, avoiding positions such as bending part of duct and drastically changing part of its sectional shape, the flow of flue gas is considerably uniformed and which is safe and easy for working. Such place where there is a serious leakage of air into a duct or there is a pile of dust or considerable falling down of dust in a duct shall be avoided.
- b) In the neighborhood of sampling position, if necessary, install a scaffold which is safe and spacious enough for operation at suitable height, and provide equipment by which the scaffold would be safely and easily accessible.

5.2 Sampling point Sampling point shall be selected in the sectional plane of duct, which has been decided as sampling position, in accordance with 5.3 of JIS Z 8808. If the difference among analysis results at each sampling point is small, and if variation of gas concentration is within $\pm 15\%$ over sectional area of sampling position, only one arbitrary point may be selected as a sampling point.

5.3 Sampling hole The sampling hole shall be as follows:

- a) The sampling hole shall have the angle by which collecting tube can be inserted nearly rectangularly to the flue gas flow in the duct.
- b) Sampling hole shall be worked as follows; in the case of chemical analysis, for instance, fix the pipe with diameter of about 1B (25A) specified in JIS G 3452 and measuring 100 mm to 150 mm in length by welding or other methods, and in the case of continuous analyzer, employ a flange⁽¹⁾ of about 100 in nominal size specified in JIS B 2238 and JIS B 2239.
- c) The material for pipe employed at sampling hole shall be carbon steel, stainless steel, or plastics⁽²⁾.
- d) When collecting tube is not inserted, the sampling hole shall be covered.

- e) When continuous analysis is carried out, if necessary, provide a sampling hole for chemical analysis in the vicinity of the hole.

When a large-diameter sampling hole for measuring the concentration of dust in flue gas is used for a sampling hole for chemical analysis, attach a diameter-reducing pipe or modify its cover so as to sample gaseous components easily.

- f) If a duct gives inside positive pressure, be careful to prevent the dangerous gush of flue gas at the time of opening the cover.

Notes (1) The nominal size and nominal pressure of a flange shall be decided according to **JIS B 2238** and **JIS B 2239** in consideration of the temperature of flue gas and load on collecting tube.

- (2) When using plastics products, the material near the sampling hole or the attaching part shall be durable for heating at around 120 °C.

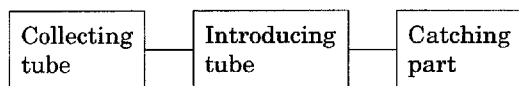
5.4 Other factors In the case of one-point sampling, unlike in the full-section sampling, it is necessary to pay full attention to the maintenance of completeness of sample by selecting a proper sampling position, point, and apparatus, conducting proper thermal insulation and heating, and at the same time, performing dehumidifying and leakage test without fail.

6 Sampling apparatus for sample gas

6.1 Construction of apparatus

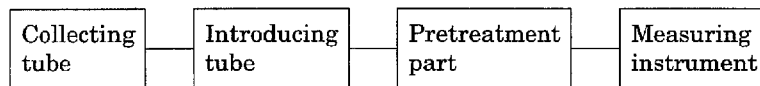
6.1.1 Sample gas absorbing/collecting method The construction of apparatus for absorbing/collecting method shall be as follows.

a) Chemical analysis

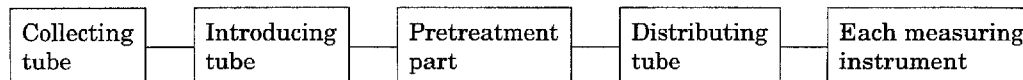


b) Continuous analysis

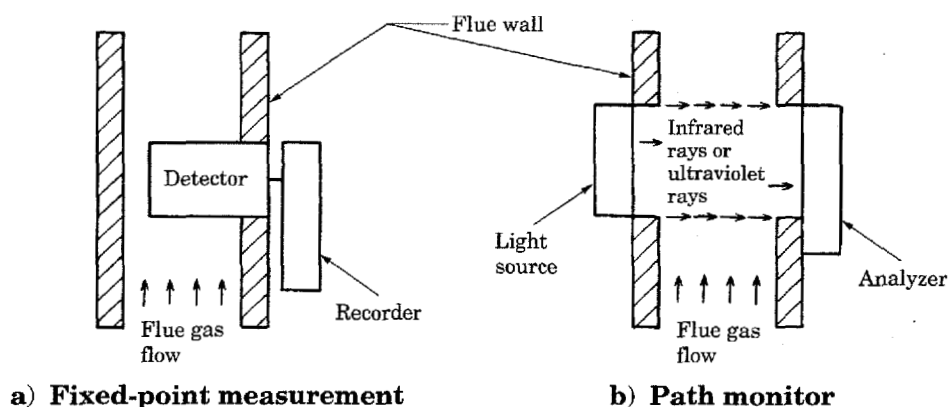
1) When analyzing single component



2) When analyzing multiple components simultaneously



6.1.2 Sample gas non-absorbing/collecting method The construction of apparatus for non-absorbing/collecting method shall be as follows.



6.2 Material The material of collecting tube, introducing tube, connecting pipe, filtering material and sample gas distributing tube shall meet the following requirements in consideration of matters such as components and temperature of flue gas.

- The chemical reaction or adsorption, etc. shall not give influence on the analysis result of flue gas.
- The material shall be anticorrosive against the corrosive component in flue gas.
- The material shall have sufficient heat resistance and mechanical strength to the temperature and flow speed of flue gas.

Table 1 shows examples of application.

Table 1 Materials for collecting tube, introducing tube, connecting pipe, filtering material, and sample gas distributing tube, and their application examples

Parts		Collecting tube and distributing tube					Introducing tube					Connecting pipe		Filtering material								
Material		Borosilicate glass	Silica glass	Stainless steel ⁽⁴⁾	Titanium	Ceramics	Ethylene tetrafluoride resin	Borosilicate glass	Silica glass	Stainless steel ⁽⁴⁾	Ethylene tetrafluoride resin	Unplasticized polyvinyl chloride	Fluororubber	Silicone rubber	Chloroprene rubber	Non-alkali glass wool	Silica wool	Sintered glass	Stainless steel net ⁽⁴⁾	Sintered stainless steel ⁽⁴⁾	Porous ceramics	Ethylene tetrafluoride resin
Maximum service temperature °C ⁽³⁾		400	1 000	800	800	1 000	200	400	1 000	800	200	70	180	150	80	400	1 000	400	700	700	1 000	200
Measur- able com- ponents	Sulfur oxide	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	Nitrogen oxide																					
	Carbon monoxide																					
	Hydrogen sulfide																					
	Hydrogen cyanide																					
	Oxygen																					
	Ammonia	○	○	○	○	○	○	○	○	○	○		○	○		○	○	○	○	○	○	○
Chlorine	○	○			○		○	○				○	○			○	○	○				
Hydrogen chloride	○	○		○	○	○	○	○			○	○	○	○		○	○	○			○	○
Hydrogen fluoride	○		○	○		○	○		○		○	○	○	○								○
Mercaptan	○	○		○	○	○	○	○			○		○	○		○	○	○				

Notes ⁽³⁾ In the case of use for a short time, ethylene tetrafluoride resin can bear up to 260 °C in service temperature.

⁽⁴⁾ The materials of stainless steel specified in **JIS G 3459** and **JIS G 4303** are graded as, SUS 304 (18Cr-8Ni), SUS 316 (18Cr-12Ni-2.5Mo), SUS 316L (18Cr-12Ni-2.5Mo-low C), etc., and they are chosen according to the target component and the kind of coexisting components.

Remarks 1) Mark ○ shows application example.

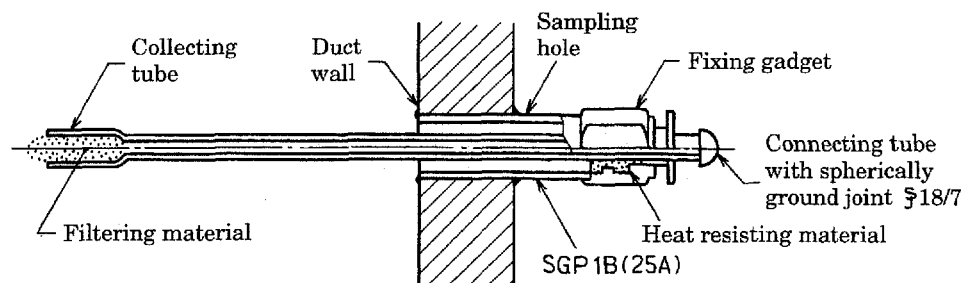
2) In the case of SUS 316 and SUS 316L, if there coexists NH₃ in the measurement of NO_x, minus errors occur due to the catalytic action of molybdenum (Mo) in stainless steel.

6.3 Collecting tube The collecting tube shall be as follows. Fig. 1 shows examples of the collecting tubes for sample gas absorbing/collecting method.

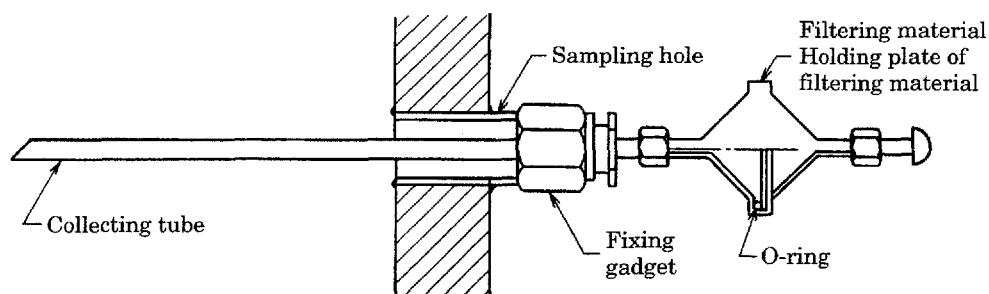
- In consideration of flow rate of sample gas, the mechanical strength of collecting tube, and simple cleaning operation, the inside diameter of the collecting tube shall be about 6 mm to 25 mm.
- The collecting tube shall be long enough to be able to reach the sampling point chosen at 5.2. When flue gas has high temperature, the countermeasure to prevent its bending is necessary.

- c) The end point of the collecting tube is preferably constructed so as to keep sample gas from mixing with dust as far as possible.

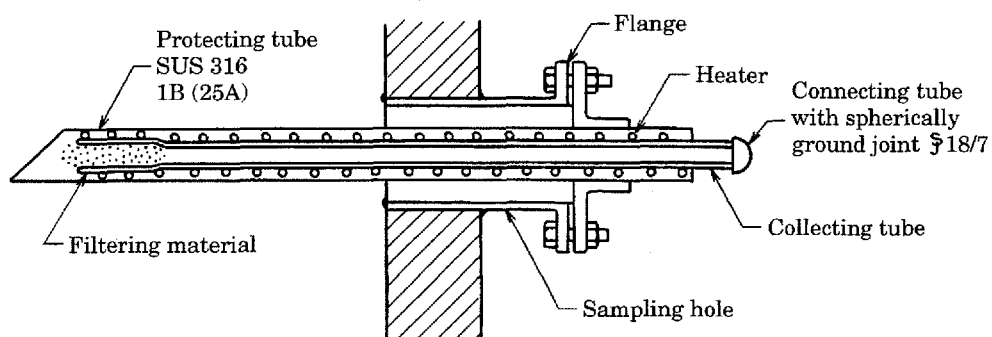
a) **For chemical analysis**



- 1) **Example of case where filtering material is attached at the end point of collecting tube**



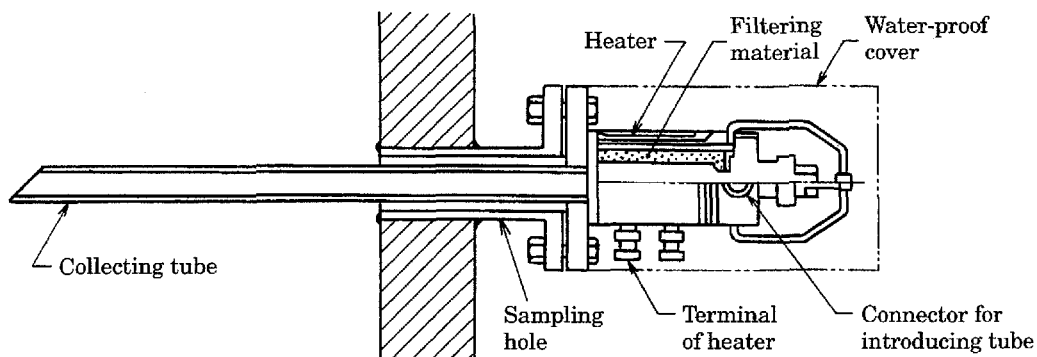
- 2) **Example of case where filtering material is attached at the rear stage of collecting tube**



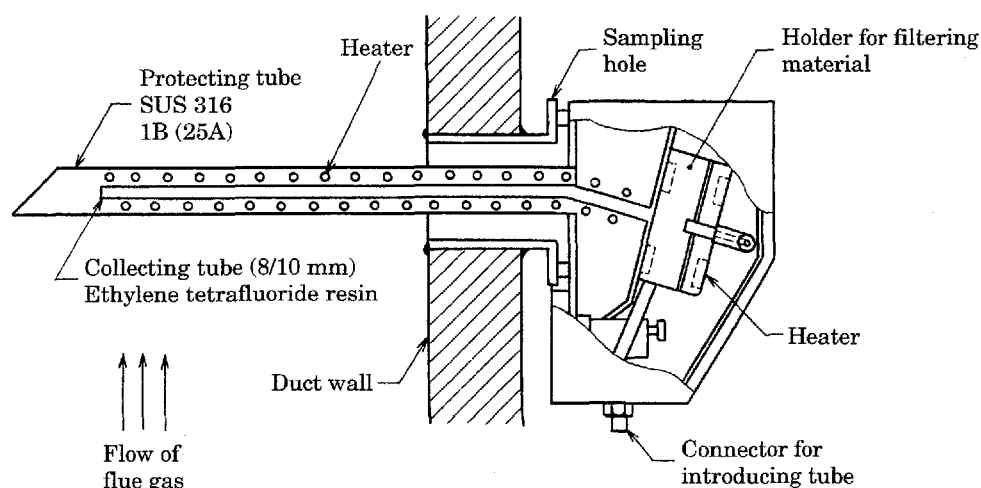
- 3) **Example of electric heating-type collecting tube with protecting tube**

Fig. 1 Examples of collecting tube for sample gas absorbing/collecting method

b) **For continuous analysis**



1) **Example of case where filtering material is attached at the rear stage of collecting tube**



2) **Example of electric heating-type collecting tube with protecting tube**

Fig. 1 (concluded)

6.4 Primary filtering material Primary filtering material shall be as follows:

- In order to prevent sample gas from mixing with dust, filtering material shall be attached, if necessary, at the end point or the rear stage of the collecting tube.
- Filtering material shall have a high dust removing efficiency and low pressure loss.
- The attaching part of filtering material has preferably simple structure to facilitate its attachment.

6.5 Fixing gadget Fixing gadget is for fixing a collecting tube firmly to a sampling hole, and its shape and material shall be suitable for both the collecting tube and sampling hole (see Fig. 1).

6.6 Introducing tube In consideration of the matters such as length of the introducing tube, the flow rate of suction gas, clogging by condensed water and power of a suction pump, the inside diameter of introducing tube shall be 4 mm to 25 mm. The length of introducing tube shall be as short as possible.

6.7 Thermal insulation or heating The thermal insulation or heating of collecting tube and introducing tube shall be carried out in order to prevent moisture and high dew-point gas components in sample gas from condensation in a collecting tube or introducing tube and also to prevent the condensed water from freezing in the introducing tube. At the part of introducing tubes which can be air-cooled and dehumidified by itself, thermal insulation or heating is not needed.

6.8 Catching part As shown in Fig. 2, the catching part used for chemical analysis consists of an absorption bottle, catching container, washing bottle, suction pump, gas meter, and so on. For connecting them, connecting tube with spherically commonly ground joint, silicone rubber tube, fluororubber tube, flexible polyvinyl chloride tube, and thick-walled rubber tube, etc. shall be used⁽⁵⁾.

Note ⁽⁵⁾ Choose any of them according to the components and temperature of sample gas.

a) **Absorption bottle** This bottle is a glass-made container to keep absorbing liquid for target component of analysis. Fig. 3 shows examples. The absorption bottle shall have a sufficient capacity with consideration of moisture content in flue gas and suction gas flow rate.

b) **Catching container** This container is for catching sample gas under gaseous condition, and there is a glass-made reduced pressure collecting bottle, syringe, catching bag, or the like. Fig. 4 shows a example.

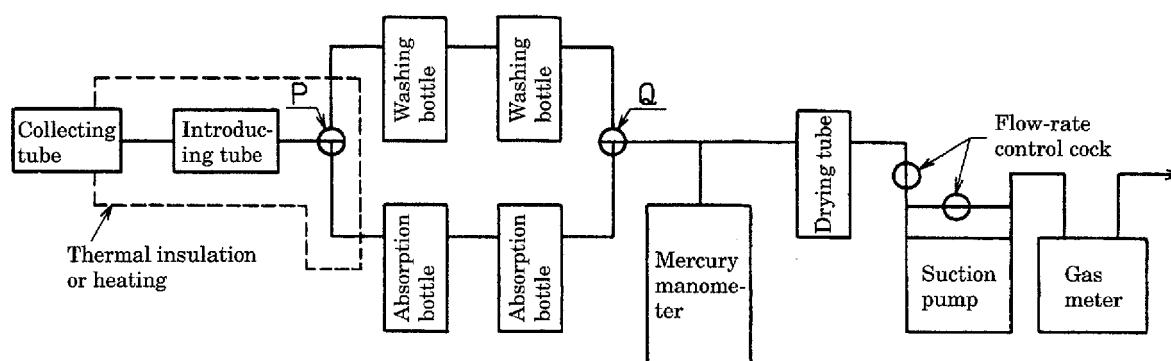
The material of catching bag to be selected shall be free from adsorption, permeation, and deterioration of the target component for analysis.

c) **Mercury manometer** Either vacuum manometer or air-open type manometer, which is capable of measuring 200 mm in difference (height of mercury column) from the atmospheric pressure shall be used.

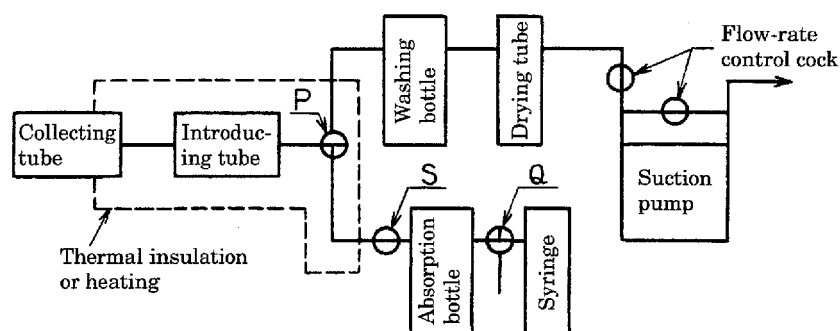
d) **Drying tube** This is used for protecting suction pump, and silica gel or the like shall be used as desiccant.

e) **Suction pump** The closed type, with an approximate 5 l/min exhausting power and equipped with a flow-rate control cock, shall be used.

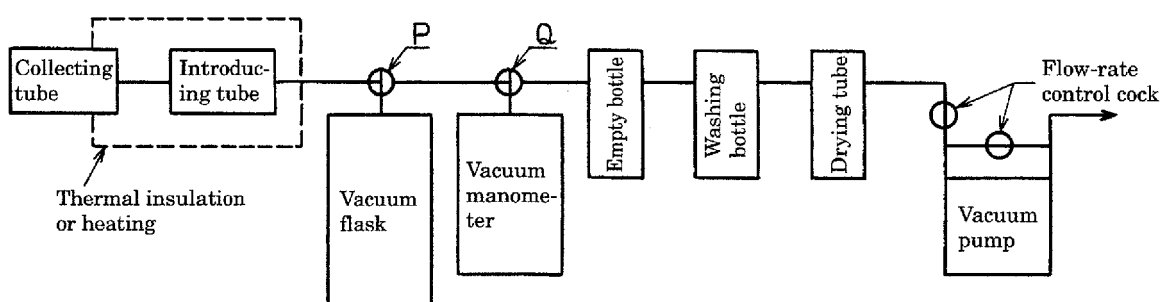
f) **Gas meter** Either dry gas meter or wet gas meter, whose power is 1 l per revolution, equipped with a thermometer and pressure gauge.



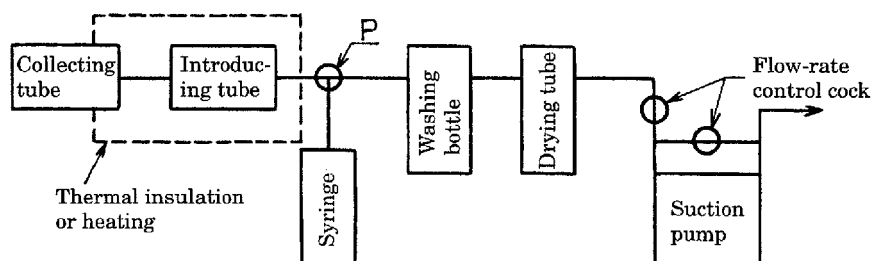
a) Absorption bottle method (case of measuring the amount of sample gas using gas meter)



b) Absorption bottle method (case of measuring the amount of sample gas using syringe)

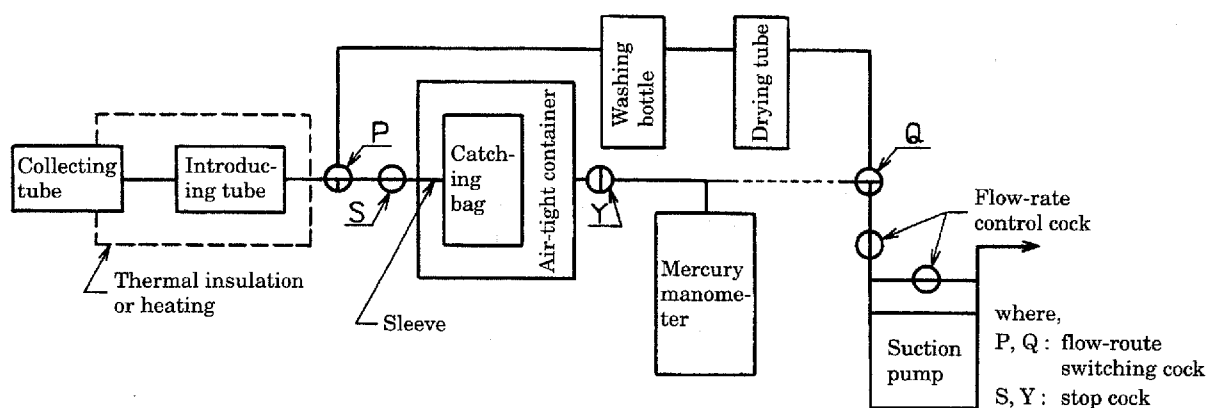


c) Vacuum flask method (method by vacuum catching bottle)



d) Syringe method

Fig. 2 Structural examples of chemical analysis sampling equipment for sample gas absorbing/collecting method



e) **Catching bag method**

Fig. 2 (concluded)

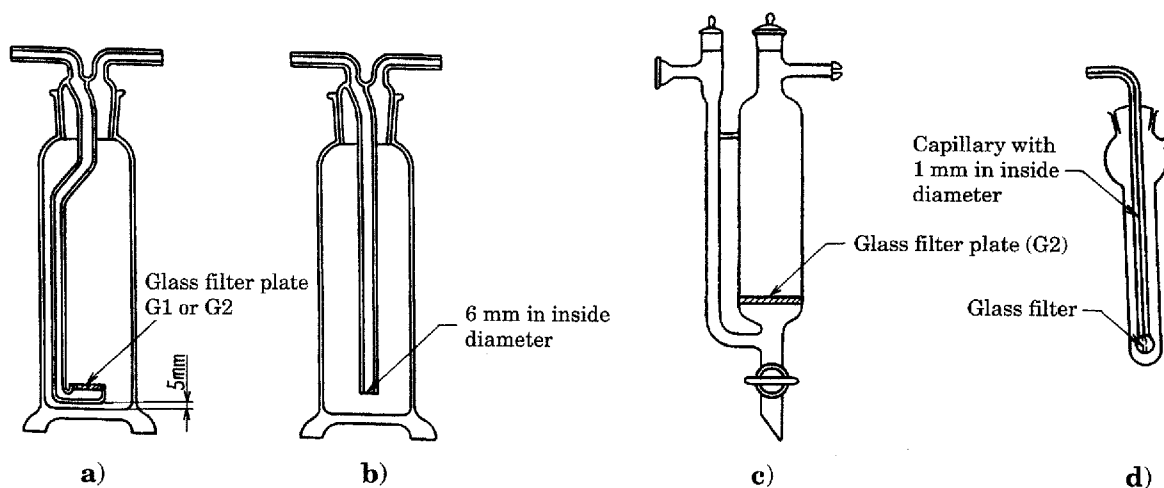


Fig. 3 Examples of absorption bottles

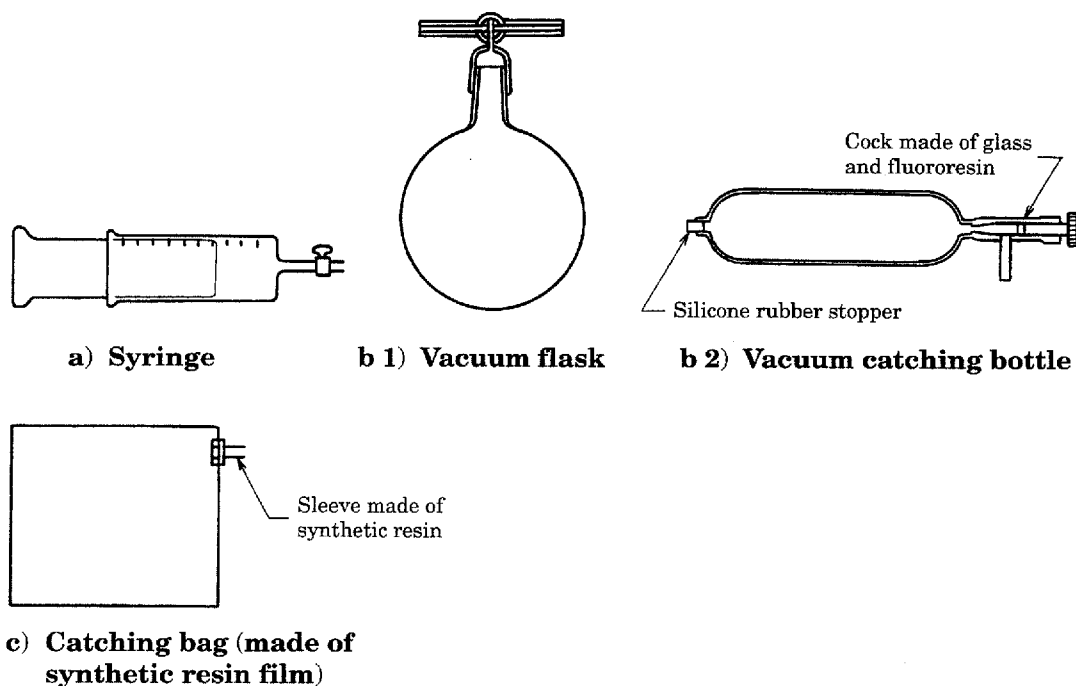


Fig. 4 Examples of catching containers