

Determination of emissions from appliances burning gaseous fuels during type-testing

Cooperating organizations

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Determination of emissions from appliances burning gaseous
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Correction

Section G. SAMPLING LINE, clause 2.2 Response time

The text should read as follows.

The time between applying the calibration gas mixture (at point 1, fig. 1) and reaching 90 % of the recorded max. concentration, shall not exceed 200 s including probe and sampling line.

AMD 8820/October 1995

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National foreword

This Published Document has been prepared under the direction of the Gas Standards Policy Committee and is the English language version of CR 1404 : 1994 *Determination of emissions from appliances burning gaseous fuels during type-testing*, published by the European Committee for Standardization (CEN).

CR 1404 was produced as a result of international discussions in which the United Kingdom took an active part.

English version

Determination of emissions from appliances burning
gaseous fuels during type-testing
BASIC DOCUMENT

This CEN REPORT has been established by MARCOGAZ under the supervision of the CEN/PC3 'Gas' and has been approved by CEN on 1993-10-28.

CEN members are the national standards bodies of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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DETERMINATION OF EMISSIONS FROM APPLIANCES BURNING GASEOUS FUELS DURING TYPE-TESTING

A. INTRODUCTION

This draft describes test methods and automatic measuring equipment for the determination of NO_x ($\text{NO} + \text{NO}_2$), CO , CO_2 and O_2 emissions in the flue gases including the sampling system and the calibration gases. The document should be introduced in the relevant gas appliances TC.

Gas cookers, flueless appliances and appliances especially designed for use in industrial processes carried out on industrial premises are excluded from the scope.

According to their principles of analysing the combustion products, the analyzers are classified into following families :

- analyzers based on the chemiluminescent effect : NO and NO_2 ,
- analyzers based on the absorption of infra-red and ultra-violet radiation : NO and NO_2 for concentrations > 100 ppm, CO and CO_2 ,
- analyzers based on the paramagnetic principle : O_2 ,
- electrochemical analyzers : they are considered to be inadequate for laboratory testing procedures.

The conversion of measured levels to reference conditions is given in appendix 1.

B. REFERENCE

ISO/DIS 10849

Stationary source emission.
Determination of the Mass Concentrations of Nitrogen Oxides.
Performance Characteristics and Calibration of Automated Measuring Systems.

ISO 10396

Stationary source emission.
Sampling for the Automated Determination of Gas Concentration.

ISO 3534 - Vocabulary and Symbols

ISO 6976 - Natural gas - Calculation of calorific value, density and relative density.

ISO 6142 - Gas Analysis - Preparation of calibration Gas Mixtures - Weighing Methods - July 1989

ISO 6141 - Gas Analysis - Calibration Gas Mixtures - Certificate of Guarantee

WECC Doc. 19-1990 - Guidelines for the expression of the uncertainty of measurement in calibrations.

VEG - 9201(23/6/92) - Practical guide for the calculation of uncertainties of measurements

C. UNCERTAINTY OF DETERMINATION

1. General

With the intention to calculate the overall tolerance on NO_x measurements, the following elements are to be taken into consideration :

- the probe systems,
- the accuracy of the analyzers, NO, NO₂, CO₂, CO, O₂,
- the calibration procedures,
- the test conditions.

2. Estimation of the total uncertainty in the determination of NO_x and CO

For the determination of the NO_x - and CO - emission the measured levels have to be converted to reference conditions. For that reason and in order to calculate the dilution factor CO₂ or O₂ shall be measured simultaneously.

The maximum tolerances on the determination of NO_x and CO emissions, including tolerances which occur during the CO₂ or O₂ measurements and the characteristics of the fuel necessary for the conversion of measured levels to reference conditions, is as given in graph 1, curve A.

The total uncertainty as given by curve A is important. There are no requirements for the individual uncertainties, except for the total systematic error.

The calculation of the uncertainty shall be done according to WECC doc - 1990 and VEG doc 9201 (annex 2). An example of the uncertainty calculation is given in annex 3. That document contains also typical values for the different uncertainties. If each individual uncertainty is equal to or better then the typical value curve A will be met. In other cases the uncertainty should be calculated.

3. Total systematic error

Systematic errors can be caused by temperature, pressure, absorption of NO₂, interference and non-linearity. If the total systematic error exceeds 2% of the measured value, then the cause of it shall be investigated and corrected. Correction should be made to limit the systematic error to 2%.

4. Reproducibility of the NO_x and CO emission

A number of factors such as relative humidity and temperature of the combustion air and gas, could affect the level of NO_x emission. For the latter, a formulae for correction derived from the BCR Programme is proposed in annex 1 "NO_x and CO conversion".

D. MAIN PERFORMANCE CHARACTERISTICS OF THE ANALYZERS

(NO, NO₂, O₂, CO and CO₂)

General

The characteristics should be checked for each range by the testing company, the certified manufacturer, or a certified institute.

1. Linearity

For linear calibration curves a check at 4 points 0/30/60/90% is sufficient.

An exact mathematical method to test the hypothesis of linearity is given in ISO 9169.

In the case of a non linear calibration curve, at least 10 measuring points are required. The linearity has to be checked at least once a year or after repairs of the analyzer.

2. Drift

Differentiation should be made between zerodrift and spandrift, and between drift with time and temperature.

The evaluation of the drift should be made according to ISO/DIS 10849, Annex B.

The estimation of the drift with time should cover a period of 8 hours, by measurement each hour.

The permissible ambient temperature range, given by the manufacturer of the equipment, shall at least cover the range from 10 to 35°C.

3. Interference

Interference with other components than N_2 present in the combustion products is possible, depending on their concentration, it shall be declared by the manufacturer.

The effect of interfering compounds shall be determined according to Annex A of doc. ISO/DIS 10849.

For the chemiluminescence method of measuring NO and NO_2 , interference can be expected from CO_2 , O_2 and H_2O . For CO and CO_2 analyzers interference from all components of combustion products can be determined by applying calibration gases.

4. Response time

The time between applying the calibration gas mixture and reaching 90% of the recorded mass concentration shall not exceed 20s.

5. Measuring range

The total uncertainty depends mainly on the lower limit of the measuring range. This is caused by a number of uncertainties which are expressed as a percentage of the full scale.

E. CALIBRATION GASES

1. Materials

General

Following materials have proven to be successful for measurement of emissions from gas appliances.

Cylinders

Parts of the cylinders in contact with the calibration gases shall be either constructed of stainless steel or aluminium alloy or be protected by nickel-plate.

Auxiliary equipment

Governors, taps, tubes, connections, etc. in contact with the sample, shall be constructed of stainless steel, Teflon (PTFE), or glass.

2. Characteristics of the calibration gases

The concentration of the calibration gases shall either correspond to 70-80% of the span value of the selected scale or to the estimated value in the combustion products.

For the correct operation and calibration of the analyzers, the following calibrating gases may be used.

- N_2 is used for all analyzers for zero point control ; for the low ranges special attention should be paid to the purity of the N_2 gas ;
- NO in N_2 ;
- NO_2 in air or NO_2 generator for testing the normal operation of the converter ;
- CO, CO_2 and O_2 in N_2 .

The conservation characteristics of the calibrating gases shall be declared by the manufacturer for a minimum period which shall not be less than 1 year.

Cylinders shall not be operated at a pressure less than 5 bar.

3. Accuracy of the calibration gases

The primary calibration gas used must be certified and traceable to an international standard, or to a national standard applicable to them in so far as in this area no harmonised standard exists.

It is advisable to use calibration gases with an accuracy of 1 or 2% of the given value. This depends on the application (linearity check and span check).

- Note :
- weighing methods for the preparation of calibration gas mixtures are indicated in ISO 6142 ;
 - gas analysis calibration gas mixtures certificates of guarantee are all indicated in ISO 6141.

F. PERIODICAL CHECKS

- The sampling transport line shall be checked at least once a month for leakage and changing in composition of the sampling gas to the analyzer, by introducing calibration gas (e.g. NO_2) at atmospheric pressure consecutively at points 1 and 7 of fig. 1.
- At least once a week check the efficiency of the converter, which should be at least 90%. If the efficiency of the converter is > 95%, no correction is necessary, provided that the total allowable systematic error is not exceeded.

At least once a year or after repair the analyzers shall be checked for linearity ; where there is some doubt then it is essential to compare the analyzer with calibration gases or with an independent method such as the wet chemical method.

G. SAMPLING LINE

1. Introduction

Three methods could apply :

- water vapour removal methods ;
- wet sampling method ;
- dilution method.

Note : the dilution method should not be used for type testing of gas appliances ; therefore this sampling method is not described in this document.

2. General

The sample of combustion products shall be representative of the average of combustion products inside the duct section. Therefore, the probe of fig. 2, 3 and 4 for flued appliances, or probe of fig. 6 for balanced flue appliances, is used. The location of the sampling probe system is indicated in figures 5, 7 and 8.

Sampling probes to alternative standards will be acceptable provided that the homogeneity of the sample can be confirmed.

2.1. Sampling probe

The sampling probe is constructed of stainless steel or glass.

2.2. Response time

The time between applying the calibration gas mixture (point 1, fig. 1) and reaching 90% of the recorded max. concentration, shall not exceed 2 s including probe and sampling line.

3. Description and arrangements of the water vapour removable method

3.1. Minimum temperature

Upstream of the dryer the sampling line shall be kept at least 15K above the water and acid dewpoint temperature of the sampled gas. A temperature control is required to keep the line temperature constant.

3.2. Transport line

To transfer the sample to the analyzers either stainless steel or PTFE (Teflon) tubes are used ; their diameter depends on the required quantity of sampled gas but shall not be smaller than 4 mm(preferable 4 to 8 mm). Rubber or silicon materials shall not be used.

3.3. Cooler or permeation dryer

Parts of the cooler in contact with the sample shall be made of glass, Teflon or stainless steel.

Cooling must be sufficient for the gas quantity and the water concentration. The dewpoint shall be sufficiently below the ambient temperature. A cooling temperature of 2 to 5° is sufficient.

It is essential to remove condensates as efficiently as possible in order to minimise the contact with the sample and the absorption of NO₂. Desiccant shall not be used.

- Note :
- when the condensation/refrigeration method is used, the removal shall take place outside the heated box.
 - where permeation drying is employed, half of the dryer tube (wet) shall be heated to at least 15K above the gas dewpoint. The manufacturer's recommendations on the quantity or purge air shall be followed.

3.4. Filter

A filter shall be positioned between the cooler and the manifold. The housing is constructed of stainless steel or glass, and its size shall be determined from the required sample flow and the manufacturer's data on the flow rate per unit area. The sinter metal, PTFE-fibre, or quartz filter shall retain particles not greater than 1 μm .

- Note :
- care should be taken to avoid contamination of the filter with particles where particulate material may react with gases to give an erroneous result.

3.5. Manifold

The manifold shall be constructed of stainless steel or Teflon with a separate connection for each analyzer. It shall be of sufficient size to accommodate the gas flow required by each analyzer, but small enough to keep the gas residence times to a minimum. The exhaust of sample must be vented.

3.6. Flow meter

In order to check the exact flow, a flow meter made of a suitable corrosion resistant material is necessary.

3.7. Sampling pump

Parts of the sampling pump in contact with the gases, shall be constructed either of Teflon, stainless steel or viton. The capacity of the pump shall be such that it can supply all the analyzers with their required flows, plus a 10% excess flow margin.

4. **Wet sampling**

The requirements and description are the same as for the water vapour removal method taking into account following considerations :

- no cooler is present in the sampling line,
- upstream of the analyzer the sampling line shall be kept at least 15 K above the water and acid dewpoint temperature of the sampled gas,
- the analyzer has to be especially designed for that method.

A correction for the water vapour in the sample must be made (see Annex 1 - Conversion - Calculation).

H. TEST PROCEDURES

1. General

Before starting measurements it is essential that all types of analyzers used during the tests are in thermal equilibrium and that they have been correctly calibrated to the manufacturer's instructions.

During measurements, it is necessary that the flow, temperature and pressure correspond to those values obtained when making the calibration ; they should be within the limits specified by the manufacturers.

After having measured high concentration, the sample line has to be purged effectively before taking further measurements.

2. Test room

The appliance is installed in a well ventilated, draught free room, according to the appropriate CEN-standards. The ambient temperature, the atmospheric pressure and the relative humidity shall be measured and recorded in the test report.

3. Calibration

- Before and after each test or at least at the beginning and at the end of each day, check zero point and span value of the instrument ranges which are used.
- The calibration function is checked by introducing calibration gases directly into the analyzers (point 7 of fig. 1).
- The setting of the analyzer before the test is carried out as follows : feed the zero gas into the analyzer and set the zero. Then feed in the calibration (span) gas and set the scale reading. Then feed in the zero gas again and check that the reading returns to zero. If not, readjust the zero and repeat.

4. Sampling

4.0. General

Sampling probes to alternative standards will be acceptable provided that the homogeneity of the sample can be confirmed.

Before starting the tests, it has to be verified that the sampling probe is clean.

4.1. Unflued appliances are excluded from the scope.

4.2. Flued appliances

The combustion products are sampled at a point in the flue 0.2 m from the outlet (see fig. 5), using the probe shown in figures 3 and 4.

4.3. Balanced flue appliances

A sampling probe as described in fig. 6 and located in the flue as indicated in fig. 7, is used to take a sample of the combustion products.

4.4. Forced draught burners in relation to the fire test tube

A sampling probe as described in fig. 6 and located in the flue as indicated in fig. 8, is used to take the sample of the combustion products.

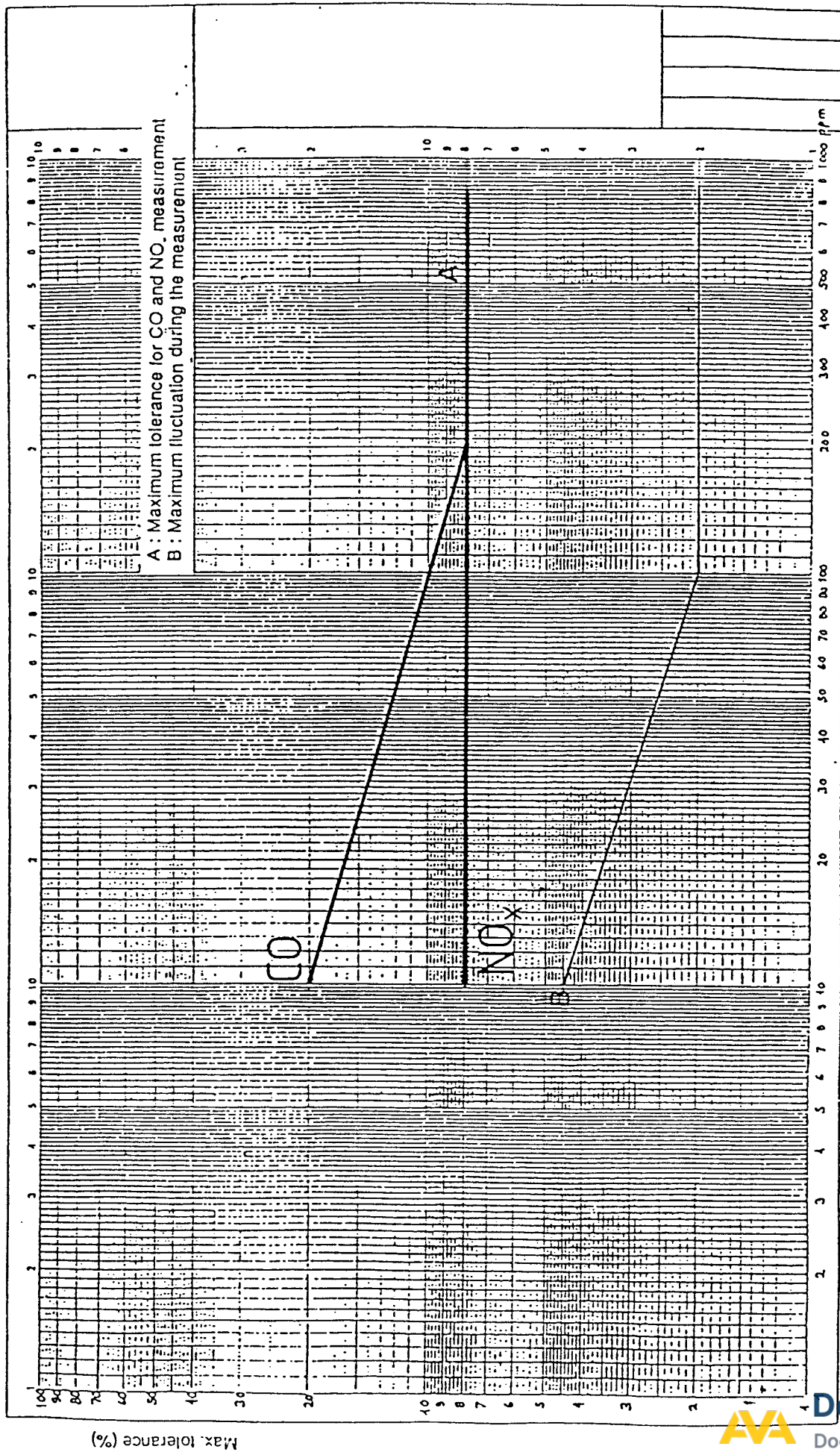
4.5. Test conditions

The tests are carried out at thermal equilibrium, the burner operates at its appropriate input under the supply pressures and reference gases depending on the burner category, as given by the particular standards.

5. **Validity of the measurements**

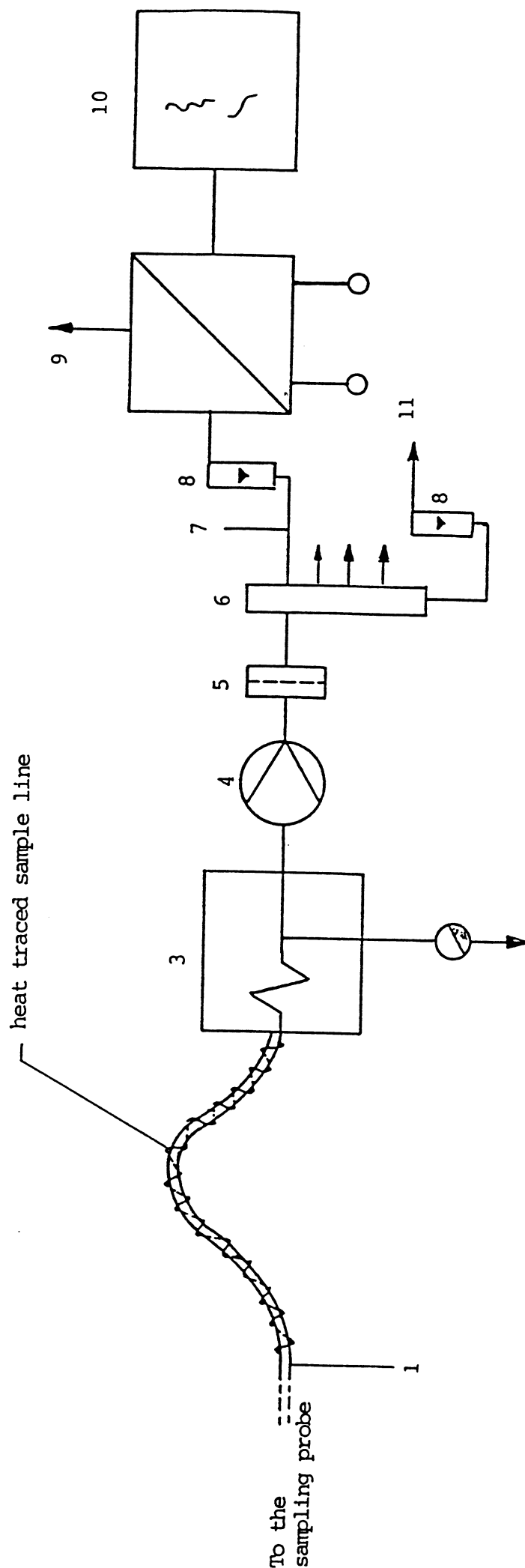
- 3 test cycles are carried out consecutively ;
- each test cycle is spread over a period determined by the need to achieve thermal equilibrium and stability of the analyzers ;
- for each cycle the average value is determined (the use of e.g. a recorder is recommended);
- if the average value differs from one cycle to another by more than the max. fluctuation authorised by curve B, graph 1, then the measurement is not valid.

GRAPH 1



value corrected: to reference conditions

FIGURE 1

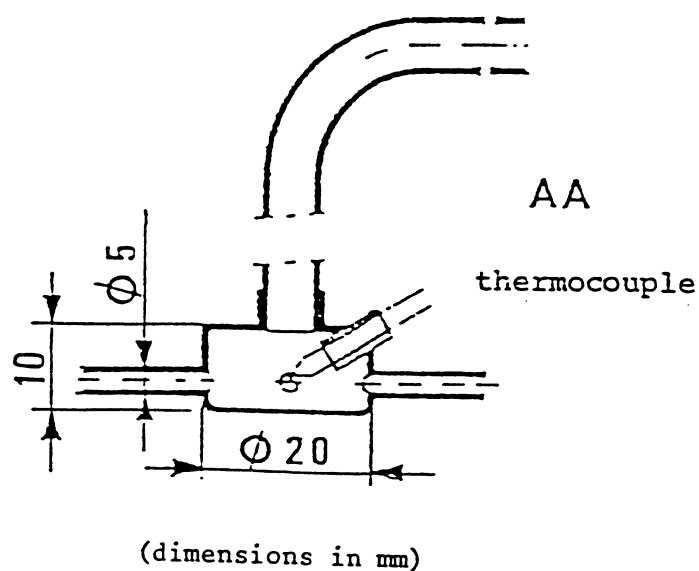
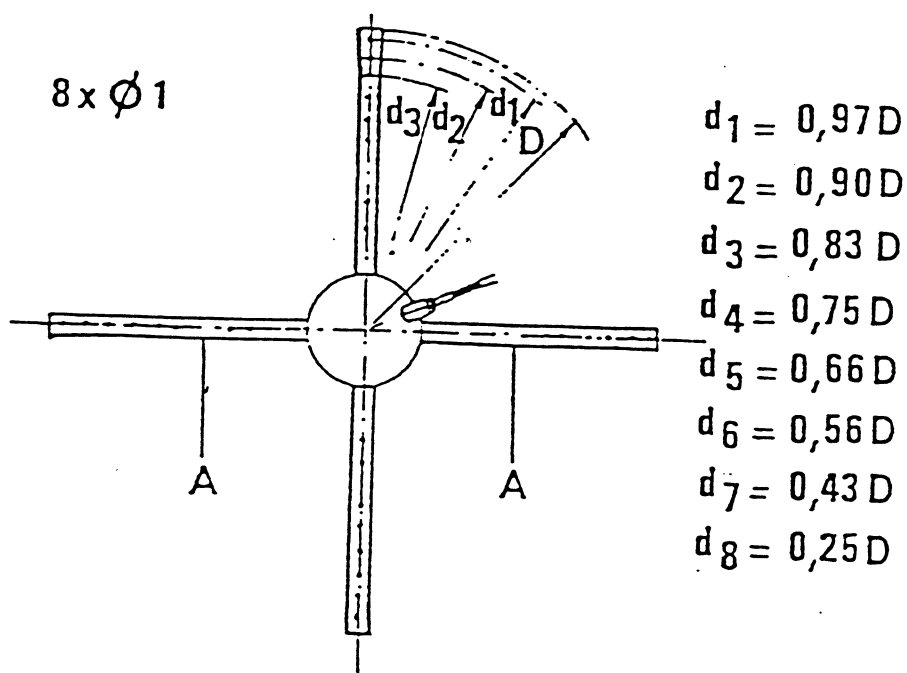


SAMPLING OF THE COMBUSTION PRODUCTS FOR WATER VAPOUR
REMOVABLE METHOD IS GIVEN AS AN EXAMPLE

FIGURE 2
SAMPLING PROBE FOR TYPE B APPLIANCES

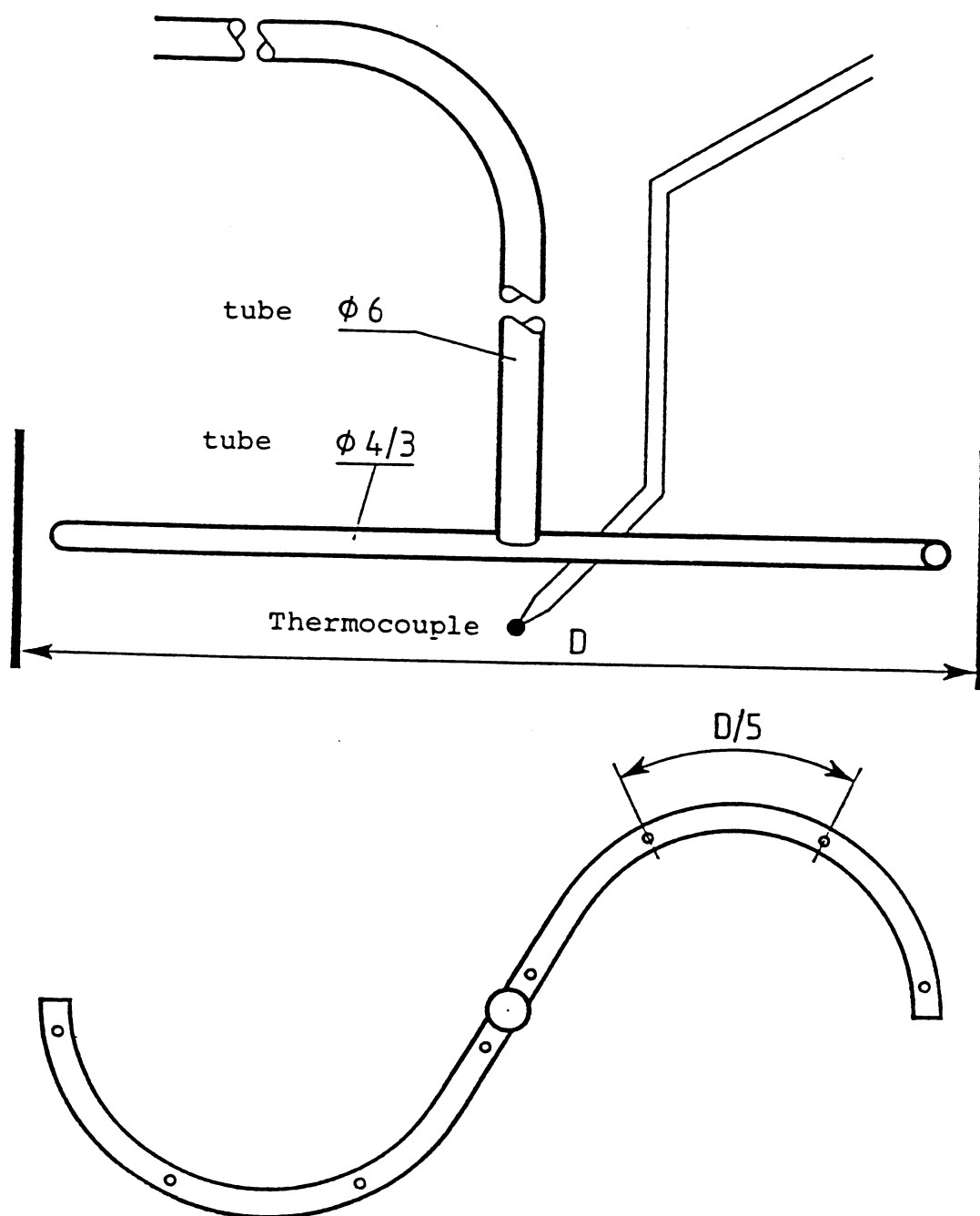
D	$d_1 = 0.97 D$	$d_2 = 0.90 D$	$d_3 = 0.83 D$	$d_4 = 0.75 D$	$d_5 = 0.66 D$	$d_6 = 0.56 D$	$d_7 = 0.43 D$	$d_8 = 0.25 D$
100	97	90	83	75	66	56	43	25
110	107	99	91	82	74	62	47	27
120	116	108	100	90	79	67	52	30
130	126	117	108	98	86	73	56	33
150	145	135	125	113	99	84	65	38
180	175	162	149	135	119	101	77	45
200	194	180	166	150	132	112	86	50
250	242	225	208	188	165	140	108	63
300	291	270	249	225	198	168	129	75
400	388	360	332	300	264	224	173	100
500	485	450	415	375	330	280	216	125

FIGURE 3 : SAMPLING PROBE



Note : for flue diameters below DN 100, an appropriate device (e.g. figure 4) should be used.

FIGURE 4 : SAMPLING PROBE FOR FLUE DIAMETERS BELOW DN 100



(dimensions in mm)

FIGURE 5

LOCATION OF THE SAMPLING PROBE FOR TYPE B APPLIANCES

B-B

