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Standard of State Environmental Protection Administration

HJ/T 76-2007

Substitute of HJ/T 76-2001

Specifications and Test Procedures for Continuous Emission Monitoring Systems of Flue Gas Emitted from Stationary Sources (on trial)

(Publication Version)

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Issued by State Environmental Protection Administration

Preface

In order to implement *Environmental Protection Law of the People's Republic of China* and *Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution*, and monitor pollutants emitted from stationary sources of air, this standard is herein stipulated.

The standard has specified the main technical indices, test items, test procedures and quality assurance measures taken in test for continuous emission monitoring system of flue gas from stationary sources. The continuous emission monitoring system of flue gas within the national environmental monitoring network shall meet the requirements of this standard.

The following revisions for *Specifications and Test Procedures for Continuous Emission Monitoring Systems of Flue Gas Emitted from Stationary Sources* (HJ/T 76-2001) have been made in this standard: modification of partial technical indices of continuous monitoring system for particulates and continuous measuring system for flow rates; further definition of test procedures of correlation coefficient in continuous monitoring system for particulates; supplement of technical indices of flue gas parameters and technical requirements for continuous emission monitoring system of flue gas during its running period of 90 days.

In its drafting course, this standard has referred to the overseas technical standards, technical indices of continuous monitoring systems of some manufacturers both at home and abroad and standards of enterprises.

The standard will come into effect from the date of implementation. And the *Specifications and Test Procedures for Continuous Emission Monitoring Systems of Flue Gas Emitted from Stationary Sources* (HJ/T 76-2001) has to be abandoned.

The standard is a guidance standard.

The standard is put forward by Department of Science, Technology and Standards of State Environmental Protection Administration.

The main drafters of the standard: General Environmental Monitoring Station of China, Shanghai Environmental Monitoring Centre, Information Center of State Environmental Protection Administration.

The standard was approved by State Environmental Protection Administration on July 12th, 2007.

The standard has been implemented from August 1st, 2007.

The standard shall be explained by State Environmental Protection Administration.

Contents

1. Applicable Scope

This standard has specified CEMS's main technical indices, test items, test procedures, and quality assurance measures taken in test.

This standard is adaptable to monitor the flue gas parameters of stationary sources, particulates in flue gas, concentrations of SO_2 and NO_X, and CEMS of total emission.

2. Normative References

The provisions in the following documents are referred to by this standard. All editions without any date indication are valid and applicable for this standard.

GB/T 16157-1996 Measurements of particulates in flue gas emitted from stationary sources and sampling method for gaseous pollutants.

HJ/T 212-2005 Transmission Standard of on-line auto-monitoring system for pollution sources.

HJ/T 75-2007 Code for continuous emission monitoring techniques of flue gas emitted from stationary sources.

3. Terms and Definitions

Particulates

Particulates denote solid and liquid granular substances suspended in liquids and flue gas generated in burning, synthesis, decomposition of fuels and other substances and in treatment of various materials.

Gaseous pollutants

Gaseous pollutants denote various pollutants dispersed in flue gases in a gaseous form.

Dry flue gas in standard conditions

Dry flue gas in standard conditions denotes the flue gas, free of moisture at 273K and under the pressure of 101325Pa.

Continuous emission monitoring, CEM

Pollutants emitted form stationary sources are continuously measured by real-time tracing with total measuring hours for each stationary source not less than 75% of total running hours of boilers and kilns and furnaces; measuring time each hour is not less than 45min.

Continuous Emission Monitoring System, CEMS

It includes all the equipment and devices required for continuous measurements of concentrations of particulates and gaseous pollutants and their emission rates; it is generally composed of three sub-systems of sampling, testing and data collection and processing.

Sampling system: collection and transportation of flue gas or isolation of flue gas from the testing system.

Testing system: measuring pollutants, and displaying physical quantity or concentrations of pollutants.

Data collection and processing system: data collection and processing, generating charts or report forms, and having controlling and auto operation functions.

Point CEMS

It denotes a CEMS for measurement at a point on cross section of gas flue or duct, or along the path equal to or less than 10% of diameter of cross section.

Path CEMS

CEMS for measurements along the path equal to or greater than 10% of diameter of cross section of the gas flue or duct

Full scale

The maximum measurement value is set for CEMS based on the practical requirements, usually 1-2 times higher than the maximum emission concentration from the emission sources.

Zero drift

Deviation between the readings of instrument and zero input after CEMS runs for a specified time under the premise of maintenance, repair or adjustment scheduled.

Span drift

Deviation between the readings of instrument and known reference value after CEMS runs for a specified time under the premise of maintenance, repair or adjustment scheduled.

Response time

The time required when the value displayed reaches the 90% of stabilized value.

Centroidal area

Geometrically central area in cross section of the gas flue or duct with its area not greater than 1% of area of the cross section of the gas flue or duct.

Pretest preparation period

The normal running time of CEMS required (not less than 168h) under the premise of maintenance, repair or adjustment scheduled, before testing the CEMS technical indices.

Test period

The running time required for testing CEMS technical indices under the premise of maintenance, repair or adjustment scheduled (initial test not less than 168h).

Retest period

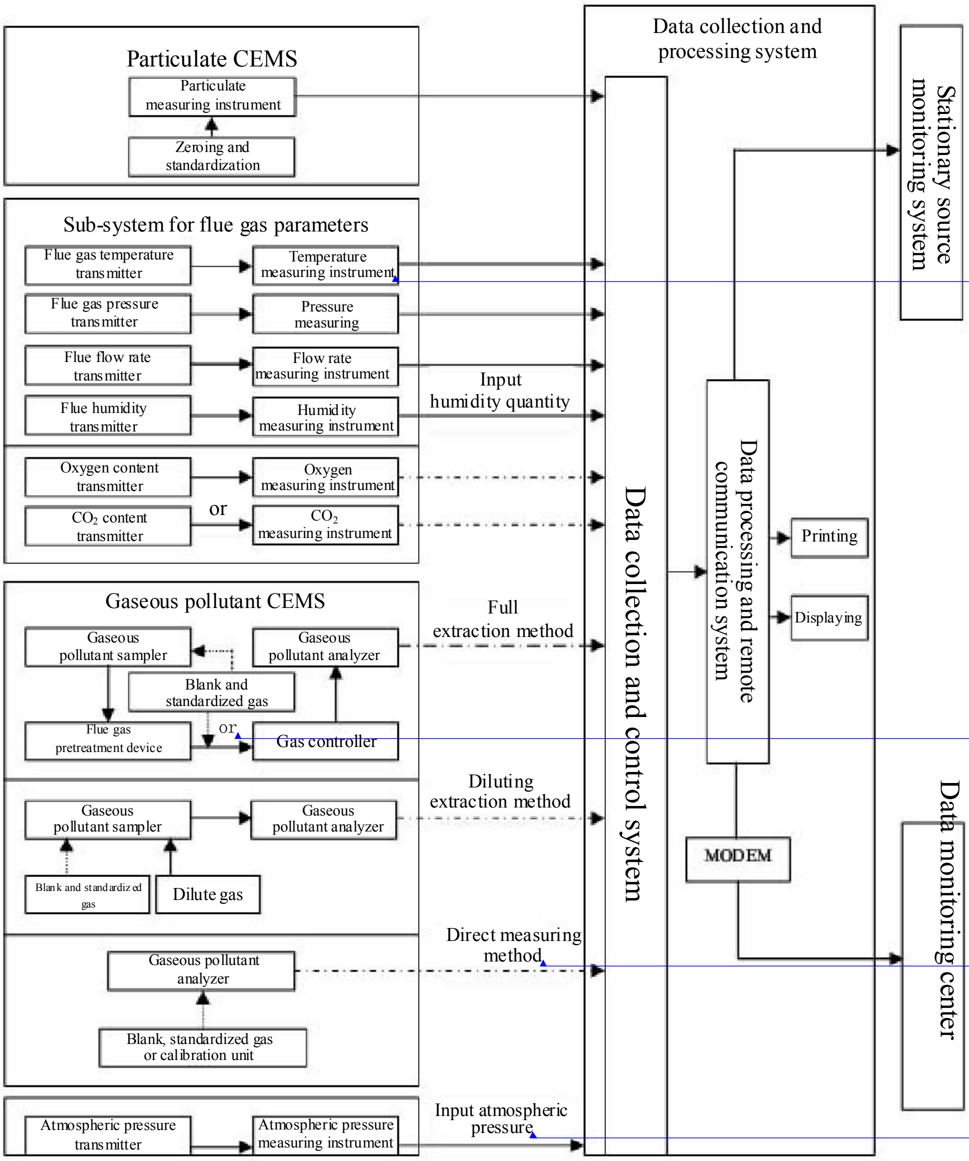
Running time required for retesting CEMS technical indices after the instrument continuously runs for 90 days upon the qualification of testing CEMS technical indices (not less than 24h); unscheduled maintenance, repair or adjustment are not allowed in the retest period.

Reference method

A standard method issued by the state or industry.

Correlation

A curve for establishing correlation between physical quantity of particulates rendered by CEMS and concentration of particulates measured with a reference method.



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...........denotes any measuring instrument of gas parameters and gaseous pollutant CEMS

Fig. 4-1 Schematic drawing of continuous emission monitoring system for flue gas

Relative accuracy

Several data pairs are composed of measuring results of synchronously measuring concentrations of gaseous pollutants in flue gas at the same time intervals with a reference method and CEMS method. The relative accuracy is a ratio of sum of absolute value of the average of differences of the data pairs and coefficient of confidence to the average of data measured with the reference method.

Velocity field coefficient

A ratio of average flow rate of flue gas running through a cross section of the gas flue or duct measured with a reference method to an average flow rate of the flue gas measured at a fixed point or measuring line of the same cross section or different cross section.

4. Structure and Description of Continuous Monitoring System

The CEMS for flue gas emitted from stationary sources is composed of a CEMS for particulates and/or a CEMS for gaseous pollutants (containing O_2 or CO_2) and a sub-system for flue gas parameters (see Fig. 4-1). It is used to measure the concentrations of pollutants in flue gas via sampling mode and non-sampling mode, as well as the temperature, pressure, flow rate or flow, and humidity (or humidity in input flue gas), oxygen content (or CO_2 content) in the flue gas, calculate the emission rate and quantity of pollutants in flue gas, and display and print various parameters and charts which are then transferred to the management department via a facsimile transmission system.

5. Technical Requirements

Appearance requirement

It shall be provided with CMC mark for manufacture of the measuring devices (certificates issued by the quality and technology supervision division of our country for measuring devices are required for imported products) and product nameplate on which the name, model number, manufacturer, ex-factory No., and date of manufacture of the instruments or devices shall be all indicated.

It shall be reliable with connections among each part of the instrument with no apparent defects on its surface. It is flexible for operational buttons and correct for positioning.

It is clear for graduates and numbers with its firmly attachment of colors on scale of display of the instrument and with no defect in readings.

Shell or outer cover of the instrument shall be featured as anti-corrosion, good seal, and prevention of dust and water.

Environmental conditions

It can normally work under the following conditions:

a. environmental temperature: -20 - 45℃;
b. relative humidity: ≤ 90%;
c. atmospheric pressure: 86 – 106kPa;
d. flue gas temperature: < 260℃.

Power voltage

AC 220V±10%, frequency 50Hz.

Safety requirements

Insulation resistance between power line of the instrument and casing at 10-35℃ and relative humidity ≤85% shall not be less than 20MΩ.

The instrument shall be equipped with an earth leakage protection device to avoid electric shock.

The instrument shall be well grounded so as to prevent the instrument from damage by lightning stroke.

Calibration

The instrument shall be calibrated manually or automatically for zero drift and span drift.

Purification

The instrument shall be provided with a purification system to prevent the optical lens and sensor inserted in gas flue or duct from pollution by flue gas; the purification system can overcome the pressure of the flue gas, and keep the optical lens and sensor inserted in gas flue or duct clean.

Data collection and processing

The instrument possesses functions of recording, storing, displaying, data processing, and outputting, printing, fault alarming, safety management and data and facsimile transmission. The instrument shall be set up with any interface in RS232, RS422 and RS485. The CEMS for particulates shall have functions of display and storage for primary physical quantity.

Data collection controller

Data collection and control

A function of data collection and control of the instrument can coordinate the time sequence of the whole system, record the measured data and data of running conditions of the instrument upon which the running state of the instrument can be diagnosed and a mark for the diagnosed state will be given following the measured data ("P"—power supply fault, "F"—stop running of emission source, "C"—calibration, "M"—maintenance, "O"—exceeding the emission standard, "Md"—missing data, "T"—over upper limit of measurement, "D"—instrument fault). The instrument will generate alarming information if it is in an abnormal condition. The instrument will generate alarming information of exceeding the standard when the sliding average of the monitoring data within 1h (a slide at every 15min) exceeds the emission standard.

Data storage

Data collection controller of the instrument can ensure to store the original data, enabling to transmit all kinds of information collected automatically or according to instruction to the controlling center.

Document management

The instrument shall be able to store and back up data files and automatically generate reports of operation parameters, data, line power failure record, and operation record, etc.

Interfaces

The interfaces of the instrument shall have expansion function with modular design, configured with single, dual or multiple paths, based on the requirements of application.

Safety management

The instrument shall be available with a safety management function, work number and password will be required if operator wants to log-in, such that he/she can access the controlling interface, all operation will be automatically recorded and filed-up by the system.

The system shall have the secondary limit of authority for operations.

a. Administrator: can make all kinds of system setting such as setting passwords for operators, operational class, and configuration for all installations.

b. General operators: can only make routine maintenances and operations, unable to change the setting of system.

Auto-resuming function in abnormal situation

The system shall automatically start, and resume the operation conditions and record the time of power failure and time of resuming running if the system was met with a strong interference from the outside or accident or power failure and resumed later on. The data collection modules shall be ensured with a UPS unit which can transmit information on power failure in time to an upstream device.

Data processing and data communication

Data communication

The instrument shall have data communication function which can periodically collect a variety of information transmitted from each data collector on-site, and handle, store and display alarming information and relevant data. The instrument is provided with function of network access, which can transmit data and charts to relevant sections in specified time and consult the data thereby at any time. It can transmit timing instruction timely and correct the clock. The transmission protocol shall meet the requirement of HJ/T212-2005.

Data inquiry and retrieval

It can display the working conditions, set conditional inquiry and display historical data, print alarming information and various charts, display on real time emission data of pollutants and relevant flue gas parameters. The instrument enables to acquire an accumulated average every 10s, display and print measured data at interval of 1min and 15min, generate hourly (at least 45min of valid data), daily (at least 18h of valid data) and monthly (at least 22d of valid data) reports in which maximum, minimum, average and number of samples will be given. The format of reporting is shown in the attached tables 1-3.

Calculation of concentrations of pollutants and emission rate

The instrument shall have function of calculating concentrations of pollutants and emission rate. The methods of conversion and calculation are shown in Appendix B.

Main technical indices of CEMS

The following testing data for each technical index are used from the final displaying and recording results of data processing and transmission units of CEMS.

Main technical indices of CEMS for particulates

Measuring range: the upper limit of measuring range shall comply with the requirement of Clause 3.8 when the instrument is set with one level of measurements; the lowest upper limit of the measuring range shall not exceed 500mg/m^3 if the instrument is set with several levels of measurements.

Zero drift: the zero drift within 24h does not exceed ±2.0% of the full scale of measuring range.

Span drift: the span drift within 24h does not exceed ±2.0% of the full scale of measuring range.

Correlation

Linear calibration curve shall meet the following conditions:

① Correlation coefficient: correlation coefficient ≥ 0.85 (when upper limit of the measuring range is lower than or equal to 50mg/m^3, the correlation coefficient ≥ 0.75).

② Confidence interval: 95% confidence level shall be within the interval composed of two straight lines in the calibration curve corresponding to ±10% of concentration limits of emitted particulates.

③ Permissible interval: shall have 95% confidence level, namely 75% of measured values shall be within the interval composed on two straight lines in the calibration curve corresponding to ±25% of concentration limits of emitted particulates.

Accuracy

Retest shall meet the following requirement:

When emission concentration of particulates measured with a reference method

a. ≤50mg/m^3, the absolute error of average of the measured results by CEMS method and reference method shall not exceed 15mg/m^3;
b. >50mg/m^3 - ≤100mg/m^3, the relative error of average of the measured results by CEMS method and reference method shall not exceed ±25%;
c. >100mg/m^3 - ≤200mg/m^3, the relative error of average of the measured results by CEMS method and reference method shall not exceed ±20%;
d. >200mg/m^3, the relative error of average of the measured results by CEMS method and reference method shall not exceed ±15%.

Main technical indices of CEMS for gaseous pollutants (including O_2 or CO_2)

Linear error: the relative error of measured values by CEMS and reference method shall not exceed ±5% if checked with a low, medium and high concentration of standard gases.

Response time: ≯ 200s.

Zero drift: zero drift does not exceed ±2.5% of full range within 24h.

Span drift: span drift does not exceed ±2.5% of full range within 24h.

Relative accuracy:

When average concentration of SO_2 and NO_X in flue gas measured with a reference method:

a. ≥ 250μmol/mol (the concentrations of SO_2, NO and NO_2 are 715mg/m^3, 335mg/m^3 and 513mg/m^3 respectively), the relative accuracy does not exceed 15%.

b. < 250μmol/mol (the concentrations of SO_2, NO and NO_2 are 715mg/m^3, 335mg/m^3 and 513mg/m^3 respectively), the absolute value of difference of the averaged results measured by reference method and CEMS shall be not greater than 20μmol/mol (the concentrations of SO_2, NO and NO_2 are 57mg/m^3, 27mg/m^3 and 41mg/m^3 respectively);

c. < 50μmol/mol (the concentrations of SO_2, NO and NO_2 are 143mg/m^3, 67mg/m^3 and 103mg/m^3 respectively), the absolute value of difference of the averaged results measured by reference method and CEMS shall be not greater than 15μmol/mol (the concentrations of SO_2, NO and NO_2 are 43mg/m^3, 20mg/m^3 and 31mg/m^3 respectively).

Main technical indices of continuous measuring system for flow rate

Measuring range: upper limit of measuring range shall be not lower than 30m/s.

Precision of velocity field coefficient: better than 5%.

Relative error of velocity: when flow rate >10m/s, the relative error of velocity does not exceed ±10%; when flow rate ≤10m/s, the relative error of velocity does not exceed ±12%.

Main technical indices of continuous measuring system for temperature

Deviation of displaying value is not greater than ±3℃.

Main technical indices of continuous measuring system for humidity

When moisture content in flue gas is measured with O_2 sensor

Calculated from oxygen content in flue gas measured with oxygen sensor, it shall comply with the technical indices of continuous measuring system for oxygen.

When moisture content in flue gas is continuously measured with humidity sensor:

When moisture content in flue gas measured with a reference method:

a. ≤5.0%, the absolute value of the averaged results measured by CEMS and reference method shall be not greater than ±1.5%;

b. >5.0%, the relative error of the averaged results measured by CEMS and reference method shall be not greater than ±25%.

6. Installation of CEMS and Its Measuring Position

6.1 Requirement for installation of CEMS for particulates and its measuring position

Installation of CEMS for particulates and its measuring position

A CEMS for particulates shall be installed at a position where it can represent the emission condition of particulates, closing to a sampling hole by the reference method as much as possible in the premise that it does not interfere the sampling with the reference method. Detail of installation is given as follows:

6.1.1.1 General requirements

It shall be satisfied with general specification in Clause 6.1 of HJ/T 75-2007.

Installation position

It shall be satisfied with general specification in Clause 6.2.2 of HJ/T 75-2007.

Measuring point of CEMS for point measurement

It shall be satisfied with specification in Clause 6.2.9 of HJ/T 75-2007.

Measuring point of CEMS for path measurement

It shall be satisfied with specification in Clause 6.2.10 of HJ/T 75-2007.

Requirement for installation of CEMS for gaseous pollutants (including O_2 and humidity) and its measuring position

General requirements

It shall be located in homogeneously mixed position of gaseous pollutants at which the measured concentration of gaseous pollutants and emission velocity can represent the emission from the stationary sources. It shall close to a sampling hole for reference method as much as possible in the premise that it does not interfere the sampling with the reference method.

It is the same to Clause 6.1.8 of HJ/T 75-2007.

Installation position

It shall be satisfied with specification in Clause 6.2.2 of HJ/T 75-2007 concerning the CEMS for gaseous pollutants.

6.2.3 Measuring position

6.2.3.1Measuring point for CEMS for point measurement

It shall be satisfied with specification in Clause 6.2.9 of HJ/T 75-2007 concerning the CEMS for gaseous pollutants.

6.2.3.2 Measuring point for CEMS for path measurement

It shall be satisfied with specification in Clause 6.2.10 of HJ/T 75-2007 concerning the CEMS for gaseous pollutants.

Installation of continuous measuring system for flue gas parameters (including flow rate, temperature, pressure) and its measuring position.

General requirements

Installation position shall be able to represent the conditions of whole cross section, but it does not influence the measurement of particulates and gaseous pollutants with CEMS.

Measuring position

Continuous measuring system for flow rate with point measurement

It shall be satisfied with specification in Clause 6.2.9 of HJ/T 75-2007 concerning the continuous measurement system for flue gas parameters.

Continuous measuring system for flow rate with path measurement

It shall be satisfied with specification in Clause 6.2.10 of HJ/T 75-2007 concerning the continuous measurement system for flue gas parameters.

7. Sampling Positions and Sampling Points for Reference Method

7.1 Reference method for measuring particulates and flue gas parameters (including flow rate, temperature and pressure).

7.1.1 Sampling position

Sampling position is the same to Clause 4.2.1 of GB/T 16157-1996. The sampling position is not coincident with a measuring position of CEMS for particulates, but close to each other as much as possible in the precondition of not interfering the measurements.

7.1.2 Position of sampling point and sampling number

It shall refer to Clause 4.2.4 of GB/T 16157-1996.

7.2 Reference method for measuring gaseous pollutants (including O_2 and humidity)

7.2.1 Sampling position

It is the same to Clause 6.2.2, but not coincident with the measuring position with CEMS for gaseous pollutants.

7.2.1.1 Position of sampling point and sampling number

7.1.2.1 When the reference method is compared to CEMS method for gaseous pollutants with point measurement, only one sampling point is set up, which is close to an area for CEMS sensor as much as possible.

7.1.2.2 When the reference method is compared to CEMS method for gaseous pollutants with path measurement, only one sampling point is set up, which is close to a central area of measuring path for CEMS sensor as much as possible.

8. Test Procedures for Main Technical Indices of CEMS

8.1 General requirements

8.1.1 Commissioning

8.1.1.1 After completing installation and initial commissioning of CEMS on site, CEMS is then put into operation with time for commissioning not less than 168h.

8.1.1.2 Besides time needed for testing zeroing and calibration of range of instrument during the period of commissioning, any unscheduled maintenance, repair and adjustment for instrument are not allowed.

8.1.1.3 Checking zeroing and calibrating range shall be conducted every day, when drift is over the specified value it shall adjust the instrument.

8.1.1.4 If commissioning was interrupted by failure of emission source or power supply, it shall resume the commissioning after the emission source or power supply is recovered such that the accumulated running time for commissioning will be not less than 168h.

8.1.1.5 If commissioning was interrupted by failure of ECMS, it will restart commissioning for 168h running time after CEMS is recovered to a normal condition.

8.1.2 Testing

8.1.2.1 Test will be performed after the instrument runs normally for 168h. The testing period may not be followed by commissioning period. The testing period shall be not less than 168h.

8.1.2.2 Besides time needed for testing zeroing and calibration of range of instrument during commissioning, any unscheduled maintenance, repair and adjustment for instrument are not allowed.

8.1.2.3 Any time can be set up (with interval of 24h) to automatically adjust zero point and calibrate the range of measurement.

8.1.2.4 If commissioning was interrupted by failure of emission source or power supply, it shall resume the commissioning after the emission source or power supply is recovered such that the accumulated running time for commissioning is not less than 168h.

8.1.2.5 If commissioning was interrupted by failure of ECMS, it will restart commissioning for 168h running time after CEMS is recovered to a normal condition.

8.1.3 Retesting

8.1.3.1 Retesting resumes after the instrument has continuously run for 90 days if testing technical indices of CEMS is qualified. The retesting period is not shorter than 24h.

8.1.3.2 The same to classes 8.1.2.2 and 8.1.2.3.

8.1.3.3 If commissioning was interrupted by failure of emission source or power supply, it shall resume retest for 24h after the emission source or power supply is recovered.

8.1.3.4 If commissioning was interrupted by failure of power supply, it shall resume retest for 24h after the power supply is recovered.

8.1.4 90 days of running

8.1.4.1 Service is given to CEMS in test as per the quality assurance and quality control plan delivered and remote transmit the CEMS data as specified.

8.1.4.2 Record running of CEMS, unscheduled maintenance, repair and adjustment are not allowed.

8.2 Test of main technical indices of CEMS for particulates

8.2.1 Zero drift and span drift

When testing period starts, zeroing and range of instrument shall be manually or automatically calibrated, recording the initial simulated readings of zero point and range. The zero point and range shall be measured and recorded (manually or automatically) every 24h (see attached table 4); followed by calibration of zero point and range of the instrument and record readings of zero point and range for consecutive 168h (7 days). Calculate zero drift and span drift according to formulas (1)-(4).

a. Zero drift:

$$\Delta Z=Z_i-Z_0 \cdots\cdots\cdots\cdots\cdots\cdots (1)$$

$$Zd=\Delta Zmax/R\times100\% \cdots\cdots\cdots (2)$$

wherein: Z_0—initial reading of zero point;

Z_i—zero point at the i^{th} reading;

Z_d—zero drift;

ΔZ—absolute error of zero drift;

ΔZ_{max}-maximum absolute error of zero drift;

R—full range of instrument.

b. Span drift:

$$\Delta S=Si-S0 \cdots\cdots\cdots\cdots\cdots\cdots (3)$$

$$Sd=\Delta S\ max/R\times100\% \cdots\cdots\cdots (4)$$

wherein: S_0—initial reading of range;

S_i—range of the i^{th} reading;

S_d-span drift

ΔS-absolute error of span drift;

ΔS_{max}-maximum absolute error of span drift;

8.2.2 Relevant calibration

8.2.2.1 During the period of testing, it shall fairly consider process operation for emission sources and/or purification facilities, sampling process by reference method and CEMS for particulates; for example, it must ensure process operation under objective condition and the normal operation of CEMS for particulates, as well as the data collection and processing system.

1) Coordinate the time to start and stop the CEMS operation for particulates and sampling process by reference method, for CEMS for particulates of discontinuous sampling, the sampling with reference method shall start at the same time of sampling for CEMS for particulates.
2) Mark in the attached table 6 and record the time that changed the sampling hole for reference method and the time that suspended the reference method so as to adjust the CEMS data for particulates accordingly (if necessarily).

8.2.2.2 If the reference method and CEMS are conducted simultaneously, CEMS will record an accumulated value every minute which forms a data pair with its averaged value together with values measured with reference method at the same time interval. At least 15 pairs of valid testing data pairs have to be achieved.

1) When data pairs for relevant calibration are more than 15, some data pairs can be abandoned.
2) Explanation for 5 pairs of data abandoned does not be required.
3) Explanation for more than 5 pairs of data abandoned must be given.
4) All data must be reported including abandoned data pairs.

8.2.2.3 Ensuring proper distribution scope of data tested for relevant calibration.

1) Concentration of particulates having three different ranges of distribution can be achieved through change of process conditions, operation parameters of controlling devices for particulates or standard addition in particulates.
2) Concentration of particulates in three different levels shall be within the whole range of measurement.
3) At least 20% of measured data in all valid data pairs of measurement shall be within each range as follows:
   a) Range 1: maximum concentration of particulates measured in a range between 0-50%;
   b) Range 2: maximum concentration of particulates measured in a range between 25-75%;
   c) Range 3: maximum concentration of particulates measured in a range between 50-100%.

8.2.2.4 Conversion of results measured with reference method to measuring condition for CEMS (i.e.: mg/m^3, practical volume).

8.2.2.5 Calculation of correlation

1) Calculation before correlation

Measured value Y (proper unit) of reference method shall first match with response X (average within a span of time), the matched data must meet the requirement for quality control/quality assurance.

a) Output of CEMS for particulates and tested data of reference method before testing shall be adjusted to unified clock time (response time of CEMS for particulates must be considered).
b) Calculate the data output of CEMS for particulates during testing with reference method (arithmetic average), evaluate all the CEMS data for particulates and judge whether the averaged values of CEMS data for particulates will be abandoned in the calculation.
c) The measured results of reference method and CEMS for particulates are based on the same condition of flue gas, converting the concentration (dry base at a standard state) of particulates measured with reference method to the unit under the measuring conditions of CEMS for particulates.

2) Calculation of linear correlation

In the calculation of correlation, each measuring value by reference method shall be all treated as discrete point of data.

a. Calculate the equation of linear correlation, which generates predetermined concentration $\hat{Y}$ of particulates as a function of response X of CEMS for particulates as shown in (5)

$$\hat{Y} = a + bX \quad (5)$$

erein:

$\hat{Y}$: predetermined concentration of particulates;

a: intercept on linear correlation curve, see Formula (6);

b: slope on linear correlation curve, see Formula (8);

X: response value of CEMS for particulates.

Calculation for intercept is shown in Formula (6):

$$a = \overline{Y} - b\overline{X} \quad (6)$$

wherein:

$\overline{X}$: average of response of CEMS for particulates, see Formula (7).

$\overline{Y}$: average of concentration of particulates, see Formula (7).

$$\overline{X} = \frac{1}{n}\sum_{i=1}^{n} X_i \qquad \overline{Y} = \frac{1}{n}\sum_{i=1}^{n} Y_i \quad (7)$$

wherein:

X_i: response value of CEMS for particulates in the i^{th} datum;

Y_i: concentration of particulates in the i^{th} data pair;

n: number of data pairs.

Slope is calculated according to Formula (8):

$$b = \frac{S_{xy}}{S_{xx}} \quad (8)$$

wherein:

S_{xy}, S_{xx}: are calculated according to Formula (9):

$$S_{xx} = \sum_{i=1}^{n}(X_i - \overline{X})^2 \qquad S_{xy} = \sum_{i=1}^{n}(X_i - \overline{X})(Y_i - \overline{Y}) \quad (9)$$

b. Predetermined concentration of particulates at average=X, half width of 95% confidence interval is calculated according to Formula (10):

$$CI = t_{df,1-a/2} S_E \sqrt{\frac{1}{n}} \quad (10)$$

wherein:

CI: half width of 95% confidence interval at average=X;

$t_{df,1\text{-}a/2}$: student's statistic t value when d_f=n-2, see attached table 5;

S_E: precision of correlation curve is calculated according to Formula (11):

$$S_E = \sqrt{\frac{1}{n-2}\sum_{i=1}^{n}(\hat{Y}_i - Y_i)^2} \quad (11)$$

Half width of confidence interval as a percentage of emission limits at average=X is calculated according to equation (12):

$$CI\% = \frac{CI}{EL}100\% \quad (12)$$

wherein:

EL: proper emission limit of concentration of particulates.

c. Half width of permissible interval at average=X is calculated according to Formula (13):

$$TI = k_t S_E \quad (13)$$

TI: half width of permissible interval at average=X;

k_t: calculated according to Formula (14);

S_E: calculated according to Formula (11):

$$k_t = u_{n''} V_{df} \quad (14)$$

wherein:

n": number of measured data pairs;

$u_{n''}$: 75% permissible coefficient, see attached table 5;

V_{df}: df=n-2, see attached table 5.

Half width of permissible interval as a percentage of emission limits at average=X is calculated according to Formula (15):

$$TI\% = \frac{TI}{EL}100\% \quad (15)$$

d. Linear correlation coefficient is calculated according to Formula (16):

$$r = \sqrt{1 - \frac{S_E^2}{S_y^2}} \quad (16)$$

S_E: calculated according to Formula (11);

S_y: calculated according to Formula (17);

$$S_Y = \sqrt{\frac{\sum_{i=1}^{n}(Y_i - \overline{Y})^2}{n-1}} \quad (17)$$

8.2.3 Accuracy

8.2.3.1 Input the qualified calibration curve according to 8.2.2 into CEMS

① During retest, testing accuracy can be performed when the facilities in test reach the productivity over 70% upon the normal operation of production equipment and facilities for treatment.

② It is the same to b in 8.2.2, at least 5 pairs of valid data pairs are achieved, but it must report all of the data pairs, including the abandoned data pairs and a reason for such abandonment.

8.2.3.2 Absolute error and relative error

Absolute error and relative error are calculated upon the comparison between the measured values of reference method and displaying values of CEMS after the calibration curve was imputed.

8.3 Test of main technical indices of CEMS for gaseous pollutants (including O_2)

8.3.1 Standard gas

a. Blank gas: is required to contain SO_2 and NO_X not more than 0.1μmol/mol [SO_2, NO_X (counted on NO_2) is 0.3mg/m^3, 0.2mg/m^3, respectively], when measuring CO_2 in flue gas, CO_2 content in blank gas will not exceed 400μmol/mol (786 mg/m^3), concentrations of other gases contained in blank gas will not interfere the readings on instrument or generate readings of SO_2, NO_X or CO_2 (when measuring CO_2 in flue gas).

b. Standard gases: national standard gases with uncertainty within ±2% in a valid period. Standard gas at a low concentration: 20-30% of full scale; standard gas at a medium concentration: 50-60% of full scale; standard gas at a high concentration: 80-100% of full scale.

8.3.2 Linear error

8.3.2.1 Calibration

a. Blank gas runs through the instrument, zeroing the instrument.

b. Calibrate the instrument using standard gas at a medium concentration as a calibration gas, adjusting the displaying value of instrument to be consistent with concentration of standard gas after the calibration gas runs through.

c. After the instrument calibrated, standard gases at a low concentration and high concentration run through separately, take results via readings once the displaying value is stabilized.

d. Use blank gas and each standard gas alternately with measurements repeated for three times such that the results are averaged, liner error is then calculated according to Formula (18):

$$L_{ei}=(\overline{C}_{di}-C_{si})/C_{si}\times 100\% \quad (18)$$

wherein: L_{ei}— linear error;

$\overline{C}_{di}$— measured average of concentration of standard gas;

C_{si}— concentration of standard gas;

i— standard gas in the i^{th} concentration.

Linear error tested is recorded in attached table 7.

8.3.3 Response time

When standard gas at a medium concentration runs through for testing linear error, the time changed from displaying value instantly changed to 90% of stabilized value is measured with a stop watch; the average of measured values is taken as a response time.

The results tested for response time are recorded in attached table 7.

8.3.4 Zero drift and span drift

8.3.4.1 When using calibration device to test zero drift and span drift, it shall select a device which can generate a zero point and a response value in 50-100% of the full range to test zero drift and span drift, the test procedure is the same to Clause 8.2.1.

8.3.4.2 Test using blank gas and standard gas

a. Zero drift

Initial value Z_0 of reading zero point is recorded after the readings are stabilized when blank gas runs through the instrument, press zeroing button to adjust its zero point. After 24h, Z_1 read at zero point is recorded upon the stabilization of readings, press zeroing button to adjust the zero point. Repeat the procedure at the following day to record Z_i for continuous 7 days, and then calculate zero drift Z_d according to equation (2).

b. Span drift:

Initial value S_0 of stabilized reading is recorded after standard gas runs through the instrument to 50-100% of the full scale, press calibration button to calibrate the instrument. After 24h, the same standard gas runs through, S_1 read for standard gas is recorded after the readings are stabilized, press the calibration button to calibrate the instrument, repeat the procedure at the following day, record S_i for continuous 7 days, and then calculate span drift S_d according to Formula (4).

Results tested for zero drift and span drift of CEMS for gaseous pollutants are recorded in attached table 8.

8.3.5 Relative accuracy

a. Relative accuracy can be tested when zero drift, span drift and linear error were tested and qualified and production facilities have reached over 50% of maximum productivity.

b. CEMS and reference method are carried out simultaneously, a data collector will continuously record one accumulated averaged value every minute until the end of test with reference method. The data in the time interval same to the reference method are then averaged.

c. A data pair is formed by values measured at the same time interval with both reference method and CEMS which the same condition (temperature, pressure, humidity and O_2 concentration) for measurement is ensured, over 9 pairs of data shall be acquired every day, at least 9 pairs of data are used to calculate for relative accuracy, but all of the data must be reported, including the abandoned data pairs, measurement must be continuously carried out for 7 days.

d. Relative accuracy is calculated according to Formula (19).

$$RA = \frac{|\overline{d}| + |cc|}{\overline{RM}} \times 100\% \quad (19)$$

wherein: RA— relative accuracy.

$$\overline{RM} = \frac{1}{n}\sum_{i=1}^{n} RM_i \quad (20)$$

wherein: n— number of data pairs;

RM_i— measured value of reference method in the i datum;

$$\overline{d_i} = \frac{1}{n}\sum_{i=1}^{n} d_i \quad (21)$$

$$d_i = RM_i - CEMS_i \quad (22)$$

wherein: d_i-difference of each data pair;

$CEMS_i$— measured value of CEMS in the i datum;

[Note: when calculating the sum of differences of data pairs, positive and negtive marks of the differences have to be reserved]

wherein: confidence coefficient (cc) is expressed by statistic value in t table and standard deviation of differences of data pairs:

$$cc = \pm t_{f,0.95}\frac{S_d}{\sqrt{n}} \quad (23)$$

wherein: $t_{f.0.95}$— achieved from t table, then f=n-1;

S_d— standard deviation of differences of data pairs measure by both reference method and CEMS method.

$$S_d = \sqrt{\frac{\sum_{i=1}^{n}(d_i - \overline{d_i})^2}{n-1}} \quad \text{……………………………………………… (24)}$$

The relative accuracy of CEMS for gaseous pollutants evaluated by reference method is given in attached table 9.

8.4 Test of main technical indices of continuous measuring system for flow rate

8.4.1 Velocity field coefficient

Velocity field coefficient is determined according to Formula (25) upon testing averaged flow rate of flue gas at the cross section by reference method and averaged flow rate of flue gas at a stationary point and path of measurement at the same time interval with continuous measuring system:

$$K_V = \frac{F_s}{F_p} \times \frac{\overline{V_s}}{\overline{V_p}} \quad \text{……………………………………………… (25)}$$

wherein: F_S— area of cross section measured by reference method, m^2;

F_p— area of cross section measured at a stationary point or measuring path, m^2;

$\overline{V_s}$— average flow rate at cross section measured by reference method, m/s;

$\overline{V_p}$— flow rate at cross section at a stationary point or measuring path, m/s.

8.4.2 Precision of velocity field coefficient

At least 5 velocity field coefficients shall be acquired every day upon which daily average of velocity field coefficient is then calculated, but all of the data must be reported, including abandoned data and reasons. For the 7 consecutive days, 7 daily average values of velocity field coefficients are achieved upon which precision of velocity field coefficient is calculated according to Formula (26).

$$CV\% = S / \overline{\overline{K_v}} \times 100\% \quad \text{……………………………………… (26)}$$

wherein: CV— relative standard deviation, %;

$\overline{\overline{K_v}}$—average of daily averaged values of velocity field coefficient during testing;

S— standard deviation of velocity field coefficient.

$$S = \sqrt{\frac{\sum_{i=1}^{n}(\overline{K_{vi}} - \overline{\overline{K_v}})^2}{n-1}} \quad \text{……………………………………………… (27)}$$

wherein: n-number of daily velocity field coefficient;

$\overline{K_{vi}}$—daily average of velocity field coefficient during testing.

8.4.3 Relative error of velocity

a. Input average of daily averaged values of velocity field coefficient acquired according to 8.4.2 into CEMS.

b. Reference method and CEMS are carried out synchronously; CEMS records a displaying value every minute.

c. At least 5 pairs of data shall be acquired; all of the data must be reported, including abandoned data and reasons. Relative error is calculated by an averaged displaying value of CEMS flow rate of velocity field coefficient input subtracted from average of cross section measured by reference method divided by measured value by reference method.

8.5 Test of main technical indices of continuous measuring system for temperature

a. Reference method and CEMS are carried out synchronously; CEMS records a displaying value every minute.

b. At least 5 pairs of data shall be acquired every day for continuously 3 days, but all of the data must be reported, including abandoned data and reasons. Average measured at cross section by reference method is subtracted by a displaying value for temperature of CEMS, upon which deviation of displaying values is then calculated.

8.6 Test of main technical indices for humidity

8.6.1 Continuous measuring system for humidity with dry and wet oxygen calculation

A continuous measuring system for dehumidification from flue gas first and oxygen content later shall meet the requirement of 8.3.

8.6.2 Continuous measuring system with humidity sensor

a. Reference method and CEMS are carried out synchronously; CEMS records a displaying value every minute.

b. At least 5 pairs of data shall be acquired every day for consecutive 3 days, but all of the data must be reported, including abandoned data and reasons. Average measured at cross section by reference method is subtracted by a displaying value for humidity of CEMS, upon which absolute and relative errors of humidity are then calculated.

9 Quality Assurance

9.1 Quality assurance for installation

9.1.1 Installation position shall meet the requirement specified in this standard; there is no water fume and mist on measurement path. When relevant calibration for CEMS for particulates cannot meet the requirement technically, it shall carry out the following checks:

a. test process of reference method

b. sampling position

c. reliability of sampling device

d. running condition of stationary source, especially of purification facilities

e. composition and distribution of particulates

f. number of calibration data and distribution of data

Except for other reasons other than installation position, CEMS shall be installed at a required position for retest.

9.1.2 In principle, a CEMS is required for each of stationary sources (boiler, industrial kiln, and incinerator). The CEMS shall be installed in main vent pipe as much as possible if ventilated gas of a stationary source enters the main vent pipe via several gas flues or ducts, but it shall be convenient for reference method to calibrate CEMS for particulates and CEMS for flue gas flow rate; installation of CEMS at a single gas flue or duct and measured values used as the emission results are not proposed. However, the identical sensors installed at each of gas flue or duct are permitted which each sensor shall meet the requirement of 3.4 in terms of monitoring time per hour.

9.1.3 Constant rate sampling can be realized with measuring flue gas by S type Pitot tube when measuring particulates with reference method. When a flow rate is lower than 5m/s, it is difficult to measure flow rate with a pitot tube with poor accuracy of measuring results. Therefore, the sampling point for reference method shall be at a position selected with a flow rate > 5m/s as much as possible.

9.1.4 Maximum permissible emission concentration in smoke dust of boilers denotes the concentration of smoke dust when excessive air factor at outlet of a duster reaches the specified value, thus, the CEMS sensor for particulates shall be installed a position close to outlet of the purifier as much as possible, satisfied with requirement of Clause 6.

9.1.5 The sampling platform set-up must be accessible and have enough space and ease to operate; it is firm and satisfied with requirement for safety measures; when the sampling platform is set up at height a spiral ladder or elevator shall be provided to access to the platform.

9.1.6 In order to calibrate accurately the CEMS for particulates and continuous measurement system for flue gas flow rate, the CEMS for particulates and continuous measurement system for flue gas flow rate must be installed at a position with flow rate over 5m/s.

9.1.7 Slope of whole pipeline from the sensor to dehumidifier or analyzer by a fully abstraction sampling method must not be smaller than 5 degrees.

9.1.8 If relative accuracy of CEMS for gaseous pollutants can not meet the requirement, it shall be solved upon the investigation of causes. In case the cause remains unclear the measured data of CEMS can be adjusted according to formulas (28) and (29); if measurement cannot be conducted accurately after adjustment the CEMS shall be installed at a more representative position for retesting.

$$CEMS_{adi} = CEMS_i \times E_{ac} \quad (28)$$

wherein: $CEMS_{adi}$— adjusted data of CEMS at the i time;

$CEMS_i$— measured data of CEMS at the i time;

E_{ac}— bias of adjusted factor.

$$E_{ac} = 1 + \overline{d_i} / \overline{CEMS_i} \quad (29)$$

wherein: d_i— average of differences calculated according to Formula (21);

$CEMS_i$— average of measured data of CEMS at the i data pair.

9.1.9 When a dilution system is used to measure the gaseous pollutants in flue gas according to formulas (30), (31);

• diluting gas sample without dehumidification

$$C_d=C_w / (1-X_{sw}) \quad \cdots\cdots (30)$$

wherein: C_d— concentration of pollutant in dry flue gas, mg/m^3;

C_w— concentration of pollutant in wet flue gas, measured by CEMS, mg/m^3;

X_{sw}— humidity of flue gas, volume percentage, %.

• diluting gas sample with dehumidification

$$C_d=C_{md} (1-X_{sw}/r) / (1-X_{sw}) \quad \cdots\cdots (31)$$

wherein: C_{md}— concentration of pollutant in dry flue gas, measured by CEMS, mg/m^3;

r— dilution ratio.

9.1.10 When fully abstraction system with complete heating and without dehumidification is used to measure pollutants in gaseous state, the measured results are converted to concentrations of pollutants in flue gas according to Formula (30).

9.1.11 If CEMS for test and data collection and subsystem for handling are installed in a room, air conditioner must be installed in the room where the indoor environment shall be kept clean with relation humidity ≤ 85% and ambient temperature of 5-30℃.

9.2 Quality assurance for testing

9.2.1 In initial test and retest, a special person in charge of supervision must monitor the working conditions; the enterprises with emission pollutants must adjust the working conditions or running parameters of purification facilities as required as relevant calibration, keeping relative stability during testing.

9.2.2 In order to ease the measurement error and ensure the accuracy of results, it is proposed to use a sampler having a function of automatic tracing smoke dust to carry out the relevant calibration and test of accuracy. The same sampler is used for initial test and retest as much as possible. Check of running shall be carried out before measurement to ensure the normal condition of sampler.

9.2.3 When particulates are sampled at a cross section by reference method, the sampling quantity shall be not less than 10mg or gas sampling quantity not less than 0.5m^3.

9.2.4 When reference method is used to measure gaseous pollutants, it must be calibrated before and after (immediately) sampling with standard gas.

9.2.5 In order to achieve assuredly the measured data at the same time interval with both reference method and CEMS for gaseous pollutants, the time (lagging time) of gaseous pollutants reaching a detector for pollutants and response time of CEMS shall be deducted for fully abstraction type and dilution abstraction type. The time of gaseous pollution reaching the detector for pollutants can be estimated according to Formula (32):

$$t = V/Q_{sl} \quad \cdots\cdots (32)$$

wherein: t— lagging time, min;

V— volume of vent pipe, L;

Q— flow rate of gas run through the vent pipe, L/min.

9.2.6 Reference method shall follow the standard analytical method published by the state or industry or methods listed in "Analytical methods for monitoring air and spent gases" (State Environmental Protection Administration).

9.2.7 When conducting calibration of zero point and range of measurement for fully abstraction type and dilution abstraction type CEMS for gaseous pollutants, in principle, the same path where the blank gas and standard gases run through (such as sampler, filter, scrubber, controller) must be followed.

9.2.8 For CEMS for gaseous pollutants is used to direct measurements, when calibrating zero point and range of measurement, in principle, blank gas and standard gas are required for calibration.

9.2.9 Testing CEMS shall be carried out in the condition that the stationary sources emit pollutants normally.

9.3 Quality assurance at 90 day running period

CEMS must run for 90 days, the CEMS shall meet the following basic requirements in running period for quality assurance.

9.3.1 CEMS for particulates

9.3.1.1 Auto-calibration for zero point and range of measurement of the instrument shall be conducted in less than 24h, during calibration period, zero drift and span drift shall comply with requirement of 5.8.1.2 and 5.8.1.3.

9.3.1.2 Manually calibration of zero point and range of measurement of the instrument shall be conducted in less than 15 days, zero drift and span drift shall comply with requirement of 5.8.1.2 and 5.8.1.3.

9.3.1.3 Air filter has to be replaced in less than one month.

9.3.1.4 Clean glass window isolating flue gas and optical sensor in less than three months, check alignment of optical path of the instrument.

3.3.2 CEMS for gaseous pollutants

9.3.2.1 Calibration of zero point and range of measurement of the instrument shall be conducted with blank gas and standard gas in high concentration in less than 15 days, zero drift and span drift and response time shall comply with requirement of 5.8.2.4 and 5.8.2.5, and 5.8.2.2; Test of linear error shall be conducted in less than 30 days, the linear error shall meet the requirement of 5.8.2.1; test of relative accuracy shall be performed in less than 3 months, the relative accuracy shall meet the requirement of 5.8.2.5.

9.3.2.2 Filtering material for sampling sensor has to be replaced in less than 3 months.

9.3.2.3 Materials for dehumidification and duct filtration must be replaced in less than 3 months.

9.3.2.4 It must use standard materials in valid period.

9.3.2.5 Condensed water inside the air compressor must be evacuated every day.

9.3.2.6 It is the same to 9.3.1.4 for CEMS for direct measuring gaseous pollutants.

9.3.2 CEMS for flow rate

9.3.3.1 Auto-calibration for zero point and range of measurement of the instrument shall be conducted for zero point and (or/and range of measurement) in less than 24h.

9.3.3.2 For manually calibrating instrument, a sensor for velocity measurement has to be taken out from the gas flue or duct, the precipitated smoke dust on it shall be clarified and zero point (or/and range of measurement) is calibrated with a calibration device.

9.3.4 Effective use factor

When test of drift calibrated at a low level (zero) or high level exceeded two folds of drift specified for consecutive 5 days, it indicates that the instrument is met with malfunction during which the data achieved are invalid, and cannot used for calculation of effective use factor. The effective use factor is specified as follows:

$$\text{Effective use factor of instrument} = \frac{\text{Total running time of instrument}}{\text{Total running time of emission source}} \times 100\%$$

10. Test of Adaptability

Monitoring and test center for quality of environmental monitoring instruments in State Environmental Protection Administration is responsible for test and retest of CEMS in the National Environmental Monitoring Network according to the items and methods of test in this stipulation. Monitoring and test center for quality of environmental monitoring instruments in State Environmental Protection Administration shall periodically conduct sampling inspection on the qualified instruments, which pass the test of adaptability.

11 Test Items

See test items in Table 11.1.

Table 11.1 Test Items

Item			Index	Test method
Particulates CEMS	Test period	Zero drift	≤±2.0%F.S.	Clause 8.2.1
		Span drift	≤±2.0%F.S.	Clause 8.2.1
		Correlative coefficient	≥0.85	Clause 8.2.2
			≥0.75 (When upper limit of measuring range≤50mg/m^3)	
		Half width of confidence interval	≤10%	Clause 8.2.2
		Half width of permissible interval	≤25%	Clause 8.2.2
	Retest period	Zero drift	≤±2.0%F.S.	Clause 8.2.1
		Span drift	≤±2.0%F.S.	Clause 8.2.1
		Accuracy	When emission concentration ≤50mg/m^3, absolute error≤±15mg/m^3; >50 mg/m^3~≤100mg/m^3, relative error≤±25%; >100 mg/m^3~≤200mg/m^3, relative error≤±20%; >200mg/m^3, relative error≤±15%	Clause 8.2.3
SO_2 CEMS	Test period	Linear error	≤±5%	Clause 8.3.2
		Response time	≤200s	Clause 8.3.3
		Zero drift	≤±2.5%F.S.	Clause 8.3.4
		Span drift	≤±2.5%F.S.	Clause 8.3.4
		Relative accuracy	When emission concentration≥250μmol/mol (715mg/m^3), relative accuracy≤15%.	Clause 8.3.5
			When emission concentration<250μmol/mol (715mg/m^3), absolute error≤20μmol/mol (57mg/m^3).	

			When emission concentration<50μmol/mol (143mg/m^3), absolute error≤15μmol/mol (43mg/m^3)	
	Retest period	Zero drift	≤±2.5%F.S.	Clause 8.3.4
		Span drift	≤±2.5%F.S.	Clause 8.3.4
		Relative accuracy	When emission concentration≥250μmol/mol (715mg/m^3), relative accuracy≤15%.	Clause 8.3.5
			When emission concentration<250μmol/mol (715mg/m^3), absolute error≤20μmol/mol (57mg/m^3).	
			When emission concentration<50μmol/mol (143mg/m^3), absolute error≤15μmol/mol (43mg/m^3).	
NO_X CEMS	Test period	Linear error	≤±5%	Clause 8.3.2
		Response time	≤200s	Clause 8.3.3
		Zero drift	≤±2.5%F.S.	Clause 8.3.4
		Span drift	≤±2.5%F.S.	Clause 8.3.4
		Relative accuracy	When emission concentration≥250μmol/mol (513mg/m^3), relative accuracy≤15%.	Clause 8.3.5
			When emission concentration<250μmol/mol (513mg/m^3), absolute error≤20μmol/mol (41mg/m^3).	
			When emission concentration<50μmol/mol (103mg/m^3), absolute error≤15μmol/mol (31mg/m^3).	
	Retest period	Zero drift	≤±2.5%F.S.	Clause 8.3.4
		Span drift	≤±2.5%F.S.	Clause 8.3.4
		Relative accuracy	When emission concentration≥250μmol/mol (513mg/m^3), relative accuracy≤15%.	Clause 8.3.5
			When emission concentration<250μmol/mol (513mg/m^3), absolute error≤20μmol/mol (41mg/m^3).	
			When emission concentration<50μmol/mol (103mg/m^3), absolute error≤15μmol/mol (31mg/m^3).	

Table 11.1 Test Items (continued)

Item			Index	Test method
O_2 or CO_2 CEMS	Test period	Linear error	≤±5	Clause 8.3.2
		Response time	≤200s	Clause 8.3.3
		Zero drift	≤±2.5%F.S.	Clause 8.3.4
		Span drift	≤±2.5%F.S.	Clause 8.3.4
		Relative accuracy	≤15%	Clause 8.3.5
	Retest period	Zero drift	≤±2.5%F.S.	Clause 8.3.4
		Span drift	≤±2.5%F.S.	Clause 8.3.4
		Relative accuracy	≤15%	Clause 8.3.5
Continuous flow rate measuring system	Test period	Precision	≤5%	Clause 8.4.2
	Retest period	Relative error	When flow rate >10m/s, relative error≤±10% ≤10m/s, relative error≤±12%	Clause 8.4.3
Continuous temperature measuring system	Test period	Indication deviation	≤±3℃	Clause 8.5
	Retest period	Indication deviation	≤±3℃	Clause 8.5
Continuous humidity measuring system (humidity sensor)	Test period	Relative error	When humidity of flue gas ≤5.0%, absolute error≤±1.5% >5.0%, relative error≤±25%	Clause 8.6
	Retest period	Relative error	When humidity of flue gas ≤5.0%, absolute error≤±1.5% >5.0%, relative error≤±25%	Clause 8.6

Note: F.S.=Full scale; NO_X is calculated as NO_2.

Appendix A Attached Table

Table 1 Daily report of average value per hour for CEM

Name of emission source:____

Number of emission source:________________Date of monitoring: ______YYYY______MM______DD

Time	Particulates			SO_2			NO_X			Flow rate m^3/h	O_2, %	Temperature℃	Water Content %	Load %	Remark
	mg/m^3	Convert into mg/m^3	kg/h	mg/m^3	Convert into mg/m^3	kg/h	mg/m^3	Convert into mg/m^3	kg/h						
00~01															
01~02															
02~03															
03~04															
04~05															
05~06															
06~07															
07~08															
08~09															
09~10															
10~11															
11~12															
12~13															
13~14															
14~15															
15~16															
16~17															
17~18															
18~19															
19~20															
20~21															
21~22															

22~23 23~24												
Average value												
Maximum Value												
Minimum Value												
Number of samples												
Total volume of daily emission, t	—		—			—				—		

Unit of total volume of daily emitted flue gas: X$10^4 m^3/d$

Table 2 Monthly report of average daily value for CEM

Name of emission source:____

Number of emission source:________________________ Month of monitoring:______YYYY______MM

Time	Particulates			SO_2			NO_X			Flow rate m^3/h	O_2, %	Temperature℃	Water Content %	Load %	Remark
	mg/m^3	Convert into mg/m^3	kg/h	mg/m^3	Convert into mg/m^3	kg/h	mg/m^3	Convert into mg/m^3	kg/h						
1 2															
3 4															
5															
6															
7															

8 9														
10														
11														
12														
13 14														
15														
16														
17														
18														
19														
20														
21														
22														
23 24														
25														
26														
27														
28 29														
30														
31														
Average value														
Maximum Value														
Minimum														

Value Number of samples															
Total volume of daily emission, t	——			——		——				——					

Unit of total volume of monthly emitted flue gas: X10^{4}m^3/m

Reported by (Seal): Principal: Reporter: Date of report: YYYY MM DD

Table 3 Annual report of average monthly value for CEM

Name of emission source:____

Number of emission source:__________________________ Year of monitoring: ____________YYYY

Month	Particulates			SO_2			NO_X			Flow rate m^3/h	O_2, %	Temperature℃	Water Content %	Load %	Remark
	mg/m^3	Convert into mg/m^3	kg/h	mg/m^3	Convert into mg/m^3	kg/h	mg/m^3	Convert into mg/m^3	kg/h						
1															
2 3															
4															
5															
6															
7 8															
9															
10															
11															
12 Average value															

Maximum Value													
Minimum Value													
Number of samples													
Total volume of daily emission, t	——			——		——				——			

Unit of total volume of annually emitted flue gas: X$10^4 m^3$/a

Reported by (Seal): Principal: Reporter: Date of report: YYYY MM DD

Table 4 Test of zero drift and span drift of particulate CEMS

Test associate Manufacturer of CEMS
Place of test ________________ Type and number of CEMS ________________
Position of test ________________ Standard value ________________
Principle of CEMS

Date	Time		Unit (mg/m3, mA, mV, opacity %) Zero reading		Absolute error of zero drift	Adjust zero point? (Yes or No)	Calibration of reading superscript		Absolute error of span drift	Adjust span? (Yes or No)	Clean the lens? (Yes or No)	Remark
	Beginning	End	Starting point (Z0)	End point (Zi)			Starting point (Z0)	End point (Zi)				
Maximum value of absolute error of zero drift (Formula 1) Zero drift (Formula 2)							Maximum value of absolute error of span drift (Formula 3) Span drift (Formula 4)					

Table 5 Parameters for calculation of confidence interval and permissible interval

f	t_f	v_f	n'	$u_{n'}$ (75)
7	2.365	1.7972	7	1.233
8	2.306	1.7110	8	1.233
9	2.262	1.6452	9	1.214
10	2.228	1.5931	10	1.208
11	2.201	1.5506	11	1.203
12	2.179	1.5153	12	1.199
13	2.160	1.4854	13	1.195
14	2.145	1.4597	14	1.192
15	2.131	1.4373	15	1.189
16	2.120	1.4176	16	1.187
17	2.110	1.4001	17	1.185
18	2.101	1.3845	18	1.183
19	2.093	1.3704	19	1.181
20	2.086	1.3576	20	1.179
21	2.080	1.3460	21	1.178
22	2.074	1.3353	22	1.177
23	2.069	1.3255	23	1.175
24	2.064	1.3165	24	1.174
25	2.060	1.3081	25	1.173
30	2.042	1.2737	30	1.170
35	2.030	1.2482	35	1.167
40	2.021	1.2284	40	1.165
45	2.014	1.2125	45	1.163
50	2.009	1.1993	50	1.162

$f=n-1$

Table 6 Calibration of particulate CEMS by reference method

Test associate ____________ Manufacturer of CEMS ____________

Place of test ____________ Type and number of CEMS ____________

Position of test ____________ Principle of CEMS ____________

Instrument (adopted by reference method) manufacturer ______ Type and number ______ Principle ______

Date	Time (hour and minute)	Reference method					CEMS method	Color of particulates	Remark
		Sequence number	Number of filter cartridge	Weight of particulate (mg)	Volume of collected air (NL)	Concentration (mg/m^3)	Measured value (no dimension)		

Table 7 Test of linear error and response time of gaseous pollutant CEMS

Test associate ______________________ Manufacturer of CEMS ______________________

Place of test ______________________ Type and number of CEMS ______________________

Position of test ______________________ Principle of CEMS ______________________

Response value of standard gas concentration or calibration device Low concentration ________ Medium concentration ________ High concentration ________

Name of pollutant ________ Unit ________ Date of test ________

Sequence number	Reference value of	Indicating value of CEMS	Average indicating value of CEMS	Relative error (%)	Response time (s)		Remark
					Measured value	Average value	

Table 8 Test of zero drift and span drift of gaseous pollutant CEMS (including O_2 and CO_2)

Test associate | Manufacturer of CEMS
Place of test ________________ | Type and number of CEMS ________________
Position of test ________________ | Principle of CEMS ________________
Response value of standard gas concentration or calibration device | Name of pollutant

Sequence number	Date	Time	Unit (mg/m3, mA, mV, opacity %)								Remark
			Zero reading		Absolute error of zero drift	Full scale, %	Calibration of reading superscript		Absolute error of span drift	Full scale, %	
			Starting point (Z0)	End point (Zi)			Starting point (S0)	End point (Zi)			
1 2											
3											
4											
5											
6											
7											
8											
Maximum value of absolute error of zero drift (Formula 1)							Maximum value of absolute error of span drift (Formula 3)				
Zero drift (Formula 2)							Span drift (Formula 4)				

Table 9 Evaluation of relative accuracy of gaseous pollutant CEMS by reference method

Test associate　　　　　　　　Manufacturer of CEMS

Place of test ____________ Type and number of CEMS ____________

Position of test ____________ Principle of CEMS ____________

Instrument (adopted by reference method) manufacturer ____________ Type and number ________ Principle ________

Date of test YYYY MM DD Name of pollutant ________ Unit ____________

Number of sample	Time (hour, minute)	Reference method (RM) A	CEMS method B	Data difference B -A
Average value of reference method (Formula 20)				
Absolute value of average difference (Formula 21)				
standard deviation of data difference (Formula 24)				
Confidence coefficient (Formula 23)				
Relative accuracy (Formula 19)				

Standard gas	Name	Guaranteed value	Measured result by reference method		Relative error (%)	
			Before sampling	After sampling	Before sampling	After sampling

Table 10 Velocity field coefficient during test (primary test)

Test associate ____________________ Manufacturer of CEMS ______________________

Place of test Type and number of CEMS

Position of test ____________________ Principle of CEMS ______________________

Instrument (adopted by reference method) manufacturer ____________ Type and number ________ Principle ___________

Unit of reference method __________________ Unit of CEMS ____________________________

Date	Method	Times of test							Average value	Standard deviation	Relative standard deviation (%)
		1	2 3 4	5	6	7	8	9			
	Manual CEMS Velocity field coefficient										
	Manual										
	CEMS										
	Velocity field coefficient Manual CEMS										
	Velocity field coefficient										
	Manual										
	CEMS Velocity field coefficient										
	Manual										
	CEMS										
	Velocity field coefficient										
	Manual										
	CEMS Velocity field coefficient										
	Manual										
	CEMS										
	Velocity field coefficient										

	Manual										
	CEMS										
	Velocity field coefficient										
	Manual										
	CEMS										
	Velocity field coefficient Manual										
	CEMS										
	Velocity field coefficient										
Average value of velocity field coefficient				Standard deviation				Relative standard deviation (%)			

Table 11 Test of deviation of indicated temperature

Test associate ____________________ Manufacturer of CEMS ____________________

Place of test Type and number of CEMS

Post of test ____________________ Principle of CEMS ____________________

Instrument (adopted by reference method) manufacturer Type and number Principle

Date	Method	Times of test								
		1	2	3	4	5	6	7	8	9
	Manual									
	CEMS									
	Deviation of indicated temperature									
	Manual									
	CEMS									
	Deviation of indicated temperature Manual CEMS									
	Deviation of indicated temperature									
	Manual									
	CEMS Deviation of indicated temperature									
	Manual									
	CEMS									
	Deviation of indicated temperature									
	Manual CEMS									
	Deviation of indicated temperature									

	Manual CEMS								
	Deviation of indicated temperature								

Table 12 Test of relative or absolute error of temperature

Test associate ____________________ Manufacturer of CEMS ____________________

Place of test ____________________ Type and number of CEMS ____________________

Position of test Principle of CEMS

Instrument (adopted by reference method) manufacturer ____________ Type and number ____________ Principle ____________

Date	Method	Times of test 1	2	3	4	5	6	7	8	9
	Manual									
	CEMS									
	Relative or absolute error									
	Manual CEMS Relative or absolute error									
	Manual									
	CEMS									
	Relative or absolute error									
	Manual									
	CEMS									
	Relative or absolute error									
	Manual									
	CEMS									
	Relative or absolute error									

	Manual CEMS					
	Relative or absolute error					
	Manual					
	CEMS					
	Relative or absolute error					

Appendix B Determination of flue gas parameters and requirements of conversion of pollutant concentration and calculation of flue gas parameters

1. Determination of Flue Gas Parameters

1.1 Determination of Flue Gas Temperature

Continuously determine the flue gas temperature by thermal couple set by CEMS or thermal resistance temperature sensor, deviation of indicating value not exceeding ±3℃.

1.2 Determination of Moisture Content in the Flue Gas

a. Continuous determination by oxygen sensor or humidity sensor

Determine oxygen content and calculate moisture content in the flue gas by oxygen sensor set by CEMS before and after dehumidification or continuously determine moisture content in the flue gas by humidity sensor.

When determine moisture content in the flue gas based on the oxygen content before and after dehumidification, calculate humidity of flue gas according to the following formula B1.

$$X_{sw} = 1 - \frac{X'_{O_2}}{X_{O_2}} \quad \text{(B1)}$$

In the formula:

X'_{O_2} — Volume percentage of oxygen in wet flue gas, %

X_{O_2} — Volume percentage of oxygen in dry flue gas, %

b. Determination by manual method

According to Clause 5.2 of GB/T16157——1996, select weight method or condensation or wet/dry bulb method and input average value into CEMS.

1.3 Determination and Calculation of O_2 and CO_2 in the Flue Gas

a. Continuously determine O_2 content by oxygen detector set by CEMS.

$$CO_2 = CO_{2\max}\left(1 - \frac{O_2}{20.9/100}\right) \quad \text{(B2)}$$

b. Calculate CO_2 content in the flue gas according to formula B2.

In the formula:

CO_{2max}—Maximum volume percentage of CO2 generated during combustion of fuel (%), which can be obtained from Table B2 of approximate value of CO_{2max}.

Table B2 Approximate value of CO_{2max}

Type of fuel	Bituminous coal	Meager coal	Anthracite coal	Fuel oil	Petroleum gas	LPG	Wet natural gas	Dry natural gas	Town gas
CO_2max (%)	18.4~18.7	18.9~19.3	19.3~20.2	15.0~16.0	11.2~11.4	13.8~15.1	10.6	11.5	10.0

1.4 Calculation of Flue Gas Density and Molecular Weight of Gas

Calculate flue gas density and molecular weight of gas according to Clause 6 of GB/T16157——1996.

1.5 Determination and Calculation of Flue Gas Flow Rate and Flow Amount

a. Determinate of atmospheric pressure

① Determination by barometric pressure sensor set by CEMS

② Based on average values of last month or last year provided by meteorological station and different heights of test points and meteorological station, calibrate these values in line with increment or subtraction of 10m and 110Pa and input into the CEMS as average barometric pressure in current month or year.

b. Determination of flue gas flow rate

Continuously determine flue gas flow rate on a fixed point, located in the flue or on the cross-section of the pipeline, by pitot tube speed detector or target flowmeter speed detector, or continuously determine quality flow rate of flue gas on a fixed point, located on the cross-section, by heat balancer, or continuously determine line average flow rate of flue gas on the cross-section by supersonic speed detector.

① Calculation of flue gas flow rate

- According to formula B3, calculate flow rate in the flue or on the cross-section of pipeline by pitot tube method, heat balance, supersonic method (install the speed detector on the rectangular flue or pipeline) and target flowmeter:

$$\overline{V_s} = K_v \times \overline{V_p} \quad \text{(B3)}$$

In the formula:

K_v — Velocity field coefficient;

$\overline{V_p}$ — Determine average flow rate of emitted wet gas on a certain fixed point (located on the cross-section) or measurement line, m/s;

$\overline{V_s}$ — Determine average flow rate of emitted wet gas on the cross-section, m/s.

- According to formula B4, calculate average flow rate in the flue or on the cross-section by supersonic method (install the speed detector on the rectangular flue or pipeline):

$$\overline{V_s} = \frac{1}{2\cos\alpha}\left(\frac{1}{t_A} - \frac{1}{t_B}\right) \quad \text{(B4)}$$

In the formula:

l—Distance between A (receiver/transmitter) and B (receiver/transmitter) installed on both sides of flue or pipeline (subtract wall thickness of flue), m;

α—Included angle of l between centerline of flue or pipeline and AB;

t_A—Transmission time of sound pulse from A to B (in the same direction of air flow), s;

t_B—Transmission time of sound pulse from B to A (in the reverse direction of air flow), s.

② Calculation of flue gas flow rate

- According to formula B5, calculate flow amount of wet flue gas Q_s under working condition:

$$Q_s = 3600 \times F \times \overline{V_s} \quad \text{(B5)}$$

In the formula:

Q_s—Flow amount of wet flue gas under working condition, m^3/h;

F—Area of cross-section used for determination, m^2.

- According to formula B6, calculate flow amount of dry flue gas Q_{sn} under standard condition:

$$Q_{sn} = Q_s \times \frac{273}{273 + t_s} \times \frac{B_a + P_s}{101325} \times (1 - X_{sw}) \text{……………………} \quad (B6)$$

In the formula:

Q_{sn}—Flow amount of dry flue gas under standard condition, m^3/h;

B_a—Barometric pressure, Pa;

P_s—Static pressure of flue gas, Pa;

t_s—Temperature of flue gas, ℃;

X_{sw}—Volume percentage of moisture in the flue gas, %.

1.6 Calculation of Concentration of Particulates or Gaseous Pollutant and Emission Rate

a. According to formula B7, calculate emission concentration of particulates or gaseous pollutant:

$$C' = bx + a \text{………………………………………………} \quad (B7)$$

In the formula:

C'—Concentration of particulates or gaseous pollutant in dry flue gas under standard condition, mg/m^3;

When gaseous pollutant CEMS complies with relative accuracy, C'=x

x—Physical quantity indicated by CEMS;

—Slope of regression equation;

—Intercept of regression equation, mg/m^3.

When adopt μmol/mol as the indicated unit of gaseous pollutant concentration, conversion coefficients for converting SO_2, NO and NO_2 into the unit of mg/m^3, under standard condition, are as followings:

SO_2: 1 μmol/mol=64/22.4 mg/m^3

NO: 1 μmol/mol=30/22.4 mg/m^3

NO_2: 1 μmol/mol=46/22.4 mg/m^3

b. According to formula B8, calculate emission concentration of particulates or gaseous pollutant:

$$C = C' \times \frac{\alpha}{\alpha_s} \text{………………………………………………} \quad (B8)$$

In the formula:

C—Concentration of particulates or gaseous pollutant when converting into excessive air coefficient α, mg/m^3;

C' —Concentration of particulates or gaseous pollutant in dry flue gas under standard condition, mg/m^3;

α—Excessive air coefficient measured at the test point;

α_s—Excessive air coefficient stipulated in relevant emission standard.

c. According to formula B9, calculate excessive air coefficient:

$$\alpha = \frac{21/100}{21/100 - X_{O_2}} \quad \text{(B9)}$$

d. According to formula B10, calculate emission rate of particulates or gaseous pollutant:

$$G = c' \times Q_{sn} \times 10^{-6} \quad \text{(B10)}$$

In the formula:

G—Emission rate of particulates or gaseous pollutant, kg/h;

Q_{sn}—Emitted volume of dry flue gas under standard condition, m^3/h.

Appendix C Embodiment about calibration of particulates by reference method

The followings are average values of flue gas parameters tested by the particulate CEMS in a coal-fired power plant.

Temperature: 120℃; Static pressure: -0.14kPa (gauge pressure); Oxygen content: 7%; Humidity: 4%.

Emission limit value: 150mg/m^3.

Original records of test results are shown in Table C1 (Concentration range is 0~200mg/m^3).

Table C1 Original records of determination of particulates in flue gas by CEMS and reference method

No.	Indicating value of CMES	Reference method (mg/m^3)	No.	Indicating value of CMES	Reference method (mg/m^3)	No.	Indicating value of CMES	Reference method (mg/m^3)
1	109.3	71.4	13	98.1	55.5	25	89.8	53.0
2	106.1	71.2	14	60.0	34.6	26	98.0	52.5
3	111.2	69.9	15	80.0	48.0	27	68.6	35.2
4	85.2	59.0	16	73.5	46.3	28	76.4	48.1
5	119.6	73.7	17	89.5	58.9	29	130.6	94.4
6	110.1	72.4	18	160.7	110.0	30	120.8	88.0
7	123.6	72.9	19	158.9	113.6	31	118.0	75.5
8	147.4	102.1	20	170.3	120.8	32	135.0	90.2
9	139.8	99.2	21	168.3	109.3	33	110.3	71.4
10	124.7	88.6	22	150.4	108.8	34	125.5	89.6
11	139.8	95.8	23	178.9	123.4	35	100.4	74.4
12	119.9	72.0	24	73.6	47.4	36	98.9	70.2

Note: In the table, unit adopted in reference method is converted into the unit under actual condition of flue gas, and indicating value of CEMS has no dimension.

1. Calculation by Linear Regression Equation

$$\overline{X} = 115.9$$

$$\overline{Y} = 76.9$$

$$S_{xx} = 33235.0$$

$$S_{xy} = 25539.0$$

$$S_{yy} = 20527.3$$

$$\hat{Y} = 0.7684X - 12.2$$

2. Calculation of Half Width of Confidence Interval

Precision of regression line: S_E=5.15,

According to Table 5, t=2.030,

Thus, half width of confidence interval CI=1.74 when average value X=115.9 (indicating value of CEMS).

According to the stipulations of the coal-fired power plant, excessive air coefficient is 1.4, emission limit value 150mg/m3 (standard condition of dry flue gas). Actual emission concentration is 110mg/m3 (Actual condition of flue gas) based on the calculation by State Equation of Ideal Gas, formula 30, formula B7 and B8.

Thus, half width of confidence interval of emission limit value percentage CI%=1.58% when average value X=116 (indicating value of CEMS).

3. Calculation of Half Width of Permissible Interval

According to Table 5, k_t=1.46.

Thus, half width of permissible interval TI=7.50 and half width of permissible interval of emission limit value percentage TI%=6.82% when average value X=115.9 (indicating value of CEMS).

4. Correlative Coefficient

r=0.978

5. Graphic Examples of Linear Curve, Confidence Interval and Permissible Interval

95% confidence interval $\hat{Y} = 0.7684X - 12.2 \pm 1.74$

95% permissible interval $\hat{Y} = 0.7684X - 12.2 \pm 7.50$

Calculation and graphic examples are shown in Figure C1.

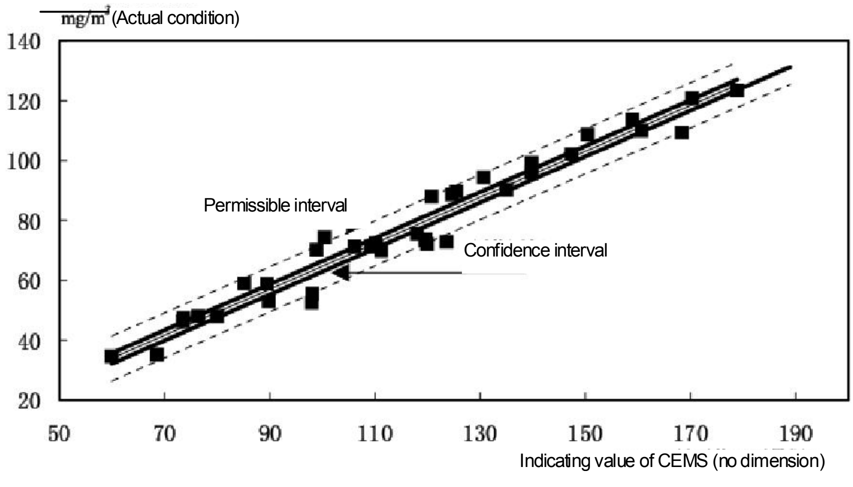

Figure C1 Linear curve, confidence interval and permissible interval

Appendix D Determine concentrations of SO_2 and NO_X emitted from stationary pollutant source——instrument analysis method

1. Principle and Application Scope

1.1 Application Scope

Only when having been specified in this standard and used for testing relative accuracy of gaseous pollutants, SO_2 and NO_X, determine concentrations of SO_2 and NO_X emitted from stationary pollutant source. Refer to this procedure for determination of other gaseous pollutants.

1.2 Principle

Continuously extract flue gas from chimney/flue, feed part of sample gas into an analyzer and determine concentrations of SO_2 and NO_X according to the standard analytical methods, enacted by country or industry, or the methods listed in *Monitoring and Analytical Method for Ambient Air and Exhaust Gas* (State Environmental Protection Administration). To ensure the reliability of data, performance, specifications and test procedures are provided.

2. Measuring Range and Sensitivity

2.1 Measuring Range

For this method, measuring range is decided by span of selected measurement system. However, concentration of gaseous pollutant shall not be lower than 30% of the span of selected measurement system. If concentration of gaseous pollutant exceeds selected span at any moment during a test period, the determination will be invalid.

2.2 Sensitivity

Minimum detection limit shall be lower than 20% of span.

3. Definition

3.1 Measurement System

To determine gas concentration, all required equipment is composed of following subsystems:

3.1.1 Sampling system

This system is used in obtaining and transferring samples, adjusting the sampling or protecting analyzer from the impact of substance emitted from chimney.

3.1.2 Gas analyzer

This component is used in detecting gas to be tested and generating output signal, which is proportional to the concentration of gas.

3.1.3 Data recorder

Strip-chart recorder, analog computer or digital recorder is used for recording the measured data outputted from analyzer.

3.2 Calibration Error of Analyzer

Directly infuse standard gas into the analyzer, which will indicate the difference between gas concentration and given concentration of standard gas.

3.3 Deviation of Sampling System

Infuse concentration-given gas through the outlet of sampling probe and measurement system will show the difference between gas concentration and concentration indicated by measurement system when same gas is directly infused into the analyzer.

4. Stipulation about Performance of Measurement System

4.1 Calibration Error of Analyzer

Calibration error of standard gas (zero, medium and high concentration) shall be lower than ±2% of span.

4.2 Deviation of Sampling System

Deviation of standard gas (zero, medium and high concentration) shall be lower than ±5% of span.

4.3 Zero Drift

Lower than ±2.5% in each operation cycle.

4.4 Span Drift

Lower than ±2.5% in each operation cycle.

5. Equipment

5.1 Measurement System

Select measurement systems, which have passed adaptability test conducted by monitoring and test center for quality of environmental monitoring instruments in State Environmental Protection Administration, including any SO_2 or NO_X measure system complying with the stipulations in this method. Necessary components of this system are as followings:

5.1.1 Sampling probe

Glass, stainless steel or equivalent shall be long enough to be moved on the sampling point. Sampling probe shall be heated to avoid coagulation.

5.1.2 Sample pipeline

Heat stainless steel or polytetrafluroethylene duct (adequately avoid coagulation) to transfer sample gas into dehumidification system.

5.1.3 Transfer pipe of sample

Stainless steel or polytetrafluroethylene duct to transfer sample gas from dehumidification system to sampling pump, flow controller of sample and branch pipe of sample.

5.1.4 Components of calibration valve

When being adopted for calibration method, three-way valve or equivalent can be used in closing sample gas flow and infusing calibration gas into measurement system.

5.1.5 Dehumidification system

Refrigerating condenser or similar equipment (dryer) can be adopted in removing the water vapor in the sample gas. Water vapor removal system isn't required for analyzer, which can determine sample gas concentration under wet condition. However, conversion formula of wet-based concentration to dry-based concentration shall be approved by environmental protection department.

5.1.6 Filtration film of particulates

Filtration film, made of borate, silicate or quartz glass cotton or glass fiber cotton, shall be placed in the chimney/flue or heated (adequately avoid coagulation of water vapor) and placed outside of chimney/flue. Filtration film can be used at the outlet or inlet of water vapor removal system and inlet of analyzer in order to prevent particulates accumulating in the measurement system and prolong service life or components. Material of film shall not react with sample gas.

5.1.7 Sampling pump

The pump can be used in supplying power to sampling system and transferring sample gas to the analyzer. It can be made from any material which doesn't react with sample gas.

5.1.8 Flow controller of sample

Flow control valve, rotary flowmeter or equivalent can be used in maintaining constant flow amount of sample within precision of 10%.

(Note: Test associate can choose a back pressure regulator to keep branch pipe under normal pressure, avoiding excessive pressure on the analyzer and reducing requirements for flow control).

5.1.9 Branch pipe of sample gas

Through this pipe, part of sample gas can be transferred to the analyzer, others to the outlets of braches. Branch pipe of sample gas shall also include spare parts, through which standard gas can be directly infused into the analyzer, and can be made from any material which doesn't react with sample gas.

5.1.10 Gas analyzer

Continuously determine concentrations of SO_2 and NO_X according to the standard analytical methods, enacted by country or industry, or the methods listed in *Monitoring and Analytical Method for Ambient Air and Exhaust Gas* (State Environmental Protection Administration). Performance of analyzer shall comply with the stipulation in Chapter 4 of this appendix. Additional tool for flow control and instruments for measuring flow amount shall also be provided (precise rotary flowmeter and pressure gauge used for controlling total downstream flow).

(Note: Place the analyzer in a clean, constant-temperature and anti-corrosive environment to reduce the drift after calibrating analyzer.)

5.1.11 Data recorder

Strip-chart recorder, analog computer or digital recorder can be used in recording measured data. Resolution of data shall be 0.5% of span. Digital or analog head, whose resolution is 0.5% of span, can be used in manual record of reading.

6. Performance Test Procedures of Measurement System

Finish following procedures before measuring emission concentration.

6.1 Preparation of Measurement System

Prepare and test analyzer and other systematic components according to user's manual provided by manufacturer.

6.2 Calibration Error of Analyzer

6.2.1 Select standard gas, complying with 8.3.1 in this technical specification, and infuse Blank gas, medium-concentration and high-concentration standard gas into the analyzer. During inspection period, adjustment isn't required except for ensuring correctly calibrated gas flow, and record response value of each kind of standard gas on the analyzer (Table D1).

6.2.2 If concentration of any kind of standard gas, indicated by analyzer, exceeds ±2% of span, inspection for calibration error of analyzer will be invalid. To handle with invalid inspection, take corrective measures and re-inspect calibration error of analyzer to reach acceptable indices of performance.

6.3 Inspect Deviation of Sampling System

Inspect deviation of sampling system by infusing standard gas through calibration valve installed at the outlet of sampling probe. From medium and high-concentration standard gases, select standard gas, nearest to emission concentration, and Blank gas. Then, conduct inspection according to following methods.

6.3.1 Infuse standard gas, nearest to emission concentration, and record response value of analyzer in Table D2. Then, infuse Blank gas and record response value of analyzer. Blank gas can also be infused before injecting standard gas.

During inspecting deviation of sampling system, operate the system at normal sampling flow. Regulation for the analyzer isn't required except for ensuring properly calibrated gas flow.

Meanwhile, record response time, which shall not exceed 180s. Inspection procedures of response time shall be conducted according to 8.3.3 in the technical specification.

6.3.2 For Blank gas or any kind of standard gas, if difference of indicated value between inspection for calibration error of analyzer and inspection for deviation of sampling system exceeds ±5% of selected span, inspection for deviation of sampling system will be invalid. To handle with invalid inspection, take corrective measures and re-inspect calibration error of analyzer until acceptable performance is provided. If analyzer is needed to be adjusted, firstly re-inspect calibration error. Then, re-inspect deviation of sampling system.

7. Determination Procedures of Emission Concentration

7.1 Select Cross-section and Point of Sampling

Select cross-section and point of sampling according to the requirements of GB/T16157-2001.

7.2 Collection of Samples

Collect samples at the same flow amount in the inspection for deviation of sampling system and maintain constant flow during the whole operation, and single sampling time shall be longer than 2 times of response time of measurement system.

7.3 Zero Drift and Span Drift

Conduct this procedure before and after sampling. Don't adjust measurement system before finishing the inspection for drift. Record response value of analyzer in Table D2.

If zero drift and span drift exceed the limit, this operation will be invalid. Before restarting operation, repeat inspection procedures of calibration error of analyzer and deviation of sampling system.

8. Calculation of Emission Concentration

Calculate gas emission concentration according to formula D1.

$$C_{gas} = (\bar{C} - C_0)\frac{C_{ma}}{C_m - C_0} \quad \text{(D1)}$$

In the formula:

C_{gas} - Concentration of emitted gas;

$\bar{C}$ - Average gas concentration indicated by gas analyzer;

C_0 - Average systematic response value of Blank gas before and after sampling;

C_m - Average systematic response value of standard gas before and after sampling, whose concentration is close to emission concentration;

C_{ma} - Standard gas concentration, which is close to actual emission concentration.

Table D1 Calibration error of analyzer

Production unit of standard gas:__________________ Span: __________________

Tested by: __________________________________ Date: __________________

Standard gas	Standard value of gas	Response value of analyzer	Absolute difference	Error (percentage of span)
Blank gas				
Medium concentration				
High concentration				

Table D2 Deviation of sampling system and data of drift

Production unit of standard gas:__________________ Span: __________________

Tested by: __________________________________ Date: __________________

Standard gas	Response value of calibration error of analyzer	Before sampling		Before sampling		Drift
		Response value of system	Deviation of system	Response value of system	Deviation of system	
Blank gas						
Close to actual situation Emission concentration Standard gas						

Deviation of system=(Response value of system-response value of analyzer)/spanX100