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Quality assurance and control at the site of online monitoring equipment of the flue gas

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Abstract. To ensure the stable operation of online monitoring equipment, reduce equipment failure and improve the effective operation rate, this paper analyzes the quality assurance and control measures that we should take strictly from such aspects as the installation, operation, maintenance, calibration and comparison of the equipment, and puts forward auxiliary means for further verifying the accuracy of the data from online monitoring equipment. The results show that in the actual operation and maintenance work, we can discover and eliminate problems in operation in time and ensure the long-term standard operation of online monitoring equipment, provided we operate the equipment in strict accordance with technical specifications.

Keywords. Online monitoring equipment, quality assurance, operation and maintenance, equipment failure.

1. Introduction

As the environmental management requirements are increasingly stringent, the standard limit of pollutant emissions is gradually tougher, which requires enterprises to adopt more advanced desulfuration, denitration, dedusting and other treatment processes and technologies. Although the pollutant emission concentration is significantly reduced, the environmental conditions for the flue gas emitted from pollution sources become worser. For example, after the use of the wet desulphurization treatment process, the humidity of the flue gas obviously increases, the temperature decreases, and the corrosion is enhanced, due to which online monitoring equipment undergoes continuous automatic monitoring under the condition of low temperature, high humidity and strong corrosion, and cannot run stably and reliably for a long time, the failure rate rises and the valid data rate declines. Based on this, only by enhancing the quality assurance and control in the site operation and maintenance can all links be effectively controlled and the online monitoring equipment provide true, accurate and valid data and be under control at all times.

2. Basic composition of continuous emissions monitoring system of the flue gas emitted from stationary sources (online monitoring equipment)

Online monitoring equipment, which is generally composed of such units as particulate matter measurement, gaseous pollutant measurement, flue gas auxiliary parameter measurement, and data acquisition and processing, can measure the particulate matter concentration in the flue gas, the concentration of sulfur dioxide, nitric oxide and other gaseous pollutants, and the flue gas auxiliary parameters such as temperature, pressure, flow rate, humidity and oxygen in real time and accurately, calculate the emission rate and total amount of pollutants in the flue gas, display and record data and parameters, generate relevant graphics, texts and tables, and transmit them to the ecological environmental management department by data, graphics, text or other means [1].

3. Quality assurance and control requirements for site installation conditions of online monitoring equipment

Whether the installation position of the equipment meets relevant technical specifications and standards is the most basic and important condition to ensure the accuracy of the measurement. The installation site must be representative and at the downstream of the treatment equipment of stationary sources, ensuring that the sampling section should be set at the position that is not less than four times the flue diameter downstream of the flow rate disturbance source and not less than two times the flue diameter upstream of the flow rate disturbance source [1], and should exhibit stable laminar flow; when a straight pipe that meets the installation requirements cannot be found, the section on which the flue gas and particulate matter are in relatively uniform and stable distribution may be selected as much as possible to ensure that there is no turbulence; the flow rate, an important parameter, directly determines the accuracy of the pollutant emission rate. The flow rate of the flue gas determines the measurement method. If the current meter is improper, large measurement errors may be produced, and a S-type pitot tube should be installed in a position where the flow rate in the flue is greater than 5 m/s [1], and an ultrasonic current meter can be used if the flow rate is low. The equipment in the monitoring site should not be significantly affected by light and electromagnetic radiation, and the less the vibration of the flue, the better; the interference of fog drops in the flue gas should also be avoided. While not affecting the measurement of each other, the reference method sampling aperture should be as close to the monitoring section of online monitoring equipment as possible [1] to facilitate the accurate comparative monitoring. Only when the installation position meets the technical specifications can basic conditions be created for the stable operation of the equipment in the future.

4. Quality assurance and control requirements for standard materials

The quality of standard materials is an important condition that affects the measurement. The standard gas used to calibrate and verify online monitoring equipment must be the national primary or secondary standard gas approved by the national administrative department of measurement, which can be traced to the source of the national standard gas, such information as the concentration value, manufacturer, validity period and uncertainty of the standard gas should be specified, and the factory certificate should be provided. The zero standard gas is usually the gas containing less than 0.1 μmol/mol of sulfur dioxide and nitrogen oxide, and the concentrations of other gases in it should not interfere the reading of the instrument; the range standard gas is the gas whose concentration is within the full range (80% 100%), with the uncertainty of no more than ±2.0% [1], and it should be used within the validity period.

5. Quality assurance and control requirements for daily operation and maintenance

5.1. Quality assurance and control requirements for daily inspection and maintenance

Deviations may occur in the long-term continuous operation of online monitoring equipment. Before the deviations reach the error range allowed by relevant technical specifications, the standard gas is effectively calibrated and maintained according to the requirements for the operation and maintenance period of different modules, components and parts of online monitoring equipment to eliminate the possible errors in advance, thus making the errors always within the range allowed by technical specifications. The operating company should fill in records for the equipment maintenance and repair, replacement of parts and other activities, and keep photos, electronic documents and so on, and the records should be complete, clear and accurate for inspection and traceability. The ecological environment inspectors shall inspect the operation of online monitoring equipment on the site according to the requirements of relevant technical specifications; when consulting relevant records and data, they shall issue such decisions as making rectification within a prescribed time limit, warning and punishment based on the severity of the behaviors that are found not in line with technical specifications. For sites where equipment is not operated and maintained according to technical specification, thus causing high equipment failure rate, disordered management and plenty of problems, the on-site law-enforcement inspections must be strengthened and increased. Where necessary, the inspectors may compare online monitoring equipment on the site and timely solve the problems found, to ensure the valid operation of online monitoring equipment.

5.2. Quality assurance and control requirements for calibration

Instrument calibration of different principles has different methods and cycles, and thus should be carried out in accordance with technical specifications, instructions, technical specifications of operation, technical standards and management regulations. The calibration results should be recorded in detail, ensuring that they can be found in the data acquisition instrument for inspection. Zero and range calibration, and system response time and indication error tests are carried out on the online monitoring equipment; if technical indicators fail to be met, it is necessary to timely find the reasons, take effective corrective actions, and shorten the interval of the next calibration and maintenance. As desulphurization technology advances constantly, the concentration of sulfur dioxide has significantly decreased, which even reaches zero, and yet the moisture in the emitted flue gas has significantly increased, suggesting a bad condition of the flue gas. Large deviations may occur when sulfur dioxide is used for full range calibration in practice, and then we should check whether the temperature of the heat tracing pipe is too low, whether dew forms in the pipe, or whether there are other crystal substances absorbing sulfur dioxide, which results in low results. Where necessary, the sampling system in which samples are dehydrated by freeze drying may be used, and the dilute phosphoric acid solution can be added in the condenser or heat tracing pipe to inhibit the absorption of sulfur dioxide by condensed water or other substances in the flue gas.

5.3. Quality assurance and control requirements for verification

Normally, online monitoring equipment, as long as passing the verification, runs normally and meets the technical indicators in the technical specifications, and its data are legal and valid. However, during the actual operation, a small number of operation and maintenance personnel show a- poor sense of responsibility. In the event of less obvious problems to online monitoring equipment, to reduce the workload of operation and maintenance, they fail to maintain the online monitoring equipment and find out the reasons in accordance with the frequency and content specified in the technical specifications, and even modify some data to make the verification data seemingly match the online monitoring data and the error range seemingly meet the requirements of the technical specifications. Some also use equipment that fails the verification or has expired. Due to these behaviors, the credibility of the manually compared data will be reduced, problems generated in the operation of online monitoring equipment will be covered up, online monitoring data will be out of control and many invalid data will be produced, which is not conductive to the ecological environment management department's supervision of emissions from pollution sources. Therefore, the following methods can be used to verify whether online monitoring data match the actual production process, production status, pollution treatment level and other aspects, to further judge and verify the accuracy and rationality of the online monitoring data.

5.3.1. Auxiliary methods for verifying the accuracy of the flue gas temperature

At present, the temperature of the flue gas from pollution sources is measured mainly by such methods as platinum thermal resistance and copper thermal resistance. For example, the value of PT-100 platinum thermal resistance varies with temperature, and the temperature corresponds to the value. The value of platinum thermal resistance can be easily measured on the site; the theoretical temperature of the flue gas is calculated by consulting the correspondence between the temperature and value of PT-100 platinum resistance, or the calculation formula between the value and temperature [2]; then the result is compared with the temperature value monitored by the online monitoring equipment to further verify the temperature measured by the online monitoring equipment; if they are close, it suggests that the temperature measured by online monitoring equipment is accurate, otherwise, inaccurate, and the reasons should be searched in time.

5.3.2. Auxiliary methods for verifying the accuracy of the flue gas humidity

The flue gas humidity affects the concentration and total emissions of pollutants, which easily produces deviations in the actual operation, and not much attention is paid to it. Thus, emphasis should be placed on it. The humidity of the flue gas from different pollution sources varies greatly in different industries, generally ranging from a few percent to tens of percent, which is mainly related to the production processes and pollution treatment methods of enterprises. If the hydrogen-containing gas is used as fuel and no straight-line heating furnace is equipped for treatment equipment for desulfurization and denitration at the end, the flue gas humidity is mainly related to the hydrogen content in the fuel gas. Combining the residual oxygen content in the flue gas and the humidity of the air, the approximate range of humidity in the flue gas can be calculated. The moisture content is high in this kind of flue gas, reaching tens of percent to the maximum extent. If the production process is a simple physical process, such as crushing, then the humidity consists of the humidity of air and that caused by water evaporation in the material, and there is usually a few percent points; if the emitted glue gas can be treated by the wet pollution treatment process, such as wet desulfurization, due to the full contact between the air and the liquid, the moisture in the absorption liquid evaporates greatly, and then the humidity of the flue gas is generally considered to be saturated, and it is unrelated to the moisture content in the flue gas before the wet treatment and is only related to the temperature of the emitted flue gas, namely the saturated vapor pressure of the flue gas at this temperature. For example, when the flue gas temperature is 40℃, the humidity is about 7%; when the flue gas temperature is 50℃, the humidity is about 12%; when the flue gas temperature is 60℃, the humidity is about 20% [3]. The humidity measured by the online monitoring equipment can be verified according to the above situations. If the actual measured data deviates greatly, there are errors in the humidity measurement results, and the online monitoring analyzer is faulty.

5.3.3. Auxiliary methods for verifying the accuracy of the sulfur dioxide concentration in the flue gas

To determine the accuracy of the sulfur dioxide concentration, we need to calculate the actual emission concentration of sulfur dioxide in the flue gas based on such known conditions as the emission of waste gas from pollution sources, consumption of desulfurizers per unit time, and concentration of sulfur dioxide in the initial flue gas, and the usual desulfurization efficiency, combined with the sulfur content in the raw material and fuel, production process, desulphurization equipment, desulphurization method, types of desulfurizers and operation status, and then compare the result with the long-term experience accumulation and data measured by online monitoring equipment. If the sulfur dioxide concentration value measured by online monitoring equipment is zero, constant, abnormally high, or abnormally low for a long time, while the production status does not change obviously and the desulfurization equipment operates normally, we can determine that the data measured by the online monitoring equipment are inaccurate and illogical, and reasons should be searched in time. In addition, the high content of carbon monoxide in the flue gas may interfere with the determination of sulfur dioxide by non-disperse infrared and produce high data, which should also be paid sufficient attention.

5.3.4. Auxiliary methods for verifying the accuracy of the nitric oxide concentration in the flue gas

To determine the accuracy of the nitric dioxide concentration, we need to calculate the emission concentration of nitric dioxide in the flue gas based on such conditions as the emission of waste gas, consumption of denitrfying agents, and content of nitric dioxide in the initial flue gas, combined with the production process, denitration method, types of denitrfying agents and operation status, and then compare the result with the online monitoring data. If the nitric dioxide concentration value measured by online monitoring equipment is constant, abnormally high, abnormally low, fluctuates greatly or is zero for a long time, while the production status does not change obviously and the denitration equipment operates normally, we can determine that the data measured by the online monitoring equipment are inaccurate.

5.3.5. Auxiliary methods for verifying the accuracy of the particulate matter concentration in the flue gas

To determine the accuracy of the particulate matter concentration, we need to consider the production process, method and type of dust removal, operation status and other conditions. If the particulate matter concentration is zero or abnormally low for a long time, the online monitoring equipment must be faulty and the measurement is inaccurate, which often occurs in the actual operation; if the particulate matter concentration gets abnormally high suddenly and then returns

to normal, increases unconventionally, fluctuates abnormally, or is displayed in full range, while the operation status does not change obviously, the particulate matter online analyzer may also be faulty, and we should timely search and analyze the reasons, rather than just attribute it to the production.

5.3.6. Auxiliary methods for verifying the accuracy of the oxygen concentration in the flue gas

Oxygen is an important indicator to display the production status and for the conversion of emission standards. If the value is constant, the equipment may be installed improperly and the flue gas fails to pass through the oxygen analyzer, or the oxygen analyzer is damaged, and the equipment needs to be relocated or repaired; if the value displayed on the oxygen analyzer is high, significantly deviates from the baseline oxygen content, and does not match the production status, there may be a leak in the sampling pipeline or the oxygen online analyzer may be faulty.

5.3.7. Auxiliary methods for verifying the accuracy of the flow rate of the flue gas

The accuracy of the flow rate data can be determined by comparing the data calculated based on the product output, production load, diameter of the exhaust funnel, flue gas temperature, flue gas humidity, flue gas pressure and other conditions with the online monitoring data. As long as the production is stable, the flow rate of the flue gas will fluctuate around this calculated value. The S-type pitot tube applies to the site where the flow rate of the flue gas is greater than 5 m/s, and the ultrasonic current meter applies to the site with a lower flow rate of the flue gas. The flow rate should be measured by proper methods, otherwise large errors will be produced. If the flow rate is or is close to zero, the current meter may be faulty or the pipeline may be blocked, or an improper current meter is chosen; if the flow rate fluctuates greatly, an improper measurement site may be chosen, and there may be obvious turbulence in it, which does not meet the requirements of monitoring sites specified in the technical specifications; of the flow rate is abnormal and the static pressure value remains unchanged for a long time or displayed in full range, the static pressure pipeline may be blocked by water.

6. Quality assurance and control requirements for the third-party comparative monitoring

The third-party comparative monitoring means that the enterprise entrusts a qualified social monitoring organization to conduct manual monitoring according to the standard analytical methods in force issued by the state or industry in synchronization with online monitoring equipment, the manual monitoring results are used as the basis for checking and verifying the accuracy of the online monitoring equipment, and performance indicators of the manual monitoring instrument used meets the requirements and are within the validity period of verification or calibration [4]. The flow rate, air tightness and other aspects of the instrument should be checked before use to ensure that the sampler function is normal. The particulate matter sampler should support isokinetic tracking, and the flue gas at the same site, within the same time period and in the same state must be acquired by the manual monitoring method and online monitoring equipment. When testing the accuracy of the particulate matter, sulfur dioxide, nitric oxide and auxiliary parameters, the number of groups, duration, gas sampling volume and other factors to be compared should meet the relevant technical specifications and standards, otherwise the data are invalid.

The third-party comparative monitoring is the most effective proof to test the accuracy and reliability of the data measured by online monitoring equipment. When the monitoring pollution factors and auxiliary parameters of the online monitoring equipment are found to exceed the error range required by the technical specifications, operation and maintenance personnel and management personnel of the enterprise should carefully search the reasons for the error, and correct relevant parameters, such as the correlation coefficient of particulate matter, accuracy of gaseous pollutants, and velocity field coefficient of the flow rate, so that they can always ensure that the data measured by online monitoring equipment are accurate, reliable and controlled..

7. Conclusion

Through the comprehensive quality assurance and control management in the whole process, including installation, maintenance, calibration, verification, comparison and other links, deviations and errors produced in the operation of online monitoring equipment can be promptly found, and failure can be reduced, and effective actions can be taken to eliminate them in a targeted way. In this way, the online monitoring equipment can operate stably for a long time and its technical indicators conform to the *Specifications for Continuous Emissions Monitoring of Flue Gas Emitted from Stationary Sources*. The failure rate of the online monitoring equipment will significantly decrease, the validity of data will significantly increase, so that pollution source data received by the ecological environment management department will be effectively controlled. In this way, the government can truly master the concentration and total emission of pollutants from the enterprises, gradually reduce the total pollutant emission and effectively allocate indicators for controlling the total pollutant emission, thus creating conditions for the sustainable development of the economy and the improvement of the ambient air quality, and making its contributions to a green and low-carbon life.

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