Feature Article

Overview of Continuous Emission Monitoring of Stack Gas emitted from Stationary Sources in China
中国の固定発生源における連続モニタリングの概要

Hideki HATAKENAKA

畠中 秀起

With constant economic level it reached recent years, concern over environmental preservation also remains higher attention in China. Developments of laws including air pollution prevention are performed and gas discharged from chimneys of thermal power plants or various factories is taken up as a control subject. These measurements are performed by the continuous emission monitoring systems of stack exhaust gas, which acquired China national certification. Based on HORIBA group progress on the exhaust gas measurements in China, this article is trying to describe the actual situation of China's exhaust gas measurement from the topics of China national certification application and system installation examples. And the overview of the HORIBA system is also introduced.

一定の経済レベルに達した中国では，近年，環境保全に対する関心が高まっている。大気汚染防止を初めとする環境についての法整備が行われ，火力発電所や各種工場の煙突から排出されるガスは規制対象となっている。これら規制対象の計測は，国家認証を有する煙道排ガス連続監視システムによって行われる。HORIBAグループの中国における排ガス計測の歩みを踏まえ，国家認証取得への取り組み，およびシステム設置例を取り上げ，中国の排ガス計測の実状を述べる。また，HORIBAの計測システムの概要についても合せて紹介する。

Introduction

In China, where remarkable progress continues by economic priority policies, thermal power plants and heavy chemical plants are built. The amount of exhaust gas released into the atmosphere is rapidly increasing and environmental pollution problems are becoming more serious every year. Since the last half of the 1990s laws have been developed for real environmental improvement, and there is a higher need for environmental measurements to monitor air quality and to improve the environment. In this situation, Horiba Group entered the field of measuring air and stack exhaust gas. Power plants and other manufacturing facilities that emit gas from stacks and various boilers are called stationary sources, and the substances that cause air pollution are subject to regulation. These substances are measured by the stack exhaust gas Continuous Emission Monitoring System (called CEMS below). Dust, NOx and SO_2 value are measured by CEMS, and total amount of the emission is calculated with flow rate, temperature and pressure.
CEMS also has functions for running calculations, saving data, and communicating with environmental monitoring organizations. A representative CEMS configuration example is shown in Figure 1.

For introduction into the Chinese market, a CEMS needs to obtain the Chinese national certification[1]. In 2003, the Horiba took this certification test in Shandong Province and obtained certification. In 2004, 25 sets of CEMS were delivered to the city of Chongqing as a Chinese national project. Through this project, the exhaust gas of

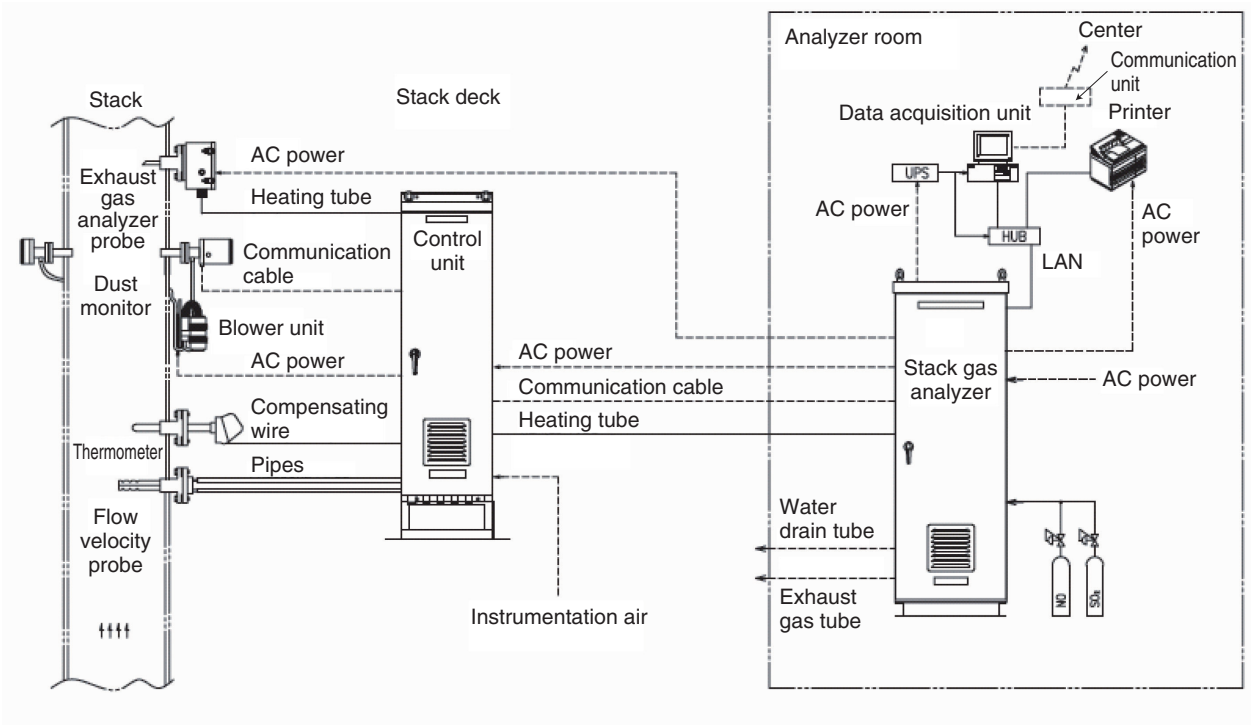

Figure 1 CEMS system configuration (example)

large and small boilers in power plants, chemical plants, cement factories, and others located urban area was measured, and the Horiba got an understanding of the actual circumstances and infrastructure situation for exhaust gas measurement in China. In this report, considering our past experiences for measuring exhaust gas from stationary sources in China, actual situation for exhaust gas regulations, obtaining certification of China, and introducing CEMS are explained.

Trends in Chinese Exhaust Gas Regulations

In Japan, Europe and North America, air pollution became a social problem along with the industrialization in the last half of the 1950s. Laws such as Air Pollution Control Law and other relevant laws were developed, and policies for controlling exhaust gas were implemented. In China, the Environmental Protection Law was amended in 1989, 33 air pollutants were listed comprehensive emission standards, and separate comprehensive emission standards for stationary sources such as boiler exhaust gas and thermal power plants were respectively issued in 2001 and 2003. Also, critical regulatory areas were established for SO_2 and acid rain, and projects were implemented for regulating emissions. However, it is a fact that there are problems of regional disparity, insufficient funding and manpower, and the goal according to the plan have not been achieved. As for the other policies, major thermal power plants are obliged to install desulfurization system, to equip environmental monitoring systems and to be imposed penalty when exceeding the management value. In this way, demand for CEMS has been created in the last 3 or 4 years, and we estimate that more than 10,000 sets of CEMS have been installed in China. The Chinese State Environmental Protection Administration (SEPA) has been upgraded to the Chinese Ministry of Environmental Protection (MEP) in 2008, and environmental preservation policy is being emphasized more than ever in the 12th Five-Year Plan (2011-2015). Real regulations for removing NOx are also expected to be developed, and in the future, the environmental measurement market will likely expand drastically.

CEMS Certification Overview

In China, HJ/T76-2007 is a standard that outlines technology requirements and test methods for Continuous Emission Monitoring Systems for stack exhaust gas from stationary sources. To introduce CEMS in China, the requirements of this standard must be met. It requests 24 hour drift test and comparison with manual analysis in

Table 1 CEMS Chinese Certification Test Items & Standards

Equipment	Test item	Standard
Dust	Zero, span drift	≤±2% FS /24 h
	Correlation coefficient	≥0.85
SO_2, NOx	Linearity	≤±5%
	Response speed	≤200 s
	Zero, span drift	≤±2.5% FS /24 h
	Relative accuracy	≤15% (when exhaust gas concentration≥250 ppm)
Flow velocity	Precision	≤5%
Temperature	Error	≤±3 °C

(This is an excerpt of representative inspection items. For definition details, please see HJ/T76-2007.)

the measurement of SO_2, NOx, O_2, Dust, flow rate and temperature (Table 1). The certification test is composed of 1) Primary test (8 days), 2) Continuous operation (90 days), and 3) Secondary test (2 days), and is conducted by a certification officer of the Chinese National Environmental Monitoring Center. There are no specified test locations. The test of CEMS is conducted at the exhaust stack of the stationary source which is actually in operation. For this reason, various preparations must be made, such as researching the test site, selecting an installation point, building a stack deck and container house to store the system, and installation of the CEMS. Various conditions, such as factory equipment, are also involved, so the certification test has a high difficulty, and if 10 manufacturers take the test, only about half of those will pass. If a CEMS doesn't pass the test, It cannot be re-taken the test at the same site, so it will be necessary to start over with researching a new site.

Key Points for Obtaining CEMS Certification

The Horiba Group took the test in the city of Qingdao in Shandong Province in 2003, cooperated with engineering companies in Beijing and obtained Chinese CEMS certification. The Horiba also took the updated test in 2006 in Beijing, and passed. Several key points for obtaining certification are listed below.

- The stationary source emission concentration and total value must be changed to fit the test conditions, so the operating conditions of the factory equipment must be changed. During the approximate 4-month period of the test, stable continuous operation of the stationary source will be required. It is necessary to secure a test site that satisfied the above conditions. There is also a condition of allowing Chinese government officials to visit the factory, so major companies and thermal power plants are desirable for test sites, and personal connections are also a key point.
- In the comparison test with the manual analysis, the measurement results differ based on differences in measurement points, such as gas flow velocity, dust amount, exhaust gas concentrations and so on (Example: Correlation will be poor if the gas flow velocity is 5 m/s or less in principle), and whether these values are stable. For this reason, it is essential to get an understanding of the operating conditions of the factory equipment and to consider factors for adjusting the equipment to appropriate conditions. The Horiba PG-250 portable gas analyzer is used as the manual analysis equipment.
- For dust concentration, the correlation between the manual analysis and the CEMS value is an index to judge the test result. In the test procedure, it requires to vary the actual dust concentration, and the load control precision and stability of the precipitator influence the test results.
- As a method for linearity test of the exhaust gas analyzer, 3 different gas concentration cylinders (low, medium, and high concentration) are prepared for the test range, and the analyzer linearity test is conducted using these gases as a standard, so the gas concentration precision and correlation between the gas cylinders are important. Per the above, not only the CEMS unit itself, but various elements such as the test site, equipment operating conditions, and calibration devices are involved in obtaining certification.

General Stationary Sources in China

The major fuel used in boiler equipment in factories and power plants where CEMS units take measurements is coal, which makes up 70% of the overall fuel demand. China has a large amount of coal reserves, and the main reason why it is used is because it is inexpensive. However, coal contains a large amount of sulfur and generates many air pollutants when burned, such as SO_2, soot, and dust. Low-sulfur coal is used in high-grade exhaust gas processing equipment in thermal power plants and major companies, and bag filters and electrostatic precipitators are installed. However, in medium- to

small-sized general factories, it is common to only have a cleaning shower desulfurization tower and lime powder neutralization equipment.

Based on the fuel and processing equipment situation, the exhaust gas concentrations from stationary sources in China are still high.

Example of Measuring Stationary Sources Using CEMS

The inland city of Chongqing having many heavy industries is one of the central controlling cities such as Beijing and Shanghai, and air pollution is a serious environmental problem. Chongqing has been selected as an environmental model city for environmental improvements. In this situation, a Chinese national project was launched for the purpose of building environmental monitoring systems, and the Horiba Group installed 25 sets of CEMS in 2004. Since it is a model case, large- and small-scale factories in various industries were selected as sites for installation. 70% of the installation was in the area around the city, but some chemical factories located 300 km far from the center of the city were also included, so the project covered very wide area. CEMS units were installed at the final emission points,mainly from steam or power equipment, in thermal power plants, and other factories for automobiles, chemicals, cement, and food. In the 25 sets of exhaust gas processing equipment installed, 13 sets were installed in general factories that had cleaning desulfurization towers only, and 5 sets were installed in plants with cleaning desulfurization towers and electrostatic precipitators. 7 sets were installed in thermal power plants with absorption towers, desulfurization equipment with lime processing unit and electrostatic precipitator. Facility examples are shown in Figure 2, 3, and 4. We saw many quality problems, such as utilities having frequent power outages, system down for days at a time, unstable pressure in air sources for purging pipes, and contamination by water, oil and dust in air sources. When we started system operation, the dust concentration was high, which frequently clogged the sampling filter, and it was important to take maintenance into account. The actual site situation was worse than we had thought, and made us really realized the current situation and the difficulty of environmental countermeasures in China.

CEMS Specifications

In this actual situation, the Horiba Group has developed and provided CEMS to China. The system overview of

Figure 2 Desulfurization tower, general factory

Figure 3 Electrostatic precipitator, thermal power plant

Figure 4 Coal warehouse, general factory

Horiba Group's CEMS and the software screen image are respectively shown in Figure 5 and 6.

The basic CEMS functions are collecting data, data processing calculations, saving data and forwarding data

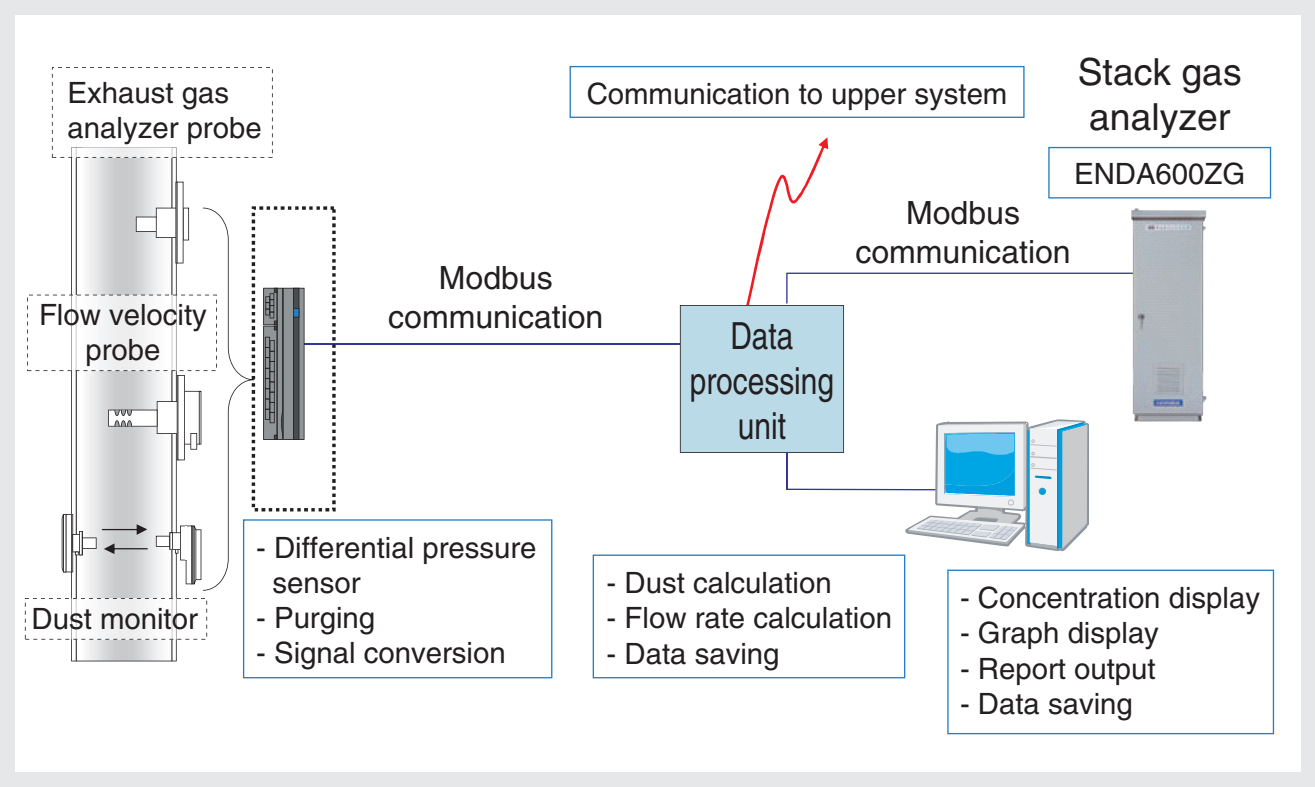

Figure 5 Horiba CEMS system overview diagram

Figure 6 Software screen (example)

externally. We considered the following points when thinking about the Chinese installation environments.

- Must be capable of handling continuous operation
- Must be secured from any damage or loss of data
- Must be easy to do maintenance and make adjustments
- Must be possible quick installation

With general CEMS in China, in many cases data are collected and processed using a factory computer. However, this situation is unsuitable for continuous operation, so we provide an exclusive data collection and processing unit (PLC) that is appropriate for continuous operation. This unit is used for calculating concentrations, flow velocity, and dust amount, as well as communicating with upper system. Even if the computer for processing and displaying data breaks down, operation continues and data continues to be sent to the relevant organizations. A temporary data saving function is also provided, which compensates for any data loss due to computer breakdowns. Also, using field buses to connect among units reduces the amount of cabling and allows digital signals processing, and shortens installation time and achieves highly reliable signals.

Conclusion

CEMS has a long history in the mature markets in advanced regions such as Europe and North America, but is just starting in the markets in developing nations such as China and India, and laws are just being developed. Environmental preservation in China has been closely examined in recent times, and there is increasing concern about reducing environmental pollution. In this report, the Horiba Group introduced an overview of measuring exhaust gas from stationary sources, and we would like to

utilize our experience to propose useful environmental monitoring systems for environmental preservation in China.

Reference

[1] Standard of the Chinese State Environmental Protection Administration, Specifications and Test Procedures for Continuous Emission Monitoring Systems of Flue Gas Emitted from Stationary Sources. HJ/T76-2007

Hideki HATAKENAKA
畠中 秀起
System Solutions Department
Environmental Process Systems Division
Horiba, Ltd.