Motor Exhaust Gas Analyzer MEXA-7000 Series
1. Product Concept

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<Abstract>

Along with increasing concern regarding global environmental issues, various efforts have been made to further clean and reduce the amount of gases emitted from internal combustion engines used, for example, in automobiles. Consequently, the measurement items, content and range of emission gases, that must now be measured, have become more diversified and more complex.
HORIBA has applied years of achievements and the very lastest technology in the development of the MEXA-7000 series of motor exhaust gas analyzers. This paper focuses on the development concept behind the entire MEXA-7000 series, and introduces its characteristic functions and specifications.

1. Introduction

HORIBA has developed exhaust gas analyzers since the '60's when smog caused by exhaust gas from automobiles became a recognized problem. In 1964, HORIBA put the MEXA-1 motor exhaust gas analyzer onto the market. Since then, HORIBA has shipped over 4,000 units of large-size, multi-component analyzers to countries around the world. HORIBA's main product in this area has been the MEXA-9000 series. This system is being put to use in engine development and production sites around the world. This digital system was the first to use a μ-CPU in an exhaust gas analyzer. In recent years, restrictions placed on the analysis of automobile exhaust gas have become increasingly severe. This includes reinforced regulations regarding NOx emissions from diesel engines in Japan, low pollution controls implemented in California, and tougher regulations put into practice in the EU. In addition, the U.S. Clean Air Act was revised in 1990. Consequently, the exhaust gas regulations of almost all internal combustion engines were reviewed, such as regulations imposed by the International Marine Organization (IMO) on NOx/SOx emissions from ships and emissions from building equipment in Japan. Against this background, it was necessary that HORIBA develop a high-performance exhaust gas analyzer that was both expandable and flexible in responding to diversified regulations.

2. Product Concept and Features

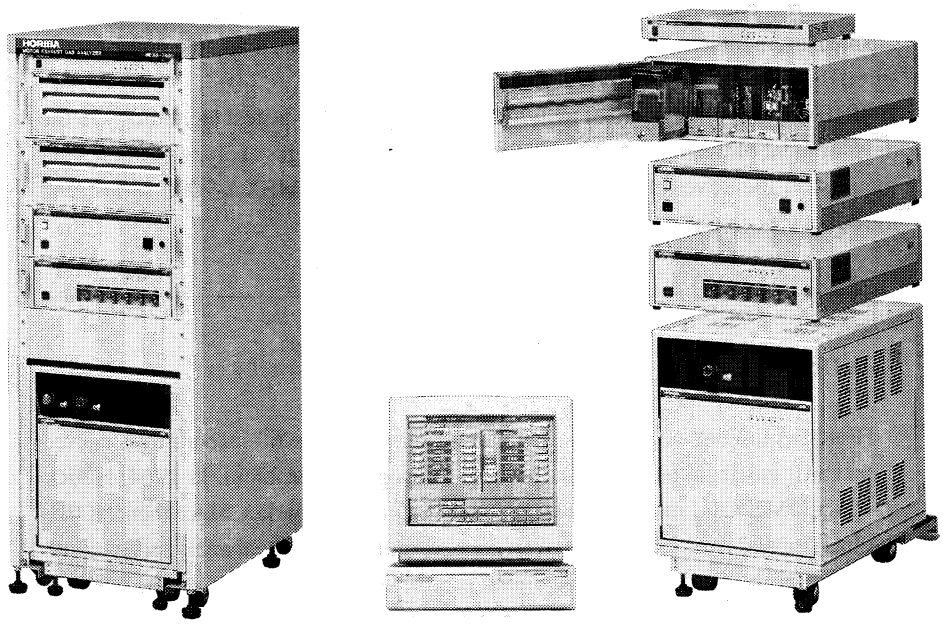
In response to increasingly complex and diverse measurement needs, HORIBA has developed a completely new analyzer, the MEXA-7000 series (simply called "MEXA-7000" from here on).

The following describes the main development concept and features of the MEXA-7000.

2.1 Modular Configuration

In order to combat exhaust emissions, research and development into the engine periphery is being vigorously pursued. This includes substituting fuels, lean burning techniques, exhaust gas recirculation (EGR), and diesel catalysts. To facilitate these tests, there is a strong need for a measurement system capable of adapting to changing test requirements.

The MEXA-7000 organizes the various functions of a complex system into modules. These modules are then capable of being connected and configured to meet the changing need of the testing requirements. Each of these modules is housed in a 19" standard rack to minimize analyzer installation space.



(A) MEXA-7400 (B) Main control unit (C) MEXA-7100

Fig.1 Motor exhaust gas analyzer MEXA-7000 series

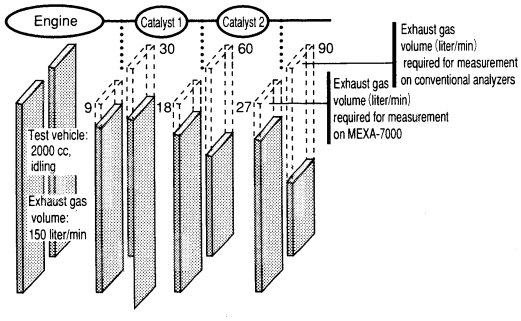


Fig. 2 Reduction in test sample volumes

2.2 Reduction in Sample Test Volume

A major issue for testing is reducing sample volume while maintaining response speed.

For conventional analyzers, lower flow rate meant slower response. Also, overall sample size may be limited, as in the case of small engines. Other problems arise when a catalyst is mounted on the engine for treating exhaust gas. This introduces the risk that catalyst activity may be influenced by the sampling amount.

The MEXA-7000, the analyzer size and sampling system have been improved. Now, the sample volume has been reduced to 1/3 (in-house comparison) with response speed equivalent to that of conventional models. (Figure 2)

2.3 Expanded Concentration Ranges

As a result of tougher regulations, the concentration range of the analyzer must be expanded. As the composition of exhaust gas diversifies with increased use of natural gas vehicles and general-use small engines, the concentration range that must be measured has greatly increased.

The MEXA-7000, we have reviewed the analyzer structure and the signal amplification system, and have considerably expanded each of the analyzer's concentration ranges.

2.4 Laboratory Automation

At HORIBA we are promoting laboratory automation of engine exhaust gas related products under the catchword ILAS (Integrated Laboratory Automation System).

On the MEXA-7000, a personal computer is used as the main controller (MCU), and UNIX*1 is used as the operating system (OS) for enabling connection to a host computer. This allows peripherals such as a constant volume sampler (CVS) or dilution tunnel to be controlled on a single MCU. It also has various ILAS-oriented functions transcending the concepts of conventional exhaust gas analyzers. These include averaging and accumulation of measurement data, real time graphic display, calculation of air-fuel ratios, additional equipment status monitoring and history management functions. Moreover, communications between modules, the MCU and the host computer are carried out over a local area network (LAN), enabling mass processing of data and high-speed data transfer.

*1 UNIX : UNIX is a registered trademark of X/Open Co.,Ltd

2.5 Reduction in Running Costs

A major theme today is also the reduction of running costs generated by the consumption of span and zero gases used for calibration. These gases are vital for maintaining high measurement and accuracy. Other costs are associated with replacement of filters for removing impurities and power consumption.

On the MEXA-7000, both sample volumes and zero/span gas volumes have been reduced. Improvements in analyzer stability have resulted in lengthening the calibration interval and further reducing the amount of gases used. Power consumption is greatly reduced as a result of longer-life consumables and smaller-size equipment and components.

2.6 Improved Maintenance

Each of the MEXA-7000's analyzers are designed as sensors (detectors) with the aim of being "black boxes" that do not require adjustment. Also, the MCU centrally manages all information relating to the operating status of the measurement system — zero/span gas coefficients, calibration curve history, alarm messages and time generated, temperature, flow rate, power supply fluctuations, etc. — to improve maintainability.

3. Configuration of MEXA-7000

Figure 3 shows the system configuration of the MEXA-7000 with the MCU as its core. Each of the units are equipped with an interface unit (IFC) for signal conversion, and communicate with the MCU over the LAN.

Figure 4 shows a signal diagram of how each of the units are connected. Each of the analyzer racks (ANR) for housing the analyzer module are located under the IFC. Solenoid valve selectors (SVS) that house all the valves for zero, span and other operating gases, sample handling system (SHS) for suction and processing of samples, and the gas division controller (GDC), for checking and preparing curves, are connected to the IFC. Two or more units can be connected to a single IFC. The following briefly describes each of the modules in the system.

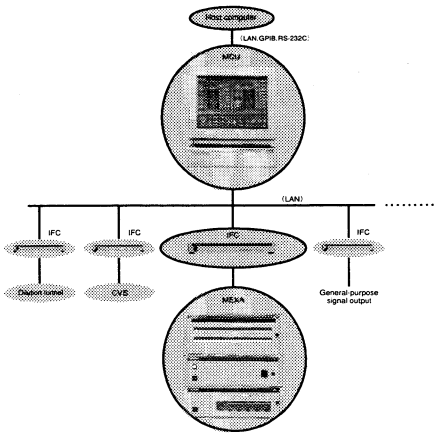


Fig. 3 MEXA-7000 series communications network centering on the MCU

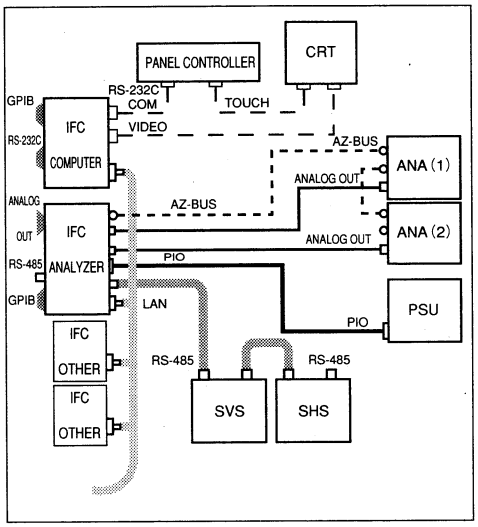


Fig. 4 MEXA-7000 series signal processing system

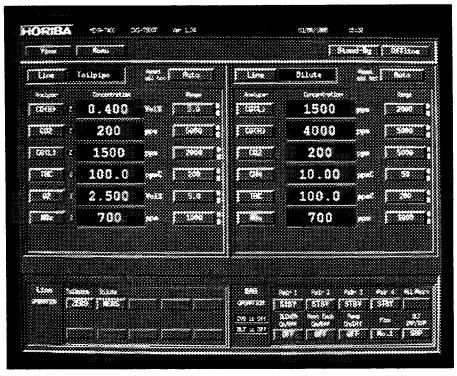


Fig. 5 MCU Basic Image

(1) Main Control Unit (MCU)

The MCU functions as the core of the MEXA-7000 signal processing system. A personal computer is used as its hardware.

With conventional systems, signal noise reduction, output linearization, interference compensation and sensitivity calibration are built-in. On the MEXA-7000 system, the user can change and select these functions to meet specific measurement conditions and conditions of use. Figure 5 shows the MCU Basic Image.

(2) Interface Controller (IFC)

The IFCs centrally handle all of the signals of subordinate modules, and are equipped with functions for handling communications between the respective module and MCU. IFCs are general-purpose units that are capable of housing up to three analog/parallel I/O boards and of supporting their own specifications as required.

(3) Analyzer Rack (ANR)

The ANR contains slots that have up to five 76 mm (W)×400 mm (D)×160 mm (H) ultra-compact analyzers (for measuring seven components). In the standard specification, direct sample analysis and CVS diluted sample analysis can be configured in individual ANR modules. High-precision automatic pressure regulating valves are incorporated in the ANR modules to minimize changes in analyzer readings caused by pressure fluctuations. Atmospheric pressure compensation sensors are also built-in. The ANRs and IFC are connected by a high-speed

digital bus. After being converted by a 24-bit A/D converter inside the analyzer, the resultant digital analyzer signals are sent to the IFC at 20 Hz (standard). DC power supplies are used on ANRs and analyzers to minimize influence caused by fluctuations in the power voltage and frequency.

(4) Solenoid Valve Selector (SVS)

The SVS handles selection of all gas valves. A single SVS unit contains the solenoid valves required for two ANRs. Quick connectors are provided on the front panel to connect to external calibration gas and checkers when carrying out maintenance on the analyzer. The SVS is also equipped with a built-in standard gas humidifier (bubbler) so that moisture interference in the analyzer can be automatically checked in compliance with the Code of Federal Register (CFR).

(5) Sample Handling System (SHS)

Reducing the sample flow rate to about 9 liters/min allows the main components of the SHS to be downsized. As a result, a single SHS is capable of processing up to three sample lines including those for EGR and CO_2. Various other modifications have been made to enable prolonged continuous measurement. These include continuous automatic discharge of water after draining from the cooler, and a flow for preventing mixing of water to the primary filter. At the same time, these modifications also have lengthened filter life and reduced replacement cycle. Figure 6 shows the basic flow of the SHS.

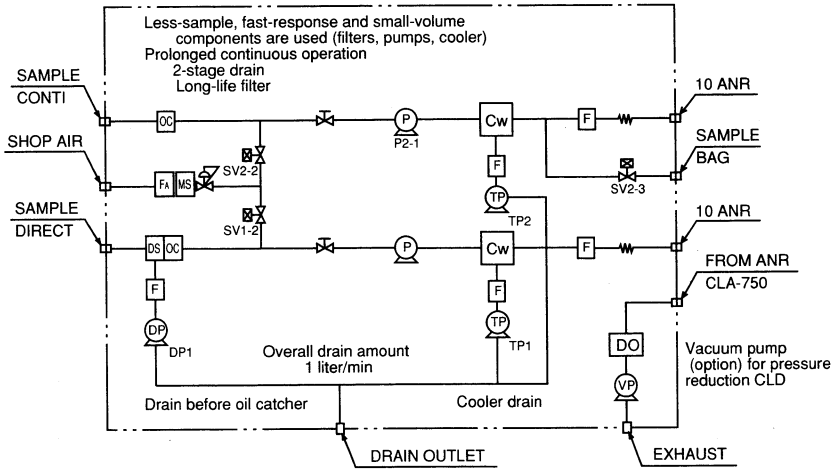


Fig. 6 MEXA-7400 Sampling flow

Signals between the SVS, SHS and IFC are transferred in series over the RS-485 interface to simplify wiring and make the setup more generally applicable.

(6) Power Supply Unit (PSU)

The PSU modules supply DC power to each of the modules. A single PSU has enough capacity for up to two ANRs.

(7) Span Gas Selector (SGS)

The SGS is for selecting the span gas supplied to the SVS when a scale must be calibrated for each analyzer range. The SGS can also be used for fully automating checking of the analyzer's calibration curves by the gas division controller (GDC). By making the SGS an independent module, it placed near the gas cylinder, simplifying the supply piping. This unit is also controlled by the IFC via the RS-485 interface.

(8) Service Note Book (SNB)

On the MEXA-7000, the MCU, the center of operations, is often located in an instrument room away from the testing site. The service note book was developed as a portable MCU terminal. The SNB, as its name implies, is a notebook computer that allows you to take readings such as concentrations, sensor outputs, voltage and temperature readings at sites away from the MCU, for example, next to the analyzer. You can use the SNB as a high-function remote controller or as a support tool when carrying out maintenance or monitoring the operating status of communications lines.

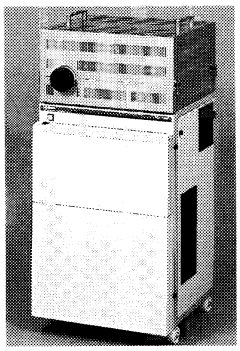


Fig. 7 Heating analysis unit

(9) Heating Analysis Unit, Oven (OVN)

All high-temperature type analyzers are integrated with an oven as pretreating equipment. (See Figure 7) In addition to conventional heated FID (THC meters), the MEXA-7000 has a built-in heated CLD (NOx meter) and a sampling pump. This unit is configured to supplying gas treated by the oven to the room-temperature analyzer units. Two FIDs for THC and CH_4 can be mounted in a single unit. Though there are slight limitations in the length of the heated line, a sample point function for selecting up to four sample points can be added. The OVN is connected to the MCU over a LAN by an independent IFC.

4. Conclusion

When HORIBA developed the MEXA-7000, it was a full-scale, global research project. Managers within the HORIBA group in Japan, South Korea, United States and Europe took an entire year to compile and formulate the product concept. Over the years, HORIBA's motor exhaust gas analyzers have racked up an impressive sales records in all countries around the world, and have allowed vast amounts of analysis data to be collected. This data was used in finalizing the product concept. The result is a design that is matched to each country's individual needs. Development was started only after all of the countries involved had reached agreement. Then Japan was put in charge of development of the basic analyzer hardware, while software development was shared by both Japan and the United States. Engineers from local subsidiaries in the UK, Germany and France also participated in the project team. Through this effort, HORIBA was able to set up a global development system jointly with overseas bases.

In the future, we hope to successively begin local production of the MEXA-7000 in five locations—Japan, South Korea, United States, UK and Germany—to supply modules and software. We also plan to establish suitable bases around the world for development, production, marketing and customer support in further response to our customer needs.

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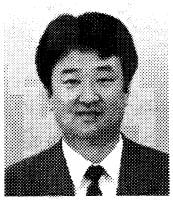

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