Featured Articles

ZAXIS-6 Series Hydraulic Excavators Equipped with Latest Environmental Technology

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OVERVIEW: Exhaust emission regulations are becoming progressively tighter for construction machinery just as they are for ordinary cars, with the Tier 4 regulations introduced in 2011 commencing as the final stage of regulation in 2014. Coinciding with this, Hitachi Construction Machinery Co., Ltd. released the ZAXIS-6 Series. In addition to complying with exhaust emission regulations, this new range of hydraulic excavators incorporates numerous market requirements identified from market research into existing models and demand for lower fuel consumption (energy efficiency performance). Hitachi has also taken steps to utilize information technologies to obtain timely information about vehicle status and provide support. The ZAXIS-6 Series are currently being released in the North American market.*

INTRODUCTION

ALONG with initiatives on a variety of fronts being undertaken in recent years to reduce the load on the environment, exhaust emission regulations for construction machinery, too, are being tightened internationally. In response, Hitachi Construction Machinery has developed the ZAXIS-6 Series of hydraulic excavators designed to comply with new exhaust emission regulations, and released them in North America.

The ZAXIS-6 Series has both systems that are compliant with engine exhaust emission regulations and that achieve low fuel consumption. Hitachi Construction Machinery has fitted the ZAXIS-6 Series with urea-based selective catalytic reduction (SCR) systems to achieve compliance with engine exhaust emission regulations, and made improvements to its existing system to improve fuel consumption. To improve maintenance safety, safety rails have been added on top of the main housing. Hitachi Construction Machinery has also utilized information technologies to improve its Global e-Service in order to enhance vehicle status monitoring and respond more quickly to faults.

Along with adopting the urea SCR system (a new technology), Hitachi Construction Machinery has conducted long-term operational testing of the ZAXIS-6 Series with customers in Japan and overseas to evaluate the practicality of components used for urea handling and their reliability when exposed to urea in aqueous solution.

This article describes the new environmental and energy-efficiency technologies, safety improvements, and use of information technology on the ZAXIS-6 Series (see Fig. 1).

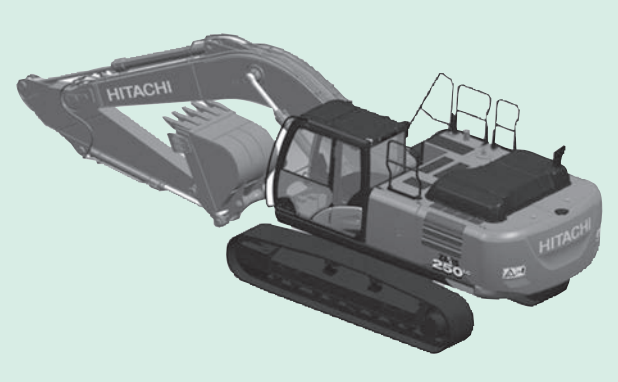

Fig. 1—ZAXIS-6 Series.
The photograph shows a ZAXIS 250LC-6.

NEW ENVIRONMENTAL AND ENERGY-EFFICIENCY TECHNOLOGIES

Urea SCR System (a New Environmental Technology)

The new exhaust emission regulations that entered force in 2014 place limits on particulate matter

* ZAXIS is a trademark of Hitachi Construction Machinery Co., Ltd.

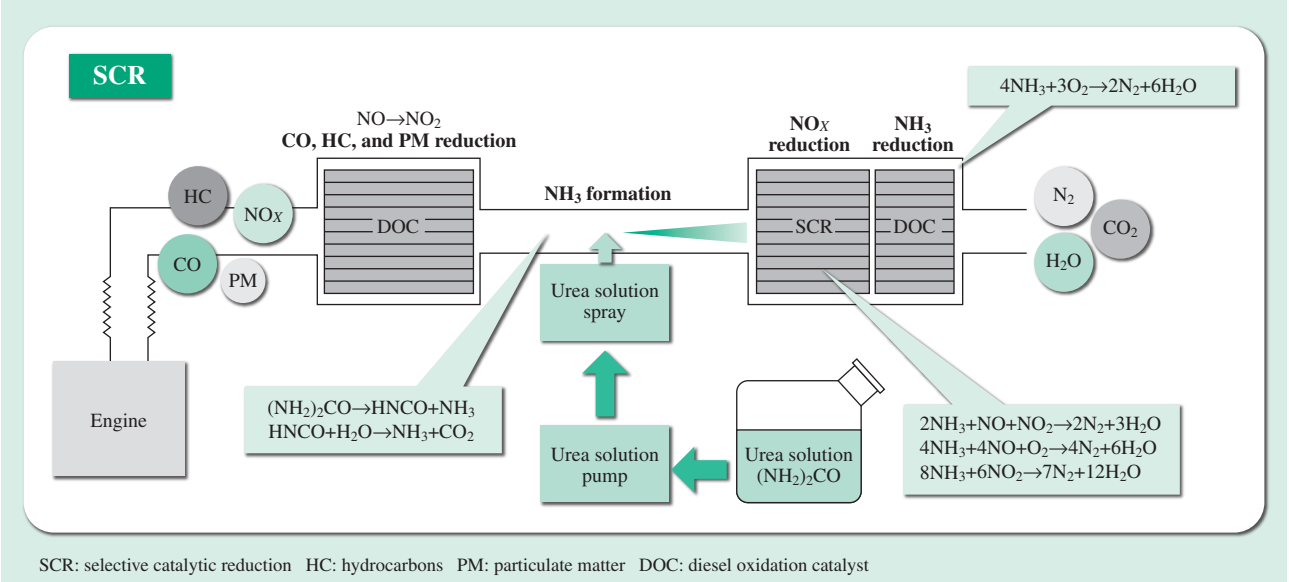

Fig. 2—Overview of Urea SCR System.
Spraying an aqueous solution of urea into the exhaust forms ammonia, which reacts with the NOx and breaks it down into harmless nitrogen and water.

(PM) (0.02 g/kWh, same as previous regulations) and nitrogen oxides (NO*x*) (0.4 g/kWh, one-fifth of previous regulations). That is, the rules on NO*x* emissions have been significantly tightened. Because of the trade-off between the quantities of PM and NO*x* in engine exhaust emissions, there is a limit to how far the engine itself can be improved to satisfy the regulations, and this has made exhaust treatment techniques that use a catalyst to remove pollutants from the exhaust gas essential. Exhaust treatment systems were first fitted to hydraulic excavators on the earlier ZAXIS-5B and ZAXIS-5N Series models. These used diesel oxidation catalyst (DOC) and catalyzed soot filter (CSF) exhaust treatment systems. CSF consists of a ceramic carrier coated with catalyst in which the edges of adjacent cells are alternately sealed off. It significantly reduces PM emissions by filtering PM out of the inflowing exhaust gas as it passes over the ceramic walls between cells.

For the engines in the new ZAXIS-6 Series, Hitachi Construction Machinery adopted a new urea SCR system to comply with the tighter NO*x* emission regulations. The technology for urea SCR is already in use in the truck engine used as a base. However, whereas trucks use CSF and urea SCR together, Hitachi Construction Machinery removed CSF and chose to use DOC and SCR only on the engine for the new hydraulic excavator.

In the urea SCR system, the urea solution is sprayed into the hot exhaust gas inside the exhaust treatment unit to form ammonia. Under the influence of the catalyst, this ammonia then reacts with the NO*x* to break it down into harmless nitrogen and water (see Fig. 2). As a result, in addition to the engine and exhaust treatment unit, the ZAXIS-6 Series also includes a large number of components used by the urea SCR system, including a tank to store the urea solution; a sensor unit to measure its quantity, temperature, and concentration; a pump and hoses to supply it; and the sprayer inside the exhaust treatment unit.

Because the load conditions (engine speed and torque, etc.) and operating conditions (vibration and heat, etc.) for a hydraulic excavator engine are significantly different from those for a truck engine, factors taken into account by Hitachi Construction Machinery during development included studies of equipment layouts, control system matching, and testing under different environmental conditions to ensure the performance and reliability of the engine when used in a hydraulic excavator.

Properties of urea solution include that it freezes at –11°C and that it expands on freezing. Accordingly, the volume of expansion needed to be taken into account when designing the urea solution tank to ensure that it would not fracture should this happen. To decide on the capacity of the urea solution tank, Hitachi Construction Machinery used predictions and verification testing to determine the volume of expansion, satisfied legal requirements for tank capacity, and consulted with customers about how long the machine should be

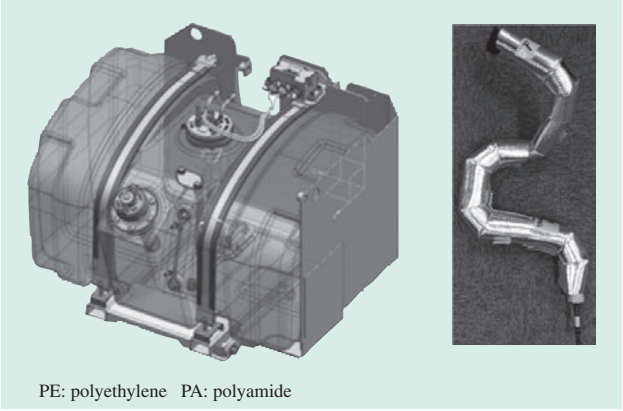

Fig. 3—Urea Solution Tank and Thermally Insulated Urea Solution Hoses.
PE, which is highly resistant to corrosion by urea, is used for the urea solution tank, and PA is used for the urea solution hoses.

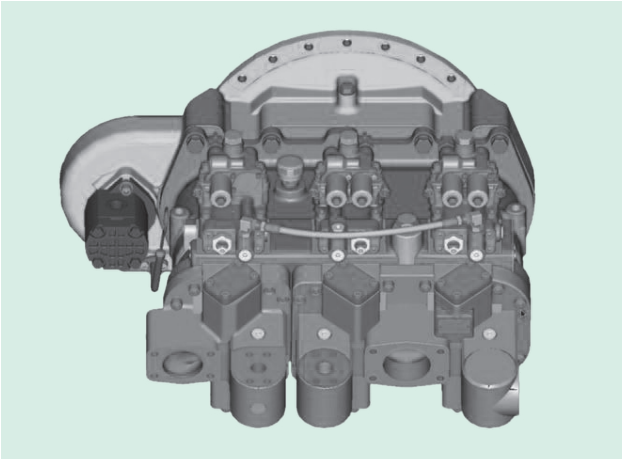

Fig. 4—New Main Pump.
The pump includes an electromagnetic valve that was not present on previous main pumps for optimal control of pump output.

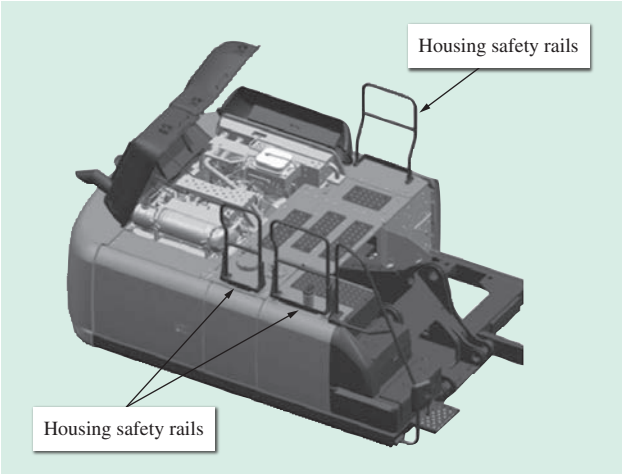

Fig. 5—ZAXIS 240-6 Housing Safety Rails and Engine Cover Structure.
Hand rails have been fitted on the housing access-way for greater safety, and the engine cover structure has been modified to provide better access to the engine and surrounding parts.

able to operate before needing a refill of urea solution (see Fig. 3). The urea solution tank was located at the front right of the excavator and the ease of refilling was assessed during operational trials by customers.

Because urea solution is easily affected by the ambient temperature, ambient temperature needed to be considered when designing the components that handle urea. Thermal insulation was fitted to the urea solution hoses to provide insulation when hot and to maintain the temperature when cold. The minimum thickness of thermal insulation and where to place it were determined based on the ambient temperature where the hose was used and its length.

New Hydraulics System

The new hydraulics system maintains the excellent ease-of-operation of its previous system while also achieving lower fuel consumption through the addition of detailed electronic control (see Fig. 4).

Specifically, because it has better control of pump output, it reduces losses in the hydraulics system by controlling pump output based on control lever position. The control valve spools have also been tuned to achieve optimal balance with respect to the pump output. This significantly improves fuel efficiency compared to previous models.

As a result, the ZAXIS 250LC-6 has 12% lower fuel consumption in economical mode than previous models.

SAFETY AND MAINTENANCE IMPROVEMENTS

Existing safety features have been augmented by new functions to improve safety and maintenance.

Safety Rails on Housing and Engine Cover Structure

To improve the safety of maintenance work on top of the main housing, hand rails that comply with ISO 2867 have been fitted as a standard feature on top of the housing. Meanwhile, the engine cover has been designed to open on the counterweight side to improve maintenance by eliminating the need to work on top of the counterweight and by enabling the exhaust treatment unit cover to be opened and closed (see Fig. 5).

Battery Disconnection Switch

A battery disconnection switch has been provided as a standard feature to improve safety when working on electrical circuits. This makes it easy to turn the power supply on or off (see Fig. 6).

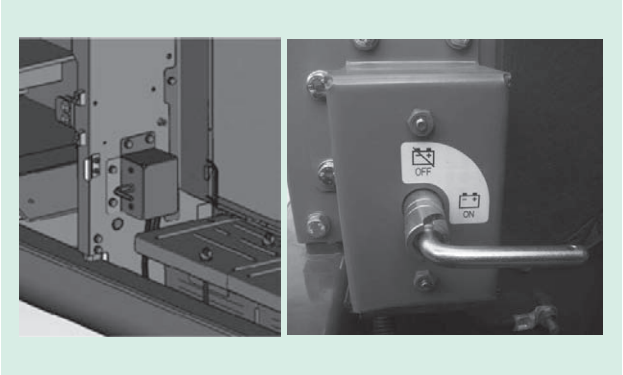

Fig. 6—Battery Disconnection Switch.
The hand-operated switch makes it easy to turn the power supply on or off.

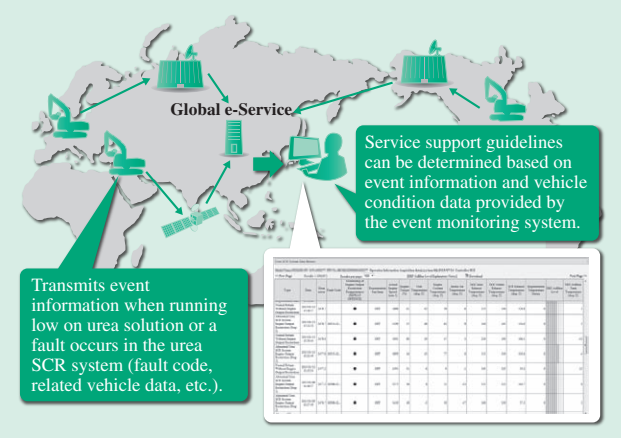

Fig. 7—Overview of Event Monitoring System.
Event information from throughout the world can be viewed from the office.

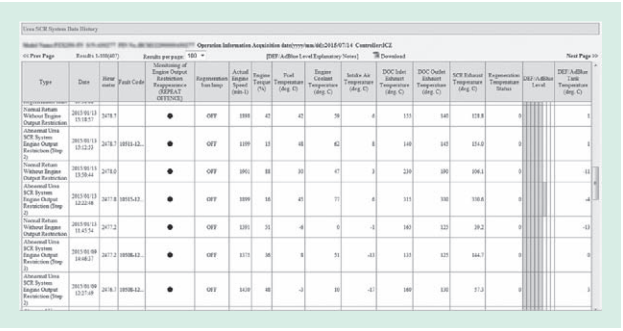

Fig. 8—Event Monitoring System for Urea SCR System.
The status of the urea SCR system can be monitored using event information sent from a machine and the appropriate actions to take are displayed on the screen.

FUNCTIONAL ENHANCEMENTS TO GLOBAL E-SERVICE TO FACILITATE EFFECTIVE USE OF INFORMATION TECHNOLOGY

The new exhaust emission regulations require that engine output be progressively limited if the machine is operated within a range where it will exceed permitted emissions.

For example, if the fault diagnosis function detects that the system cannot spray urea solution, such as when the level of urea solution is low, there is a hardware fault on the urea SCR system, or when an unauthorized modification such as a fake sensor is present, the engine output (torque and revs) must be progressively limited to the bare minimum required. Limiting the engine output in this way restricts the operation of the machine, meaning it cannot be used for its usual work.

Accordingly, one way Hitachi Construction Machinery has made effective use of information technology has been to upgrade the functions of its Global e-Service to enhance vehicle status monitoring and shorten the time taken to respond to faults.

An enhancement made to vehicle status monitoring was the addition of an event monitoring system for the urea SCR system (see Figs. 7 and 8). If engine output is limited due to the level of urea solution being low or the detection of a fault on the urea SCR system, the associated fault code and related vehicle data are sent to the Global e-Service server in realtime.

The event monitoring system uses this server data to provide realtime monitoring of vehicle status. To shorten the time taken to respond to a fault, the system also provides service support guidelines for the urea SCR system based on the fault code and vehicle status information.

CONCLUSIONS

This article has described the new environmental and energy-efficiency technologies, safety improvements, and use of information technology on the ZAXIS-6 Series.

As part of the development and testing of the ZAXIS-6 Series, it has undergone long-term operational trials by customers in Japan and overseas to improve its commercial performance.

In the future, Hitachi Construction Machinery intends to continue with developments that enable it to supply products that are sought by a larger number of users by improving customer satisfaction and strengthening the “Made by HITACHI” brand.

REFERENCE

(1) “Role of Construction Machinery in Building Prosperous and Comfortable Society,” Hitachi Review **62**, (Mar. 2013).

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