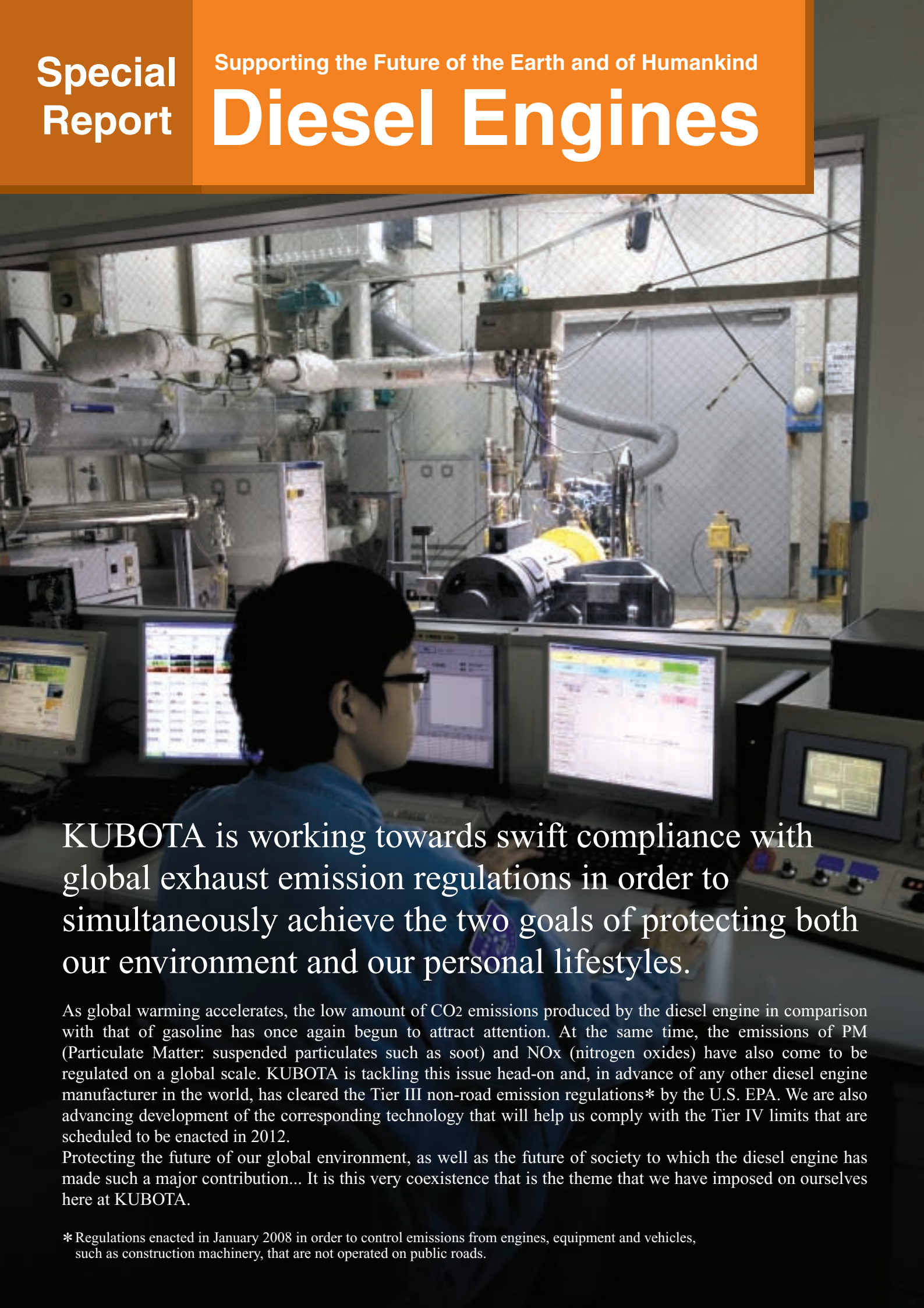


Special  
Report

Supporting the Future of the Earth and of Humankind

# Diesel Engines



KUBOTA is working towards swift compliance with global exhaust emission regulations in order to simultaneously achieve the two goals of protecting both our environment and our personal lifestyles.

As global warming accelerates, the low amount of CO<sub>2</sub> emissions produced by the diesel engine in comparison with that of gasoline has once again begun to attract attention. At the same time, the emissions of PM (Particulate Matter: suspended particulates such as soot) and NO<sub>x</sub> (nitrogen oxides) have also come to be regulated on a global scale. KUBOTA is tackling this issue head-on and, in advance of any other diesel engine manufacturer in the world, has cleared the Tier III non-road emission regulations\* by the U.S. EPA. We are also advancing development of the corresponding technology that will help us comply with the Tier IV limits that are scheduled to be enacted in 2012.

Protecting the future of our global environment, as well as the future of society to which the diesel engine has made such a major contribution... It is this very coexistence that is the theme that we have imposed on ourselves here at KUBOTA.

\*Regulations enacted in January 2008 in order to control emissions from engines, equipment and vehicles, such as construction machinery, that are not operated on public roads.

# Facing a New Chapter In the Issue of Global Warming

## Warning from the IPCC

Having collected and organized the scientific research of international specialists on global warming, the IPCC (Intergovernmental Panel on Climate Change) adopted its Fourth Assessment Report in November 2007 in order to put the brakes on the continuing advancement of global warming.

In this report, it was concluded that 90% or more of the cause of global warming is in greenhouse gas emissions of man-made origin. This report has finally sounded the serious warning that, if immediate measures are not drafted, there is a possibility that, by the end of this century, the average temperature will rise as much as 6.4°C above that of the last century and sea level will rise by as much as 59 cm.

## Inducing participation by emerging nations

The framework for the post-Kyoto Protocol era was discussed at CoP13 (the 13th session of the Conference of Parties to the United Nations Framework Convention on Climate Change) in 2007, and all of the main exhaust emitting countries have agreed to participate, including the United States—a non-participant in the Kyoto Protocol even though it is the world's largest producer of greenhouse gas emissions—as well as China and India with their remarkable development.

Global warming is said to be the cause of an increase in and strengthening of intense, anomalous weather, including a change in air and water temperature, a rise in sea levels and in the amount of precipitation and snowfall, as well as flooding and droughts, intense heat and hurricanes, and there is also the possibility of it resulting in large-scale extermination of various life forms as well. And now, the obligation for emission reduction—something that only certain advanced countries had previously owed up to—has been expanded globally, and the focus is being applied to securing greater implementability. It can thus be said that measures for controlling global warming have finally been taken to a new level.

# Diesel Engines are Once Again Becoming the Center of Focus

## Low CO<sub>2</sub> emissions

Since around the end of the 1990s, Europe in particular has come to positively reassess the value of the diesel engine due to the fact that its CO<sub>2</sub> emissions—the main cause of global warming—are less than that of the gasoline engine. Because CO<sub>2</sub> is emitted in proportion to the amount of fuel consumed, the excellent thermal efficiency that diesel engines display results in lower CO<sub>2</sub> generation.

Though the use of the diesel engine in Japan is centered mainly on industrial applications, such as with agricultural and construction machinery and on ships, it is installed in a large number of passenger cars in Europe, and the ratio is increasing even further.

## Indispensable for industrial power

Amongst all practicable internal combustion engines, the diesel engine excels most in its thermal efficiency. This enables a variety of different liquid fuels to be used, such as both light and heavy oils. Since the advent of the 20th century, diesel engines have taken an active role in a wide range of fields, from their use as small, high-speed engines to installations as low speed engines on massive ships. KUBOTA diesel engines, in particular, have been installed as the power units for tractors and shovels, and have contributed greatly to

primary industries and infrastructure maintenance. Durability, fuel efficiency, and general-purpose usability... Whichever you choose, it's not likely that you'll be able to discuss modern industry without including the diesel engine as a main source of power.



V3800DI-TI

## Biotech fuel works as well

The recent sudden rise in the price of oil is one reason that biotech fuel is currently garnering attention as a substitute for fossil fuel. Having been originally developed as just such a fuel, peanut oil may be one answer due to the possibility of its comparatively smoothly implementation as a next-generation response in diesel engines, and so research into its practical use has been actively promoted. This is yet another example of why the diesel engine has begun to be focused on once again.



# Rapid Response to Global Emission Regulations

## Constantly leading the world in regulation compliance

At the beginning of the 1990s, the eyes of regulation turned towards the industrial diesel engine, and the target became the suspended particulate matter and nitrogen oxides contained in exhaust emissions. With minimal CO<sub>2</sub> emission and in wide use at the very foundation of society and in peoples' daily lives, that was simply a test that diesel engines needed to overcome.

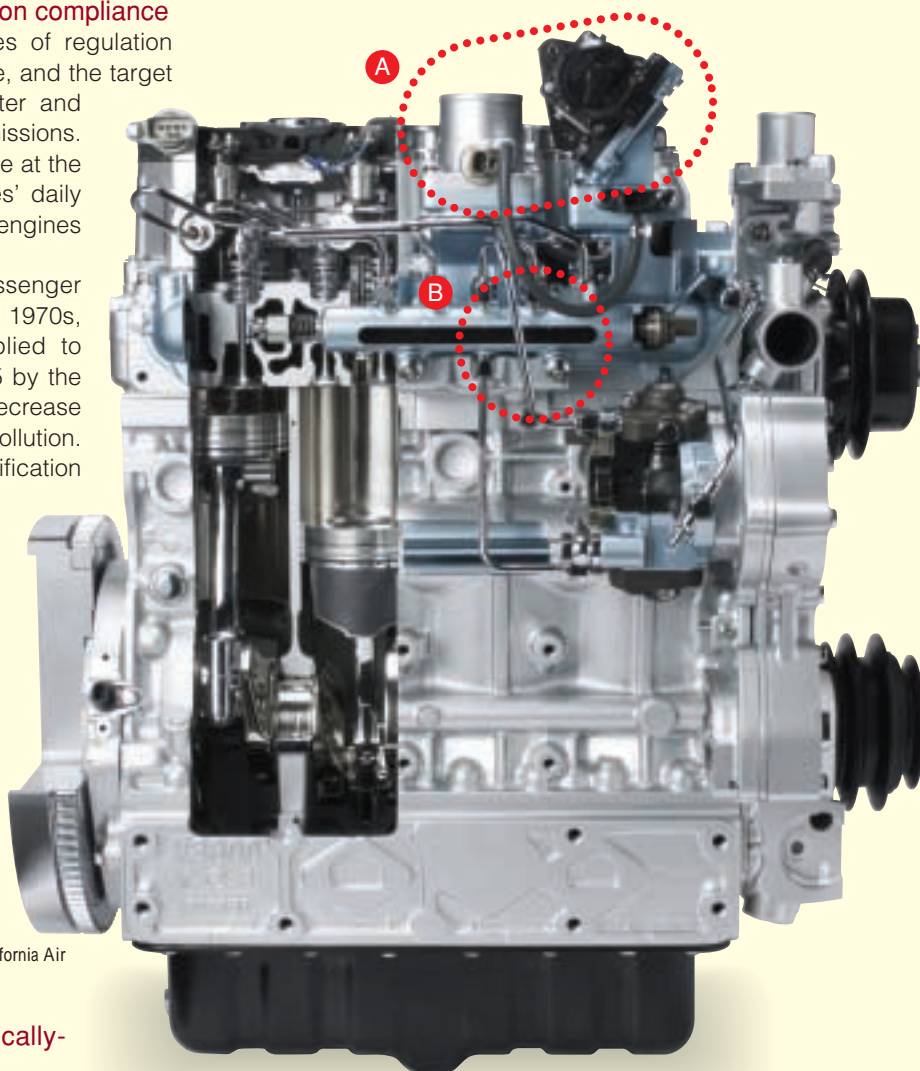
Just like the regulations placed on passenger cars that had been in effect since the 1970s, exhaust emission regulations were applied to nonroad vehicles for the first time in 1995 by the State of California (U.S.A.) in order to decrease the negative environmental impact of air pollution. In answer to that, KUBOTA acquired certification under CARBULGE (Utility Lawn & Garden Equipment) regulations\* in the under 19 kW class earlier than any other diesel engine manufacturer in the world. Since then, we have always responded in advance of everyone else to the regulations that are becoming more and more strict at each and every stage. Tier III emissions limits were then implemented in 2008 at about 1/3 times the restrictions of Tier I regulations (which was enacted in 1996), thus demanding the development of even higher-level emission control technology.

\* Restriction on exhaust emissions applied to engines installed in general utility, lawn, and garden equipment by the State of California Air Resources Board.

## KUBOTA's first completely electronically-controlled engine

Since the very beginning of exhaust emission regulations, KUBOTA had always stuck with mechanical control and we have held the top share in the small, compact diesel engine market, having supplied those engines throughout the globe. However, in order to clear the very strict values of the Tier III for over 75 kW class engines, as well as the Tier IV regulations that will be starting in 2012, there are limits to mechanical-type control. So KUBOTA began working on the difficult problem of introducing a fully electronically-controlled system without changing the conventional engine's form, while at the same time making improvements to basic performance. After the utmost efforts of many successfully overcame numerous issues, in 2006 we announced the V3800DI-TI, a completely electronically-controlled diesel engine integrated with state-of-the-art technology, like the EGR (Exhaust Gas Recirculation) and common rail systems.

The level of PM and NO<sub>x</sub> emissions is greatly decreased with this engine and a close to 10% power increase over the conventional model has been achieved while simultaneously clearing Tier III level regulations. With the



The V3800DI-TI:  
KUBOTA's first completely electronically-controlled diesel engine

V3800DI-TI, a diesel engine was unveiled that could easily be called "epoch-making".

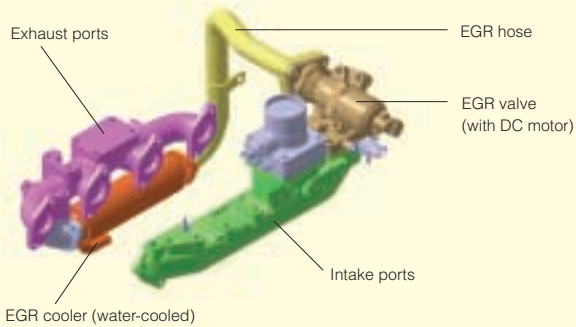
## Support from the Engine Environmental Management & Promotion Department

From information collection to the construction of a service system, various management departments exist to support the consolidation of the strengths of our Development & Technology Department and the delivery of state-of-the-art diesel engines that clear restrictions to the world at large.

In 1992, KUBOTA set up the Engine Product Environmental Management Section in order to acquire certification under industrial engine exhaust emission regulations in the United States. This section embarked on the collection of regulation information overseas, its dissemination both in-house and outside the company, negotiations with authorities and the industry, construction

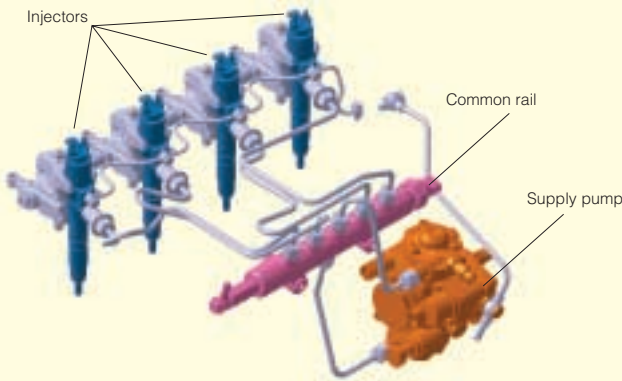
### A EGR (Exhaust Gas Recirculation) System

KUBOTA's unique electronically-controlled, cooled EGR system ensures easier cold starts while decreasing exhaust gas emissions.

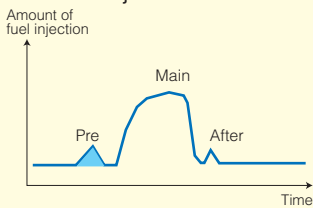


### B Electronically-controlled common rail system

Several injections deliver high power output with low fuel consumption, greatly decreased PM and NOx emissions, and lower combustion noise.



#### ■ Fuel injection ratio with several injections



ER108 Combine Harvester with V3800DI engine built-in

of an in-house system, and the improvement of efficiency in certification procedures.

Full-time employees on exhaust gas emissions were located in Chicago in 1994, the Quality Inspection Facility was set up in 1999, and, in 2006, our Engine Environmental Management & Promotion Department was organized. Along with strengthening our ability to respond to restrictions that currently extend over a global scale, this organization is further heightening our capability of supporting our service departments by expanding and enhancing the function of our wide-world service net and constructing a service system specifically for electronically-controlled engines, etc.

Always at the forefront of the industry, such integrated capabilities have been condensed into a power that enables KUBOTA to swiftly respond to ever-stricter regulations.

## Development Secrets

### The ECU data setting was the main hurdle

Two systems that have a major effect in clearing exhaust emission regulations are installed in the V3800DI-TI, KUBOTA's first completely electronically-controlled engine.

The EGR (Exhaust Gas Recirculation) System lowers the combustion temperature and suppresses NOx exhaust by cooling a portion of the exhaust emissions, returning it to the intake, and mixing it with the air newly taken into the engine. The "common rail" system ascertains the current operation conditions and accurately injects a spray of accumulated fuel at a high pressure of up to 1,600 atmospheres in order to achieve greater combustion efficiency. And a computer, known as the ECU (Engine Control Unit), controls both processes.

As a result, fuel consumption is improved and energy thus conserved, combustion temperature is lowered, and NOx emission is decreased. In looking forward to stricter Tier IV restrictions, such electronic control systems will be absolutely indispensable.

However, a problem remained with the ECU's data settings. Tuning that is matched to the slightly different "characteristics" of each and every installed engine, and to each of its parts, one by one, was conventionally accomplished by hand. The parameters (an element of the program construction) were in the tens of thousands. And then, it also had to be made practical to manufacture and to perform service. The requirements were mind-boggling; the very definition of infinity itself.

The diesel engine has been seen as one of KUBOTA's core products for a great many years, and now its ECU program, built upon KUBOTA's huge database with users worldwide, is one of our proudest accomplishments, and one that other companies simply cannot duplicate.



Kiyoshi Hataura  
Team Leader of  
Engine Engineering Dept.

Mitsuru Kamiyama  
Engine Engineering Dept.

# High Appraisal in a Growing Global Market

## An Engine with High Environmental Performance Knows No Borders

KUBOTA has obtained the solid trust of the U.S. market with our small diesel engine. Besides mowers, utility vehicles, and construction machinery, our engines are installed in mini-excavators, boring machines, small-sized mixers, sweepers and generators... With their use in agricultural machinery including installation into tractors and loaders, KUBOTA diesel engines take an active part in a wide range of fields.

In fact, in the case of engines installed in machines sold in the United States, there are more than a few cases of these units being exported to Europe, South America and Southeast Asia. The reality is that they cross borders so easily, we could say, "KUBOTA engines know no borders". Specifically today, with environmental controls being implemented on a global scale, the expectations for KUBOTA diesel engines will surely expand significantly as well.

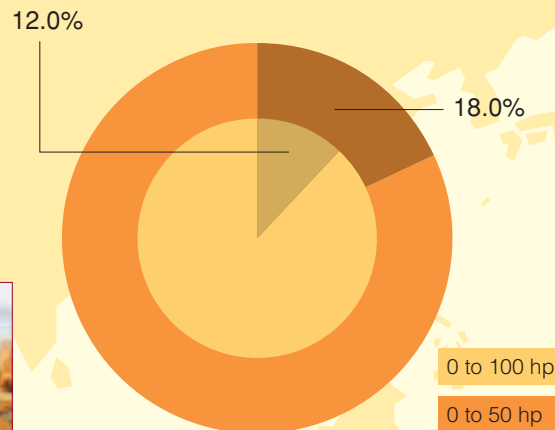
And in such times, on top of the natural needs in the United States and Europe, the demand for combines in China and tractors in Thailand is rapidly increasing and the application for KUBOTA engines will surely grow as well. This too is due to the abundant evidence of KUBOTA quality.

The high appraisal abroad of the value that KUBOTA engines deliver, in other words its operability, its compact size, its flexible installation, its low vibration, low noise, and clean emissions are all firmly established and well known.



"M9540" M-type mid-sized tractor

### ■ KUBOTA's share of the global multi-cylinder industrial engine market



\* From PSR Co. research (2007 data)



"Zero Turn" mower



Mini-excavator with new-type engine at a construction site

## KUBOTA contributes to the stable supply of food

The food self-sufficiency rate (calorie base) in Japan dropped below 40% in 2006. And looking overseas as well, it is said that we won't have to wait even another half a century before the world's population reaches nine billion, so a stable supply of food that is sufficient to support life in each country is in doubt. The stimulation of agriculture as one of the solutions has become a major topic of discussion.

In that regard, KUBOTA has been working to provide higher output and functionality in agricultural implements and machinery in order to realize improvements in efficiency in farm labor, as well as an improved and easier interface and more comfortable operating environment for senior citizens. Though agriculture in Japan is advancing in a fragmented bipolar direction (with full-time and small-scale part-time farms) due to a new governmental farm policy, KUBOTA is involved in offering a wide lineup of hardware that meets the detailed needs of either camp so that we may play a significant role in assisting the field of agriculture to support the stable supply of food worldwide.



KUBOTA engines contribute to food production the world over



# Hoping for a Bright Future for the Earth and Society

## Enhancing our global network

The electronically controlled system we introduced in order to comply with current and future exhaust emission regulations calls for further innovation in all the parts around the engine. Response by the service department will be especially difficult using only conventional mechanical technology, and the creation of a new system based on computer technology is rapidly being advanced through a service network that extends to 69 countries and 900 locations in all parts of the world.

## A unique stance on biotech fuel

Diesel engine manufacturers throughout the world have already begun their involvement in the development of units compatible with the biotech fuel that is drawing attention as a next-generation substitute for petroleum. And KUBOTA as well is carefully advancing on the path to completing its response at the B5 level (5:100 ratio between biotech fuel and light oil).

There are 3 reasons for this. First of all, there are uneven characteristics and quality involved in the biomass. Next, it is not easy to determine the effects of investment, and then there are even questions about using crops, originally intended for peoples' sustenance, as fuel. And third, especially today as we face the fears of a food crisis, KUBOTA, in its role as a business related to agriculture, is working to ascertain the proper balance between products and food.

## KUBOTA's policy is the coexistence of the environment and society

If it cannot comply with regulations and the diesel engine ends up disappearing from the marketplace, the brakes will be slammed down on the "foundation-maker of industry", a role that the diesel engine has borne up to the present day. And, in that case, businesses will be unable to fulfill their obligation of continuing to supply important products to their customers.

Compliance with exhaust emission regulations means defending the sustained development of society while simultaneously protecting the global environment. And, it's the production of diesel engines that enable both of those goals to coexist that is the basic policy here at KUBOTA.

## Comments from customers

"I've never experienced major problems with KUBOTA engines in the field. I fully trust KUBOTA engines and I'm quite sure that KUBOTA will supply engines which will meet even further strong emission regulation."



Mr. Bernhard Neubeck  
NEUBECK (Germany)



Yoshihiko Tabata

General Manager of Engine Division, Managing Director

## The diesel engine will continue to play a major role in the future

The diesel engine already has a history of more than 100 years. Its simple, solid structure; its high output and low fuel consumption performance... Those basic features have not changed, but it is still necessary to expand the output lineup according to the needs of the times and continue to evolve its design while adding various functions. Diesel engines have taken an active part in a wide range of genre worldwide, from assisting with the urban infrastructure of advanced countries to use in agricultural implements and machinery in developing countries. Well-earned confidence has been placed on

the diesel engine and the demand for its contributions has been firmly developed.

Recent exhaust emission regulations that originate in the attempt to protect our global environment can also be considered to be the opinions of stakeholders in a major sense. Certainly, they are strict opinions, but this is also turning the major expectations held for the diesel engine inside out. And, because there are still many situations that demand the capabilities of the diesel engine, the mission that we need to accomplish in response is to offer engines that future customers can use in a confident manner and without qualms. To that end, KUBOTA as a whole is committed to working on the development of engines that boast higher environmental performance and greater innate capabilities.