

## Development of PC78US-6 and PC78UU-6

Hiroshi Imai

*With the popularity of short tail swing hydraulic excavators increasing, the PC78US-6 and the PC78UU-6 were put on the market as new-generation construction machines symbolized by GALEO in August 2001.*

*In this paper, I will introduce the main features of the PC78US-6 short tail swing hydraulic excavator, which is superior to the standard excavators in all phases, and the PC78UU-6 all-direction short tail swing hydraulic excavator which has eliminated all the drawbacks of the conventional short tail swing hydraulic excavators.*

**Key Words:** Short Tail Swing Hydraulic Excavator, New-generation Standard

### 1. Introduction

The PC75UU short tail swing hydraulic excavator was model-changed into the Dash 2 in 1992 and equipped with the electronic control system, round cab, and offset boom having work equipment hoses which were epoch-making at that time. Since its concept met the market needs, it sold well mainly for pipe laying. It had the drawbacks of a narrow cab, large noise at operator's ear, small fuel tank, difficulty in maintenance, etc., however, as it was a short tail swing hydraulic excavator.

On the other hand, the PC78US was model-changed into the Dash 5 as a short tail swing hydraulic excavator having production capacity equivalent to that of the standard PC60, by using the PC75UU as the base and mounting the large-sized round cab of the PC128US which was one rank larger. As its safety and reliability concept was evaluated in the market, it sold more than standard machines.

The PC78US was inferior to standard excavators, however, in the noise at operator's ear, fuel tank capacity, travel performance, and ease of maintenance. In addition, since it has only the specifications for Japanese market, it could not be exported to the foreign markets where it seemed it would sell better.

In this paper, I will describe the features of the PC78US-6 and the PC78UU-6 which have followed the concept of GALEO and solved the above problems (**Photo 1**).

#### Concept of GALEO

- Providing optimal IT solutions
- Reducing impact on the environment
- Ensuring safer operating conditions
- Supplying powerful, superior-quality equipment



**Photo 1** External view of machine

**2. Development concept**

We intended to make a new-generation standard machine which would be superior to the standard model as well as the current model. The development concept was as follows.

- Much improvement of operating comfort and small tail swing radius
- Increasing of operating performance and travel performance and increase in fuel tank capacity
- Maintainability higher than standard model
- Improving of safety and reliability and meeting environmental requirements, globalization, and information technology

**3. Measures to attain these targets**

**3.1 Much improvement of operating comfort and small tail swing radius**

(1) Mounting of large-sized cab conformed to ISO standard  
 The large-sized cab is mounted by changing the layout of the machine body and its projection from the track is minimized. The positions of the engine, main valve, and hydraulic tank are changed properly (Fig. 1).

The projection of the tail is 80 mm, which is the same with the PC40MRx short tail swing hydraulic excavator (Table 1).

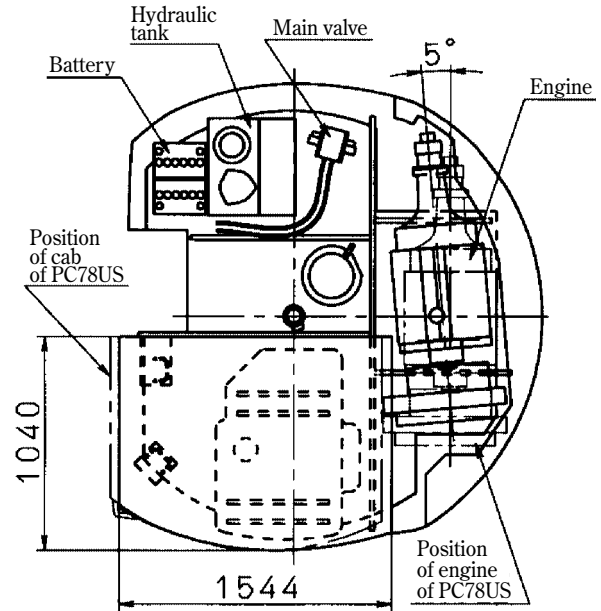


Fig. 1 Large-sized cab

Table 1 Comparison of projection of tail from track

Model	PC78US/ UU-6	PC78US-5	PC75UU-3	PC60-7
Projection	80 mm	130 mm	0 mm	675 mm

In particular, the PC78UU-6 has much larger operating space compared to the current model (Fig. 2, Table 2). Because of this large space and the low noise at operator's ear described below, the operator can work comfortably.

Table 2 Comparison of operation space

Model	Comparison with PC78US-5	Comparison with PC75UU-3
Volume	Increased by 9%	Increased by 37%
Elbow clearance	Increased by 77 mm	Increased by 150 mm
Head clearance	Increased by 64 mm	Increased by 64 mm
Foot space	Increased by 29 mm	Increased by 90 mm

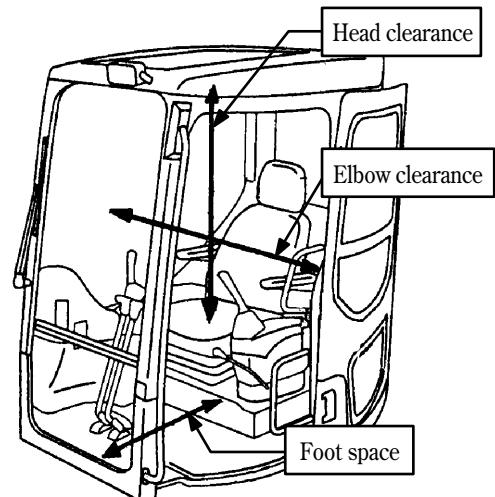


Fig. 2 Operation space

(2) Reduction of noise at operator's ear

The noise at operator's ear is reduced remarkably by sealing the floor, increasing the rigidity of the cab side walls, changing the rated engine speed, mounting the hydraulic piping through rubber cushions, and increasing the accuracy of the swing machinery gears. The noise of this machine is lower than the common sense in the short tail swing excavators. With this feature, the operator is much less fatigued (Table 3).

Table 3 Comparison of reduction in noise level at operator's ear

Model	PC78US/ UU-6	PC78US-5	PC75UU-3	PC60-7
With no load	Reduced by 3 dB	Increased by 2 dB	Increased by 3 dB	Standard
When relieved	Reduced by 3 dB	Increased by 3 dB	Increased by 2 dB	Standard
During swing	Reduced by 4 dB	Same	Same	Standard

(3) Interior same with medium-sized hydraulic excavators

The interior of the current models is still the interior of a mini-excavator. The interior of the PC78US-6 and PC78UU-6, however, is the same with the PC228US-3 which is the highest model of the US Series. Accordingly, the operating comfort and textures are much improved (Photo 2). The operating comfort is much higher than that of the standard model.

The improvement items are as follows.

- Employment of fresh air-type large-capacity air conditioner  
Air blows out from four outlets which the operator can select.
- Employment of defroster
- Employment of FM/AM radio  
The FM radio is stereo, of course.
- New monitor installed in front of the operator's seat for easy check (Photo 3)
- Employment of full garnish with magazine rack
- Employment of cup holder
- Employment of remote windshield wiper interlocked with windshield washer  
Since the motor is installed under the monitor and the wiper blade is retractable, the blade and motor are normally out of sight and the visibility is increased.



Photo 2 Retractable wiper



Photo 3 New monitor

### 3.2 Improvement of productivity

(1) Increase in production

The engine speed sensing system is employed first in this class. Since the engine horsepower can be used fully, the production can be increased.

The E-mode in which low fuel consumption has priority to reduce the environmental load is added to the A-mode in which high production has priority. In both modes, the engine output horsepower is controlled finely with the controller according to the operation of the work equipment control lever to increase the production and reduce fuel consumption (Table 4).

A-mode: Fuel consumption is the same with the current model but production is increased by 10%.

E-mode: Production is the same with the current model but fuel consumption is reduced by 8%.

Table 4 Comparison of production

Model	PC78US/UU-6		PC78US-5	PC60-7
Mode	A-mode	E-mode	—	—
Comparison of production	110	103	100	100
Fuel consumption ratio	102	92	101	100

(2) Increasing of travel performance

With the engine speed sensing system and the double pump system, the travel speed on flat places and slopes is increased and the travel speed during steering is also increased and the ability to travel through is improved remarkably (Fig. 3). As a result, the travel performance is increased, compared to the standard model as well as the current model (Table 5).

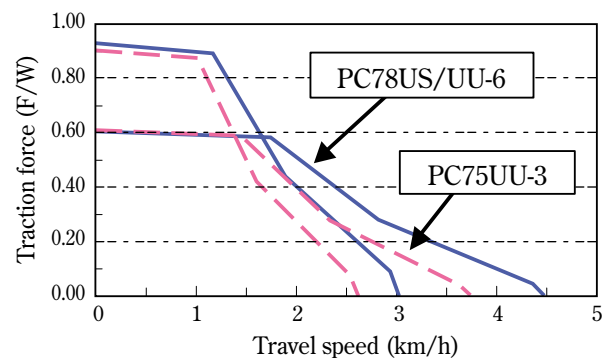


Fig. 3 Traction force curves of PC78US/UUS-6 and PC75UU-3

Table 5 Comparison of travel performance

Model	PC78US/UU-6	PC78US-5	PC75UU-3	PC60-7
Max. speed ratio	100	89	82	100
Steering speed ratio	117	86	93	100
Traction force ratio	116	115	115	100

Note) Steering speed is value at turning radius of 10 m.

(3) Increase of fuel tank capacity

The newly designed plastic fuel tank is installed under the floor to increase capacity. As a result, its capacity is almost the same as the tank of the standard model (Fig. 4).

In the E-mode described above, the machine can operate continuously for about two days. In particular, the fuel tank capacity of the PC78UU-6 is much increased compared to the current model (Table 6).

Table 6 Comparison of fuel tank capacity and operating time

Model	PC78US/ UU-6	PC78US-5	PC75UU-3	PC60-7
Tank capacity (ℓ)	125	115	80	130
Continuous operating time (h)	15.6	13.2	9.3	14.9
Time ratio	105	88	62	100

Note: Continuous operating time of PC78US/ UU-6 is value in E-mode.

3.3 Maintainability higher than standard model

(1) Inspection without tools

The exterior structure is changed and the number of the openable covers is increased so that the operator can inspect the machine without tools (Photo 4).

The engine can be inspected through the openable covers as before.

The inspection and work items and their locations are shown below.

- Right cover
  - Supply of hydraulic oil and washing liquid
  - Inspection of main valve
- Right front cover
  - Check of battery fluid level
  - Check of hydraulic oil level
  - Taking tools out and in

(2) Remote water draining from fuel tank

The water drain valves of the current model and standard model are installed to the underside of the fuel tanks. The operator must enter under the revolving frame and remove the undercover with a tool. On the other hand, the operator can operate the remote drain valve in an easy position without tools because an inspection cover is added (Photo 5).

(3) Easy radiator cleaning

When a machine is used in a dusty place, its radiator becomes clogged with dust and its engine can overheat. To prevent the engine from overheating, the radiator must be cleaned and oil cooler must be removed. The oil coolers of the current model and standard model cannot be removed easily, however, and much labor is required. On the other hand, the operator can get access to the front side of the radiator of the new model about 10 minutes (Photo 6).

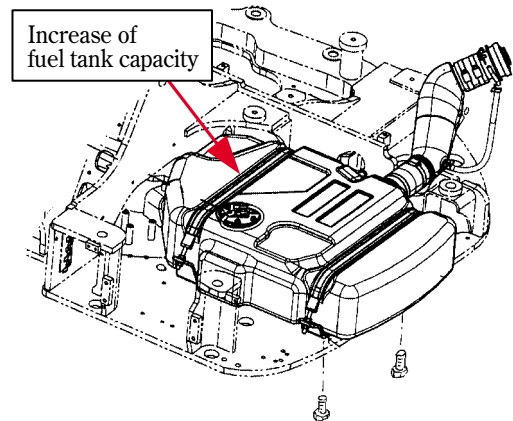


Fig. 4 Plastic fuel tank

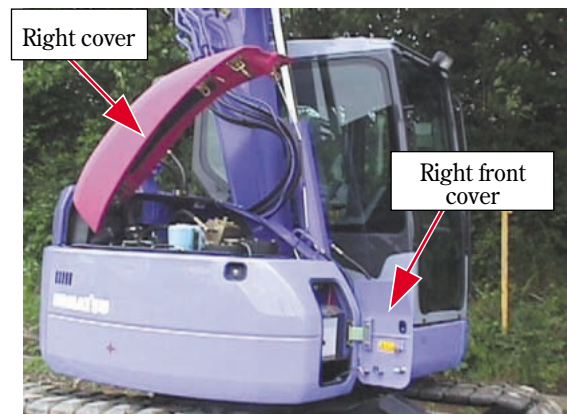


Photo 4 Exterior structure

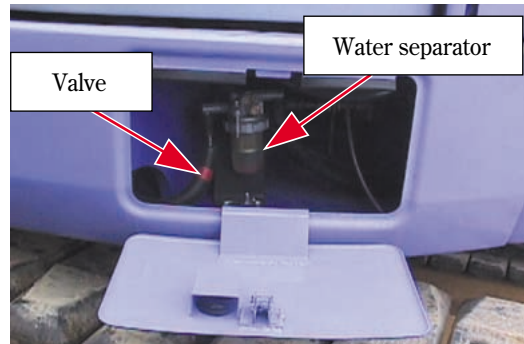


Photo 5 Fuel tank water drain valve

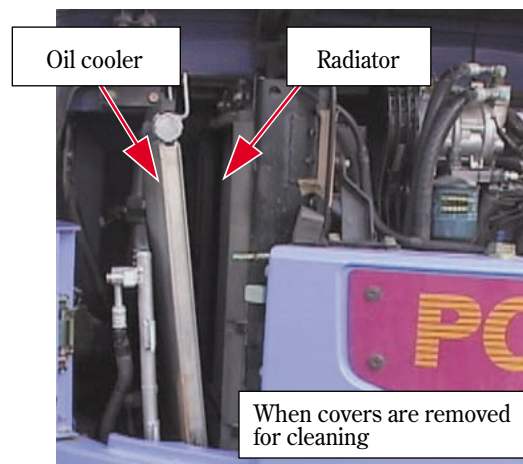


Photo 6 Easy cleaning of radiator



(4) Long greasing interval of work equipment  
 The greasing interval of the work equipment (excluding the arm top) is increased from 100 hours to 250 hours by using SCS bushings to the work equipment and blade.

(5) Long replacing period of hydraulic oil filter  
 The replacing period of the hydraulic oil filter is increased from 500 hours to 1,000 hours by employing the micro-glass filter.

(6) Easy removal of soil from track frame  
 The crawler house is slanted and the direction of the carrier roller support is changed so that soil will not accumulate and will be removed easily. As a result, the machine can be washed in a shorter time (Fig. 5).

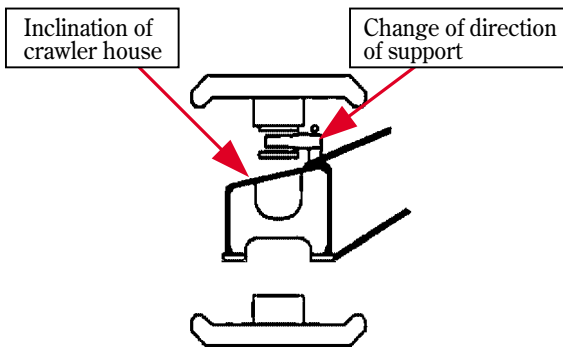


Fig. 5 Track frame

(7) Easy adjustment of air conditioner compressor belt  
 The position of the compressor is changed and the belt tension adjustment bolt is added so that the belt tension can be adjusted more easily.

Since the above items are improved carefully, the maintainability of the new models is higher than the standard model as well as the current model.

Next, I will introduce the items concerned to the safety, reliability, environment, global application, and IT in the concept of GALEO for 21st century.

**3.4 Improvement of safety**

(1) Round form with safe front and rear

The body of the short tail swing hydraulic excavator projects much less than that of the standard model and it causes contact accidents less when it swings. Accordingly, the short tail swing hydraulic excavator is taken in the JCMAS standard as a safe machine. The swing radius of the PC78US-6 is further reduced by improving the layout of the machine body and changing the link motion of the work equipment (Table 7).

Table 7 Comparison of swing radius

Model	PC78US-6	PC78US-5	PC60-7
Projection of tail (mm)	80	130	675
Projection of front (mm)	140	175	475
Swing radius of work equipment (mm)	1750	1890	1750

Note) Projected front part is handrail of cab.

(2) Cab having head guard function

The fully pressed and reinforced new cab has cleared the head guard standard of the Labor Safety and Sanitation Law and has attained high safety by increasing the strength of the pillars and reinforcing the ceiling window without adding a new guard. The front glass is the tempered green glass which has also cleared the standard of the Labor Safety and Sanitation Law.

(3) Engine neutral start mechanism

An electric circuit allows the engine start only when the work equipment lock lever is in the LOCK position. Accordingly, even if the operator tries to start the engine with the work equipment control lever in an operating position while the work equipment lock lever is in the FREE position, the engine does not start and the work equipment does not move.

**3.5 High reliability**

(1) Prevention of fuel system trouble

We had had trouble with the fuel system of the PC75UU. The new model is so improved that the reliability of the fuel system is increased. The improved items of the fuel system are as follows.

- Water separator with filter as standard  
 The water separator is installed to prevent troubles caused by dirt and water. It is installed near the water drain valve for ease of maintenance (Fig. 6).

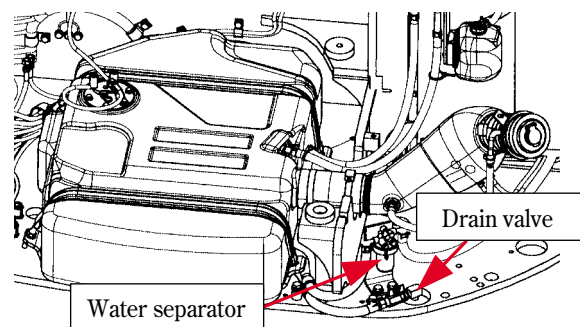


Fig. 6 Water separator

- Prevention of fuel leakage by using sensor section as cleaning window  
 Since the fuel tank of the current model cannot be removed easily, the cleaning window is installed and fuel may leak through it. On the new model, the cleaning window is eliminated and the operator can clean through the sensor section. The operator can get access to the sensor section by simply removing the inspection cover at the center of the floor. The mounting method of the tank is so changed that the tank can be removed without raising the floor when necessary (Fig. 7).
- Employment of large-sized strainer (100 ℓ/min)  
 When fuel is supplied to the current model at the rate of 100 ℓ/min, the fuel spills. Accordingly, the fuel strainer may be removed, and this is a remote cause of trouble. A large-sized strainer is installed to the new model, however, by changing the shape of the fuel supply hose (Fig. 7).

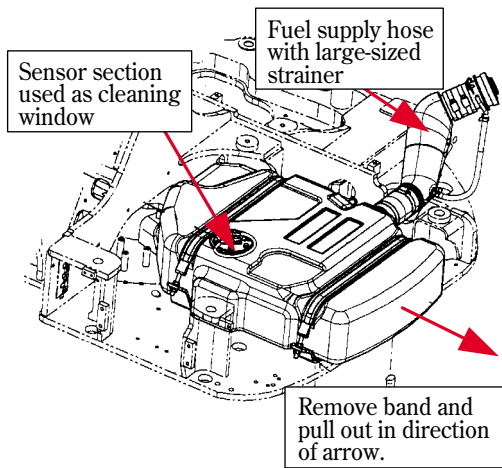


Fig. 7 Sensor section used as cleaning window

- (2) Employment of air cleaner of radial seal type  
 The air cleaner on the current model is thrust seal type. The new PC78US is equipped with a newly developed air cleaner of radial seal type to increase the reliability of the seal. Since the cleaner element is installed with three hitches, it can be replaced easily.
- (3) Increasing of reliability of hydraulic circuit  
 Since the pipe joints on the current model are taper seal type, they have oil leakage trouble. Those pipe joints are replaced with ones of O-ring face type on the new model (Fig. 8).

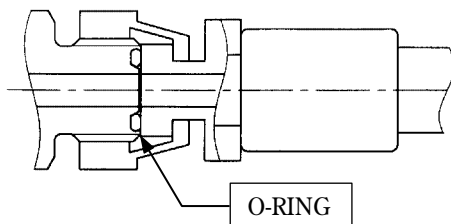


Fig. 8 O-ring face type pipe joint

- (4) Increasing of reliability of electrical parts  
 The current model has had trouble caused by bad contact of the connectors at rare intervals. The reliability of the electrical system of the new model is increased to prevent those troubles. The items improved for this purpose are as follows.
  - Employment of heavy duty wire connectors for important circuits  
 Heavy duty wire connectors which have high water resistance and which seldom have a bad contact trouble are employed for controllers and their command circuits.
  - Increase of number of fuses from 5 to 20  
 Since only five fuses are used on the current model, multiple circuits are connected to each fuse. Accordingly, when one circuit has trouble, it affects the other circuits and the circuit with trouble is difficult to find. On the other hand, 20 fuses are used and the all circuits are independent on the new model so that the cause of a trouble can be detected easily.

The above improved items are common to the PC78US and the P78UU. The following are the items improved to increase the reliability of only the PC78UU-6.

- (5) Prevention of damage to work equipment potentiometer  
 Since the UU Series has a function to stop the work equipment automatically, it is equipped with potentiometers to sense the position of the work equipment. The potentiometers of the current model are protected with the covers. Those potentiometers are moved to safer positions on the new model. The items improved for this purpose are as follows.
  - Change of position of offset potentiometer  
 The potentiometer is moved from the top of the 1st boom to the side of the same boom so that it will not hit against something easily (Photos 7 and 8).

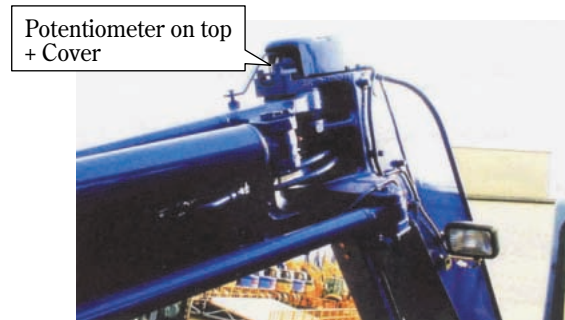


Photo 7 Current model



Photo 8 New model

- Inside installation of arm potentiometer

The arm potentiometer is moved from the side of the arm to inside so that it will not be damaged easily (**Photos 9 and 10**).

The UU Series is often used for pipe laying work. When the arm potentiometer is lowered into a groove, it can be damaged. The arm potentiometer cover on the current model is installed to protect the potentiometer in this case.

### 3.6 Improved items for the environment

- (1) Reduction in discharge of CO<sub>2</sub>

Since the E-mode is added as a new working mode, the fuel consumption is reduced by 8%. As a result, the discharge of CO<sub>2</sub> is reduced to 92% compared to the current model.

- (2) Increasing of recyclability

More recyclable materials are used.

- Employment of radiator and oil cooler made of aluminum
- Employment of kenaf for ceiling of cab
- Employment of PET (polyethylene terephthalate) as a part of sound absorbing material

### 3.7 Improved items for global application

The current model has the specifications for only the Japanese market. New specifications are added to the new model for overseas markets where the sales seem to increase. Those specifications are explained below.

We started to export the PC78US-6 to North America, which is the main target of our sales activities, in December 2001 as planned.

- (1) Widening of allowable atmospheric temperature range

The allowable atmospheric temperature range is widened as standard so that the machine can be exported all over the world (excluding special districts). The main improvements for this purpose are increase of cooling capacity and improvement of heat balance temperature by change of the air flow.

- (2) Installation of defroster as standard

Since the defroster is required in North America, it is installed as standard.

- (3) Facilitation of installation of travel alarm

Since the travel alarm is required in North America, the circuit for it is installed to the standard wiring harness so that it can be installed later easily.

- (4) Conformance to EU Noise Regulations as standard

The standard specification conforms to the EU Noise Regulations.

### 3.8 Improved items for IT (information technology)

- (1) Preparation of KOMTRAX as option

In Japan, KOMTRAX employed by the PC200-7 as standard is prepared as an option. It is to be put on the market in the spring of 2002.



Photo 9 Current model

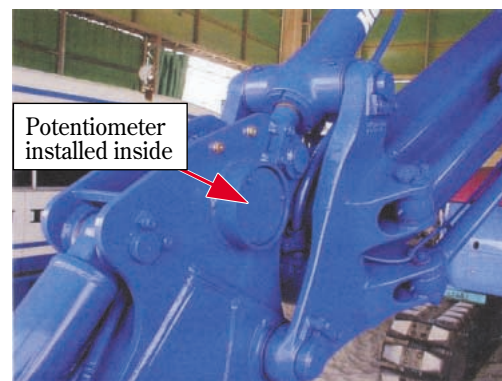


Photo 10 New model

#### 4. Closing remarks

The PC78US-6 and PC78UU-6 were put on the market in August 2001. Receiving many favorable comments from users, we confirmed that our concept was correct.

The main favorable comments are as follows.

- Operating comfort is excellent.
- Noise is outstandingly lower in this class.
- The cab and visibility are wide.
- The work equipment moves fast and has high power.
- Controllability is perfect.
- Since the side cover opens wide, inspection is easy.
- Long fuel refilling intervals save time and labor.

We expect that these two models will sell more in North America as well as in Japan and contribute to increase of sales and profits of Komatsu.

We are very grateful to everyone who gave us cooperation in developing these models and putting them on the market.

#### Introduction of the writer



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#### **[A few words from the writer]**

During the development period of these machines, I sometimes wondered, "Is there answer to this problem?"

After the developing team had worked together perseveringly, however, we succeeded in completing the machines.

I was convinced through this development that Komatsu shows its latent power in cases of necessity.