Technical Paper

Introduction of Construction Machine EMC Test Facility

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The construction machine EMC (electromagnetic compatibility) test facility where an intense electric field can be applied to a construction machine in an actual machine condition was relocated from Mooka Plant to Oyama Plant in December 2010. This new test facility can accommodate from a mini construction machine such as PC30MR to a large-sized construction machine for mining such as WA1200, and EMC tests can be conducted for these machines in an actual operating condition. Construction machines are required to meet ISO13766 and EN13309 regulations. In this test facility, tests which conform with these regulations can be conducted.

Fig. 1 Overall view of test facility

Fig. 2 Laboratory

1. Introduction

Electronic control operation in construction machinery began before 1980 and has been widely used such as shift control of dump trucks and pump control of excavators. The electronic control system is indispensable to the improvement of operability, realization of comfort and meeting exhaust gas regulations. With this computerization of construction machinery, a number of electronic circuits and parts of control equipment have increased, causing noise interference problems. At the same time, sensitivity to electromagnetic interference and static electricity has been increasing.

In recent years, control equipment and sensors are connected each other through the network to function as a system like the systems in automobiles. Therefore, noise effects should be avoided in normal machinery operation.

What indicates tolerance for these electromagnetic noises is electromagnetic compatibility (EMC) and standards and regulations are specified for construction machinery as validation of safety.

In this paper, the outline of standards and regulations currently specified and "construction machine EMC test facility" which verifies the conformity to the standards and regulations are introduced.

2. EMC standards and regulations of construction machinery

Some of construction machines can obtain a license plate and travel on a public road in Japan. On such models, the safety standards of the Road Transport Vehicle Law are applied. Although specific limit values are not presented, it is required not to cause troubles to the surroundings.

In the EU, the conformity with EN13309 and ISO13766 is required in the EMC directive and machine directive, and it is necessary to satisfy both regulations. The EMC evaluation of construction machinery consists of the following three elements.

1) Electromagnetic Interference (EMI)

This regulates electromagnetic radiated emissions from the construction machine

2) Electromagnetic Susceptibility (EMS)

This regulates the immunity to electromagnetic radiation of the construction machinery.

3) Electrostatic Discharge (ESD)

This regulates the immunity to electrostatic discharge of the construction machinery.

Specific limit values and normative references required in EN13309 and ISO13766 are shown in the following chart.

Table 1 Normative reference

	Normative reference		Current
	Construction machinery	EAS (Electrical subassemblies)	
EMI	CISPR 12 CISPR 25	CISPR 12 CISPR 25	Radiated emissions over the frequency range of 30 to 1000 MHz must not exceed the permitted value.
EMS	ISO 11451-2 (derived from ISO13766)	ISO 11452-2 ISO 11452-3 ISO 11452-4 ISO 11452-5 (derived from ISO13766)	ISO/JIS 20 to 1000 MHz AM control system: A field strength of 100 (80) V/m non-control system: A field strength of 30 (24) V/m must not produce any problems to the machine. EN 20 to 800 MHz AM A field strength of 30 (24) V/m must not produce any problems to the machine. 800 to 2000 MHz PM A field strength of 30 (24) V/m must not produce any problems to the machine.
ESD	ISO 10605	ISO 10605	Air discharge: ± 15 KV Contact discharge: ± 8 KV

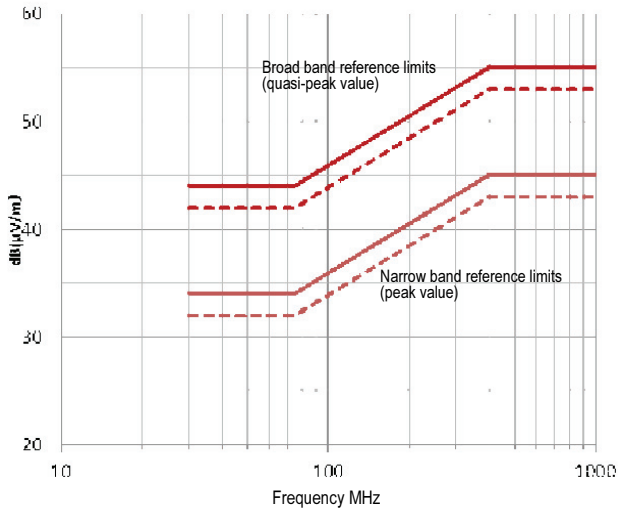

Fig. 3 EMI limit value

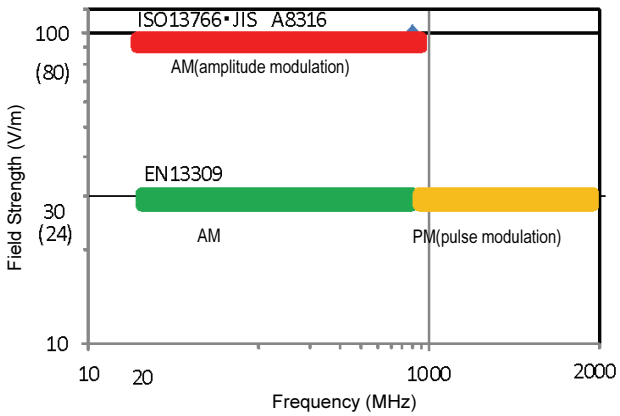

Fig. 4 EMS limit value

3. Construction machine EMC test facility

In the EMC evaluation of construction machinery, the electromagnetic disturbances due to the electromagnetic radiation must not be created to the surrounding environment. For this reason, an isolated test environment is realized as the construction machine EMC test facility. The EMC laboratory (anechoic chamber) and measurement system which are the core of the test facility are introduced below.

3.1 EMC laboratory

The structure of the laboratory is shown in **Fig. 5** while the main specifications are shown in **Table 2**.

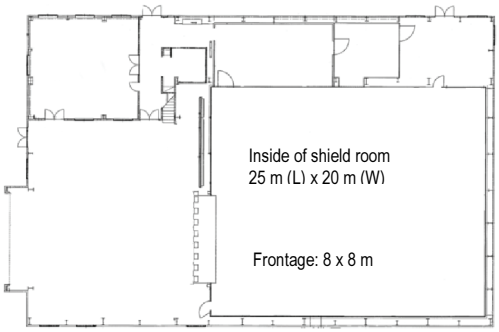

Fig. 5 Structure of laboratory

Site attenuation characteristics* are shown in **Fig. 6**.

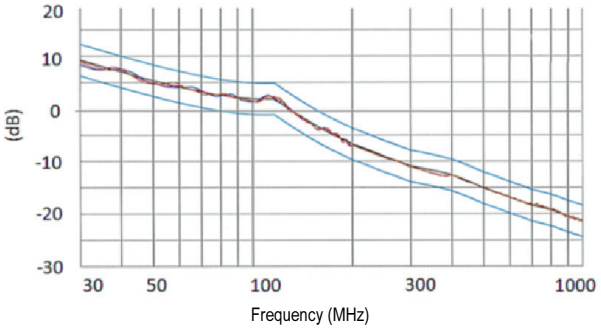

Fig. 6 Site attenuation

These specifications and characteristics keep isolation from the surrounding environment, and allow for the conduct of safe and reliable tests without the leakage of the electromagnetic field even if an intense electric field is produced in the laboratory.

* Site attenuation is a measure of the transmission path loss between two antennas.

Table 2 Main specifications of laboratory

	Type	Frequency range	Attenuation characteristics
Shield characteristics	Magnetic field	150 kHz to 30 MHz	60 dB or more
	Electric field	150 kHz to 30 MHz	100 dB or more
	Plane wave	30 MHz to 1 GHz	100 dB or more
		1 GHz to 10 GHz	80 dB or more
Power line interruption characteristics	Excluding light electric system	150 kHz to 10 GHz	100 dB or more

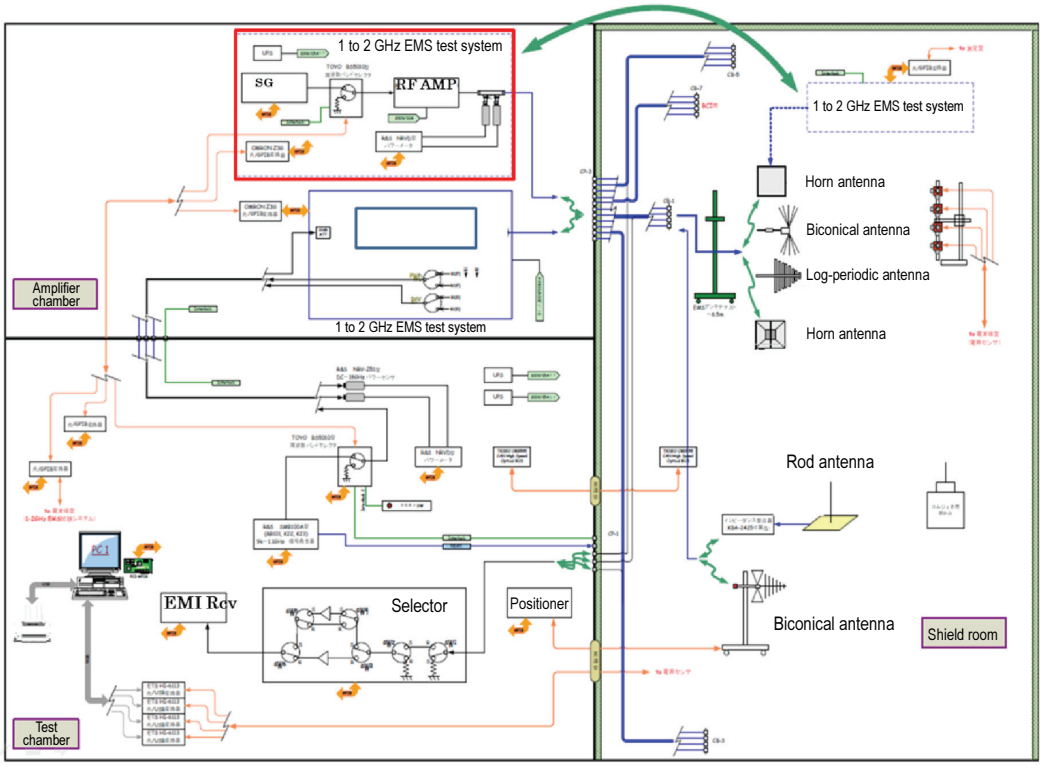

Fig. 7 Structure of measuring system

3.2 Measurement system

The configuration of the measurement system is shown in **Fig. 7**. The EMC test is conducted under a condition in which a construction machine is actually operated.

Examples of conducting each test are shown below.

a. Electromagnetic Interference (**Fig. 8**)

A construction machine is placed in the EMC laboratory and electromagnetic emissions radiated from the construction machine is measured and evaluated using a dedicated measuring antenna and reception equipment.

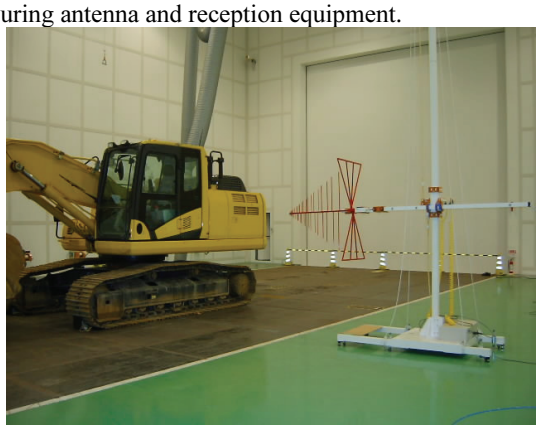

Fig. 8 Emission (EMI) test

b. Electromagnetic Susceptibility (**Fig. 9**)

A construction machine is placed in the EMC laboratory and an intense electric field is applied to the construction machine to check that its functions are not impaired.

Fig. 9 Radiated immunity (EMS)

c. Electrostatic discharge

A construction machine is placed in the EMC laboratory and electrostatic discharge is applied to the parts of the construction machine by a static electricity simulator to check that the functions of the machine are not impaired.

3.3 Safety device

Because emission and radiated immunity measurements are conducted in the closed space and no operator is allowed to enter the area during the test, the EMC laboratory is equipped with safety devices, which are introduced below.

a. Gas detector (**Fig. 10**)

Fig. 10 Gas detector

This monitors gas (O_2, CO, H_2, CH_4) concentration in the laboratory.

b. Exhaust system

This performs forced exhaust appropriate for the displacement of a construction machine.

c. Door interlock system

When an electric field is applied, closed conditions of all doors of the laboratory are checked by the sensors and the transmission of electromagnetic waves is forcibly stopped when any door is opened, to prevent the leakage of electromagnetic waves outside the anechoic chamber.

d. Emergency stop device

This device is connected to the machine's disconnect switch and shuts off the main power supply using an air actuator in an emergency.

4. Future development

With the development of the radio wave circumstances and high frequency use in the world, the EMC environment of construction machinery has changed and standards and regulations (ISO13766 and EN13309) have also changed, which has resulted in the difference as shown in **Table 1**. We would like to make a contribution by conducting activities toward the harmonization between ISO and EN.

Furthermore, EMC standards and regulations (for example, low voltage directive) other than those shown here are required to be met due to the computerization, hybridization and electrification of construction machinery itself. We always would like to be prepared to make optimal and best test evaluation for changes of EMC requirements for construction machinery from the market and work on the realization of safer construction machinery.

Introduction of the writers

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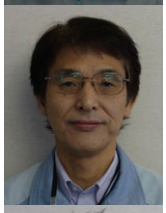

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[A few words from writers]

The standards and regulations are changing to fit the actual condition of the circumstances, and the unification of EN and ISO standards described in this report is an example of such trend.

We are going to operate this facility to utilize it for producing better products at all times.