EL653. Low-noise Construction Machinery

[EL653-2002/2/2005-68]

1. Scope

The scope shall apply to the machine provided for construction work (hereinafter referred to as “construction machine”).

2. Definition

“Construction work” refers to maintenance and management works related to civil engineering·construction, river·road and other facilities.

3. Certification

3.1 Environmental Criteria

Noise [sound pressure level or acoustic power level] of product shall satisfy the following requirements. In case of existing both measurement results of sound pressure level and acoustic power level, the measurement result of sound power level shall be preferably applied.

Type of Construction Machine	Range of Engine Output [kW]	Sound Pressure Level [dB(A)]	Acoustic Power Level (L_{WAd}) [dB(A)]
Excavators	< 55	≤ 73	≤ 100
	55~103	≤ 76	≤ 104
	103~206	≤ 79	≤ 105
	≥ 206	≤ 82	≤ 107
Loader	< 55	≤ 76	≤ 102
	55~103	≤ 79	≤ 104
	103~206	≤ 82	≤ 107
Compressor	< 55	-	≤ 101
	≥ 55	-	≤ 105
Generator	< 55	≤ 74	≤ 98
	≥ 55	≤ 76	≤ 102
Rock Drill	-	≤ 85	≤ 106
Concrete Crusher	< 55	≤ 73	≤ 99
	55~103	≤ 76	≤ 103
	103~206	≤ 79	≤ 106
	≥ 206	≤ 82	≤ 107
Pile Driver, Vibratory	-	≤ 85	≤ 107

Hammer			
Roller	< 55	≤ 76	≤ 101
	≥ 55	≤ 79	≤ 104
Concrete Pump	< 55	≤ 84	≤ 100
	55~103	≤ 84	≤ 103
	≥ 103	≤ 84	≤ 107
Concrete Cutter	-	≤ 88	≤ 106

3.2 Quality Criteria

For the product, the formal approval of construction machine shall be made in accordance with the Article 18 of Construction Machine Management Act, or the formal report of construction machine shall be made in accordance with the Article 11 of the enforcement ordinance of the same act.

3.3 Information for Consumers

Indication on the items that the product contributes to the reason for certification (less noise) during its consumption stage

4. Test Methods

Certification Criteria	Test and Verification Methods
Environmental Criteria	• Measurement of sound pressure level: Conform to the 'regulation on recommendation of noise indication on low-noise product of high-noise machine' (Ministry of Environment notification 2001-180) • Measurement of acoustic power level: Conform to KS A ISO 11201(sound - noise released from machine and equipment - ways of measuring the level of released sound pressure at the work position and other designated position - ways of practical measurement at the semi-free sound filed on the reflective surface), but regarding the measurement conditions, conform to the 'regulation on recommendation of noise indication on low-noise product of high-noise machine' (Ministry of Environment notification no. 2001-180)
Quality Criteria	Formal approval of construction machine in accordance with the Article 18 of Construction Machine Control Act or copy of formal application document (limited to the relevant product)
Consumer Information	Verification of submitted documents

4.1 General Matters

4.1.1

One test sample shall be required for each applied product. However, if more than one test sample is needed, the former requirement may not be met.

4.1.2

Test samples shall be collected at random by a certification institute from products in market or those in storage at the production site.

4.1.3

It makes a rule that all the measurement shall be tested in the stable state in which the product is installed in the normal state of use.

4.1.4

The result of test shall be numerically set according to KS Q 5002 (Statistical interpretation method of the data – Part 1: Statistical description of the data), when testing the basis weight.

5. Reason for Certification

“Low noise”

<Annex 1> A method of measuring the sound power level [with regard to “C. Certification criteria” (1)]

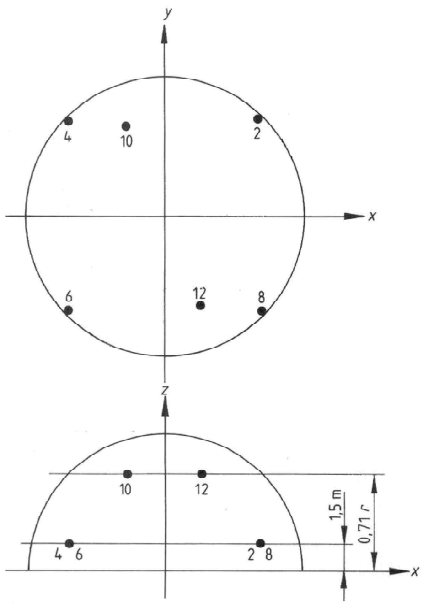
Note) This measurement method modified and re-arranged some parts (6. Test environment, 7. Time average, A. Measurement of the weighted sound pressure levels) of KS I ISO 6395 (Acoustics- Measurement at the operator's position of noise emitted by earth-moving machinery -dynamic test conditions), KS I ISO 3744 (Acoustics - Determination of sound power levels of noise sources using sound pressure-Engineering method in an essentially free field over a reflecting planes), and EU Directives 2000/14/EC, so that they fit into the certification criteria.

1. Method of setting the measurement point

A. Number of measurement spots: As a general rule, 6 spots on the surface of the virtual hemisphere should be measured at the same time, which surrounds target construction equipment.

B. Measurement positions

(1) Sound should be measured as shown in Figure 1.



Coordinates of the microphone

Microphone number	*x/r*	*y/r*	*z*
2	0.7	0.7	1.5 m
4	-0.7	0.7	1.5 m
6	-0.7	-0.7	1.5 m
8	0.7	-0.7	1.5 m
10	-0.27	0.65	0.71 *r*
12	0.27	-0.65	0.71 *r*

<Figure 1> Measurement positions (location of the microphone)

(2) The following table shows the diameter ( ) of the measurement side according to the default length ( ) of the construction equipment to measure.

default length ( ) of the construction equipment to measure [m]	diameter ( ) of the measurement side [m]
Under 1.5	4
1.5~4	10
Over 4	16

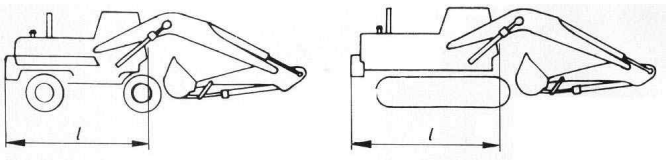
However, calculate the default length ( ) of the construction equipment to measure, as shown in Table 1.

<Table> Definition of the default length and applicable construction machinery

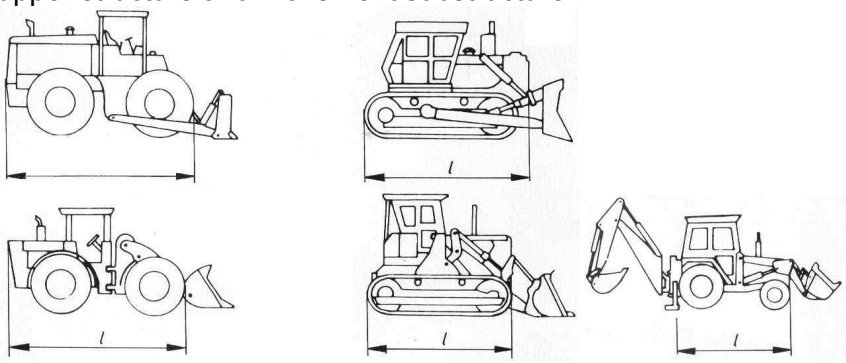
Definition of the default length	Applicable construction machinery
Overall length of the upper swing unit, if the overall length of the truck window or work engine is loaded on the upper swing unit. (However, the extraneous matter like a crane boom is excluded.)	Consumption efficiency rating, concrete pump, concrete mixer truck, crane
Overall length of construction equipment including the substructure for movement, such as the body, caterpillar, tire, and roller. (However, the extraneous matter like a towing hook and blade is excluded.)	Dozer, loader, backhoe loader, roller, grader, dump truck, asphalt finisher, concrete finisher, aggregate spreader, fork lift, road milling machinery, and oil pressure power pack
Overall length of construction equipment including the substructure for movement, such as the body, caterpillar, and roller. (However, tires are excluded.)	Air compressor, electric generator, and electric welder
Overall length of construction equipment that becomes the base machine or power source. (However, the length of construction equipment including the body or caterpillar movement equipment for dedicated equipment.)	Pile driver . pile extractor, hand breaker, oil pressure breaker, piercer, and concrete breaker

- Example of calculating the default length (l) of the construction equipment to test

▪ Consumption efficiency rating: The overall length of the upper swing part, excluding the extraneous matter and movement substructure.



▪ Dozer, loader, backhoe loader: Excluding the extraneous matter but including the upper structure and movement substructure.



2. Measurement environment

A. Generation conditions for the measurement spot

(1) There should be no obstacles at the measurement spot, so that the acoustic field can spread on the reflective surface without hindrance. Generally, the measurement spot should be the solid ground covered with concrete or asphalt, or similar outdoor places. The place that can affect sound level measurement significantly should be avoided, such as the factory, work site, construction site, airfield, or railroad.

(2) There should be no obstacle that reflects sound within the three times distance of the diameter of the hemisphere from the center of the sound source (center of the hemisphere).

B. Measurement spot: Earth's surface condition

(1) Solid reflective surface (concrete or asphalt pavement)

(A) Application target

1) When measuring all operation modes of all construction equipment with rubber tire wheels.

2) Construction equipment for soil preparation

3) When measuring the stationary oil pressure mode of construction equipment of which bottom transfer equipment is caterpillar or steel wheel.

4) When measuring the drive mode of construction equipment of which bottom transfer equipment is a wheel.

(B) Measuring surface: The test side surrounded by a microphone should be composed of concrete or non-porous (dense grade) asphalt.

(2) Combination of concrete or asphalt pavement and sand

(A) Application target: When measuring the stationary oil pressure mode of construction equipment of which bottom transfer equipment is caterpillar or steel wheel, or when measuring a rock drill.

(B) Measuring surface

1) Put sand on the runway of construction equipment to test, and the earth's surface between construction equipment and microphone should be the solid reflective surface (concrete or asphalt pavement). Sand should be wet with less than 2mm in size. Sand depth should be at least 0.3m. If caterpillar-type construction equipment cannot be driven smoothly, the depth of the sand-bed should be increased.

2) The combination place with the minimal dimension can be composed of the sand path along the side, and the reflective surface of the hemisphere. Drive construction equipment forward two times (to the different direction), using three microphones. The same method can be used for the reverse mode.

(3) Sand

(A) Application target: If the following conditions are met, the alternate test place composed of sand only can be used, when measuring the drive mode of the caterpillar type construction equipment and stationary oil pressure operation mode.

1) If the background noise compensation value (K_1) according to ISO 4872 is lower than 3.5dB (A).

2) Background noise compensation: Make compensation for the calculation of the sound power level, if K_1 is higher than 0.5dB(A).

(B) Measuring surface: The surface should be entirely covered with sand. Sand should be wet with less than 2mm in size. Sand depth should be at least 0.3m. If caterpillar-type construction equipment cannot be driven smoothly, the depth of the sand-bed should be increased properly.

C. Weather conditions: Measurement should not be performed under the following conditions.

(1) If it rains, snows, or hails.

(2) If the earth's surface is covered with snow.

(3) If the temperature is under -10 ℃ or over 35 ℃.

(4) If the wind speed exceeds 8 m/s.

D. Background noise conditions: It is desirable that the average of the sound pressure levels measured at 6 positions is lower than 15dB(A), compared with the measure sound pressure level. It should be lower than 6dB(A) at least. In addition, the background noise measured at each measurement position should be 10dB(A) lower than the sound pressure level measured when driving construction equipment.

E. Others

(1) A windbreak net should be attached to a microphone, if the wind speed is faster than 1 m/s.

(2) The construction equipment to measure should be measured in an operation mode.

3. Use and handling of the measurement device

A. Sound level meter to use

(1) The regular sound level meter defined in KS C 1502 (Sound level meter), or the meter with better performance.

(2) Grade 1 equipment defined in IEC 61260.

B. General items

(1) The sound level can be measured by connecting a sound level meter, recorder, and voice recorded. Or, the device can be connected that can record, measure, and analyze at the same time. However, only the sound level meter can be used, if the sound level meter has an internal memory device and displays the frequency analysis results.

(2) Check the power and operation of the sound level meter, recorder, and voice recorder, and perform correction before measurement. (Connect the output terminal of the sound level meter to the input terminal of the recorder.)

(3) If the sound level meter, recorder, and voice recorder are connected, pay attention to the influence of the sound level meter's overload output on the noise results.

C. Level weighting and dynamic characteristic conditions

(1) Fix the level weighting circuit of the sound level meter to the A characteristic for measurement.

(2) Use the "fast" dynamic characteristic of the sound level meter.

4. Placement and start-up of construction equipment

A. General items

(1) As a general rule, the construction equipment to test should be attached with the device needed for work, and measurement should be performed while equipment is running, and windows and doors are closed.

(2) Fan speed: The fan directly connected to the engine or oil pressure operating device must be running during the test, and measurement should be performed at the speed in one of the following cases. The machine manufacturer should specify, set, and indicate the state and application conditions of construction equipment on the test report.

(A) If fan driving is directly connected to the engine or the oil pressure system (e.g., belt operation), the fan must be running during the test.

(B) One of the followings should be performed for the fan running at different speed.

1) Run at maximum working speed and measure.

2) Calculate the A-weighted sound pressure level by combining the sound pressure level, which is measured by not running the fan, and the sound pressure level measured, which is measure by running the fan at top speed, according to the following expression.

$$L_{pA} = 10\log(0.3\times10^{0.1L_{pA.0\%}} + 0.7\times10^{0.1L_{pA.100\%}})$$

Here, $L_{pA.0\%}$: Equivalent sound pressure level when a fan is not running.

$L_{pA,100\%}$: Equivalent sound pressure level when a fan is running at top speed.

(C) If the fan speed is constantly changing: Follow (B) or run the fan in such way that the fan speed set by the manufacturer doesn't drop under the 70% of top speed.

(3) The battery-powered product should be fully charged.

(4) Set the manually-operated part in the condition similar to the actual work condition before measurement.

(5) All safety rules and driving instructions of the manufacturer must be followed during a test. The moving-forwarding warning sound and congestion warning sound should not be activated during a test.

B. Arrangement and operating conditions of the construction equipment to test

(1) Machinery for high-idle measurement

(A) Start measurement in a stationary state that only the engine of the testing construction equipment is running, and the work device or transfer device is not running. Pre-heat the engine and oil pressure system sufficiently, and perform measurement while the engine is idling at rated service speed.

(B) The central point of the default length of testing construction equipment should match C in Figure C, and long axis central point of construction equipment should match the X axis.

(C) Annex table 2 shows the operating conditions of various construction equipment.

(2) Machine to measure the drive mode

(A) The speed of construction equipment should be recorded on the test result report during the measurement period.

(B) If several engines are mounted, they should be started at the same time. If the engines cannot be started simultaneously, every possible engine combination should be measured.

(C) Measure the AB sector in Figure 2 to measure the drive mode. Align the internal central line of the construction equipment to test along the X axis. Measure the equivalent sound level while the central point of the testing construction equipment is passing through A and B in Figure 2. Forwarding driving of construction equipment should be performed from A to B direction, whereas that of reverse driving should be performed from B to A direction.

(D) Annex table 2 shows the operating conditions of various construction equipment.

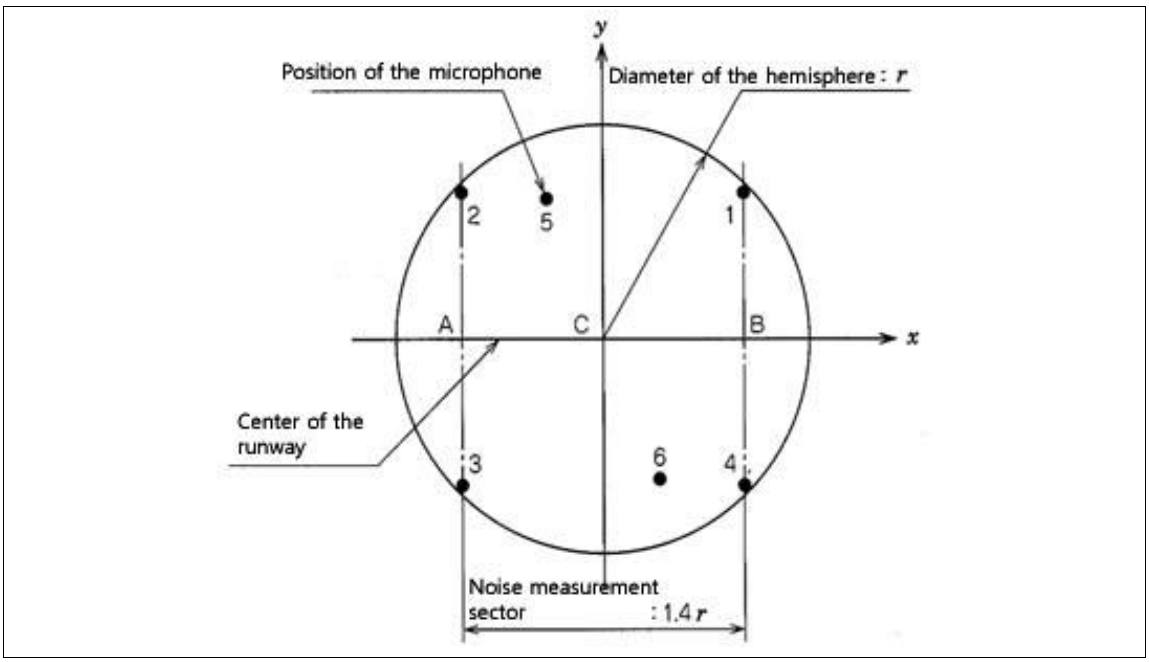
(3) Arrangement of construction equipment based on the stationary oil-pressure operating method

(A) Align the long-axis central line of the construction equipment to test along the X axis, and face the front of construction equipment to the B direction. Align the central point of the default length ( ) of the testing construction equipment to C in Figure 2.

(B) Annex table 2 shows the operating conditions of various construction equipment.

(4) Construction equipment that has the upper center of rotation

Align the central point of the upper swing unit to C in Figure 2. Align the long-axis central line of the construction equipment along the X axis, and face the front of construction equipment to the B direction. Run construction equipment at the placed position according to Annex table 2.



<Figure 2> Runway

5. Analysis of the measurement data

Note) This measurement method modified and re-arranged some parts (8. Sound measurement) of KS I ISO 6395 (Acoustics- Measurement at the operator's position of noise emitted by earth-moving machinery -dynamic test conditions) and KS I ISO 3744 (Acoustics - Determination of sound power levels of noise sources using sound pressure-Engineering method in an essentially free field over a reflecting planes), so that they can be applied to the certification criteria.
The measurement data can be analyzed and summarized as follows, and numbers are rounded off to the nearest hundredths.

A. Average calculation

Calculate the time-average equivalent sound level of the measurement hemisphere, according to the following expression, based on the equivalent sound level measurement value at each microphone position.

$$\overline{L_{pAeq,T}} = 10\log\left(\frac{1}{6}\times\sum_{i=1}^{6}10^{0.1L_{pAeqi}}\right)$$

Here, $\overline{L_{pAeqi}}$: Equivalent sound level [dB(A)] of the i^{th} microphone.

B. Calculation of the sound power level

$$L_{WA} = \overline{L_{pAeq,T}} - K_1 - K_2 + 10\log(S/S_0)$$

Here, K_1: The background noise compensation value that is calculated by the method in D.

K_2: The environment compensation value that is calculated by the method in E.

S: Area of the measurement side [㎡], $2\pi r^2$

S_0: Reference area 1 ㎡

C. Determination of the sound power level

Perform measurement three times repetitively, and calculate three sound power levels. Repeat measurement until at least two of three measurement values are not different more than 1dB(A). Then, calculate the average of two larger values among the values of which difference are less than 1dB(A), and calculate the constant value by rounding off at the nearest tenth.

D. background noise compensation value (K_1)

$$\Delta L = \overline{L_{source}} - \overline{L_{back}}$$

Here, $\overline{L_{source}}$: The average sound pressure level [dB(A)] of six spots measured while running the target construction equipment.

$\overline{L_{back}}$: The average background noise level [dB(A)] of six spots.

$6 \le \Delta L \le 15$: $K_1 = 10\log(1-10^{-0.1\Delta L})$

$15 < \Delta L$: $K_1 = 0$

(However, the test result is not valid, if $\Delta L < 6$.)

E. Environment compensation value (K_2)

Calculate the environment compensation value (K_2), if the reflective surface is not “2. Measurement environment” B. (1) or (2) on the surface of the measurement side. If K_2 exceeds 0.5dB(A), compensation is required when calculating the sound power level.

$$K_2 = L^*_W - L_{Wr}$$

Here, L^*_W: The sound power level measured in the target construction equipment measurement environment while setting the K_2 value to 0.

L_{Wr}: The sound power level of the base sound source that is corrected in the anechoic room, hemi-anechoic room, or echo room.

However, the K_2 value can be set to 0 on the concrete or asphalt floor.

In addition, the appropriateness criteria of the test environment are as follows.

$K_2 \leq$ 2 dB(A)

<Annex 2> Start-up conditions of construction equipment [with regard to “C. Certification criteria” (1)]

Related regulations	Construction equipment concerned
KS I ISO 6395	Excavator, dozer, loader, backhoe loader, non-vibrating roller, grader, dump truck
EU Directives 2000/14/EC	Vibrating roller, asphalt finisher, concrete finisher, aggregate spreader, fork lift, mobile crane, tower crane, concrete pump, piercer, pile driver. pile extractor, concrete breaker, oil pressure power pack, air compressor, electric generator, concrete mixer truck, hand breaker, oil pressure breaker, road milling machinery, electric welder, joint cutter

▪ KS I ISO 6395: Acoustics- Measurement of exterior noise emitted by earth-moving machinery-Dynamic test conditions
▪ EU Directives 2000/14/EC: Council Directive 2000/14/EC of 8 May 2000 on the approximation of laws, of the member States relating to the noise emission in the environment by equipment for use outdoors

Note) These conditions modified and re-arranged Appendix III, EU Directives 2000/14/EC, and Appendix, KS I ISO 6395, by the type of construction equipment.

1. Excavator (oil pressure and rope driving type)

A. Installation of construction equipment: The bucket produced by the manufacturer’s specification, such as the hoe, shovel, grab, or drag line, should be equipped. The engine speed governor (controller to keep engine’s RPM regularly) should be operated in a high-idle mode. All start-ups should be performed at top speed. Be careful not to activate a safety valve, or touch the barrier of the runway. Install the excavator on the solid reflective surface as defined in Annex table 1 “2. Measurement environment” B. (1).

B. Operation of construction equipment

(1) Basic operating cycle: As described in the below paragraph (2) ~ (5), position construction equipment as defined in Annex table 1. “4. Placement and start-up of construction equipment” B. (4) for the dynamic interval that doesn't move the material. Then, go to the left side of the driver and return to the current position (90° turning) for three times. Each turning should return from the X axis to the Y axis, and then, to the X axis. One cycle is composed of complete continuous operation for 3 times, which the attached matter at the end of the front returns to the original position after 90° turning.

(2) Attaching a hoe: The default dynamic operation cycle is composed of trench excavation and putting a hoe besides the hole. At the beginning of the cycle, adjust the boom and arm, so that the bucket is positioned at 75% of the maximum range from 0.5m above the ground. Put the excavation blades of the bucket, which is located at the front rotated position, at 60° against the measurement side at the test site. First, lift

the boom and pull the arm at the same time, and keep the bucket 0.5 meter above the test site at the remaining 50% sector of the boom and arm movement distance. Then, rotate the bucket backward or retract the bucket. Lift the boom to raise the bucket, and pull the arm to imitate the space (30% of the maximum height to lift a bucket) that is required to circle across the edge of the hole. Circle 90° to the left side of the driver. Lift the boom while circling around and spread out the arm to the 60% of the maximum height that the bucket lifts the boom. Then, spread out the arm until it is extended to 75%. Rotate the bucket forward or spread out, so that the excavation blades become vertical. Lower down the boom and retract the bucket to return to the starting point. One dynamic cycle is composed of three times repetition of the above action. Note)

(3) Attaching a shovel bucket: The operating cycle is to excavate at the wall height. Put the excavation blades in parallel with the surface at the beginning of the cycle. The bucket at 75% retracted position should be 0.5 meter above the test site. Keep the original direction of the bucket and spread it out to the 75% of the moving distance. Then, rotate the bucket backward or retract and lift it up to the 75% of the maximum height or the 75% of the overall dipper arm length. Circle 90° to the left side of the driver, and start the bucket lowering device at the end. Perform the circling process that retracts the bucket by 75% and returns to the original position (0.5 meter above the test site.) One dynamic cycle is composed of three times repetition of the above action. Note)

(4) Attaching a grab: The operation cycle is hole excavation. At the beginning of the operating cycle, the grab should be 0.5 meter above the test site while it is opened. Close the grab first. Then, lift up the grab to the half of the maximum lifting height. Circle 90° to the left side of the driver. Open the grab. Lower down the attachment to the original position, and turn to the original position. One dynamic cycle is composed of three times repetition of the above action. Note)

(5) Attaching a drag line: The operating cycle is one layer excavation in a hole, and lowering down a drag line around the hole. Install the boom at 40° during the cycle. Put the bucket under the boom vertically, and don't put a drag chain on the ground and install it 0.5 meter above the test site. First, pull the bucket towards the body as much as possible, and keep 0.5 meter above the earth's surface. Circle 90° to the left side of the driver while the bucket is retracted. At the same time, lift the bucket to the 75% of the maximum height, and spread out from the loaded bucket position to the maximum range, and return to the original position. At the same time, start bucket lowering and retract to the original position. One dynamic cycle is composed of three times repetition of the above action. Note)

Note) Repeat the one time dynamic cycle for three times, according to Annex table 1. "Measurement data analysis" B. (3)

2. Dozer

A. Installation of construction equipment: The dozer should be equipped with the pre-defined blades that fit into the manufacturer's production version.

B. Operation of construction equipment

(1) Drive mode: The dozer runway is defined in Annex table 1. “4. Placement and start-up of construction equipment” B. (2) and Figure 2. Put sand on the runway for the caterpillar and steel wheel type dozer equipped with blades, and use the solid reflective surface as defined in Annex table 1 “2. Measurement environment” B. (1) for the rubber tire wheel type dozer. The dozer blade should be put 0.3±0.05 m above the runway, and the speed governor should be operated in a high-idle mode. The engine speed governor (controller to keep engine’s RPM regularly) should be operated in a high-idle mode. The speed of moving forward should be 4Km/h (caterpillar and steel wheel type) or 8Km/h (rubber tire wheel type), and the regulation speed must be kept. Use the reverse gear regardless of speed, and use first gear when moving forward or backward. As the ground speed of oil-pressure driving equipment cannot be accurately controlled, drive equipment at 3.5~4 km/h(caterpillar and steel wheel type) or 7~8 km/h(rubber tire wheel type). If the lowest speed gear exceeds the regulated speed, drive at the engine speed (high-idle) at the maximum speed governor position and use gear. For oil pressure driving equipment that runs the engine at the maximum speed governor position (high-idle), control the ground speed according to the regulation speed described above. The sound pressure level should be measured when the central points is on the runway between A and B in Figure 2 in Annex table 1.

Note) A driver should adjust steering apparatus when construction equipment passes through the test course, so that the runway of construction equipment is on the central line of the test course. In addition, perform individual moving forward and backward cycles for three times, according to Annex table 1, “5. Measurement data”, C.

(2) Calculation of the combined forward and reverse mode cycle: As the forward and reverse mode are two individual modes, measure the time and sound pressure level separately. The formula used to calculate the equivalent sound level of the combined dozer operating cycle is as follows.

$$\overline{L_{pAeq,T}} = 10\log\frac{1}{T_1+T_2}\left[\left(T_1\times 10^{0.1L_{pAeq,1}}\right) + \left(T_2\times 10^{0.1L_{pAeq,2}}\right)\right]$$

Here, T_1: The time interval that passes through the defined runway in a moving forward mode.

T_2: The time interval that passes through the defined runway in a reverse forward mode

$L_{pAeq,1}$ and $L_{pAeq,2}$: The equivalent sound level measured during T_1 and T_2.

3. Loader

A. Installation of construction equipment: The loader should be equipped with the blades that fit into the manufacturer's production version. All start-ups should be performed at top speed. Be careful not to activate a safety valve, or touch the barrier of the runway.

B. Operation of construction equipment

(1) Drive mode: The loader runway is defined in Annex table 1. "4. Placement and start-up of construction equipment" B. (2) and Figure 2. Put sand on the runway for the caterpillar, and use the solid reflective surface as defined in Annex table 1 "2. Measurement environment" B. (1) for the wheel type loader. Construction equipment should transfer the empty bucket 0.3±0.05 m above the runway for driving. Construction equipment should be driven at regular forward and reverse speed, and the speed governor of the maximum engine should be driven in a high-idle mode. Drive the engine's speed governor in a high-idle mode. The speed of moving forward should be slower than 4Km/h (caterpillar) or 8Km/h (wheel type). Use the reverse gear regardless of speed. Use first gear when moving forward or backward. As the ground speed of oil-pressure driving equipment cannot be accurately controlled, drive equipment at 3.5~4 km/h(caterpillar) or 7~8 km/h(wheel type). This operation mode doesn't move the bucket, and passes the hemisphere in two directions without stopping. If lower speed gear exceeds the regulated speed, drive at the engine speed (high-idle) at the maximum speed governor position and use gear. For oil pressure driving equipment that runs the engine at the maximum speed governor position (high-idle), control the ground speed according to the regulation speed described above. The sound pressure level should be measured when the central points is on the runway between A and B in Figure 2 in Annex table 1.

Note) A driver should adjust steering apparatus when construction equipment passes through the test course, so that the runway of construction equipment is on the central line of the test course. In addition, perform individual moving forward and backward cycles for three times, according to Annex table 1, "5. Measurement data", C.

(2) Calculation of the combined forward and reverse mode cycle: As the forward and reverse mode are two individual modes, measure the time and sound pressure level separately. The formula used to calculate the equivalent sound level ($L_{pAeq,3}$) of the combined dozer operating cycle is as follows.

$$\overline{L_{pAeq,T}} = 10\log\frac{1}{T_1+T_2}\left[\left(T_1\times 10^{0.1L_{pAeq,1}}\right) + \left(T_2\times 10^{0.1L_{pAeq,2}}\right)\right]$$

Here, T_1: The time interval that passes through the defined runway in a moving forward mode.

T_2: The time interval that passes through the defined runway in a reverse forward mode

$L_{pAeq,1}$ and $L_{pAeq,2}$: The equivalent sound level measured during T_1 and T_2.

(3) Stationary oil pressure mode: The second operation mode of this test is to move the center of construction equipment to the center of the hemisphere C in Figure 2 of Annex table 1, and perform the procedure described below. The engine should be operated in a high-idle mode at the top speed governor position. Put the gears in neutral. Lift the bucket to the 75% of the maximum height from the transfer position, and return to the original position. Repeat this action three times. These actions are regarded as one time work cycle for the stationary oil pressure mode.

(4) Calculation for work cycle combination in the drive mode and stationary oil pressure mode Calculate the equivalent sound level for the total loader operating cycle, using the following expression, with regard to the combined equivalent sound level.

Here, $\overline{L_{pAeq,T}} = 10 \log [\ 0,5 \times 10^{0.1 L_{pAeq,3}} + \ 0,5 \times 10^{0.1 L_{pAeq,4}}]$

$L_{pAeq,3}$: The equivalent sound level in the drive mode on the defined runway

$L_{pAeq,4}$: The equivalent sound level of the stationary oil pressure mode.

4. Backhoe loader

A. Installation of construction equipment: The backhoe loader should be equipped with the pre-defined backhoe and bucket that fit into the manufacturer's production version. For backhoe operation, the engine speed governor should be set to the high-idle mode or the position defined by the manufacturer. All start-ups should be performed at top speed. Be careful not to activate a safety valve, or touch the barrier of the runway.

B. Operation of construction equipment

(1) Measurement side at the test site: For all operating modes of the backhoe loader, the measurement side should be the solid reflective surface as defined in Annex table 1 “2. Measurement environment” B.

(2) Backhoe operation: Besides replacing the 90° angle defined in this chapter with the 45° angle, perform the backhoe operation mode of construction equipment according to the procedure define din “1. Excavator” B. Operation of construction equipment, (1) and (2).

(3) Loader operation: Put the backhoe bucket on the transfer position and perform this operation mode according to the procedure defined in “3. Loader," B. Operation of construction equipment.

(4) Calculation of the combined equivalent sound level in the backhoe and loader operation mode. Calculate the combined equivalent sound level ($\overline{L_{pAeq,T}}$) of the total backhoe loader work cycle, using the following expression.

Here, $\overline{L_{pAeq,T}} = 10 \log [\ 0,8 \times 10^{0.1 L_{pAeq,backhoe}} + 0,2 \times 10^{0.1 L_{pAeq,loader}}]$

$L_{pAeq,backhoe}$: The equivalent sound level in the backhoe operation mode.

$L_{pAeq,loader}$: The equivalent sound level in the loader operation mode.

5. Roller - Vibrating rollers

A. Installation of construction equipment: The vibrating roller should be installed on at least one proper elastic material, such as the air cushion. The air cushion should be the flexible substance (elastic body or similar substance), and should be inflated with the pressure that can float equipment at least 5 cm above the ground, in order to prevent the resonance effect. The size of the air cushion should guarantee the stability of testing equipment.

B. Operation of construction equipment

(1) Equipment must be tested while the engine is running at the rated speed (as specified by the manufacturer) in the stationary position, and the dynamic device is disconnected. Compaction equipment should be operated using the maximum compaction power, which corresponds to the combination of the highest frequency and the highest amplitude for the frequency that is specified by the manufacturer.

(2) The measurement time should be more than 15 seconds.

6. Roller - Vibrating (vibratory plates, vibratory rammers)

A. Basic criteria of measuring noise

Follow ISO 3744:1995.

(1) Test area

Follow EN 500-4 rev. 1:1998 (Mobile road construction machinery, Safety, Specific requirements for compaction machines), Annex C.

B. Start-up conditions

(1) Test while load is applied.

Follow EN 500-4 rev. 1: 1998. Annex C.

(2) Operating time

Follow EN 500-4 rev. 1: 1998, Annex C.

7. Roller - non-vibrating

A. Basic criteria of measuring noise

Follow ISO 3744:1995.

(1) Test area

Reflective surface on the concrete or non-porous (dense grade) asphalt

(2) Environment compensation value $K_2 = 0$

(3) Measurement side, number of microphone positions, measurement distance

(A) If the largest size of the base rectangular parallelepiped doesn't exceed 8 meters, the measurement side is a hemi-sphere, and the number of microphone positions is 6, and the measurement distance is determined by the default length of the equipment.

(B) If the largest size of the base rectangular parallelepiped exceeds 8 meters, the measurement side is a rectangular parallelepiped, and the number of microphone positions is determined by ISO 3744: 1995, and the measurement distance (d) is 1 meter.

B. Start-up conditions

1) No-load test

For the no-load test, the equipment engine and oil pressure system should be pre-heated according to the instruction, and safety requirements should be followed.

The test should be run in the stop mode, while no equipment is running or moved.

For the test, the engine should be idling at the speed that is not slower than the same level speed corresponding to the rated output. If equipment is powered by the electric generator or main body, the frequency of the supply current specified on the motor by the manufacturer should be stabilized at ±1Hz, if equipment is mounted with an induction motor, or ±1 %, if equipment is mounted with a commutator motor. Measure the supply voltage at non-separated cable or cord plug, or at the inlet of the equipment, if the separable cable is provided. The waveform of the current supplied by the electric generator should be similar to the one obtained from the main body.
If equipment is powered by the battery, the battery should be fully charged.
The speed in use and corresponding rated output should be specified by the equipment manufacturer and mentioned by the test report.
If several engines are mounted on equipment, these engines should be operated simultaneously during a test. If this is not available, the test should be run with the possible combination of engines.
The measurement time should be more than 15 seconds.

8. Grader

A. Installation of construction equipment: The blade should be equipped that fits into the manufacturer's specification. Install on the solid reflective surface at the position that is specified in Annex table 1. "4. Placement and start-up of construction equipment" B. (2).

B. Operation of construction equipment: Measure the sound pressure level of the grader by starting the forward-moving mode only. The construction equipment runway should follow Annex table 1. "4. Placement and start-up of construction equipment" B. (2) and Figure 2. Put sand on the runway for the caterpillar, and use the solid reflective surface as defined in Annex table 1, "2. Measurement environment" B. (1) for the wheel type loader. Construction equipment should transfer the blade 0.3±0.05 m above the runway for driving. Drive the speed governor in a high-idle mode for the regular speed of construction equipment. The speed of moving forward should be slower than 4Km/h (caterpillar type) or 8Km/h (wheel type). As the ground speed of oil-pressure driving equipment cannot be accurately controlled, drive equipment at 3.5~4 km/h (caterpillar) or 7~8 km/h (rubber tire wheel type). This operation mode doesn't move the blade, and passes the hemisphere in two directions without stopping. If lower speed gear exceeds the regulated speed, drive at the engine speed (high-idle) at the maximum speed governor position and use gear. For oil pressure driving equipment that runs the engine at the maximum speed governor position (high-idle), control the ground speed according to the regulation speed described above. The sound pressure level should be measured when the central points is on the runway between A and B in Figure 2 in Annex table 1.

Note) A driver should adjust steering apparatus when construction equipment passes through the test course, so that the runway of construction equipment is on the central line of the test course. In addition, perform individual moving forward and backward cycles for three times, according to Annex table 1, “5. Measurement data”, C.

9. Asphalt finisher, concrete finisher, aggregate spreader

A. Installation of construction equipment: The engine and oil pressure system should be pre-heated until the normal operation state is secured, considering the surrounding temperature.

B. Operation of construction equipment

(1) The construction equipment engine should be operated at nominal speed specified by the manufacturer. All work processes should be performed at the following speed.

(A) Transfer process: Over 10% of the maximum value.

(B) Destruction process: Over 40 % of the maximum value.

(C) Compaction process: Over 50 % of the maximum value.

(D) Vibration device process: Over 50 % of the maximum value.

(E) Pressure bar process: Over 50 % of the maximum value.

(2) The measurement time should be more than 15 seconds.

10. Fork lift

A. Installation of construction equipment: The engine and oil pressure system should be pre-heated until the normal operation state is secured, considering the surrounding temperature.

B. Operation of construction equipment

(1) Lifting condition: Construction equipment in a stationary state should lift the material like steel or concrete (at least 70% of the valid weight) from the position lower than the

pre-defined lifting height to the defined height at top speed. If the actual height is higher than estimation, it should be measured individually. The lifting height should be described in the test report.

(2) Drive condition: Construction equipment should run the distance at stop speed, which is further than three times of the line A-A (the line connecting the microphone 4 and 6), in no-load and stationary state, and the should keep top speed to the line B-B (the line connecting the microphone 2 and 8). If the rear side of construction equipment passes the B-B line, equipment can be decelerated gradually. If construction equipment has a multiple gear transmission, the top speed gear should be selected at the measurement distance.

(3) Measurement time

(A) Lifting mode: Overall lifting process

(B) Drive mode: Drive the fork lift until the center of the fork lift passes through the A-A line and reach the B-B line.

The sound power level results of the fork lift can be calculated as follows.

Here, $L_{WA} = 10 \log [\ 0.7 \times 10^{0.1 L_{WA.C}} + 0.3 \times 10^{0.1 L_{WA.A}}]$

$L_{WA.A}$: The sound power level in the fork lift raising mode.

$L_{WA.C}$: The sound power level in the fork lift drive mode.

11. Mobile crane

A. Installation of construction equipment: The construction equipment that fits into the manufacturer's production version must be used. If the construction equipment has the jib (protruded rotation part of the crane), install equipment in the middle of the maximum height that can be extended and lifted up.

B. Operation of construction equipment

(1) Prime the engine with the minimum engine output to drive a crane, and equip the parts to load maximum load. Operate the ventilation device at top speed, while it is attached to the engine. If construction equipment has several engines, turn off the engine for construction equipment movement, and turn of the engine for cargo movement only.

(2) Run the engine at 3/4 speed of the maximum output with an error tolerance of ±2%.

(3) Apply the variation to the maximum within the safe range, when accelerating or decelerating equipment.

(4) Measure the sound power level during four operation processes (A ~ D) at top speed.

(A) Hosting that rolls up/down shipment using the rolling up/down jib. Measure for 15 ~ 20 seconds while lifting loading with 50% of the rope power in the middle of the maximum height, and lowering it down again.

(B) Slewing that the jib circles around the vertical axis: Install the boom (the crane arm that lifts up the object) at 40°~50° from the horizon, and slew 90° to the left and return to the original point. The jib should be the minimum length, and the actual work time should be the measurement time.

(C) Derricking: Lift up a short jib at the lowest position while not loading shipment and lower it down to the original position. The measurement time should be more than 20 seconds.

(D) Telescoping that pulls or pushes the lifted cargo to the pillar without changing the height: Fix the jib at 40°~50° to the horizon while not loading the shipment, and repeat the process of maximum contraction and expansion using cylinders.

(5) Substitute the measured sound power level with the following formula to calculate the sound power level.

(A) The crane that allows telescoping

$$L_{WA} = 10\log[0,4\times10^{0.1L_{WA.A}} + 0,25\times10^{0.1L_{WA.B}} + 0,25\times10^{0.1L_{WA.C}} + 0,1\times10^{0.1L_{WA.D}}]$$

Here, $L_{WA.A}$: The sound power level during hosting that rolls up/down shipment using the rolling up/down jib.

$L_{WA.B}$: The sound power level during slewing that the jib rotates around the vertical axis.

$L_{WA.C}$: The sound power level during shipment unloading.

$L_{WA.D}$: The sound power level during telescoping.

(A) The crane that doesn't allow telescoping

Here, $L_{WA} = 10\log[0,4\times10^{0.1L_{WA.A}} + 0,3\times10^{0.1L_{WA.B}} + 0,3\times10^{0.1L_{WA.C}}]$

$L_{WA.A}$: The sound power level during hosting that rolls up/down shipment using the rolling up/down jib.

$L_{WA.B}$: The sound power level during slewing that the jib rotates around the vertical axis.

$L_{WA.C}$: The sound power level during shipment unloading.

12. Tower crane

A. Installation of construction equipment: The object lifting device should be installed, using one of the following methods.

(1) If the lifting device is loaded on the earth' surface, or fixed on the ground, it should be the solid reflective surface as defined in Annex table 1., "2. Measurement environment", B (1).

(2) If the lifting device is located on the jib, it should be installed at least 12 meters above the ground.

B. Operation of construction equipment

(1) Basic criteria of measuring noise: ISO 3744

(2) Measurement conditions

(A) Measurement side

Measure at the position of 6 microphones in the hemi-sphere from the surface, and follow ISO 3744 for the measurement distance. The jib height is the measurement height. If the lifting device is located at the height of the jib, the measurement side should be a sphere with 4m diameter, and the center of the sphere should align with the geometrical center of the winch. If measurement is performed for the lifting device while the jib is in a stationary state, a sphere is the area of the measurement side and its area (s) is 200 m^2.

(B) Location and measurement distance of the microphone

Four microphones should be located with the following distance on the horizontal side that penetrates the geometrical center of the device (H=h/2).

L= 2.8 m

d= 2.8 - /2

Here, L= the half of the distance between two microphones that are put consecutively.

= Length of the lifting device (according to the jib axis)

B = Width of the lifting device

d = Distance between the device lifting to the jib direction and microphone support

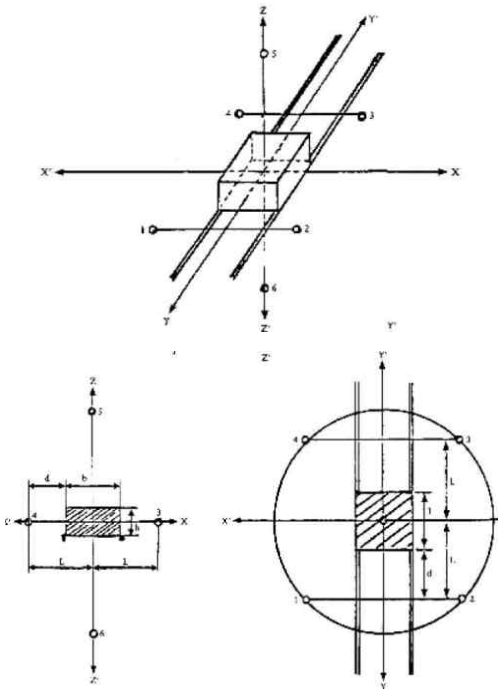


Figure 3. The position of the microphone (measurement position) at the place where the lifting device is stopped.

Two different microphones should be located at the positions that the intersection of the sphere crosses with the vertical line that penetrates the geometrical center of the device.

(2) Start-up conditions

(A) Measuring the energy generator

If the energy generator is attached to the crane, the crane should be installed on the flat reflective surface of concrete or non-porous (dense grade) asphalt, regardless of the combination of the generator and lifting device. If the energy source of the crane is independent from the carne (electric power generator, main body or air compression power source), measure the sound pressure level of the device only. If the energy generator is attached to the crane but the generator is not combined with the lifting device, the generator and lifting device should be measured separately. If these two devices are combined, measurement should be referred as an overall assembly. During measurement, the lifting device and generator should be installed and moved, according to the manufacturer's instructions.

(B) No-load test

The energy generator attached to the crane should run at the maximum output level, which is specified by the generator manufacturer. Start the lifting device without loading shipment, when the drum circles at the rotation speed corresponding to the maximum hook movement speed in the lifting and lowering mode. Select the bigger value among sound power levels measured in the lifting or lowering mode, as the test results.

(C) Load test

The energy generator attached to the crane should run at the maximum output level, which is specified by the generator manufacturer. Start the lifting device with cable tension at the drum that corresponds to the maximum load, when the hook is moving at top speed (for the minimum diameter). Load and speed should be specified by the manufacturer. Check speed during the test.

C. Calculating the sound power level

$$L_w = 10 \log \frac{1}{t_r + t_f} [(t_r \times 10^{0.1 L_{ri}}) + (t_f \times 10^{0.1 L_{fi}})]$$

Here, L_{ri}: The equivalent sound level measured during t_r.

L_{fi}: The equivalent sound level measured during t_f.

t_r: The time before activation after starting the break (within 3 seconds) [second]

t_f: The time until construction equipment stops, as the break is activated in a stop mode, and the hook is stopped. [second]

13. Concrete pump

A. Installation of construction equipment: Extend the boom type to the horizontal direction, and extend the piping type with 10 meter horizontal pipes, depending on the type of construction equipment.

B. Operation of construction equipment: Transfer concrete in the maximum load operation state.

14. Dump truck

A. Installation of construction equipment: All start-ups should be performed at top speed. Be careful not to activate a safety valve, or touch the barrier of the runway.

B. Operation of construction equipment

(1) Drive mode: Measure the sound pressure level by starting the forward-moving mode only. For the runway of construction equipment, follow Annex table 1. “4. Placement and start-up of construction equipment” B. (2) and Figure 2. Put sand on the runway for the caterpillar, and use the solid reflective surface as defined in Annex table 1, “2. Measurement environment” B. (1) for the wheel type loader. Construction equipment should transfer the blade 0.3±0.05 m above the runway for driving. Construction equipment should be driven at regular forward and reverse speed, and the speed governor of the maximum engine should be driven in a high-idle mode. Drive the engine’s speed governor in a high-idle mode. The speed of moving forward should be slower than 4Km/h (caterpillar) or 8Km/h (rubber tire wheel type). This operation mode is to pass through the hemisphere into two direction and then, stop without moving the blades. If lower speed gear exceeds the regulated speed, drive at the engine speed (high-idle) at the maximum speed governor position and use gear. For oil pressure driving equipment that runs the engine at the maximum speed governor position (high-idle), control the ground speed according to the regulation speed described above. The sound pressure level should be measured when the central points is on the runway between A and B in Figure 2 in Annex table 1.

Note) A driver should adjust steering apparatus when construction equipment passes through the test course, so that the runway of construction equipment is on the central line of the test course. In addition, perform individual moving forward and backward cycles for three times, according to Annex table 1, “5. Measurement data”, C.

(2) Stop operation mode: Move the center of construction equipment to the center of the hemisphere C in Figure 2 of Annex table 1, and perform the procedure described below. Run the engine at top speed (high-idle) and put the gears in neutral. Lift the bucket to the 75% of the maximum height that the empty bucket can move, and return to the original position. Repeat this action three times. If the engine power is not used to lift up the bucket, run the engine in idle, and put the gears in neutral. At this time, perform measurement without lifting up the bucket. These actions are regarded as one time work cycle for the stationary oil pressure mode. Measurement should be performed while not lifting the bucket up completely, and the measurement time should be more than 15 seconds.

(3) Stop idle mode: The engine should run in the minimum governor speed in a no-load state. Put the gears in neutral and measurement time should be between 15 and 30 seconds. These actions are regarded as one time work cycle for the stationary oil pressure mode.

(4) Calculation of the work cycle that combines the moving forward and stop operation mode, and stop idle mode. Calculate the equivalent sound level for the combined equivalent sound level, using the following expression.

$$\overline{L_{pAeq}} = 10\log\ [\ 0.8\times10^{0.1L_{pAeq.1}} + 0.05\times10^{0.1L_{pAeq.2}} + 0.15\times10^{0.1L_{pAeq.3}}\ ]$$

Here, $L_{pAeq.1}$: The equivalent sound level of the moving-forward drive mode on the pre-defined runway.

$L_{pAeq.2}$: The equivalent sound level in the stop operation mode.

$L_{pAeq.3}$: The equivalent sound level in the stop idle mode.

15. Piercer

Installation and operation of construction equipment: Follow EN 791 (Drill rigs. Safety): 1995, Annex A, and the measurement time should be more than 15 seconds.

16. Pile driver/Pile extractor

A. Installation of construction equipment

(1) Piling equipment should be installed on the pile that has enough resistance to work at normal speed. The impact hammer should be new and filled with wood. The upper side of the pile should be 0.5 meter above the ground.

(2) Follow ISO 6395 for the test site.

B. Operation of construction equipment

The measurement time should be more than 15 seconds.

17. Concrete breaker

Installation and operation of construction equipment: Install on the reflective surface, and run with the maximum output.

18. Oil pressure power pack

A. Installation of construction equipment: The oil pressure power pack should be installed on the reflective surface. If not requested specifically, the compressor with the antilock braking system should be installed on the 0.4 meter high support.

B. Operation of construction equipment

(1) Any device should not be connected or operated with the oil pressure power pack during a test. The oil pressure power pack should reach at the normal state within the range specified by the manufacturer, and run in nominal speed and pressure. Follow the guide given to the purchaser, regarding nominal speed and pressure.

(2) The measurement time should be more than 15 seconds.

19. Air compressor

A. Installation of construction equipment: If the manufacturer doesn’t specify the installation condition, the compressor should be installed on the reflective surface, and the compressor with the antilock braking system should be installed on the 0.4 meter high support. The compressor should be warmed up (the state that the engine can be started), and should run in a stable state with continuous operation. The compressor should be maintained according to the user’s manual provided by the manufacturer.

B. Operation of construction equipment

(1) General conditions: The sound power level should be determined in the maximum load state, or the operation that represents the nosiest operation. When the testing machine is normally used, the test must be run in operation state that represents the nosiest operation. If entire equipment should be mounted away from certain components (e.g., internal cooler), efforts should be made to separate the noise generated by such component when testing the noise level. To separate various noise sources, and decrease noise from these noise sources during measurement, special devices can be requested. The noise characteristic of the operation state and technology about this should be described in the test report.

(2) Conditions when discharging gas and air: Gas emitted from the compressor should be discharged via the pipe during a test, so that it doesn't affect the test site. The noise generated while discharging gas should be least 10dB(A) lower than the noise generated by the construction equipment to test at all measurement spots. Noise should not be generated by turbulence at the compressor discharging value, which discharging air.

(3) The measurement time should be more than 15 seconds.

20. Electric generator

A. Installation of construction equipment: The electric generator should be installed on the reflective surface. The electric generator with the antilock braking system should be installed on the 0.4 meter high support, if not in the special circumstances.

B. Operation of construction equipment

(1) Follow ISO 8528-10 (Reciprocating internal combustion engine driven alternating current generating sets) Point 9 for the operating method.

(2) The measurement time should be more than 15 seconds.

21. Concrete mixer truck

A. Installation of construction equipment: The mixer should be filled with 0 ~ 3 mm sand, and the mixture should contain 4 ~ 10% moisture.

B. Operation of construction equipment

(1) Operate the mixer at rated speed for measurement.

(2) The measurement time should be more than 15 seconds.

22. Hand breaker

A. Installation of construction equipment

(1) Positioning: All equipment must be tested while positioned vertically. If testing equipment discharges air, the axis of equipment should be located at the same distance from two measurement positions. Power supply noise should not affect the measurement of the noise generated by construction equipment. Annex table 1, Figure 1 shows the measurement position. Set the measurement positions as follows, depending on weight of construction equipment.

Weight of construction equipment, m [kg]	Diameter of the hemisphere, *r* [m]	*z* (Measurement position 2, 4, 6, 8)
m < 10	2	0.75 m
m ≥ 10	4	1.50 m

(2) Supporting construction equipment: Construction equipment during the test should be combined with the tool, which is inserted together with the cubic shape concrete block that is placed in the underground concrete hole. Insert the middle size steel piece into construction equipment and supporting tool during the test. The middle size steel piece in Figure 4 should be mounted stably between equipment and support tool.

(3) Block characteristics: The block should be rectangular that has 0.60 m±2 mm corner length. Create reinforced concrete and shake to 0.2m layer sufficiently to prevent sinking.

(4) Quality of concrete: The quality of concrete should correspond to ENV 206's C50/60. The cube should be reinforced with 8mm diameter steel bars. Each bar should be independent from each other. Figure 5 shows the installation type.

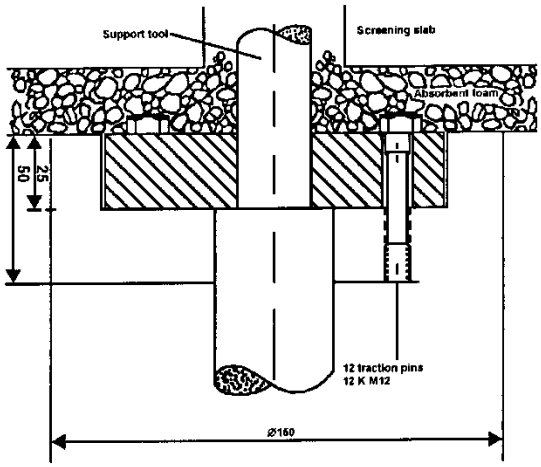
(5) Supporting tool: The tool should be inserted into the block, and should be composed of the chuck that is same with the long enough tool, so that the 178 ~ 220 diameter rammer and test equipment can be commonly used together, and ISO 1180:1983 regulation can be complied with, and the actual test can be performed. Proper handling should be performed to match two components. (See Figure 5) Fix the tool inside the block in such way that the rammer bottom is 0.3m away from the upper side of the block. The block should be mechanically fixed on the point that the supporting tool and concrete contact. It should be checked whether the tool inserted into the concrete block matches the concrete block before and after every test.

(6) Location of the cube: The cube should be installed in the hole jointed properly with concrete, and cover it with the covering slate having at 100 kg/㎡ depth, as shown in Figure 5, and make the upper side of the covering slate on a level with the earth's surface. The block should be isolated from the floor and sides of the concrete hole, to prevent surrounding (vibration) noise. The cut-off frequency of the elastic body should be described in the number of strikes per second. The strike rate of the testing construction equipment should be smaller than 1/2. The opening part of the covering slate that the chuck penetrates should be as small as possible, and should be sealed with flexible sound-proof joint.

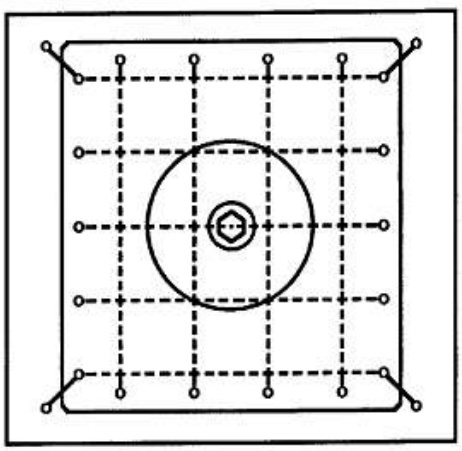
B. Operation of construction equipment

(1) The testing construction equipment should be connected to the supporting tool. The testing construction equipment should be started in a stable state, which has the same sound stability with regular services. The testing construction equipment should be started with the maximum power specified for the purchaser.

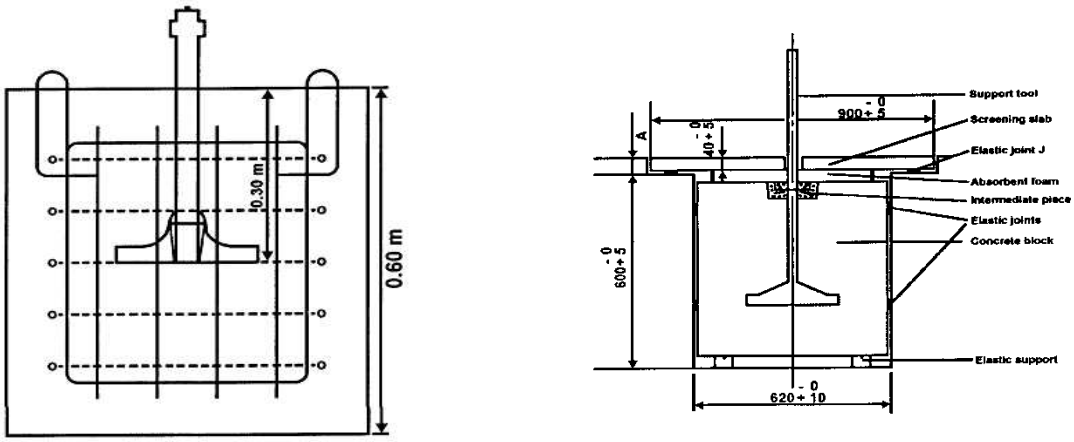
(2) The measurement time should be more than 15 seconds.



<Figure 4> Overview diagram of the sample



<Figure 5> Test block



<Figure 6> Test device

Determine the value A, so that the covering slate supported by the joint J of the elastic body can be on a level with the earth's surface.

23. Oil pressure breaker

A. Installation of construction equipment: Attach the breaker to the fixing device or excavator for the test, and use the special test block structure as shown in Figure 7.

(1) Excavator: Requirements of the test breaker's technical specification should be satisfied, in terms of the weight range, oil pressure output, supply oil quantity, and recoil pressure of the reciprocating line.

(2) Mounting: Mechanical mounting should satisfy the specification described in the technical data of the breaker, like the connection parts such as hoses and pipes. All pipes needed for mounting, and noise generated by various machinery parts must be removed. In addition, all parts must be fastened tightly.

(3) Tools: The blunt tool should be used for measurement. Tool length should satisfy all requirements specified in Figure 7.

B. Operation of construction equipment

(1) Oil pressure input and oil quantity: The operation condition of the oil pressure breaker should be properly adjusted, measured, and recorded, according to the corresponding technical specification. The test breaker should be operated in such way that it can reach the maximum oil pressure input of the breaker, and over 90% of the oil quantity. Uncertainty of measurement in p_s and Q should be ±5%. It should ensure oil pressure input within the ±10 % accuracy. When the linear correlation is assumed between oil pressure input and output sound power, it means the change under ±0.4dB(A), when determining the sound power level.

(2) Components that affect the driving power of the breaker and can be adjusted: All pre-setting of the battery (accumulator), pressure central valve, and other adjustable components should satisfy the value given by the technical data. If more than one fixed impact rate is temporary, it should be measured using all settings. The minimum and maximum value must be presented.

(3) Measurement

(A) Elements that are evaluated by the measurement and start-up factors:

Oil pressure input of the breaker $P_{IN} = p_s \times Q$

(B) Quantity to measure

p_s: The average of oil pressure supply precision pressure while the breaker is running, including at least 10 times strikes.

Q: The average of inflow oil quantity of the breaker, which is measured with Ps.

T: The oil temperature should be 40~60 ℃ during measurement. The temperature of the oil pressure breaker body should be stabilized to the normal operational temperature at the time of measurement.

P_a: The pre-filled gas pressures of all accumulators should be measured at the 15 ~ 25 ℃ temperature and in the stationary state. (The breaker is not running).

(C) Measuring the pressure of the oil pressure supply line, p_s

1) p_s should be measured near the in-port of the breaker as much as possible.

2) p_s is a pressure gauge (minimal diameter: 100 mm; accuracy grade ±1.0 % FSO)

(D) Oil quantity inflowing into the breaker, Q

1) Q should be measured at the supply pressure line near the in-port of the breaker as much as possible.

2) Q should be measured by an electric flow meter (accuracy grade of fluid quantity determination ±2.5 %).

(E) Measuring the oil temperature, T

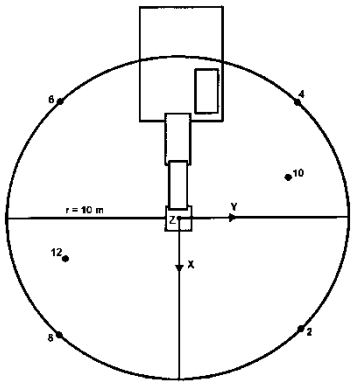
1) T should be measured at the oil pressure line connected to the excavator oil tank or breaker. Measurement points should be specified on the report.

2) Accuracy of temperature determination should be within the ±2 ℃ of the actual value.

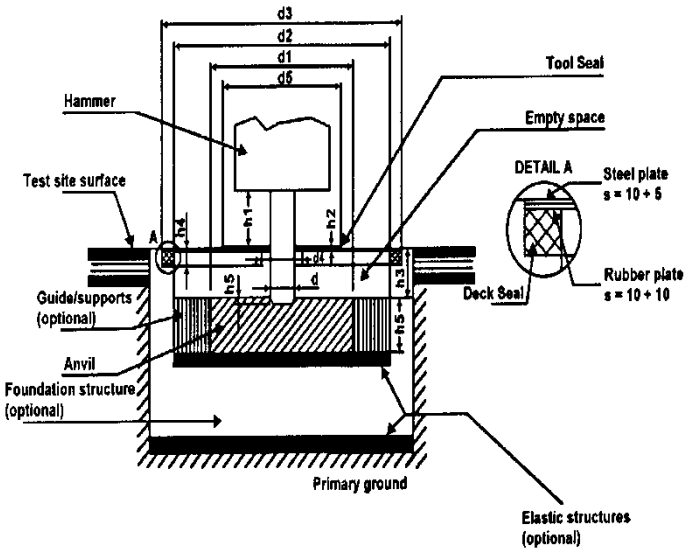
(F) The observation (measurement) time and determination of the final sound power level

1) The observation (measurement) time should be at least 15 seconds.

2) Repeat measurement three times or more, if necessary. Calculate the final result with the average of two highest values that are not different more than 1dB(A).



<Figure 7> Projection drawing and measurement positions of the test block



<Figure 8> Breaker test device

d: Diameter of the tool [mm]
d1: Diameter of the anvil, 1200±100 mm
d2: Inner diameter of the anvil support, ≤1800 mm
d3: Diameter of the test block bottom, ≤2200 mm
d4: Diameter of the tool opening on the floor surface, ≤350 mm
d5: Diameter of tool sealing, ≤1000 mm
h1: Length of the lowest part of the housing (cover), and the tool shown on the surface of tool sealing [mm], h1 = d±d/2
h2: Thickness of tool sealing on the floor surface, ≤20 mm (If tool sealing is under the floor surface, there is no limitation on thickness. It can be made of foam rubber.)
h3: Distance from the upper side of the floor and the upper side of the anvil, 250±50 mm
h4: Thickness of isolated rubber floor sealing, ≤30 mm
h5: Thickness of the anvil, 350±50 mm
h6: Tool penetrating length, ≤50 mm

If the square shape test block is used, the maximum length is (0.89 × matching diameter). The empty space between the floor and anvil can be filled with elastic foam rubber or acoustic absorbent (density <220 kg/m³).

24. Road milling machinery

A. Installation of construction equipment: Install road milling machinery in such way that its vertical axis goes in parallel with the y axis.

B. Operation of construction equipment

(1) Keep road milling machinery in the normal state within the range specified in the manual given to the purchaser. Idle the engine and all accompanying equipment at proper speed.

(2) The measurement time should be more than 15 seconds.

25. Electric welder

A. Installation of construction equipment: The electric welder should be installed on the reflective surface. The electric welder with the antilock braking system should be installed on the 0.4 meter high support, if not in the special circumstances.

B. Operation of construction equipment

(2) Run construction equipment according to ISO 8528-10, Point 9.

(2) The measurement time should be more than 15 seconds.

26. Joint cutter

A. Installation of construction equipment: Install the biggest blade in the joint cutter, which is described in the manual given to the purchaser.

B. Operation of construction equipment

(1) Run the engine at top speed that engine blades are idling.

(2) Measurement time should be at least 15 seconds.

Common Criteria, Notice No. 2012-36, the Ministry of Environment

1. Eco-label products must follow the following provisions with regard to the proper treatment of environmental pollution substances, such as air and water wastes and noxious chemical substances emitted in the process of manufacturing or service operation.

A. When first applying for certification, the product manufacturer should observe the environment related laws and agreements pertaining to the region where the production factory or the place of service operation is located for a period of one year prior to the date of application. Any case of violation of the penalty clause will be verified by confirming documents involved during a period of one year to the date of application. Regarding any violation not related to the penalty clause, confirmation will be made on the completion of appropriate measures.

B. A person who has received a certification of eco-labeling shall observe the environment related laws and agreements pertaining to the region where the production factory or the place of service operation is located during the period of certification. However, regarding any violation besides a penalty, confirmation will be made on the completion of appropriate measures.

2. As a general rule, information for consumers shall be indicated on the surface of the product in such a way not to be easily erased. However, in case that indication on the surface of the product is impossible or undesirable, it can be indicated on the appropriate part such as product packaging, product guidebook and user's manual that consumers can recognize. However, the service information should be indicated inside and outside of the place of service operation. In case that indication inside and outside of the place of service operation is impossible or undesirable, it can be indicated on the appropriate part such as an agreement, letter of delivery, letter of guarantee, and PR materials that consumers can recognize.

3. In order to establish fair trade and to protect consumer, the applicant for eco-label and the holder of eco-label license shall observe the Act on the Fairness of

Indication and Advertisement with respect to the environmental aspects of the product.

4. For Various standards referred in the certification criteria by target product, the latest revised edition applies at the date of application, if not specified otherwise.

5. In applying the quality related criteria for each target product, if no standard is available that can be applied as the quality criteria, the president of Korea Environmental Industry & Technology Institute (KEITI) (hereafter referred to as "president of KEITI") may establish and operate the quality criteria for the product involved after review by a competent committee.