AIR INTAKE SYSTEM
for CI engine

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NOTES

This document is applied for Kubota CI engines for OEM.

This document is intend to provide installation guide for the engine to the application.

The information in this document subject to change without notice.

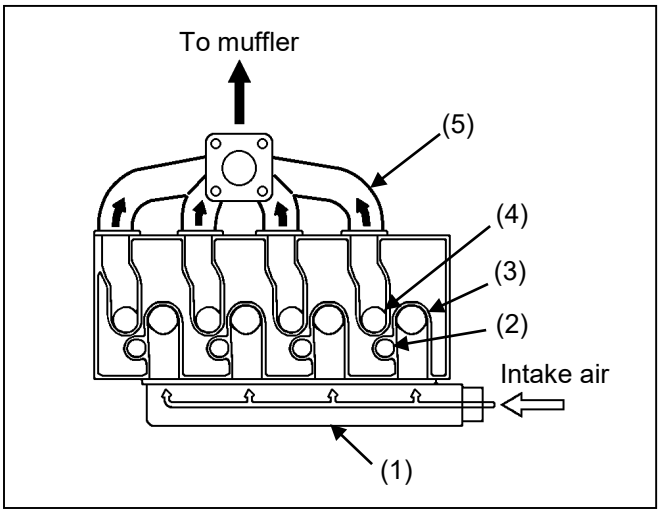
The latest document is available on the K-iSS website. Printed copies are for reference only.

AIR INTAKE SYSTEM

1. GENERAL

The intake and exhaust system is very important for engines.
In order to operate an engine smoothly, the intake and exhaust system must be efficient enough for maximizing the functions of highly reliable valve mechanism. It is best to feed clean, low temperature (Example: high density) air to the engine intake.
The intake system supplies the air required for combustion. Insufficient air intake decreases engine output. If air is not clean, wear increases on the piston, rings and cylinder and lubricating oil smear will tend to shorten engine life.

【Crossflow system】
Intake air temperature tends to rise if exhaust gas passages are near the intake passage; this leads to decreased output. To prevent this, KUBOTA engines use a crossflow system.
As shown in the figure 1, the KUBOTA engine employs the crossflow system which separates the intake and exhaust systems in opposite side of the cylinder head.
This arrangement effectively prevents heating of intake air by exhaust heat which would result in decreased output. The crossflow type cylinder head provides better volumetric efficiency of the intake, alternately placed intake and exhaust ports minimize cylinder head distortion due to exhaust gas heat. The following sections cover important elements of the intake and exhaust systems.



(1) Inlet manifold (4) Exhaust port
(2) Combustion chamber (5) Exhaust manifold
(3) Intake port

Figure 1 Crossflow type cylinder head

2. AIR CLEANER

(1) General
The air cleaner, of which purpose is to purify intake air, has two types; the dry type and wet type. The dry-type air cleaner, which is generally used in most cases, uses a filter paper element and therefore dust removing efficiency is very high regardless of the engine speed. (99.5 to 99.8%)
In KUBOTA diesel engines, the dry-type air cleaner are employed as standard part for all models.

(2) Structure of dry type air cleaner
Dust or air containing moisture will infiltrate into air cleaner through the inlet installed perpendicularly on the bodies outer circumference and direct vortex flow along the guide is created inside the body.
After this, the air passes through the element and will further be purified.
The element is made of high-quality paper filter and can inhibit infiltration of very fine dust (20 μm). Dust separated by the vortex flow will be collected into the rear-side and cover and then passed into the evacuator valve.
This evacuator valve will open and close automatically in accordance with pulsation of suction air and discharge the dust.

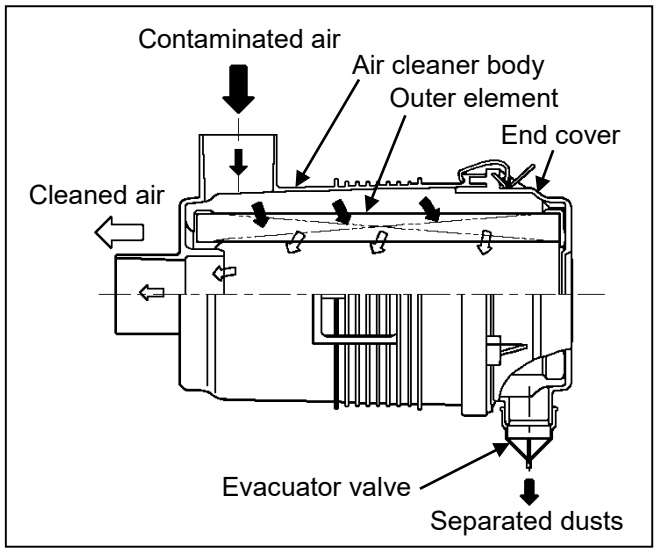


Figure 2 Structure of air cleaner

1) Structure of single element air cleaner

This air cleaner is the most popularly used type for the small-size general purpose diesel engine and is composed of the air cleaner body, outer element, rear side end cover, dust-evacuator valves, etc. The outline of the structure is shown in the figure 3.

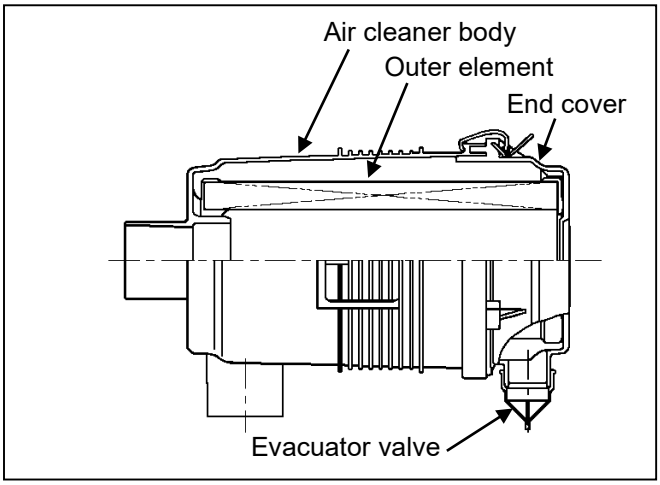


Figure 3 Structure of single element air cleaner

2) Structure of double element air cleaner

The air cleaner of double element structure is used for the engine to be used in more severe environmental conditions such as the case of construction machinery and sweeper where the amount of dust is large. This type is made by adding the inner element to the previously described single element air cleaner and the structure is shown in the figure 4.

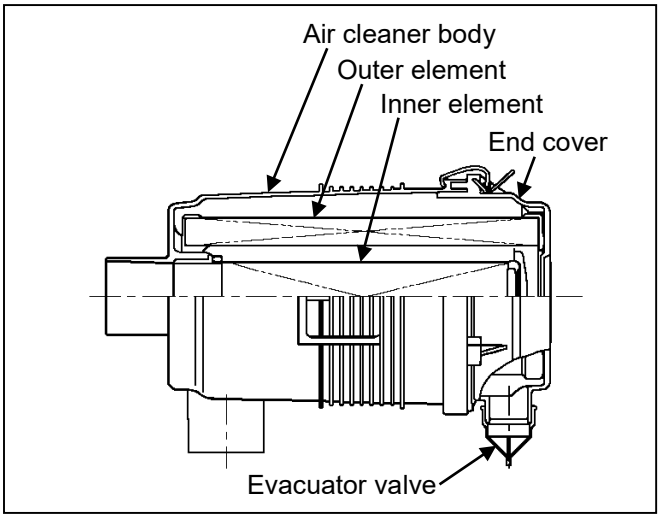


Figure 4 Structure of double element air cleaner

(3) Selection of air cleaner

1) Conditions for selection

a) Amount of suction air

b) Environmental conditions of dust

- Small-amount dust conditions:
  Generator, forklift, carrier, etc.
- Large-amount dust conditions:
  Agricultural machinery, construction machinery

c) Mounting conditions
  Mounting to engine, or mounting to machine

d) Destination
  Use in developed countries, or to developing countries

e) Use conditions
  Operating hours and quality of maintenance

f) Cost
  Initial cost and maintenance cost

2) Selection of air cleaner and the cautionary items

a) Cautionary items for environment

- In case that an air cleaner is used in high dust concentration areas (high-temperature or high-humidity area), a model of sufficient capacity should be used. (It is required to use the air cleaner of one size higher capacity than those to be used in ordinary areas.)
  The air cleaner should be the double element type.
- Reduction in the life of the air cleaner element (clogging) is often caused by comparatively small sized dust. However, in the case that there is a possibility that the suction port (air intake) of air cleaner may be clogged by large-size dust (such as fallen leaves and straw dust), it is required to move the suction port to a location with less dust or to install a pre-filter to remove such large-size dust.
- In the case that there is a possibility that the air cleaner may suck in water, a water drain hole or water-separating device should be installed. Be very careful to prevent the water entering engine when washing the machine.

b) Cautionary items when mounting to engines

- Vibration of air cleaner should not exceed the rated value verified in the field operation of the actual machinery.
  Large vibration will cause damage to various parts or allow dust leakage of the element (including the element gasket section).
- Be careful so that the suction port of air cleaner is not subjected to the detrimental conditions such as the followings:
  a) Air cleaner should not inhale hot air, such as the hot side cooling air of radiator.
  b) Air cleaner should not inhale exhaust gas.
  Particularly fine carbon will cause to early clogging.
  c) Air cleaner should not inhale the material having viscosity such as mist of crankcase.

● Cautionary items when piping to the air cleaner

a) Is the inner diameter, length, or bending of pipe appropriate?
Be careful so that the intake air resistance should not be too great.

b) Is the dust seal of piping system complete?
If there is even the least gap in the suction air system, it will result in the early wear of the moving parts of engine.

Therefore, checking of the following items is required.

1) Is clamping force of the hose clamp sufficient, and will not the hose clamp be loosened by vibration?
Is all hose connection “rubber to metal”?
Are all rubber hose connections tight on metal connections?

2) Is strength of the hose sufficient?
(Will not distortion or damage of the hose be incurred by negative suction pressure or positive suction air pressure?)

3) Will dust infiltrate through the screw holes?

c) If an extension pipe is installed to the suction port, or the hose between air cleaner and intake manifold is too long, it may result in an engine output decrease or smoke increase.

c) Cautionary items on maintenance

● Maintain the air cleaner within the time specified in the operator’s manual. (In the case of the air cleaner provided with a dust indicator, maintenance should be performed after the warning of clogging is indicated.)
Unnecessary maintenance will be the cause of problems, such as the damage or deformed element.

● Be careful so that dust adhered on the element should not infiltrate to the outlet side of air cleaner when removing the element.

● When cleaning the element, it should be done by blown air or water washing. (Depending on the kind of the element, water washing is allowed, or specified detergent can be used.) In case of blown air remember to blow air from the inside toward the outside.

● When removing the element, stop the engine.

● In case that there is a pin hole on the element, replace it with new one.

Installation example of air cleaners are shown:

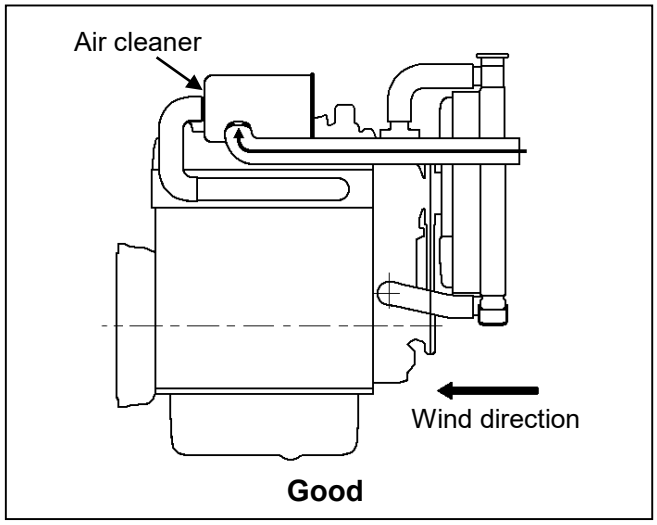


Figure 5 Air cleaner installations

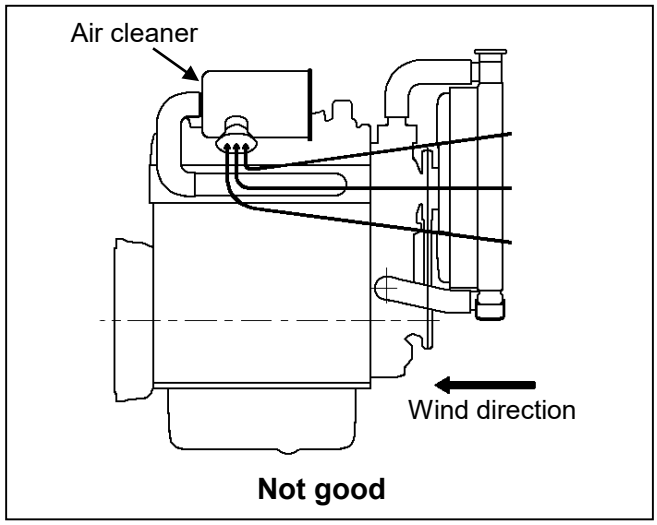


Figure 6 Air cleaner installations

3. REQUIRED AIR VOLUME

The volume of air required during engine operation can be determined by the following formula.

$Q_1 = Vh \times N \times C \times \eta \times k \times 10^{-3}$
- Q_1 = Amount of intake air (m^3/min)
- Vh = Total displacement (L)
- N = Engine speed (rpm)
- C = Coefficient 4 cycle ... 0.5
- η = Intake efficiency 0.85 to 0.87
- k = Coefficient
  - Natural aspirated engine: 1.0
  - Turbo charged engine: 1.5

The intake efficiency of KUBOTA diesel engines shall be as follows:
Natural aspirated engine
Engines of 3000 rpm or less: 0.87
Engines of 3600 rpm or less: 0.85
Turbo charged engine: 0.80

The air volume required for KUBOTA diesel engines are referred to in TECHNICAL INFORMATION documents.

Example calculation

Engine model: V2203-M,
Engine speed: 2800 (rpm)

$Q_1 = Vh \times N \times C \times \eta \times k \times 10^{-3}$
- Vh = 2.197 L
- N = 2800 rpm
- C = 0.5
- η = 0.87
- k = 1.0

$Q1 = 2.197 \times 2800 \times 0.5 \times 0.87 \times 1.0 \times 10^{-3}$
$= 2.68\ m^3$/min

4. INTAKE RESTRICTION

Restriction of the intake system is caused by the air cleaner and intake piping. This restriction must be kept below a certain point to prevent decreases of engine output performance and keep clean exhaust emissions.

See the TECHNICAL INFORMATION document for the specific limitation value of each engine model.

Note:
1) The intake restriction is the total system limit.
2) The restriction must be measured as close to the intake manifold (or turbo inlet) as possible to properly measure the entire system restriction.
3) Intake restriction must be measured at the location that is not affected by pulsation.
4) For naturally aspirated (NA) engines, conduct the restriction test at full throttle, high idle condition no load. For turbocharged engines, conduct the restriction test at full throttle rated speed full load condition.
5) The application review must be performed at the initial limit with clean filter condition.
6) If OEMs mention the restriction values on their operator manuals for service interval, refer to the TECHINICAL INFORMATION document (Limit with dirty filter).

The intake piping should be made of a high quality compounded rubber with exceptional resistance to aging, oil and cold to reduce chances of cracking during operation.

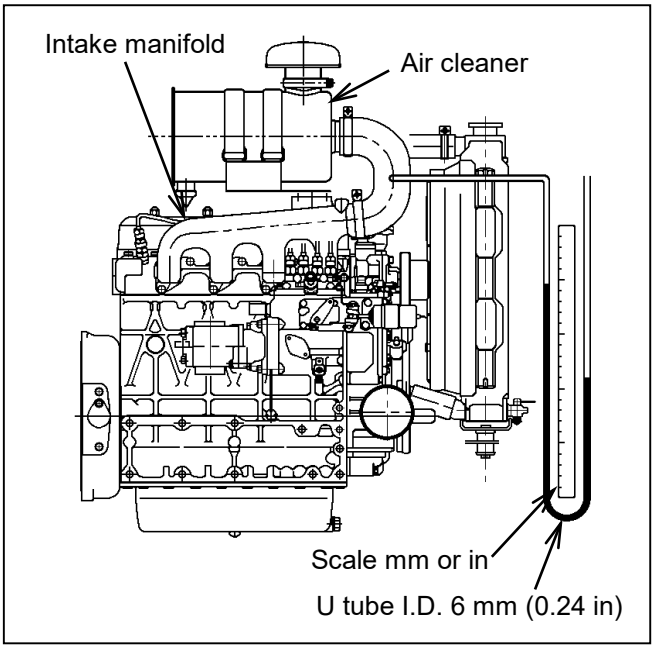


Figure 7 Intake resistance measurement point

Note:
Intake resistance measurement point should be close to intake manifold.

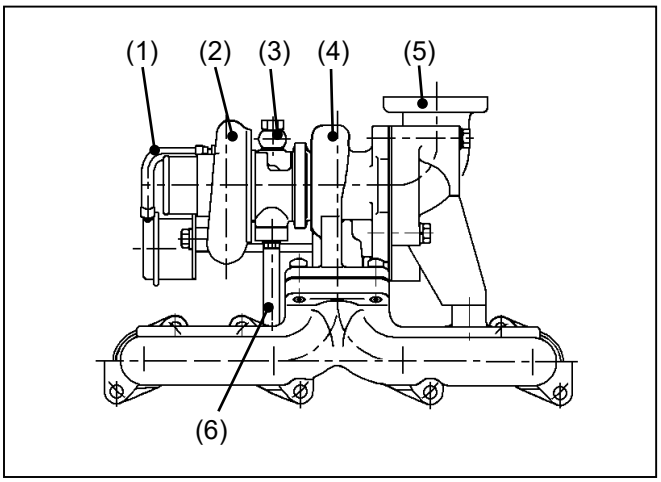
5. TURBOCHARGER

[1] GENERAL

If air can be drawn in at a greater rate before it enters the cylinder more fuel can be burned and the output will be increased.
A turbocharger discharges the compressed air into the cylinders by a turbine using energy of the exhaust gas as power. Use of a turbocharger allows a small engine to have a high output.

[2] COMPONENTS OF TURBOCHARGER

The turbocharger is a compact unit mounted on the outlet of the exhaust manifold.
It consists of a turbine portion to convert exhaust gas energy into a rotating force, a compressor to compress intake air, a waste gate valve to prevent excessive pressures at high speed operation, a lubricator to supply engine oil to bearings and a boost compensator to adjust the fuel injection amount at low speed and during acceleration.



(1) Waste gate piping (4) Turbine
(2) Compressor (5) Exhaust port
(3) Lubricating piping (6) Lubricating oil return pipe

Figure 8 Example of turbocharger

REVISION HISTORY

File Name	Remarks	Date
KORD3_17-096_6_air_intake_system.pdf	Document style standardization	Sep. 29, 2017
KORD3_21-026_ Air_intake_system_for_CI_engine.pdf	Document style standardization	Mar. 4, 2021