Diesel Particulate Filter (DPF) System

Function of the Diesel Particulate Filter (DPF) system

The Diesel Particulate Filter (DPF) system is implemented in automobile diesel engines. It uses a soot filter (SF) to collect particulate matter (PM) from the exhaust gas and safely processes it. Application of the DPF system complies with the Tier 4 emission standards set by United States Environmental Protection Agency and the emission standards set by other countries.

The outline of the system is shown in the below figure.

Figure 8-9

Structure of all devices

DPF

Structure of the DPF

The case of the DPF leads the exhaust gas into the diesel oxidation catalyst (DOC) and the soot filter (SF). The DOC and SF are made of ceramics and are held in the metallic case by a mat that is made of ceramic fibers. The case also serves to fixate the DPF itself, to uniformly lead the gas into the DOC and SF, to maintain the exhaust gas temperature, to provide a means to disassemble the SF for maintenance, and to fixate the sensors. As stated before, the DOC and SF are held by the frictional force of the mat, therefore it is important to install the DPF so that the allowed acceleration is not exceeded. For the allowed acceleration, please refer to the conditions described below. Two sensors are installed on the DPF: A differential pressure sensor that detects clogging of the SF and a temperature sensor that measures the exhaust temperature. The differential pressure sensor is installed on the DPF flange and connected to the DPF with a steel pipe and a rubber tube. The exhaust temperature sensor is installed on the outer diameter of the DPF and connected by the sensor port.

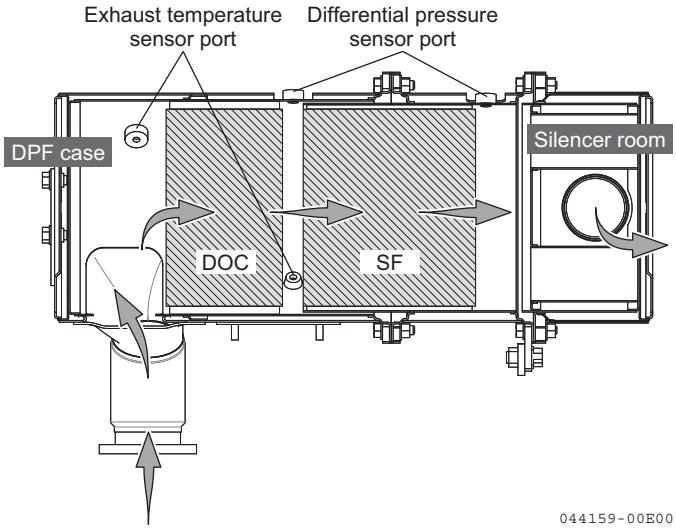


Figure 8-10

Allowed DPF vibration condition

The maximum values for the DPF are up to the below listed standards.
Regular acceleration: ≤ 55.5 m/s^2 (RMS) ... All directions
Shock acceleration: ≤ 30 G (0 - P) ... DPF axis direction
The DOC backing or soot filter can detach.
≤ 40 G (0 - P) ... Not the DPF axis direction
For DPF installation, horizontal placement in the axis direction is recommended.
There is no harmful resonance point within the range of engine rotation.

Function of the DPF

The function of the DPF is to break down harmful substances in the DOC and to collect particulate matter in the SF, thus preventing contaminants from releasing into the air. Particulate matter that accumulates in the SF causes it to clog, reducing engine performance. Therefore it is necessary to regenerate the filter. There are 3 regeneration methods: continuous regeneration, intermittent regeneration and additive regeneration. The YANMAR engine uses a continuous regeneration method, which allows the removal of particulate matter inside the DPF and regeneration at the same time while continuing operation of the engine. It regenerates the filter by burning the particulate matter that is collected in the SF with NO_2 that is created in the DPF and O_2 from the exhaust gas. The DOC cleans the HC (hydrocarbon) and CO (carbon monoxide) that is in the exhaust gas by turning them into H_2O and CO_2. The regeneration efficiency is effected by the

exhaust temperature directly before the reinstalled DOC. The exhaust temperature varies according to the operating conditions of the engine, and at minimum temperatures, the regeneration process uses NO_2, and at maximum temperatures, the regeneration process uses O_2 for regeneration. But the particulate matter cannot be burned efficiently at temperatures too low and causes clogging issues. For that reason, installation of the DPF at standard locations are unproblematic, but if you install the DPF at other locations, it is necessary to separately evaluate the exhaust temperature. Furthermore, if too much particulate matter accumulates, engine output decreases and frequent switches to assist regeneration. This causes the condition of the filter to worsen and, in the worst case, running combustion that leads to DPF damage and excessive heating of the DPF and the exhaust connection pipes, possibly resulting in fire. To avoid such a dangerous over-accumulation of particulate matter, control of the engine and creating conditions in which particulate matter burns well (all regeneration modes) advance the regeneration of the DPF (please refer to the sections in the DPF system control outline on assist regeneration, reset regeneration and stationary regeneration). Apart from particulate matter, ash also accumulates in the SF. This comes mostly from metallic components in the additives to the lubricating oil. Part of the lubricating oil burns when exposed to high temperature in the combustion chamber and is vented together with the exhaust gas. It then accumulates in the SF together with the particulate matter. But compared to the amount of particulate matter, only very little ash collects, so it does not clog the SF. But because the ash is from metallic elements, it is burned inside the DPF in the same way as particulate matter and cannot be processed. Therefore, after a long period, too much ash collects in the SF and increases pressure loss, which has a bad effect on the engine. In that case, it is necessary to remove the SF where the ash has collected from the DPF and clean it. Please refer to the service manual for the maintenance method and interval of the ash removal.

Precautions for DPF Usage

Only use the specified fuel and lubricating oil, so that the DPF can function in the above described manner. Use light oil with a sulfur content (mass) of less than 15 ppm (ultra-low sulfur). If you use other than the specified fuel, the sulfur will make the performance of the catalyzer inside the DOC deteriorate rapidly. When the regeneration performance of the DPF is inhibited and more particulate matter accumulates, the drop of engine output and the frequent switches to regeneration mode increase the fuel costs and worsen the engine condition. Use a low-ash oil as lubricating oil. If you use other than the specified lubricating oil, a lot of ash is vented through the exhaust and the DPF will clog soon. This will not only cause the engine output to decrease and the fuel costs to increase, but is also connected to early maintenance of the SF.

Sensor

DPF temperature sensor

For the sensor's shape, refer to *Diesel Particulate Filter (DPF) Inside/Inlet and Exhaust Temperature Sensors on page 14-142*.

Function of the DPF temperature sensor

As described above, the DPF controls the simultaneous processing and regeneration of particulate matter accumulation. For that purpose, the temperature sensors installed before and after the DOC and SF monitor the exhaust temperature inside the DPF. These sensors are also used for irregularity detection of the DPF.

DPF differential sensor

For the sensor's shape, refer to *Diesel Particulate Filter (DPF) Differential Pressure Sensor on page 14-143*.

Function of the DPF differential sensor

Particulate matter and ash accumulate in the SF as described above, but the amount of the accumulation is estimated by differential pressure sensors that detect the differential pressure before and after the SF.

DPF size

For the DPF size for all engine models, confirm the below table.

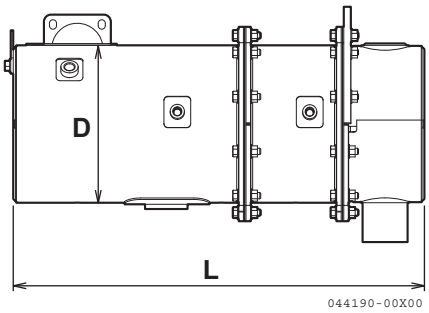


Figure 8-11

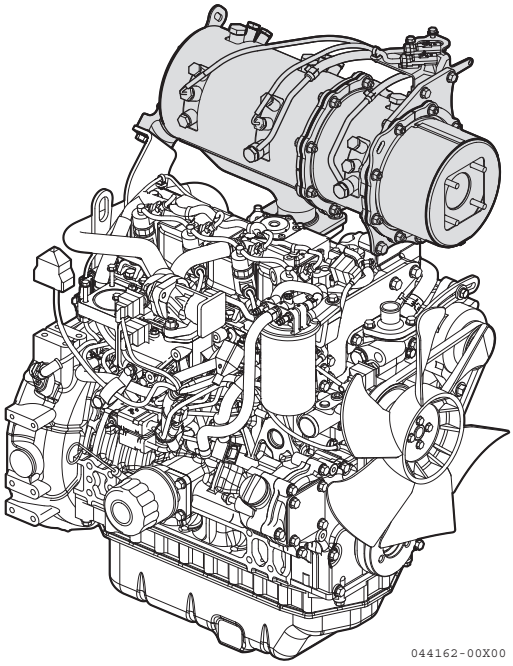
Table 8-1 DPF size list

	DPF size (mm)	Engine speed (min^{-1})										
		2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000
Engine	3TNV88C	–				ϕ 170 × L470 with Silencer						
	3TNV86CT	–					ϕ 170 × L421 w/o Silencer					
	4TNV88C	ϕ 170 × L470 with Silencer						ϕ 170 × L507 with Silencer				
	4TNV86CT	-				ϕ 200 × L432 w/o Silencer						
	4TNV98C	ϕ 200 × L520 with Silencer						–				
	4TNV98CT	ϕ 200 × L432 w/o Silencer						–				
	4TNV94CHT	ϕ 200 × L479 w/o Silencer						–				

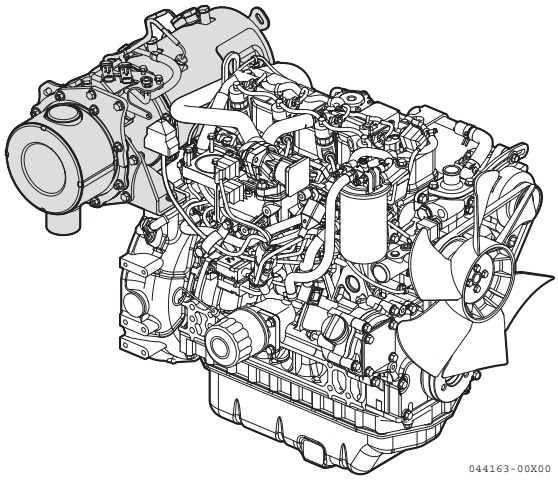
DPF installation location

We recommend the YANMAR standard engine installation as the DPF installation location. But if the installation of the implement demands that the DPF is installed on the vehicle side or a non-standard location, consult a YANMAR representative.

- **Standard DPF installation layout (example)**



4TNV88C: Exhaust Manifold Top Installation



4TNV88C-FW: Housing Top Installation

Figure 8-12

- **DPF installation requirements for non-standard lay-outs**

- Allowed exhaust gas temperature drop rate: Consult the person in charge
- DPF installation vertical orientation: When you install the DPF, consider the direction in which you remove the DOC and SF, and do it so that the axis is horizontal.
- SF case removal clearance: Install it so that there is enough space between the DPF and the implement to remove the DPF or the SF case during regular maintenance of the SF to remove ash. For SF case removal clearance, refer to the below table.

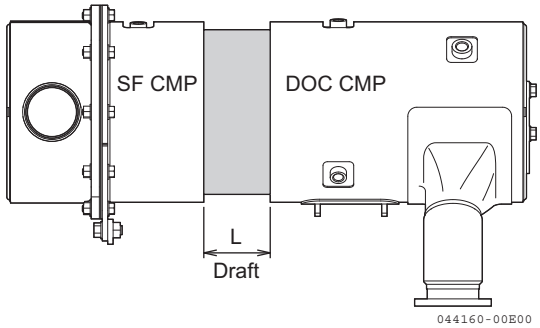


Figure 8-13

Table 8-2

Engine	3TNV88C	4TNV88C (≤ 2500 min^{-1})	3TNV86CT	4TNV88C (≥ 2600 min^{-1})	4TNV98C	4TNV86CT	4TNV98CT	4TNV94CHT
SF case removal clearance (mm)	L = 66		L = 77			L = 77 (FWH top installation) L = 57 (Exhaust manifold top installation)		L = 89

- Because the surface temperature can become high, it is necessary to take precautions against burn injuries and fire. Confirm this during installation evaluation and consider the precautions.
- Allowed location for the sensing hub: Installation hub location of the DPF temperature sensor and differential pressure sensor: For details, consult the person in charge.
  Allowed location: Circumference direction 0 - 180 degrees (refer to the figure below).

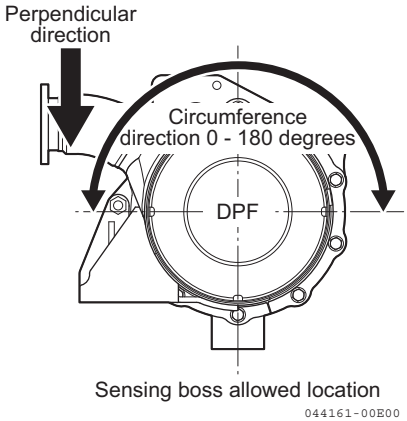


Figure 8-14 Sensing boss location limitation

- Allowed DPF vibration: For details, Refer to the *installation evaluation paragraph.*
  The maximum values for the DPF are up to the below listed standards.
  - Regular acceleration: ≤ 55.5 m/s^2 (RMS) ... All directions
    Measurement location: DPF flange
  - Shock acceleration: ≤ 30 G (0 - P) ... DPF axis direction
    Measurement location: DPF flange
    The DOC backing or SF can detach.
    ≤ 40 G (0 - P) ... Not the DPF axis direction
    Measurement location: DPF stay
  - There is no harmful resonance point within the range of engine rotation.

Precautions when inspecting the implement

- Install the DPF at a location where it is not (or as little as possible) cooled by outside air. This is because it can effect the exhaust temperature.
- Be careful, because the exhaust gas from the tail pipe becomes hotter than from engines without a DPF. Consider the direction of the tail exhaust pipe and how fresh air is taken in. On engines that, similar to conventional engines, only have a silencer, the exhaust temperature, after repeated extension, cools up to the level of the tail pipe. However, the accumulated PM is combusted and treated by using NO_2 and O_2 in the case of DPF, so that the exhaust temperature is not so reduced. Further, in the case of stationary reuse, the exhaust temperature is increased by sending non-fuel into DPF directly. For that reason, the temperature may reach maximum 600 °C.

Prohibited

- Before production, it is necessary to negotiate a contract with YANMAR about the installation location and piping of the DPF. Emissions cannot be guaranteed when the location or piping are changed. When changing an approved specification, contact YANMAR beforehand and request re-evaluation.
- The DPF is subject to emission regulations. The user is prohibited from disassembling it without permission. Please write into the manual that, in case of repairs, the engine should be taken to a specialized service shop to avoid the user disassembling the DPF.
- Do not attach a DPF of another company to a YANMAR engine. The DPF is calibrated to the engine. If you use the DPF of another company, the engine performance, emissions, engine endurance and DPF endurance cannot be guaranteed.
- Do not use a DPF that dropped.

Other

- If more than one DPF is delivered with the same order, check the engine serial number and the DPF serial number as indicated by YANMAR when you install it to the implement.
- Refer to the *service manual* for maintenance procedures of the SF.

Differential pressure sensor

Installation: Consult with a person in charge, if you want to install the differential pressure sensor notwithstanding the standard layout.