HYUNDAI INFRACORE

950106-069005EN

Installation Guide

DIESEL GENERATOR ENGINE

Forward

This installation manual provides guidelines on the correct installation of HD Hyundai Infracore generator/power unit engine.

During the installation of the engine, each of the various requirements must be met in order to prevent engine malfunction, reduced performance and errors in engine-related systems as well as to ensure that the engine delivers maximum performance and maintains long-term durability.

Accordingly, make sure to follow the installation instructions for the parts described in this installation manual when installing HD Hyundai Infracore generator/power unit engine.

This installation manual applies to HD Hyundai Infracore generator/power unit engine.

When selecting an engine, make sure to consider the intended use of the engine and the conditions of each load level as well as the power of each engine model before deciding on an engine. In the event that an incorrect engine is selected and engine failure results from a discrepancy between the intended usage conditions and the user's usage conditions, warranty-guaranteed free repairs are not provided even within the warranty period.

Part guarantees for HD Hyundai Infracore generator/power unit engine are acknowledged only when this installation manual has been complied with.

If the installation must be performed differently from the standards in this installation manual from HD Hyundai Infracore, you must notify HD Hyundai Infracore in writing; in the event of any changes, the engine must be verified again by HD Hyundai Infracore or an authorized dealer in order for the guarantee to be effective.

The images contained in this manual were included for reference purposes only in order to aid with understanding the contents; please note that they may differ from the appearance of engines or parts supplied by HD Hyundai Infracore.

HD Hyundai Infracore reserves the right to change the contents of this manual in the future without prior notice to customers for the sake of product improvement, etc. .

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HD Hyundai Infracore

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1. Engine Storage and Maintenance

General Information

Since generator engines operate under high loads, mistakes during installation may lead to phenomena such as power drops, overheating, vibrations, noise, and instability. The purpose of this manual is to ensure that customers can operate the machine stably in order to prevent unstable performance due to installation-related mistakes. In addition to the basic items which must be checked when operating the engine (fuel level, coolant level, engine oil level, state of filters, V-belt tension, battery, etc.), these check sheets summarize only factors related to inspections of the state of the generator engine installation and checking performance. HD Hyundai Infracore engines were designed and manufactured to satisfy only the essential health and safety requirements (EHSRs) of the Machinery Directive (MD) presented below; generators which are finished end products that include an engine as a component may not be sold within the European Communities (EC) until the suitability of other applicable EC guidelines aside from the Machinery Directive (MD) has been declared.

General Storage Tips

1. Store the engine in a dry, indoor space with low moisture and little to no effect from outside elements such as rain or snow.
2. Seal parts vulnerable to exposure to the air with waterproof caps or tape.
   - Coolant inlet & outlet / air filter / breather hose / fuel inlet & outlet
     (Check whether the engine packaging is secure and whether any circulation system caps have come loose)

Classification (Types) of Packaging

1) Open plastic type: A type of plastic packaging which leaves the bottom of the engine open and exposed to the external environment (foreign matter, moisture, temperature, etc.)

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2) Sealed plastic type (including wooden packaging): A type of packaging which seals the entire engine, preventing contamination from foreign matter but leaving the engine exposed to moisture and ambient air temperature

EGN210002

3) Nitrogen flush packaging: Completely seals the engine off from the external environment by means of nitrogen flushing

EGN210003

Inspection Items

No.	Inspection item	Inspection interval			
		3 months	6 months	12 months	24 months
1.	Check for external corrosion (check the pulley and FW)	○			
2.	Check electronic parts/connectors	○			
3.	Check V-belt tension and replace the belt		○		
4.	Coolant line corrosion prevention: Spray method	○			
3.	Coolant line corrosion prevention: Flushing method		○		
5.	Check for coolant line corrosion and remove rust		○		
6.	Add oil to turbocharger manually		○		
7.	Replace fuel filter and oil filter		○		
8.	Lubrication oil change interval		○		
9.	Check injectors for external corrosion, opening pressure, and injection quality			○	
10.	Replace CRS oil seal			○	
11.	Overhaul inspection of cylinder head				○

1) Pulley, flywheel: Applying a film-type anti-corrosive agent

- When visually inspecting the appearance of parts such as the pulley and flywheel, any rust found must first be removed completely.
- Prepare the corresponding NABAKEM LONG #2 film-type anti-corrosive agent.

Film-type anti-corrosive agent specifications	Type	Remarks
Long #2	Spray	

- Shake the film-type anti-corrosive agent well before use.
- Apply the agent evenly at intervals of 20 to 30 cm on the part.

2) Check the external appearance of electronic parts/connectors

- Check the ECU and electrical connectors, etc. for proper locking, external contamination, and shake them slightly by hand to check for looseness.
- In hot, humid regions in particular, there is a high risk of connectors rusting due to moisture, so inspections must be performed thoroughly.

3) Check the belt tension and external damage; replace the belt if necessary

- If you have a tension gauge, measure/adjust the tension according to the tension standards for the corresponding model (suffix).
- If you do not have a tension gauge, measure the tension manually (less than one finger joint).

4) Preventing corrosion in coolant lines

- Coolant line corrosion prevention: Spray method
  - Dilute anti-corrosive agent M640-L to a ratio of 10% and prepare a spray.

Film-type anti-corrosive agent specifications	Dilution ratio with water	Remarks
M640-L	10 : 90	

  - Open the cap on the water pump inlet.
  - Spray the diluted solution into the water pump inlet five to seven times.
  - Close the cap on the water pump.
- Coolant line corrosion prevention (if flushing equipment is available)
  - Dilute anti-corrosive agent M640-L to a ratio of 15% and prepare the flushing equipment.

Volatile anti-corrosive agent	Dilution ratio with water	Remarks
M640-L	15 : 85	

  - Connect the engine coolant inlet/outlet to the flushing equipment.
  - Allow the anti-corrosive agent to circulate through the engine coolant system for at least two minutes.
  - Using an air gun, blow air through the system for at least five minutes to remove the remaining anti-corrosive agent inside the engine.
  - Use rubber stoppers to plug the water pump inlet and outlet.

Note) If you do not have flushing equipment, discuss how to prevent corrosion in coolant lines with an authorized HD Hyundai Infracore technician (engine CS, dealer).

5) Checking for corrosion in coolant lines and removing rust

- Remove the water pump and thermostat housing; if rust is found inside, it must be removed.
- In order to remove rust, you must have either engine monitoring or coolant line circulation equipment.
- Dilute rust removal solution FMC1 to a ratio of 0.3% and pour it into the engine coolant line.

Rust removal solution	Dilution ratio with water	Remarks
FMC1	0.3 : 99.7	

- Maintain circulation in the engine monitoring and coolant lines. (If starting the engine without a load is possible, the engine may run at an unloaded idling speed.)
- Extend the operating time depending on how much rust needs to be removed.
  - Rust removal should be carried out for 20 minutes at a time, and the number of times should be increased depending on the amount of rust.
- After removing the corrosion, blow air through the system for at least five minutes to remove the remaining solution.

6) Remove the oil supply pipe and add oil to the turbocharger shaft.

7) Check the appearance of the fuel filter and oil filter as well as for oil leaks; replace if necessary.

8) Remove the injector and check its appearance for any corrosion; if necessary, check its opening temperature and atomization quality.

9) Check the oil seal for damage or leaks; replace if necessary.

- Take care to prevent secondary quality issues such as scratching the crankshaft while removing the oil seal; follow the service and maintenance manual when press-fitting the seal.

10) Remove the cylinder head and check the inside of the cylinder liner, the bottom of the cylinder head, and the valve for corrosion or damage; replace the part if necessary.

1. Engine Storage and Maintenance

Storing and Maintaining the Engine

Storage/Inspection Method for Wooden Pallet and Box Packaging

1) Store the engine in a dry, indoor space with low moisture and little to no effect from outside elements such as rain or snow.
2) Do not load other items on top of the engine storage box.
3) For engines that have been in storage for an extended period of time, remove the box and perform inspections at the inspection intervals for the corresponding type of packaging.

Checking the Engine Condition (for Each Type Of Packaging)

Open plastic type

1) Storage method

- In the case of plastic packaging, the engine is easily exposed to the external environment, so it is recommended that the engine be stored in a dry, indoor space with low moisture and little to no effect from outside elements such as rain or snow.
- Fix the engine as securely as possible in storage to prevent the plastic packaging from coming off.

2) Inspection items

- Perform inspections according to the following inspection items/intervals within the warranty period.

Type	Inspection item	3 months	6 months	9 months	12 months
Oil system	Check the exterior of the oil seal (discoloration, hardening) and replace if leaking			○	
Coolant system	Remove corrosion from coolant lines [flushing]		○		○
Fuel system	Check the exterior of fuel line hoses and fittings		○		○
Additional inspection	Check for corrosion on non-painted parts such as the pulley and flywheel	○	○	○	○
	Check V-belt tension and replace the belt	○	○	○	○
	Check rubber stoppers for looseness, quality of seal, and foreign matter	○	○	○	○
	Check the entire engine for environmental effects such as moisture or freezing	○	○	○	○
	Check the appearance of electronic parts/connectors	○	○	○	○

Sealed plastic type (including wooden packaging)

1) Storage method

- This type of storage is less affected by external impacts and foreign matter such as dust than the open plastic type of packaging, but it is recommended that the engine be stored in a dry, indoor space with low moisture.
- Wooden packaging refers to the addition of a wooden exterior to sealed plastic packaging; it is recommended that the engine be stored in an indoor space with little to no impact from humidity and temperature.
- If the packaging is not removed, a one-year guarantee is provided; no items to check aside from periodic inspections of the appearance.
  However, the packaging must be checked for damage periodically at three-month intervals; the inspection intervals are the same as those for open plastic packaging if the packaging is damaged.

2) Inspection items

- Follow the inspection items/intervals below
- If a leak is found, perform the same type of inspection as for open plastic packaging

Type	Inspection item	3 months	6 months	9 months	12 months
External check	1. Check the appearance and condition of the packaging - Check for damage such as torn packing materials - Check for external freezing or moisture	○	○	○	○

Nitrogen flush packaging

1) Storage method

- In the case of nitrogen flush packaging, if the engine is stored normally without any leaks, it may be stored long-term for up to two years.
  However, the packaging must be checked for leaks periodically at three-month intervals; the inspection intervals are the same as those for open plastic packaging if a leak occurs.
  Check for leaks using the indicator installed on the outside of the nitrogen flush packaging; record and store the indicator readings.
- Although both indoor and outdoor storage are possible, take care to ensure that the packaging is not damaged by freezing.

2) Inspection items

- Perform periodic inspections (every three months) to check for leaks (for two years)

Note) Although the table below only provides intervals for up to one year (at three-month intervals), the inspections must be carried out for two years.

- If a leak is found, perform the same type of inspection as for open plastic packaging

Type	Inspection item	3 months	6 months	9 months	12 months
Leak check	1. Check the appearance and condition of the packaging - Check for damage such as torn packing materials - Check for external freezing or moisture 2. Check the nitrogen indicator - Air humidity: %	○	○	○	○

⚠CAUTION

- **Note the following when mounting the engine in a machine after long-term storage**
  : Follow the machine (or engine) operating manual when starting the engine for the first time after long-term storage.
  - **If the engine has been in storage for over one year, replace consumables such as the fuel filter and oil filter with new ones.**
  - **Add fresh oil after draining the old oil; check the coolant (antifreeze) and replace it if necessary.**
  - **During the initial engine start-up, make sure to idle the engine sufficiently; any work which requires sudden acceleration or operating under a load is prohibited.**

1. Engine Storage and Maintenance

Attachments

Open Plastic Packaging Check Sheet

Engine Model		Engine No.		Engine Delivery Date	
Date of scheduled initial operation of engine					

No.	Inspection items	Inspection result	Inspection date	Inspected by
1	Lubricating oil system • Check the exterior of the oil seal (discoloration, hardening) and replace if leaking			
2	Fuel system • Check the exterior of fuel line hoses and fittings			
3	Cooling system • Remove corrosion from coolant lines [flushing]			
4	Non-painted parts • Check for corrosion on non-painted parts such as the pulley and flywheel - Remove corrosion or replace if corrosion cannot be removed • Check rubber stoppers for looseness and foreign matter • Check the entire engine for environmental effects such as moisture or freezing • Check rubber stoppers for looseness and foreign matter • Check V-belt tension and replace if necessary • Check the appearance of electronic parts/connectors			

• This check sheet must be maintained/stored properly to guarantee the commercial value of the engine.

Sealed Plastic Packaging (Including Wooden Packaging) Check Sheet

Engine Model		Engine No.		Engine Delivery Date	
Date of scheduled initial operation of engine					

No.	Inspection items	Inspection result	Inspection date	Inspected by
1	1. Check the appearance and condition of the packaging - Check for damage such as torn packing materials - Check for external freezing or moisture			
2	1. Check the appearance and condition of the packaging - Check for damage such as torn packing materials - Check for external freezing or moisture			
3	1. Check the appearance and condition of the packaging - Check for damage such as torn packing materials - Check for external freezing or moisture			
4	1. Check the appearance and condition of the packaging - Check for damage such as torn packing materials - Check for external freezing or moisture			
5	1. Check the appearance and condition of the packaging - Check for damage such as torn packing materials - Check for external freezing or moisture			

- This check sheet must be maintained/stored properly to guarantee the commercial value of the engine.

1. Engine Storage and Maintenance

Nitrogen Flush Packaging Check Sheet

Engine Model		Engine No.		Engine Delivery Date	
Date of scheduled initial operation of engine					

No.	Inspection items	Inspection result	Inspection date	Inspected by
1	1. Check the appearance and condition of the packaging - Check for damage such as torn packing materials - Check for external freezing or moisture 2. Check the nitrogen indicator (if installed) - Air humidity: %			
2	1. Check the appearance and condition of the packaging - Check for damage such as torn packing materials - Check for external freezing or moisture 2. Check the nitrogen indicator (if installed) - Air humidity: %			
3	1. Check the appearance and condition of the packaging - Check for damage such as torn packing materials - Check for external freezing or moisture 2. Check the nitrogen indicator (if installed) - Air humidity: %			
4	1. Check the appearance and condition of the packaging - Check for damage such as torn packing materials - Check for external freezing or moisture 2. Check the nitrogen indicator (if installed) - Air humidity: %			
5	1. Check the appearance and condition of the packaging - Check for damage such as torn packing materials - Check for external freezing or moisture 2. Check the nitrogen indicator (if installed) - Air humidity: %			

- This check sheet must be maintained/stored properly to guarantee the commercial value of the engine.

2. Engine Performance

Engine Power Standards

HD Hyundai Infracore engine power performance conforms to ISO 3046. Power is guaranteed within 0 - 5% under standard reference conditions, and the engine rpm corresponds to G2 class (G3 in the case of some engines indicated otherwise) of ISO 8528.

- Standard conditions
  - Atmospheric pressure: 100 kPa
  - Ambient temperature: 25°C
  - Relative humidity: 30%
  - Fuel temperature: 38°C
  - Satisfy the engine room ventilation system

Engine Power Rating

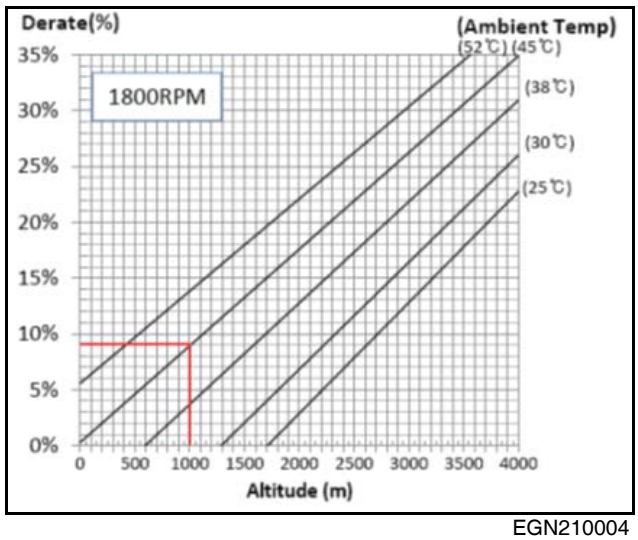
HD Hyundai Infracore generator engines have various power ratings depending on the intended purpose of the engine determined at the time of sale; these power ratings conform to ISO 8528.

- Power guidelines
  - The emergency rated power is used as an emergency power supply in the event of a power failure; overload power cannot be used. The power can be used for up to 200 hours per year at an average load factor of 70%; this includes 25 hours or less of emergency rated power per year.
  - The normal rated power may be used without limit throughout the year at a variable load.
    The average variable load within an operating period of 24 hours must not exceed 70% of the normal rated power, and the use of 100% normal rated power may not exceed 500 hours per year. 10% overload power may only be used for less than one hour per 12-hour operating period, and the total usage time of 10% overload power may not exceed 25 hours per year.
  - The continuous rated power is defined as the maximum power which can be supplied continuously while supplying a constant electrical load for an unlimited amount of time throughout the year under operating conditions determined based on the specified service and maintenance intervals and procedures.

Derating

HD Hyundai Infracore engines satisfy ISO 3046 under standard reference conditions.

If the conditions of the area in which the engine is used exceed the standard reference conditions specified above, power derating must be performed in compliance with HD Hyundai Infracore regulations. The derating regulations for generator engines are provided on the specification sheet for each engine as shown in the example below.
Ex.) How to read the derating chart (DP222LCS Spec Sheet)
If the air cleaner intake temperature reaches 45°C while operating at an altitude of 1,000 m, the engine must be derated by 9%.
In this case, the operation of the generator set should not be tested at 750 kWe; it should be tested and used at 683 kWe - the 9% derated value.



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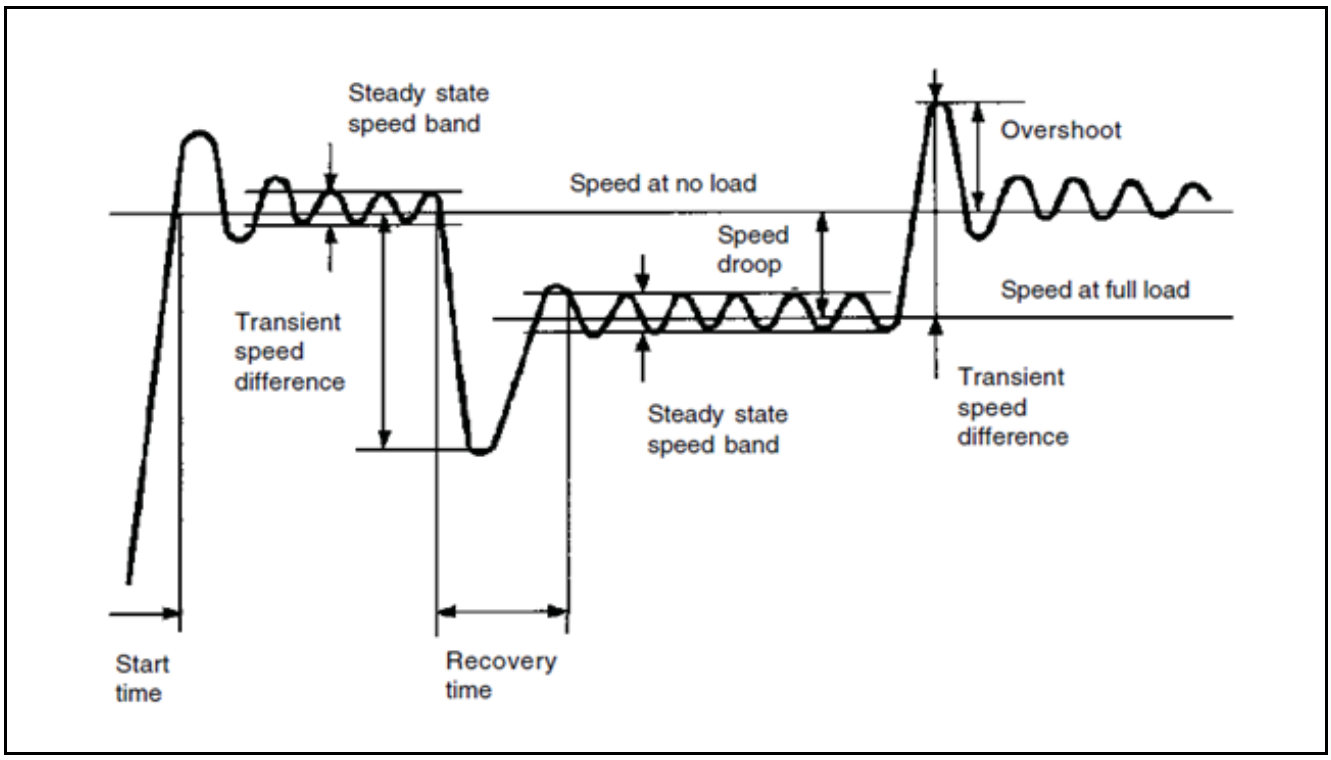
Power derating must be performed daily when operating under the same conditions; failing to perform derating may result in the following phenomena.

1) Increased exhaust gas temperature: Deformation of valves, turbocharger, and manifold
2) Increased smoke: Clogged injectors
3) Increased turbocharger wheel speed: Engine hunting and turbocharger damage

Load Acceptance Characteristics

Generator engines must be able to maintain their frequency even in case of sudden fluctuations in load. This characteristic is referred to as frequency stability or load acceptance.
The load acceptance for maintaining frequency depends on turbocharger inertia, generator unit inertia, and AVR (automatic voltage regulator) characteristics.
The load acceptance characteristics of HD Hyundai Infracore generator engines conform to ISO 8528, and the terms used to explain these characteristics are as follows.



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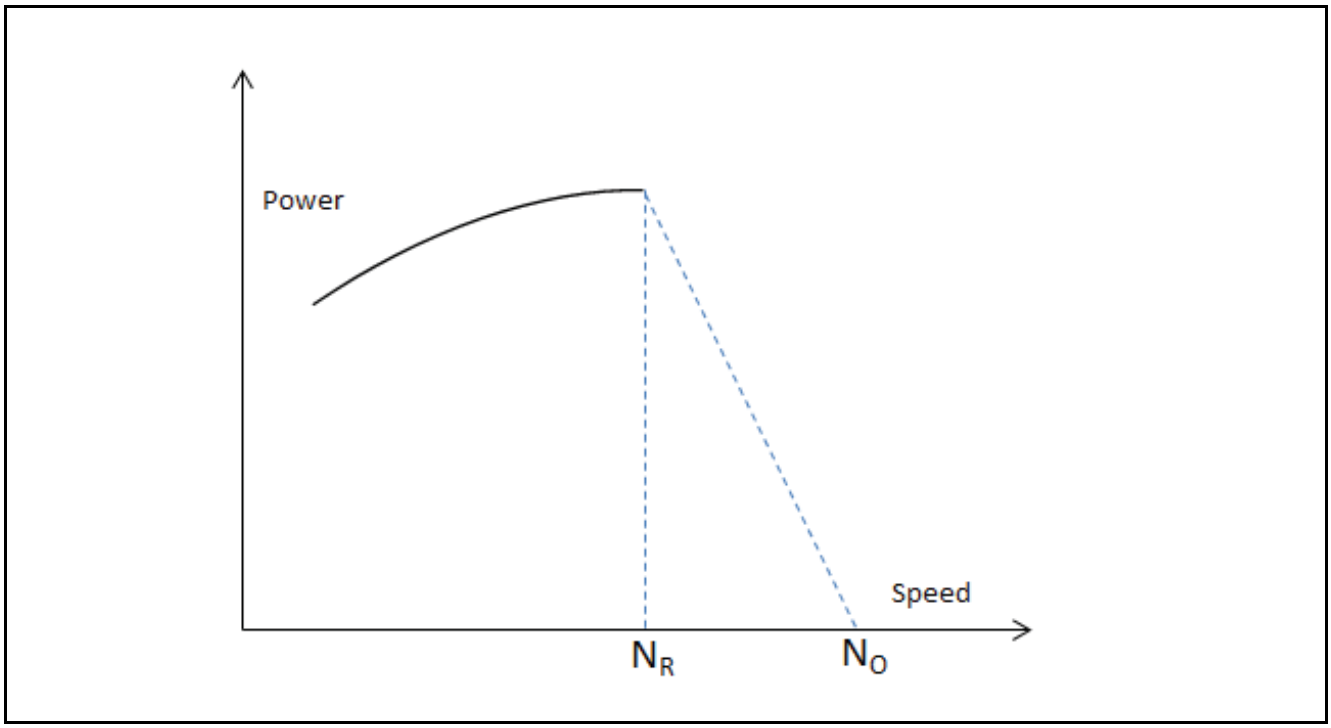
Engine Speed Control

The rpm and frequency of generator engines is controlled by the engine governor. HD Hyundai Infracore provides two types of engines: those with a mechanical governor and those with an electric governor. (Engines equipped with a common rail system are controlled by an ECU without a separate governor)
The difference between the unloaded rpm and the rated load rpm is referred to as the speed droop; this is calculated as follows.

$$\text{Speed droop \%} = \frac{\textit{No load speed } (N_O) - \textit{Full load speed } (N_R)}{\textit{Full load speed } (N_R)} \text{ X } 100$$



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The governing characteristics of HD Hyundai Infracore engines satisfy G2 class (G3 in the case of some engines indicated otherwise) of ISO8528; the relevant specifications are provided below.

- Steady state speed band (S.S.S.B.): ≤ 1.5%
- Speed droop: ≤ 5%
- Recovery time: ≤ 5 sec
- Undershoot: Manufacturer regulations (sudden power increase/one-step load)
  Frequency difference: ≤ 10%
- Overshoot: 100% to 0 (sudden decrease of load)
  Frequency difference: ≤ 12%

2. Engine Performance

3. Generator Mounting

General Information

The engine and generator are normally connected directly to one another. They are mounted on the bed frame in this connected state, while the bed frame is placed on a foundation of suitable strength and weight.
The mounting position and method of securing the engine and generator have a direct impact on the stability and vibrations of the generator set, so the relevant inspection items must absolutely be checked. For ease of machine maintenance and service, the installation and layout must enable access to filters and belts which require replacement as well as engine oil which must be refilled and coolant, etc. which must be inspected periodically.

Bed Frame

The engine and generator are secured as an assembled unit to the mounting pad of the bed frame with bolts.
The pad of the bed frame on which the engine and generator are mounted must have a flat, even square shape, and the two parts must be connected parallel to one another.
The surface of the mounting pad must not be deformed under any circumstances, and the bed frame must be strong enough to support not only the weight of the engine and generator unit but also the vibrations and various external forces which occur while the engine is running.

Generator Set Foundation

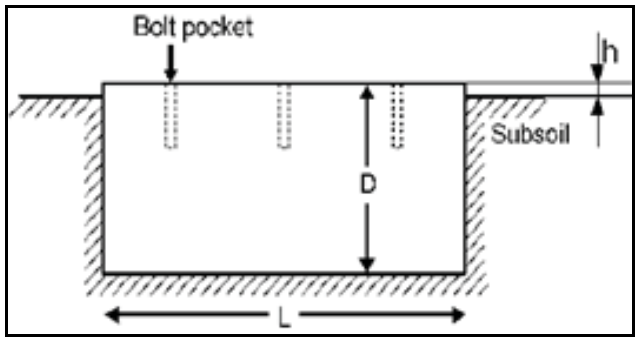
The generator set's foundation must be strong enough to withstand both its own weight and the vibrations and external forces which occur while the engine is running. Take particular care to ensure that harmful vibrations from engine operation do not affect other machines or buildings. In addition, make sure to secure the parts sufficiently and stably in order to prevent the alignment of the engine and generator unit from being affected by torsional forces during engine operation.
The total weight of the generator set refers to the total weight of the set including both fluids such as coolant, fuel, and lubricant which are supported by the foundation as well as auxiliary devices. The place upon which the foundation rests must be made of a material capable of withstanding the total weight of the generator set.

Ground and Foundation

The heavier the foundation, the fewer vibrations are transmitted to the engine, so make sure to select a foundation whose weight is sufficient for the weight of the generator set. Although the foundation may be installed on concrete, a metal structure or on the bare ground, it is recommended to install it on a separate concrete structure.
The length and width of the foundation must be at least 400 mm greater than the length and width of the generator set. In the case of a concrete foundation, the depth is determined as follows.
The length and width of the foundation must be at least 400 mm greater than the length and width of the generator set. In the case of a concrete foundation, the depth is determined as follows.

D = Depth of foundation (base)
W = Total weight of generator set (kg)
2402.8 = Density of concrete (kg/m^3)
B = Width of foundation (base) (m)
L = Length of foundation (base) (m)

$$\text{Depth D (m)} = \frac{W}{2{,}402.8 \times B \times L}$$



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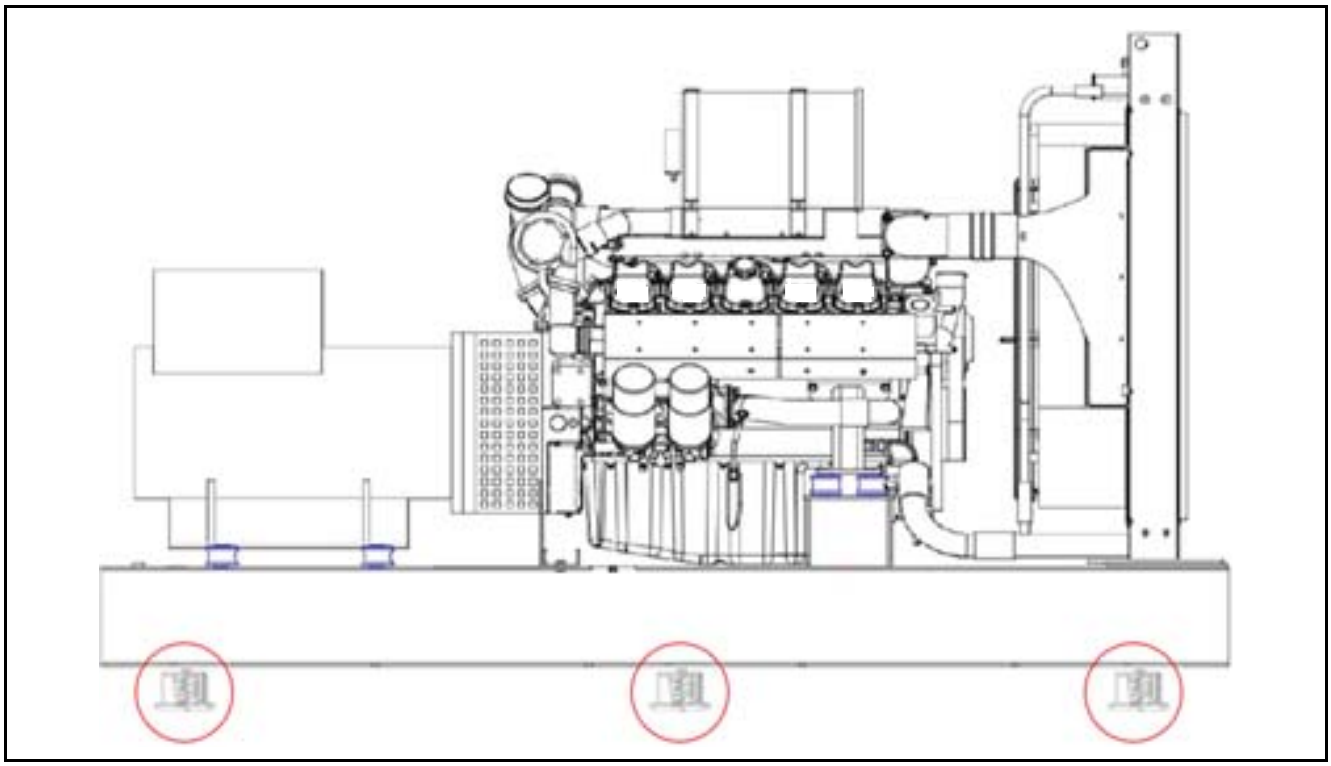
When generator sets are operated in parallel, the foundation must be made firmer than when an individual generator is operated in order to prevent the generator sets from going out of sync with one another as well as the withstand torque rebound.

In other words, the base of the foundation must be designed to withstand around three times the total weight of the generator set(s) installed on the foundation.

Anti-Vibration Unit

In general, when a generator is installed in a building, it is recommended to install a rubber plate or vibration isolator between the bed frame and foundation in order to reduce the vibrations conveyed to the base of the foundation or transmitted from the outside.
The anti-vibration unit must be installed in a place where the weight of the generator set is evenly distributed; since abnormal vibrations may occur as the unit passes through the resonance point when starting or stopping the engine, any external installations (ex. exhaust pipes, etc.) connected to the generator set must be connected using flexible couplings to prevent faults resulting from vibrations.



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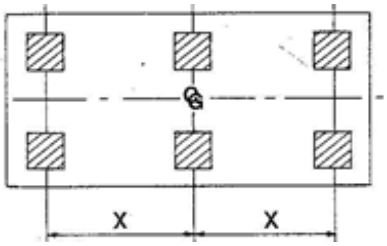
The foundation must be stronger than the anti-vibration unit when such a unit is installed. Otherwise, the foundation acts as another spring. In addition, all pipes, cables and ducts must be flexible in order to respond to deformation caused by vibrations when an anti-vibration unit is installed.

Installation Location of Anti-Vibration Unit

- When supporting six points (large engine)
  One pair of points must be located below the center of gravity, while the two remaining pairs must be located at equal distances from both ends of the frame.



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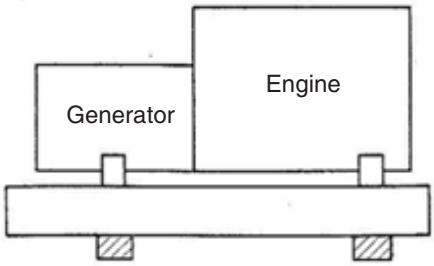
- When supporting four points (small engine)
  Both the engine and the generator unit require a pair of mounting points.



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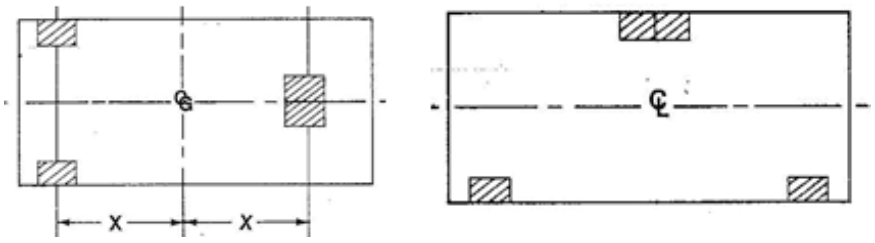
- When supporting three points
  Three mounting points with an equal load distribution are required.



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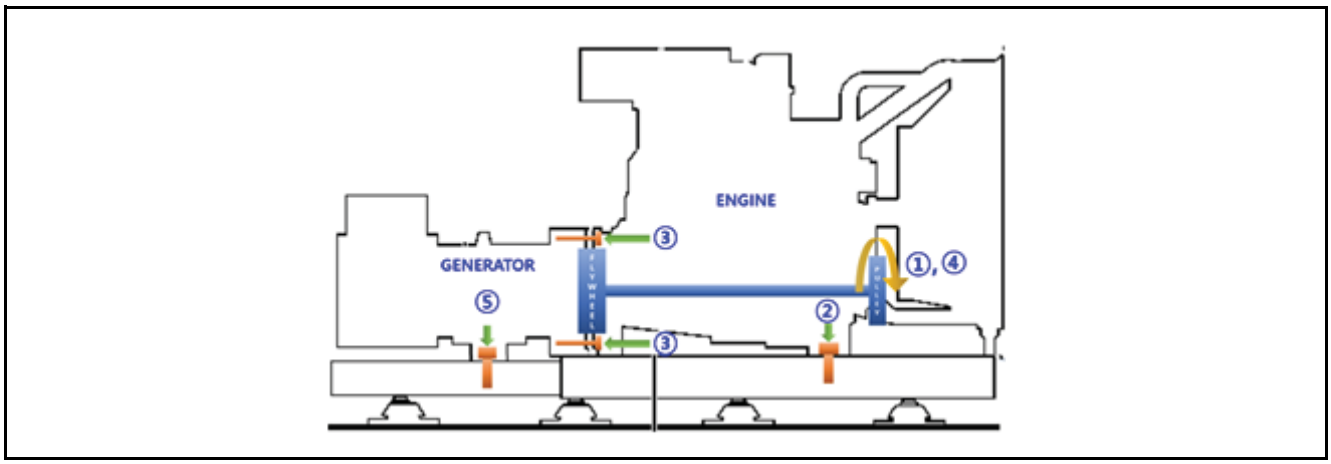
3. Generator Mounting

Procedure and Method of Connecting Generator and Engine

Connect the generator and the engine in the following order when assembling the alternator set.

① As shown in no. 1 in the following figure, turn the CRS pulley and check whether it rotates smoothly.
② Fasten two mounting points on the engine to the frame with bolts.
③ Assembling the alternator and engine, in this step, the alternator mounting points must not be fastened fully on the frame.
④ After the alternator and the engine have been assembled, turn the CRS pulley again and make sure that it rotates smoothly.
⑤ Fasten two mounting points on the alternator to the frame.
⑥ After the assembly is completed, the maximum radial misalignment must be less than 0.02 mm and turn the CRS pulley again and make sure that it rotates smoothly.

If the assembly order above is not followed, the engine thrust washers, CRS and bearings may be damaged.



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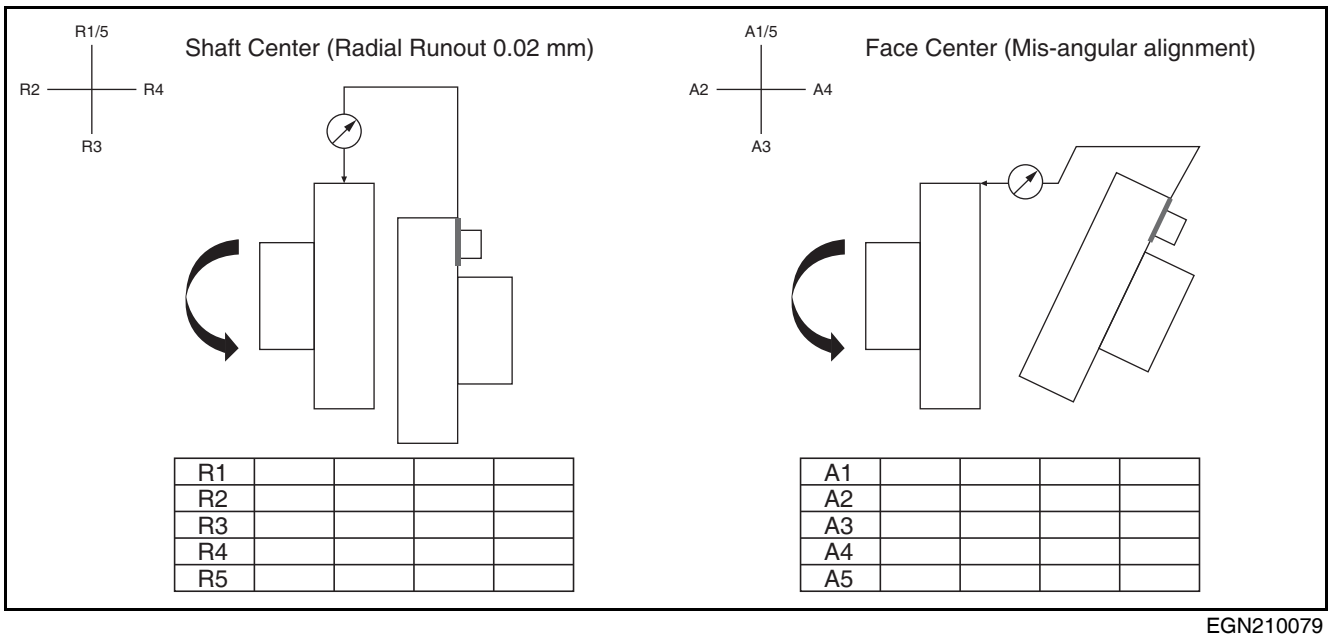

R1				
R2				
R3				
R4				
R5				

A1				
A2				
A3				
A4				
A5				

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⚠CAUTION

After completing Engine & Genset Mounting, write up Angular Misalignment using Dial-Gauge, etc.
For R1 ~ R5 & A1 ~ A5 directions, it should be checked whether the measured value falls within the spec required by each Genset Coupling.

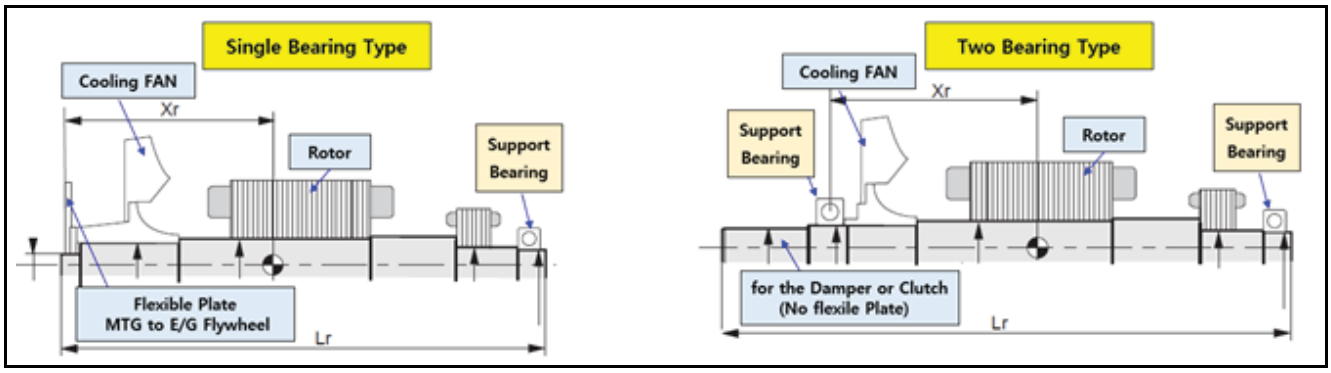
Engine and Generator Mounting

The generator set, including the engine, may be supported by four or six points depending on the conditions described below. During installation, make sure to comply with the instructions in “Procedure and Method of Connecting Generator and Engine” above.

Make sure to install a mounting cushion between the engine and the frame in order to insulate the engine vibrations. If a mounting cushion is not installed, the engine parts or the radiator may be damaged.

When connecting the engine and generator, make sure to satisfy the shaft misalignment standards as well as the additional guide provided by the manufacturer of the generator set. The completed generator set must undergo a performance test by the manufacturer.

1) Four-point support: When a single bearing type generator unit is used, the engine should have two support points at the front and the generator unit should have two or four support points.
2) Six-point support: When a two bearing type generator unit is used, the engine should have four support points at the front/rear and the generator unit should have two or four support points. The two bearing type generator unit must have a damper or clutch installed when connecting the generator unit to the flywheel.



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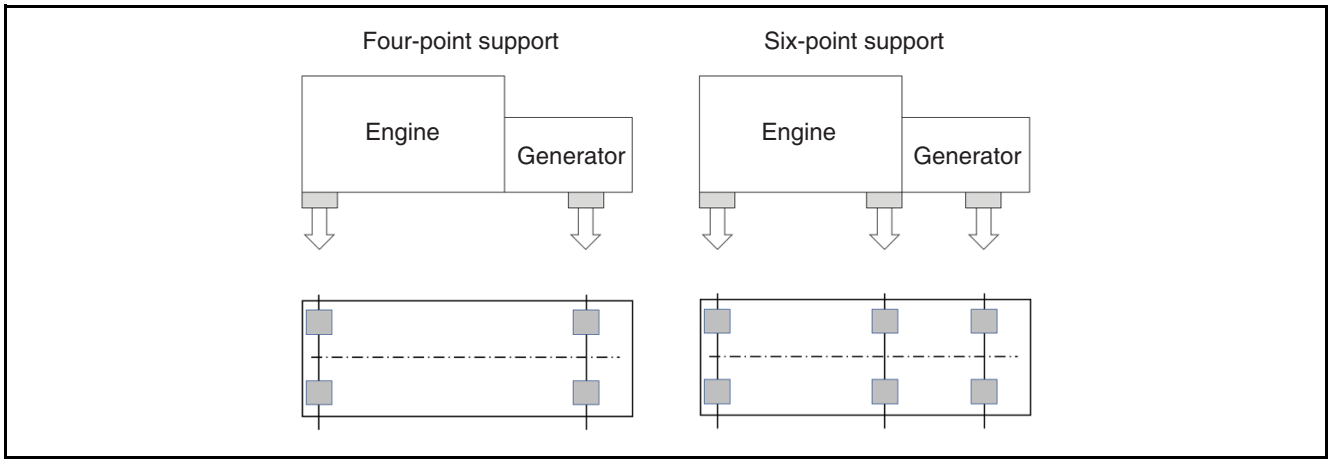


EGN210063

The engine weight for selecting a mounting cushion should be assumed to be 1.5 times the total weight (wet weight), and each mounting cushion should be arranged so as to properly distribute the engine's dynamic load in order to effectively insulate the engine vibrations.

In order to select a rubber mounting for the generator set, the engine weight and center of gravity as well as the load received by each mounting and its location must be checked. For information on how to calculate this, refer to "Calculating Center of Gravity" below. The center of gravity of the entire set must be factored into the calculation of the center of gravity of the engine generator unit.

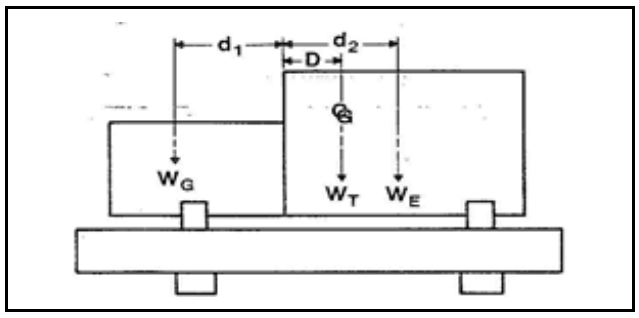
3. Generator Mounting

Calculating Center of Gravity (For Four Support Points)

- Combined center of gravity
  After all equipment has been installed, calculate and determine the center of gravity. In order to calculate the center of gravity, choose the center of an arbitrary place and determine d_1 and d_2 with reference to that place. The center of gravity must be calculated again if equipment is added or removed.

$$W_T (D) = W_G (-d_1) + W_E (d_2)$$

$$D = \frac{W_E (d_2) - W_G (d_1)}{W_T}$$

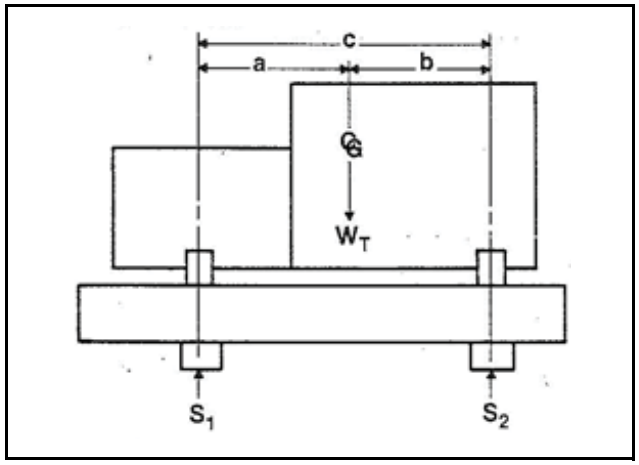


EGN210015

- Calculating individual load
  The mounting points are determined by determining the load for each respective mounting point based on the center of gravity.

$$S_1 = W_T \frac{b}{c}$$

$$S_2 = W_T \frac{a}{c}$$



EGN210016

4. Power Unit Mounting

General Information

The engine and power unit's power takeoff are connected directly to one another. They are either mounted on a bed frame in this connected state or placed on an independent foundation.
The mounting position and method of securing the engine and power takeoff have a direct impact on the stability and vibrations of the power unit, so the relevant inspection items must absolutely be checked. For ease of machine maintenance and service, the installation and layout must enable access to filters and belts which require replacement as well as engine oil which must be refilled and coolant, etc. which must be inspected periodically.

Bed Frame

When the engine and power take-off are mounted on the bed frame as an assembled unit, the pad must be flat, even and square-shaped, and the parts must be connected to each other in parallel.
The surface of the mounting pad must not be deformed under any circumstances, and the bed frame must be strong enough to support not only the weight of the engine and power unit but also the vibrations and various external forces which occur while the engine is running.

Power Unit Set Foundation

As with the generator, the power unit set's foundation must be strong enough to withstand both its own weight and the vibrations and external forces which occur while the engine is running. Take particular care to ensure that harmful vibrations from engine operation do not affect other machines or buildings. In addition, make sure to secure the parts sufficiently and stably in order to prevent the alignment of the engine and power unit from being affected by torsional forces during engine operation.
The total weight of the power unit set refers to the total weight of the set including both fluids such as coolant, fuel, and lubricant which are supported by the foundation as well as auxiliary devices. The place upon which the foundation rests must be made of a material capable of withstanding the total weight of the generator or power unit set.

Ground and Foundation

The heavier the foundation, the fewer vibrations are transmitted to the engine, so make sure to select a foundation whose weight is sufficient for the weight of the generator or power unit set. Although the foundation may be installed on concrete, a metal structure or on the bare ground, it is recommended to install it on a separate concrete structure.

Refer to the section on the generator mounting foundation for the foundation installation standards.

Anti-Vibration Unit

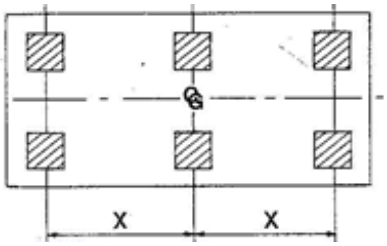
In general, when a power unit set is installed in a building, it is recommended to install a rubber plate or vibration isolator between the bed frame and foundation in order to reduce the vibrations conveyed to the base of the foundation or transmitted from the outside.
The anti-vibration unit must be installed in a place where the weight of the power unit set is evenly distributed; since abnormal vibrations may occur as the unit passes through the resonance point when starting or stopping the engine, any external installations (ex. exhaust pipes, etc.) connected to the power unit set must be connected using flexible couplings to prevent faults resulting from vibrations.

The foundation must be stronger than the anti-vibration unit when such a unit is installed. Otherwise, the foundation acts as another spring. In addition, all pipes, cables and ducts must be flexible in order to respond to deformation caused by vibrations when an anti-vibration unit is installed.

4. Power Unit Mounting

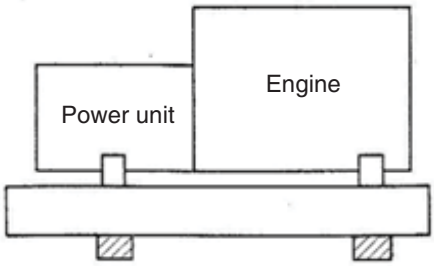
Installation Location of Anti-Vibration Unit

- When supporting six points (large engine)
  One pair of points must be located below the center of gravity, while the two remaining pairs must be located at equal distances from both ends of the frame.



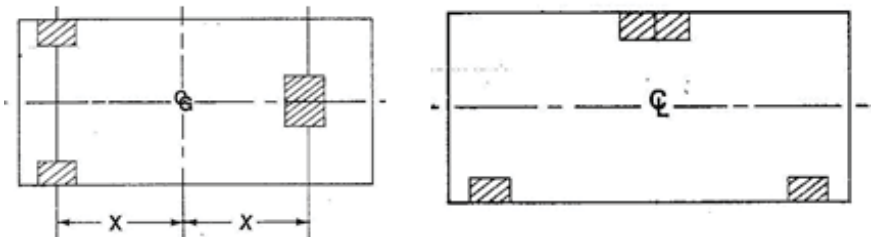
EGN210009

- When supporting four points (small engine)
  Both the engine and the generator unit require a pair of mounting points.



EGN210017

- When supporting three points
  Three mounting points with an equal load distribution are required.



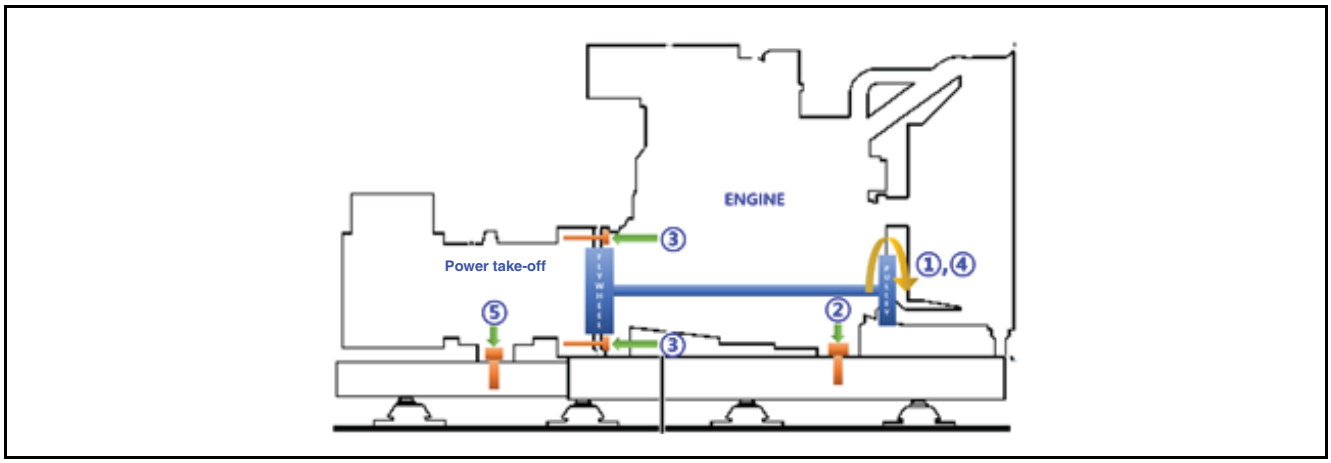
EGN210011

Procedure and Method of Connecting Power Takeoff and Engine

When assembling the power takeoff, connect it to the engine in the following order.

1. Cases where the engine and the power takeoff are connected directly to the flywheel housing without a clutch or universal joint between them.
   - ① As shown in no. 1 in the following figure, turn the CRS pulley and check whether it rotates smoothly.
   - ② Fasten two mounting points on the engine to the frame with bolts.
   - ③ Assemble the power takeoff and the engine. In this stage, the power takeoff must not be mounted on the frame.
   - ④ After the power takeoff and the engine have been assembled, turn the CRS pulley again and make sure that it rotates smoothly.
   - ⑤ Fasten two mounting points on the power takeoff to the frame.
   - ⑥ After the assembly is complete, the maximum radial misalignment must be less than 0.02 mm.

If the assembly order above is not followed, the engine thrust washers, CRS and bearings may be damaged.

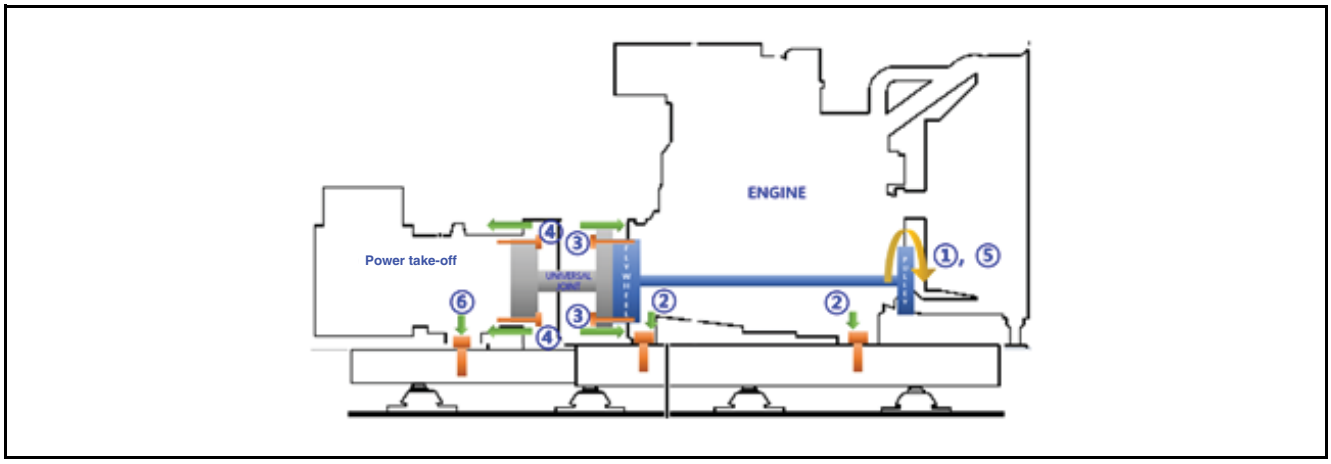


EGN210018

2. Cases where a clutch or universal joint is installed on the flywheel between the engine and the power takeoff.
   - ① As shown in no. 1 in the following figure, turn the CRS pulley and check whether it rotates smoothly.
   - ② Fasten four mounting points on the engine to the frame with bolts.
   - ③ Install the coupling for connecting the universal joint on the engine flywheel. In this stage, the power takeoff must not be mounted on the frame.
   - ④ Assemble a coupling on the power takeoff as well and connect the universal joint.
   - ⑤ After the power takeoff and the engine have been aligned, turn the CRS pulley again and make sure that it rotates smoothly.
   - ⑥ Fasten two mounting points on the power takeoff to the frame.
   - ⑦ After the assembly is complete, the maximum radial misalignment must be less than 0.02 mm.

If the assembly order above is not followed, the engine thrust washers, CRS and bearings may be damaged.

4. Power Unit Mounting



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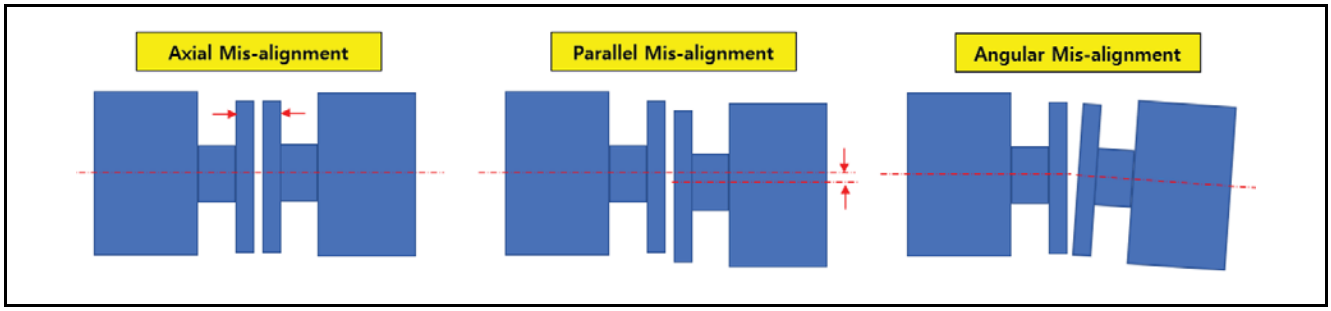
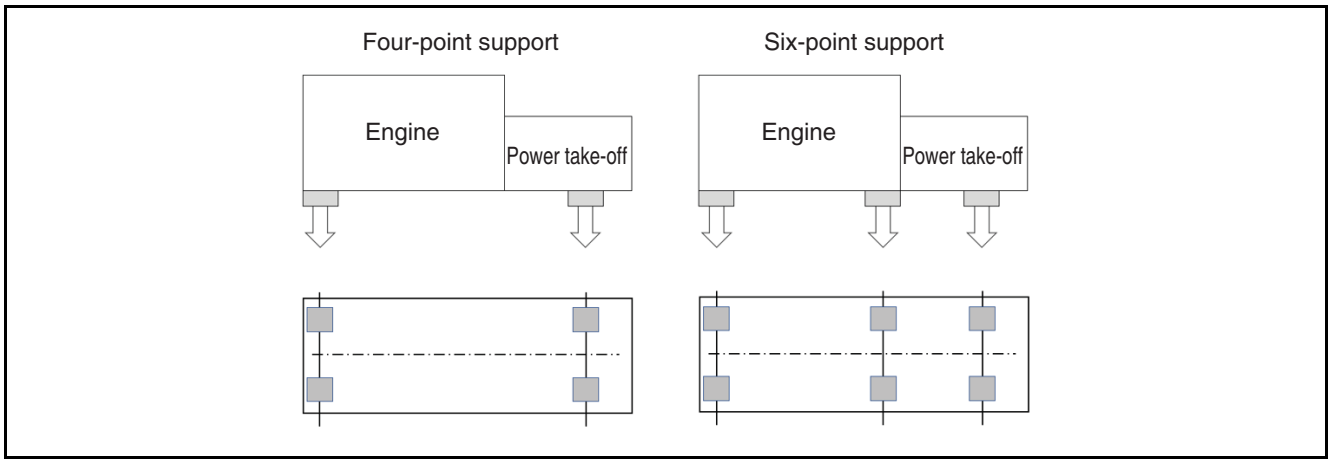


EGN210020

Engine and Power Unit Mounting

When the engine is used as a power unit, the engine may be supported by four or six points depending on the conditions described below. During installation, make sure to comply with the instructions in "Procedure and Method of Connecting Generator and Engine."
Make sure to install a mounting cushion between the engine and the frame in order to insulate the engine vibrations. If a mounting cushion is not installed, the engine parts or the radiator may be damaged. In addition, make sure to satisfy the additional guidelines from the manufacturer of the power unit set. The completed power unit set must undergo a performance test by the manufacturer.

1) Four-point support: If there is only one support bearing supporting the main shaft of the power takeoff, the engine should have two support points at the front and the power takeoff housing should have two or four support points.
2) Six-point support: If there are two support bearings supporting the main shaft of the power takeoff, the engine should have four support points at the front/rear and the power takeoff housing should have two or four support points. When a power takeoff with two support bearings is connected to the engine flywheel, it must have a clutch, damper, or universal joint.



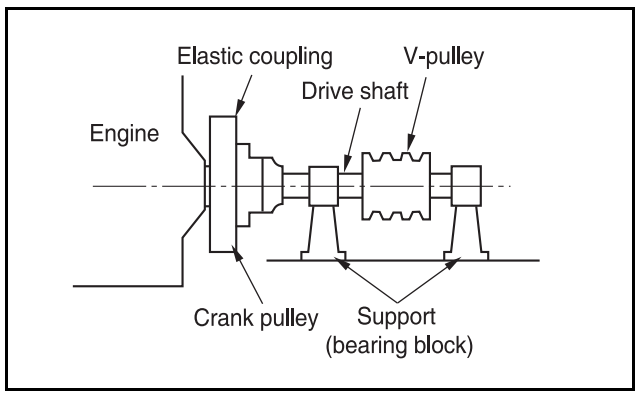
EGN210063

Front of Engine Power Takeoff (F.P.T.O.)

All auxiliary devices connected to and driven directly by the engine's crank pulley affect mostly warpage and vibrations in the engine. Excessive warpage and vibrations not only cause noise, gear malfunction and premature wear of the main bearing but can even cause damage to the crankshaft in severe cases.
Take care not to exceed the maximum usable limit for the front power takeoff recommended for each of the following models. These are the maximum values for power which can be transmitted by each clutch.

Maximum Usable Limit of Front of Engine Power Takeoff (maximum F.P.T.O.)

In order to use the front power takeoff properly, install an elastic coupling on the front of the pulley as shown in the figure, connecting the engine to the PTO pulley (V-pulley) and driveshaft. Then, install two bearing blocks capable of firmly supporting the PTO pulley and driveshaft at the front and rear. HD Hyundai Infracore recommends installing the front power takeoff (FPTO) in this way in order to prevent engine warpage and vibrations.
When using the FPTO to install the driveshaft of attachments, the alignment of the center of the shaft and the center of the contact surface must have a concentricity of less than 0.02 mm. The following table indicates the maximum capacity which can be applied to each model when auxiliary power is obtained in the way described earlier.



EA4O7001

<Maximum allowable torque of front power takeoff>

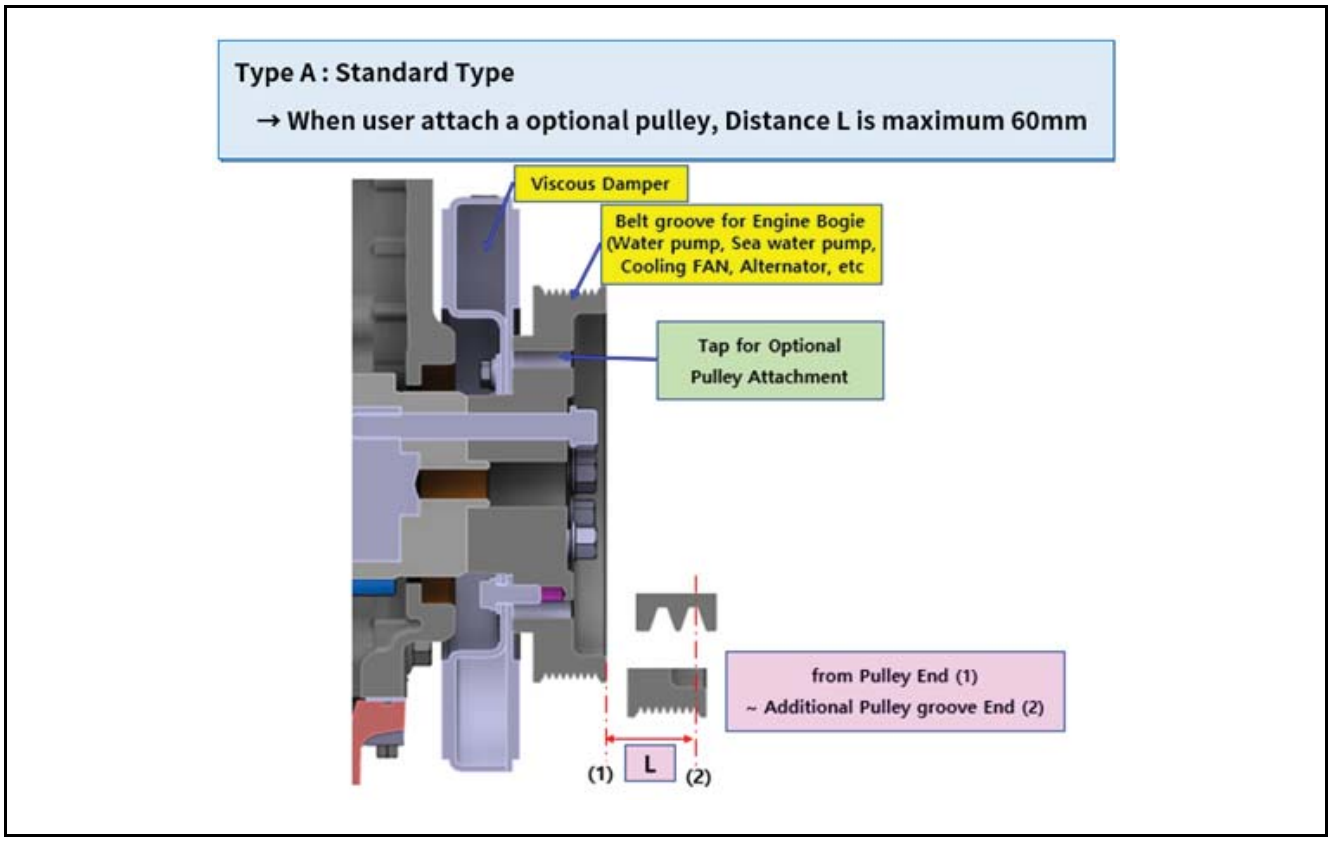
Engine Model	Rotational torque (kg.m)
D1146/PU086	60
PU126	80
PU158/180/222	140

⚠CAUTION

The maximum usable capacity of auxiliary power shown in the table above applies when the rear (flywheel) power is not used.

Maximum Allowable Power Takeoff in Open State

In the event that a support bearing is not used on the front of the PTO pulley as shown in the figure, the usable capacity varies significantly depending on how far the PTO pulley is from the tip of the crank pulley.
When power is obtained in this way, engine parts can be damaged easily (cracks in the crank pulley and bolts, premature wear of the main bearing, broken clutch, etc.) depending on the size of the load. Hence, it is safer to install a support bearing on the front whenever possible.
(Installing the PTO in this way is not advisable, so try to install the front power takeoff with a support bearing whenever possible.)
If auxiliary power is used as shown in the figure, make sure that the distance (L) from the tip of the crank pulley to the center line of the groove in the V-pulley is less than 60 mm for the sake of safety. (See figure)



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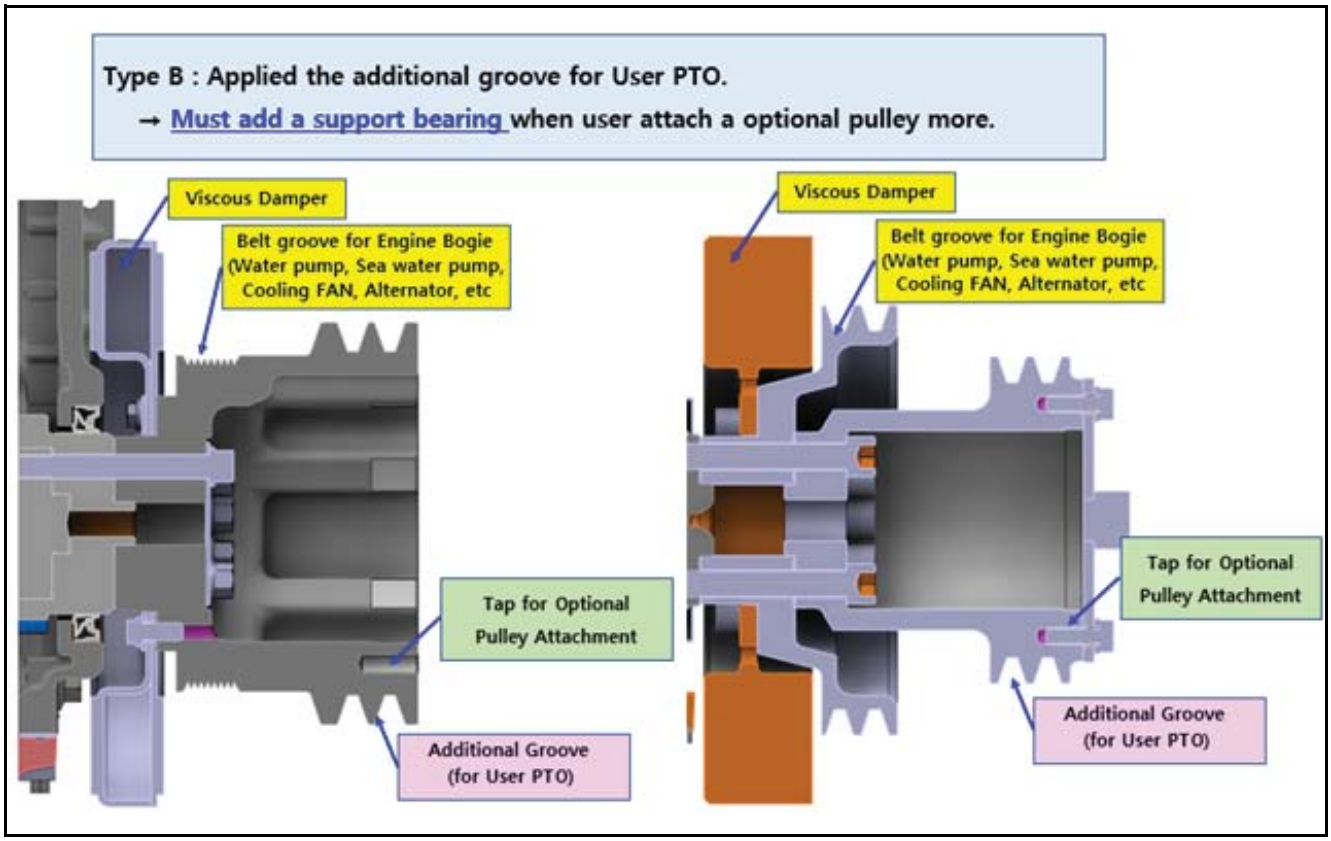


EGN210022

<Maximum allowable capacity of open power takeoff> (Distance L = max. 60 mm)

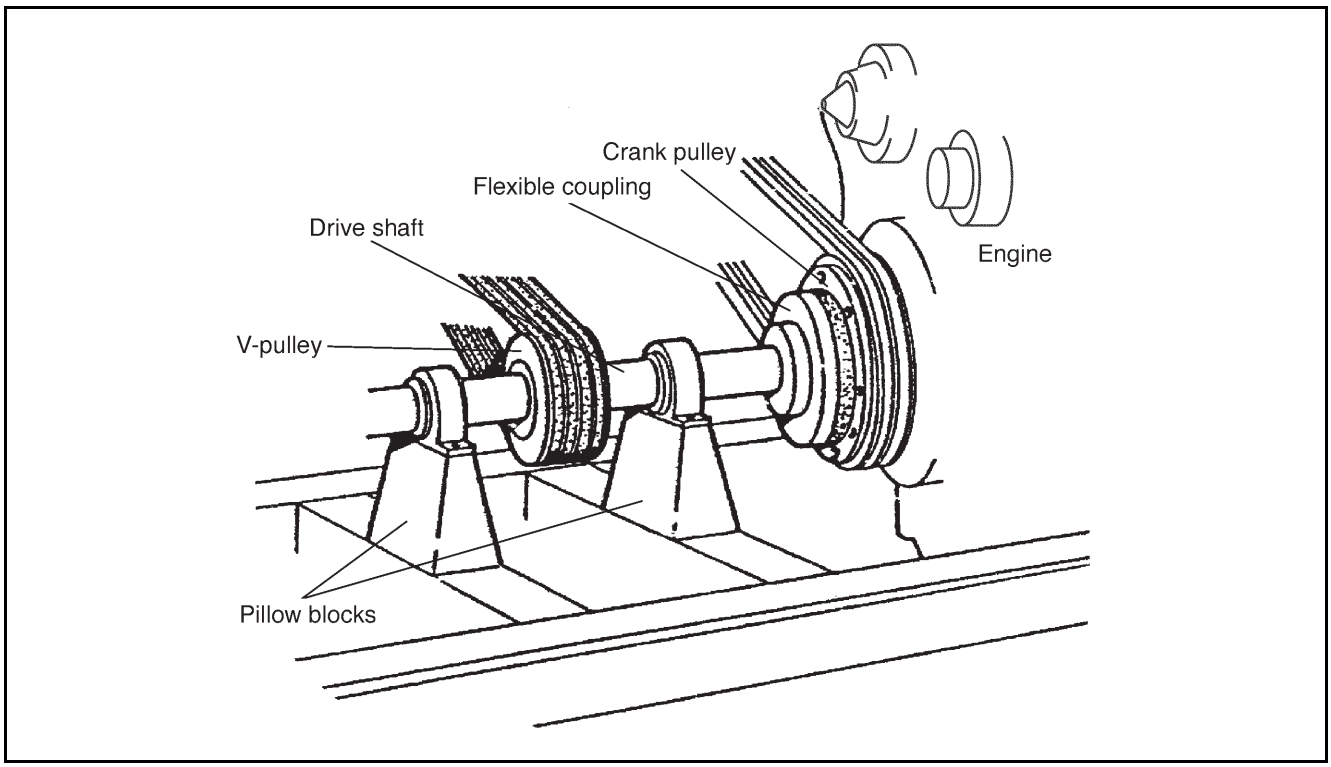
Engine Model	Rotational torque (kg.m)
D1146/PU086	60
PU126	80
PU158/180/222	140

⚠ CAUTION

The usable capacity above indicates the maximum usable capacity when the rear (flywheel) power is used.

Belt-Driven

As explained earlier, the shorter the distance between the groove in the pulley on the attachment and the tip of the crank pulley, the greater the load that can be used, while the risk of cracks, etc. becomes greater as the distance increases. In this stage, it is advisable to install a support bearing on the front in order to prevent warpage of the shaft. In addition, when more than one auxiliary power unit (generator, winch, etc.) driven by a belt run by the marine engine is used simultaneously as shown in the figure, make sure to install two bearing supports in order to minimize the direct lateral traction on the engine crank pulley and crankshaft.

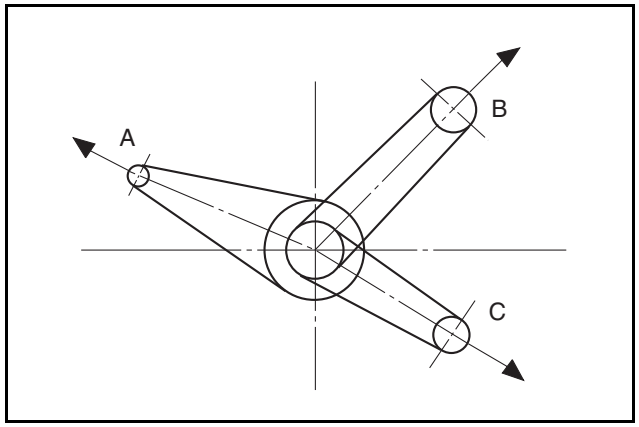


EB0O3002

Furthermore, when a V-belt pulley and flange combination is used as shown in the figure, it is advisable to cover the V-belt and flange suitably (install a protective cover) in order to prevent accidents.

- The bracket required to install an auxiliary power unit must be capable of withstanding the static and dynamic loads of the attachment, and it must be installed in order to minimize or prevent vibrations which occur within the normal operating range of the engine.
  If natural resonance occurs on the bracket within the engine's operating range, the bracket may be damaged by the effect of resonance when operating in that range. Keep this in mind during installation.
  When installing an attachment on the engine, make sure that the installation bracket can be mounted on the firm body of the engine such as the cylinder block and cylinder head whenever possible.
  Attachments must not be installed in weak places such as places which must be disassembled for regular engine maintenance or on gasket connections, etc.
- When selecting the location and capacity of the auxiliary power unit's drive unit, make sure to consider factors which may change the load of the attachment. Accordingly, when deciding on the load (capacity) of the auxiliary power unit, refer to the following design reference information described in this installation manual.

First, since the auxiliary power unit's load varies even during normal operation, a sufficient design safety factor must be multiplied with the rated power of the auxiliary unit in order to determine the maximum load (capacity) of the additional auxiliary unit applied to the engine.
Second, when mounting a belt-driven auxiliary power unit, the load applied to the crankshaft and bearing varies significantly depending on the crankshaft pulley's load and the installation direction of the drivetrain, so both the operating load and the direction of the load are extremely important. In order to mount and use two or more belt-driven auxiliary power units using a single pulley, it is advisable to install the auxiliary units in opposite directions in order to minimize the load on the shafts and to cancel out the force applied to the belts.



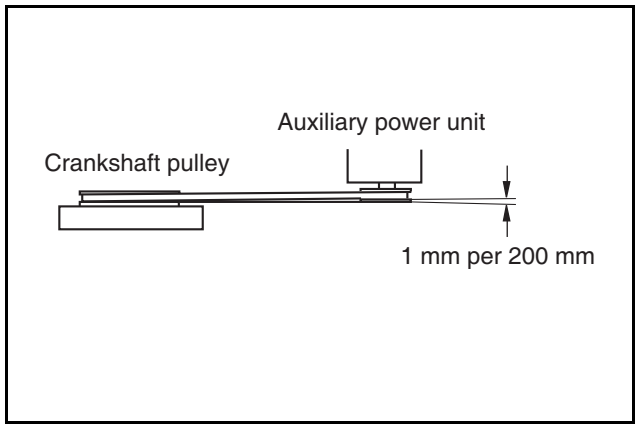
EB0O3003

⚠CAUTION

Avoid increasing the groove in the pulley or the width of the belt as this may endanger the safe load permitted for the crankshaft.

All auxiliary power units mounted on the front of the crankshaft affect crankshaft warpage, lateral tensile loads, torsional vibrations, and the load capable of being withstood by the crank pulley bolt connections, etc. Hence, the potential effects of installing attachments must be thoroughly examined prior to installation.

- Belt-driven auxiliary units must be aligned with a tolerance of less than 1 mm per 200 mm between the two pulleys.
  If the crank pulley and the auxiliary power unit's pulley are not aligned in a straight line, the belt between the two pulleys may be worn out or come off the pulleys, and the bending force of the belt is applied to the shaft, resulting in damage to the bearing and belt.
  Normally, a straightedge is used to check the straightness of the alignment.



EB0O3004

⚠CAUTION

In order to adjust a newly replaced belt, break in the engine for 10 to 15 minutes; then, adjust the tension again. This is to prevent the new belt from stretching and sagging, slipping, or coming off the pulley.

4. Power Unit Mounting

5. Cooling System

General Information

This engine is water-cooled. After coolant absorbs combustion heat from the combustion chamber and heat from engine oil in the oil cooler, it releases the heat to the outside by means of a radiator to ensure normal engine operation. In the cooling system, coolant supplied from the coolant pump flows to the oil cooler through the coolant pipe to absorb heat from the oil. Then, as it passes through the coolant jacket of the cylinder block and the cooling passage of the cylinder head, it absorbs combustion heat. This coolant which has absorbed the heat from oil and combustion flows into the thermostat through the coolant pipe. If the coolant temperature is lower than the valve opening temperature of the thermostat, the coolant flows directly into the coolant pump. If the coolant temperature is higher than the valve opening temperature, it flows to the radiator and is cooled by the cooling fan; then, it flows back to the coolant pump.
An intercooler which cools turbocharged air is used to increase engine power and reduce emissions. This engine is equipped with an air-cooled intercooler installed in the radiator assembly.
Since the cooling system is affected by the engine's ambient temperature and altitude, the operating conditions must be changed according to the various ambient environmental conditions such as the maximum ambient temperature and the altitude. Sometimes, the engine power must be lowered (derating) in order to prevent engine overheating; for more information about this, refer to the derating chart on the specification sheet.
If an additional cooling unit which uses engine coolant is used, the additional cooling performance must be checked. Since cooling performance may vary depending on changes in the airflow around the engine, precautions must also be taken when an additional air-cooled cooling unit is used.

Cooling Performance

The engine cooling performance is determined by the engine's heat radiation and cooling system specifications.

- Radiator
- Cooling fan type and O.D.
- Cooling fan rotation ratio
- Cooling fan ring type and fan location
- Engine room and air duct
- Additional cooling unit

Coolant System

The cooling system serves to discharge thermal energy from the engine and its various components through the radiator. The cooling system consists of the following circuits, including coolant.

- Engine and radiator circuit
- Engine oil cooler circuit
- Intercooler
- Expansion tank and deaeration circuit

It may also include the following additional circuit.

- Engine heater circuit (jacket heater)

5. Cooling System

Selecting Coolant

Make sure to use coolant with the specifications recommended by HD Hyundai Infracore to ensure sufficient heat transfer and to prevent corrosion and freezing of cooling system components. The amount of antifreeze in winter may vary depending on the ambient temperature as shown in the table below. HD Hyundai Infracore recommends a mixture of around 40 - 50% antifreeze in the total coolant in order to prevent freezing and corrosion in the cooling system. Each freezing point by antifreeze ratio in the table differs slightly depending on the type of antifreeze. For details, refer to the specifications provided by the antifreeze manufacturer. Make sure to also add 3 - 5% additive (DCA4) for preventing corrosion.

Ambient temperature (°C)	Coolant (%)	Antifreeze (%)
-20	67	33
-25	60	40
-30	56	44
-40	50	50

⚠CAUTION

Keep the concentration at 50%; it must remain at over 30% to ensure the minimum anti-corrosive effect.

In addition, tap water used with antifreeze must be clean water as per ASTM D4985 standards; the specifications are provided below.

Item	Standard
Total solid particles	< 340 ppm
Total hardness	< 9.5° dH
Chloride	< 40 ppm
Sulfate	< 50 ppm
pH value	5.5 - 9
Silica (to ASTM D859)	< 20 mg SiO2/l
Iron (to ASTM D1068)	< 0.10 ppm
Manganese (to ASTM D858)	< 0.05 ppm
Conductivity (to ASTM D1125)	< 500 µS/cm
Organic content, CODMn (to ISO8467)	< 15 mg KMnO4/l

In the case of HD Hyundai Infracore antifreeze, we recommend using ethylene glycol. HD Hyundai Infracore recommends using specifications without the following components in order to satisfy ASTM-D3066 standards.

- Free (amine, silicate, borate, nitrite)

To add coolant, open the radiator cap when the engine is cool and poor the coolant in slowly. Make sure to check whether air can escape from the cooling system; check the coolant level after warming up the engine and add more if necessary.

⚠DANGER

Never open the coolant pressure cap while the engine is hot. The hot steam inside may cause burns.

⚠CAUTION

When adding coolant, take care to ensure that foreign matter does not enter the engine, and make sure to add coolant through the coolant inlet.

Cooling Circuit Components (Engine and Radiator Circuit)

The cooling circuit includes the following parts.

- Coolant pump
- Cooling jacket in the cylinder block and cylinder head
- Thermostat
- Bypass pipe connecting the thermostat and coolant pump
- Radiator
- Pipes and hoses

For detailed specifications concerning the cooling circuit and cooling performance, refer to the Operation and Maintenance Manual.

Coolant Pump

The coolant pump is driven by a belt or gear; for information on the coolant flow rate of each engine, refer to the Operation and Maintenance Manual. The coolant pump is a centrifugal pump; the coolant flow rate is closely connected to the pressure resistance of the cooling system. If any other cooling unit is connected to the cooling system, the coolant flow rate decreases, so make sure to take the differential pressure characteristics of the parts into consideration before installing additional parts.

Thermostat

A thermostat is installed to keep the coolant temperature of the cooling system within a certain range. The thermostat closes when the engine is below a certain temperature, and when the engine coolant temperature increases past a certain temperature, the thermostat opens and the coolant flows into the radiator where it releases heat; then, the coolant circulates back to the coolant pump.

⚠CAUTION

The following phenomena occur if the thermostat is removed.

- **The engine warm-up time is delayed in normal ambient temperature conditions, and the coolant temperature may not increase to the optimal operating temperature when the engine is idling.**
- **The engine lubricant temperature does not rise to the optimal operating temperature, which may increase fuel consumption. In addition, the amount of exhaust gas or white smoke may increase, and the engine power may decrease slightly. If the engine runs continuously without the thermostat for an extended period of time, engine part wear accelerates, which may shorten the engine life.**
- **Only some of the coolant flows into the radiator, which may reduce cooling performance, and even if the coolant temperature sensor displays the correct coolant temperature, coolant flow may be interrupted in certain parts.**
- **If the engine is run with the thermostat removed, product quality cannot be guaranteed.**

Pipes and Hoses

Coolant pipes and hoses must be designed to enable smooth coolant flow. Make sure to avoid sudden bending, tightening, or sudden changes to the cross-sectional area as this may cause a loss of differential pressure. Hoses must also be free of problems at various coolant pressures and temperatures. The inside in particular must be resistant to ethylene glycol and anti-corrosives, while the outside must be resistant to fuel and lubricating oil. It is recommended that hoses be made of EPDM or silicone. The recommended specifications for hoses and pipes are as follows.

- The inside diameter of hoses should be slightly smaller than the outside diameter of pipes.
- The ends of all pipes must be corrugated to enhance seal quality.
- Pipes connected to the radiator must not be smaller than engine pipes.

Pressure Cap

Since coolant is incompressible, thermal expansion causes the pressure to rise suddenly. A pressure cap is used to prevent leaks or damage which may occur due to this increase in pressure within the system. When the pressure increases beyond a certain level, the cap opens and sends air out of the closed cooling system; then, when the pressure decreases again, the cap draws the air or coolant back into the system.
For information on pressure cap specifications, refer to the specification sheet.

Pressure cap	Boiling	Maximum allowable water outlet temperature			
		Sea level	1,500 m	2,500 m	3,500 m
No pressure	100°C	92°C	87°C	83°C	79°C
0.3 bar	107°C	99°C	95°C	92°C	89°C
0.5 bar	111°C	103°C	100°C	97°C	94°C
0.9 bar	114°C	106°C	105°C	104°C	100°C

Block Heater (Jacket Heater)

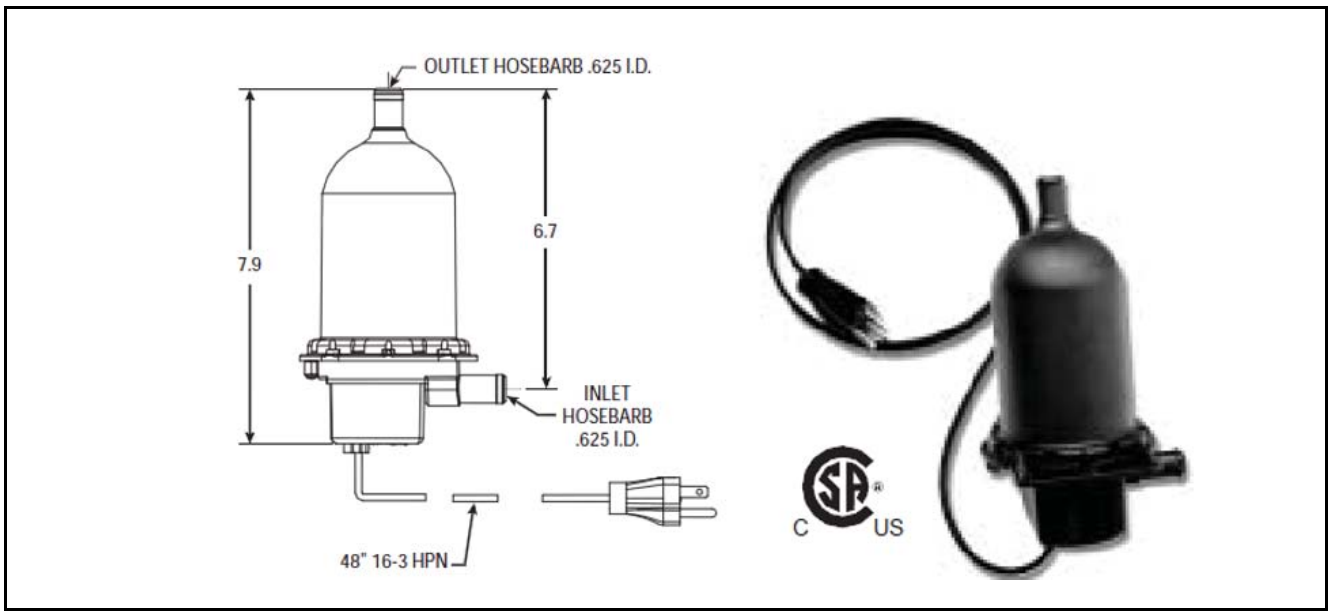
The engine heater is a device which heats the engine coolant. If the engine heater is run when the ambient temperature is cold, startability improves and the amount of white smoke decreases.

- Recommended heater operating temperature: -10°C or less

Although HD Hyundai Infracore does not provide a separate engine heater, a heater may be used depending on the operating environment. There are several types of heaters available, but HD Hyundai Infracore recommends the following types of heaters when mounting a heater on a HD Hyundai Infracore generator engine. The engine heater must use external AC power; if voltage from a battery mounted on the generator set is used, a separate battery charger which uses a constant external power supply must also be installed.

Small tank heater (500 - 2,000 watts)

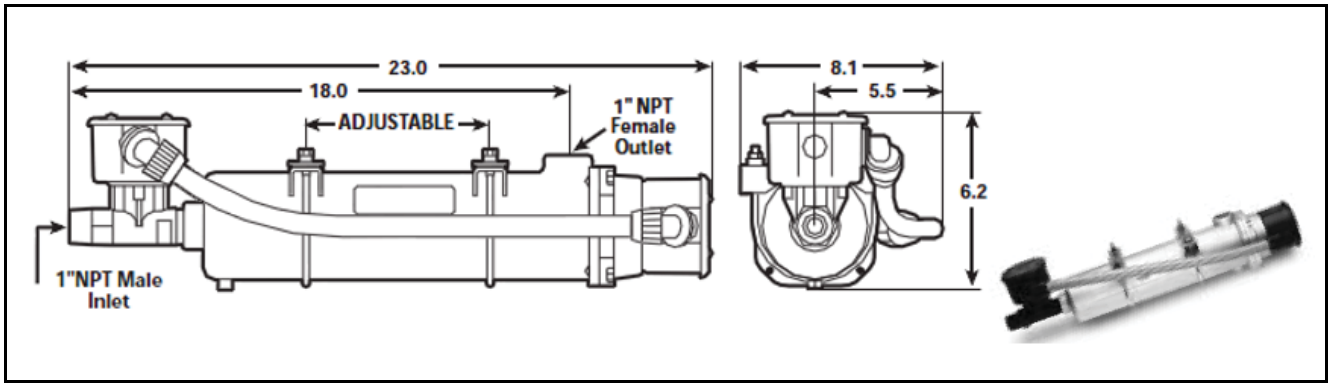
- Recommended for 11 liter (DL11) or smaller HD Hyundai Infracore generator engines models.
- Uses 1,000 to 1,500 watts depending on the size of the engine.
- For more details, HD Hyundai Infracore recommends contacting the heater manufacturer.



EGN210023

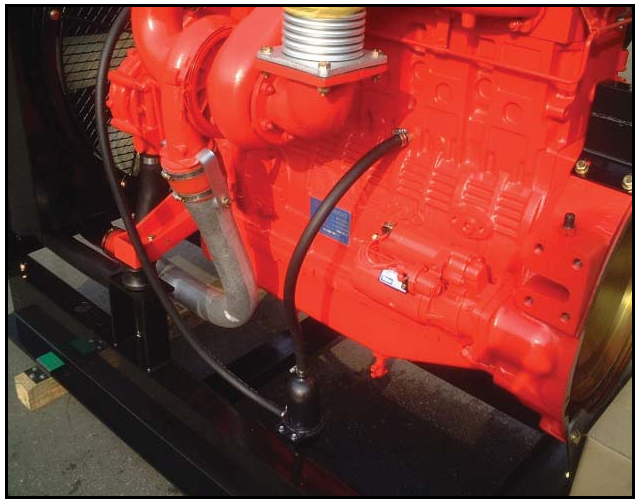
Industrial tank heater (1,500 - 5,000 watts)

- Recommended for 15 liter (DV15) or larger HD Hyundai Infracore generator engines models.
- Uses 2,500 to 3,000 watts depending on the size of the engine.
- For more details, HD Hyundai Infracore recommends contacting the heater manufacturer.



EGN210024

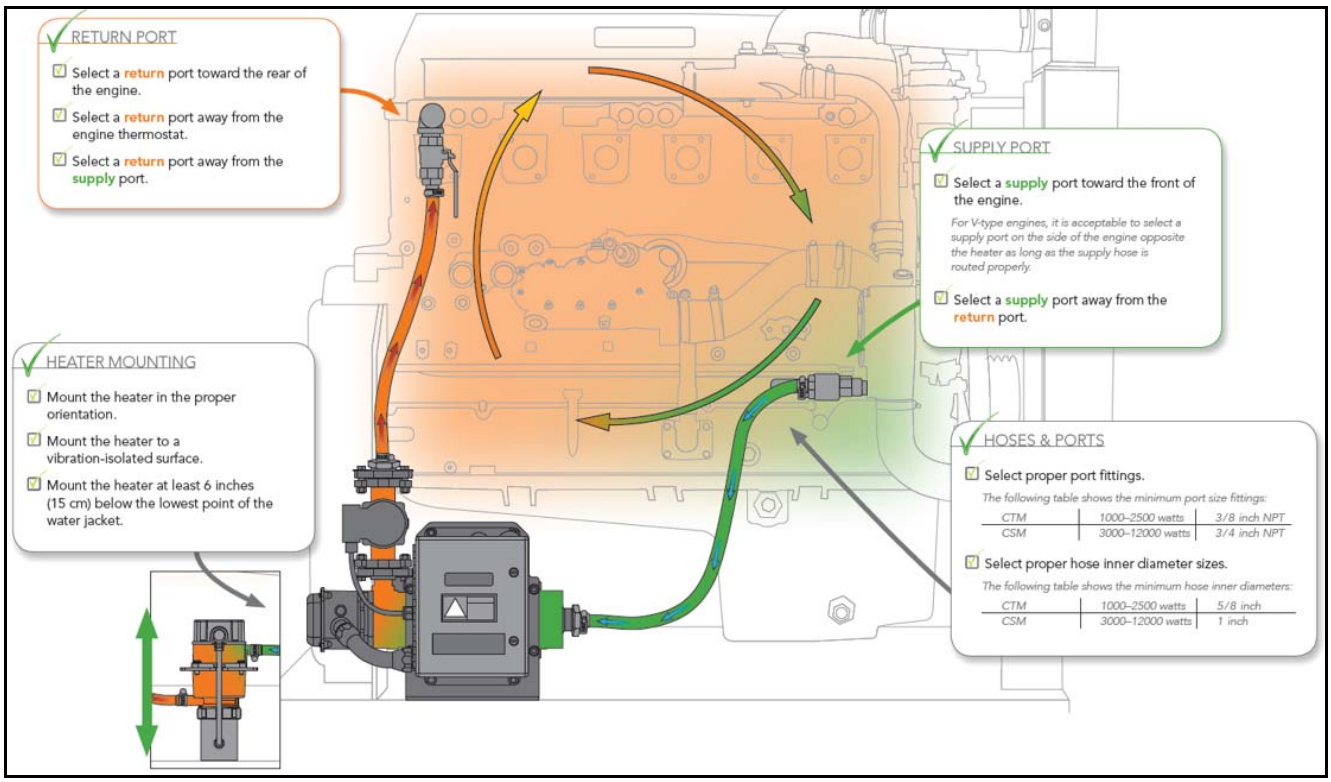
Ex.) Picture of engine with block heater installed



EGN210025

Mounting check points and best/worst practices (information provided by HD Hyundai Infracore supplier Hotstart.)

- Best Practices



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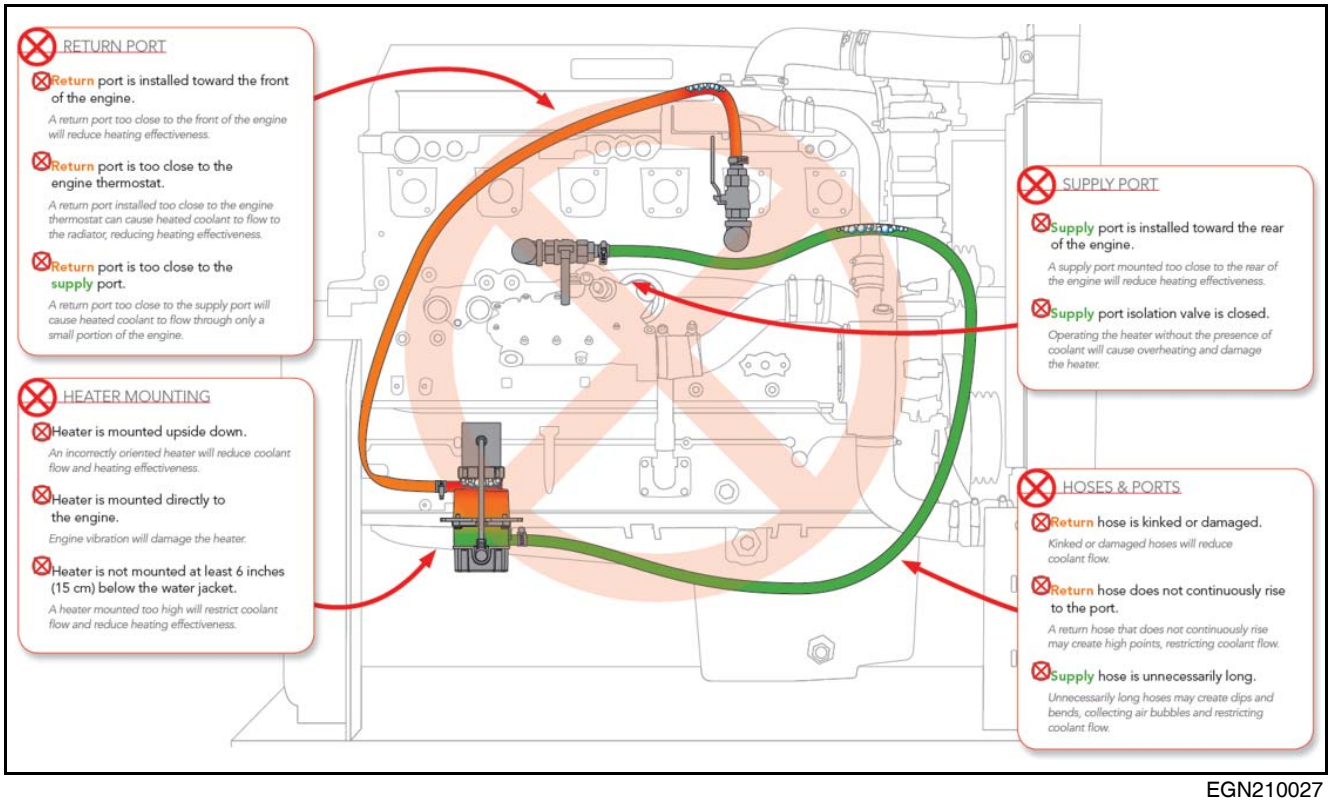
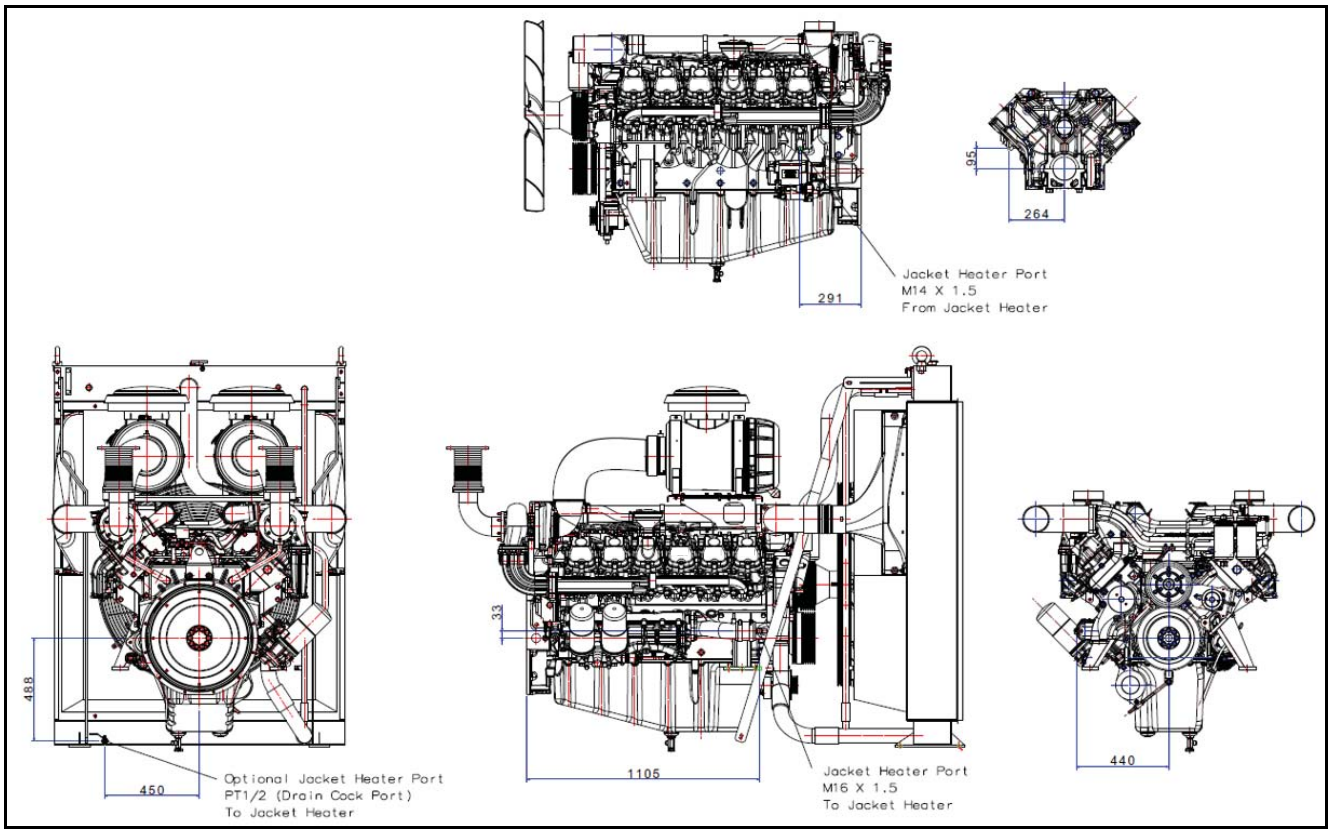
- Worst Practices



EGN210027

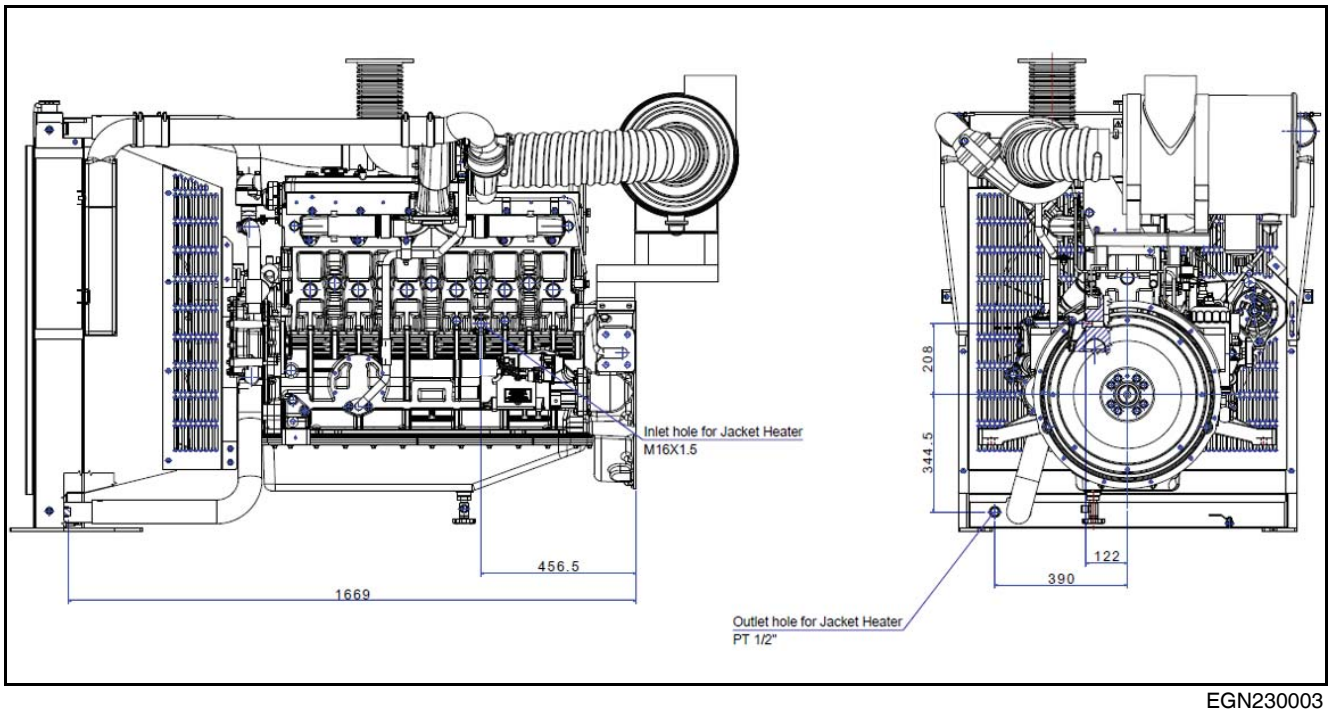
Examples from HD Hyundai Infracore (locations of in/out ports)

- DP222



EGN230002

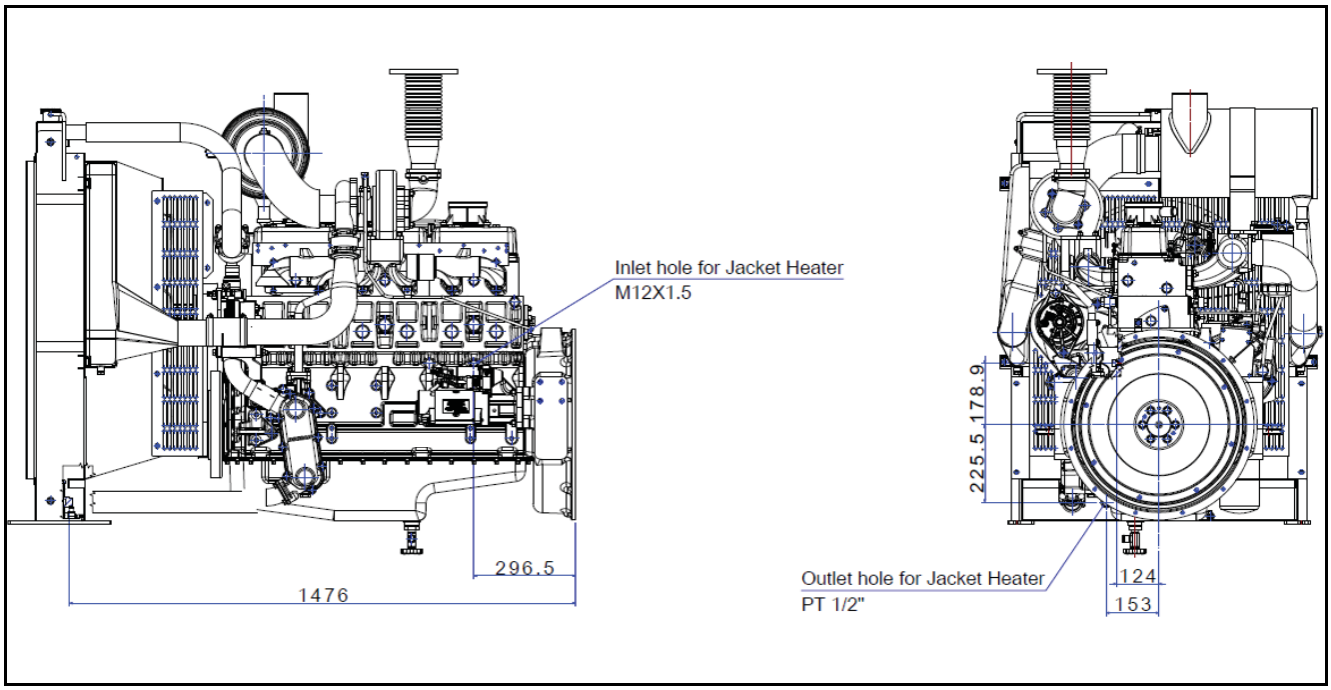
- P126TI



EGN230003

5. Cooling System

- P086TI



EGN230004

Radiator

The radiator is the part of the engine in which heat exchange occurs in the coolant from the cooling water system and the air in the cooling air system. The engine's hot coolant passes through the radiator tubes and is cooled by cold air from the cooling fan. The radiator should be small but have good cooling performance and few pressure drops. The radiator may be clogged when the engine operates in dusty conditions, so the radiator should not be too small.

Coolant heat is exchanged in the tubes. The heat exchange coefficient is much higher for water than for air, so fins are used to increase the contact surface between the air and the tubes. The radiator consists of an upper and lower tank, cooling tubes, fins, and a frame. The expansion tank is installed on the top tank for packaging.

Items to consider when installing radiator

1) Engine heat discharge to coolant
2) Heat discharge to coolant from other components such as oil cooler
3) Max. air temperature at radiator inlet
4) Max. coolant temperature at radiator inlet
5) Flow and direction of cold air
6) Pressure drop on coolant side
7) Pressure drop on cold air side
8) Surface area of radiator core
9) Fin type and distance
10) Possibility of dust or other impurities entering air from environment
11) Chances of damage and possibility of protecting against it

Items to consider when installing radiator

1) The radiator must be mounted on the same frame as the engine and the generator unit.
2) The radiator must be exactly horizontal with the engine and the generator unit.
3) A vibration isolator must be installed on the engine and the generator unit.
   : The only parts transmitting vibrations to the radiator must be the engine and the generator unit.
   No other objects must transmit vibrations.
4) Install the bed frame on which the radiator is mounted in a place away from vibrations and make sure to install a vibration isolator.
5) Do not install any objects which may transmit any other vibrations to the radiator.
6) When mounting the radiator support bracket, make sure to mount it on the same frame as the radiator.
7) Always check for foreign matter around the area where the radiator cooling fan is mounted before running the engine.

Definition of AOT and ATB & managing generator engine ATB temperature

AOT = max. temp. of engine coolant - Two + Ta
ATB = max. temp. of engine coolant - Two + Tamb
Two: Engine coolant outlet temp.
Ta: Average temperature of air entering the radiator
(Average of measurements from at least four points)
Tamb: Ambient temperature

The AOT standard is classified by the type of radiator.

- Standard type: 43°C
- Tropical type: 52°C
- Extra tropical type: 62°C

$T = Two - Twi \leq 6 - 8°C$
Two: Engine coolant outlet temp.
Twi: Engine coolant inlet temp.
(Ex.) The maximum coolant temperature limit in the engine is 103°C.
In this case, if a radiator with an AOT of 43° is used, ATB = 103-Two + Ta, i.e. Ta = 43°. Hence, in order to meet the engine cooling performance requirements, the average temperature of air entering the radiator must be maintained at less than 43°.

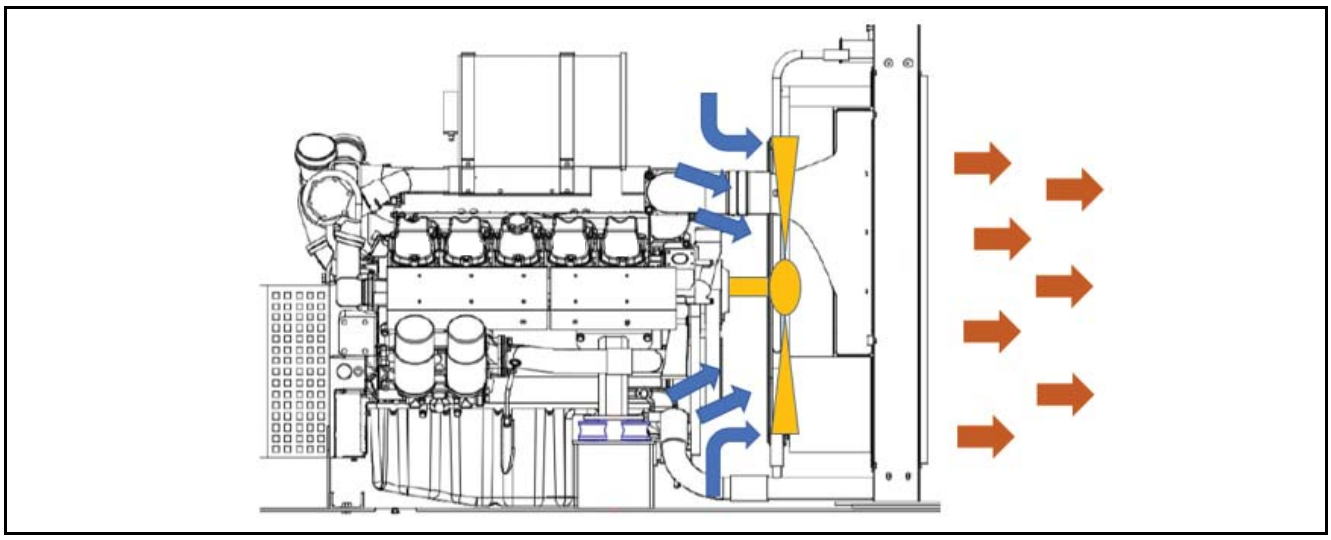
Cooling Fan

Fan Functions

The purpose of the fan is to create a flow of cold air. The fan increases the pressure, and this creates airflow. The more quickly cold air passes through the radiator core, the more effective the heat transfer between the fins and the air. The airflow provided by the fan is affected significantly by drops in pressure of system components.

Fan Types

There are two types of cooling fan: the suction type and the blower type. In general, generator engines use the blower type fan.

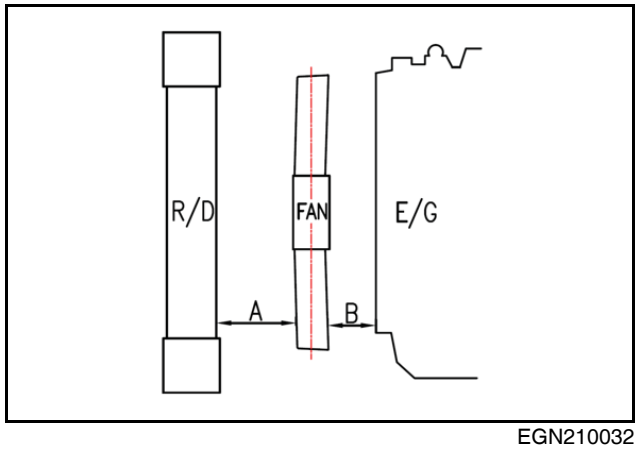


EGN230005

Installation Location of Cooling Fan

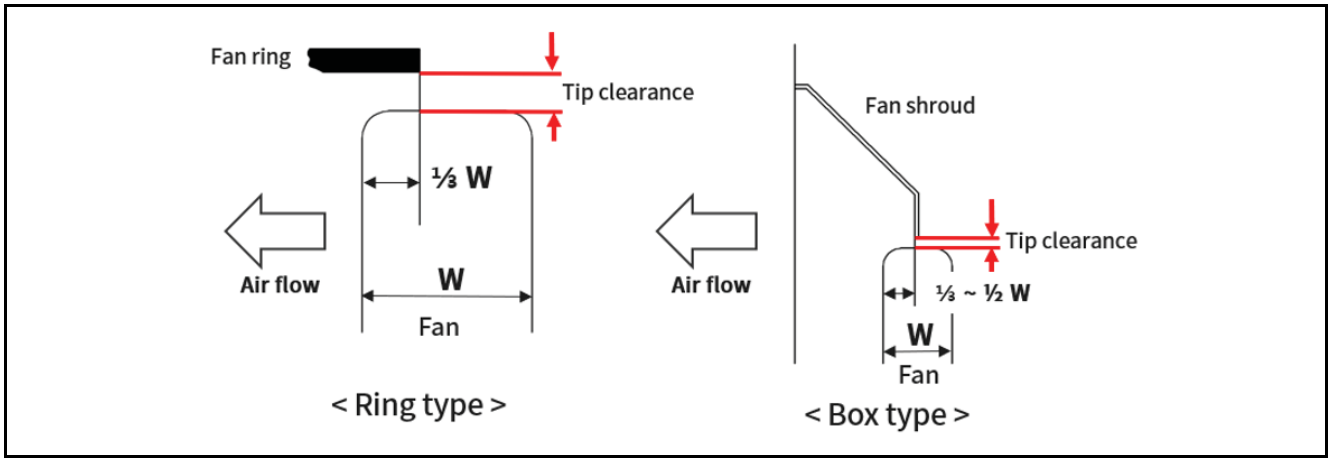
When the cooling fan is being installed, "A" (the distance from the radiator core to the cooling fan) must be at least 2 inches (50.8 mm), and if possible, a distance of 4 inches (101.6 mm) must be maintained.

"B" (the distance from the cooling fan to the engine) must maintain a sufficient distance, but this should be determined in consideration of the bending moment.



EGN210032

The cooling fan's projection width should be 1/3 for a ring type shroud and 1/3 to 1/2 for a box type shroud.
The cooling fan's tip clearance should be 0.5 inches (12.5 mm) or around 1% of the cooling fan.

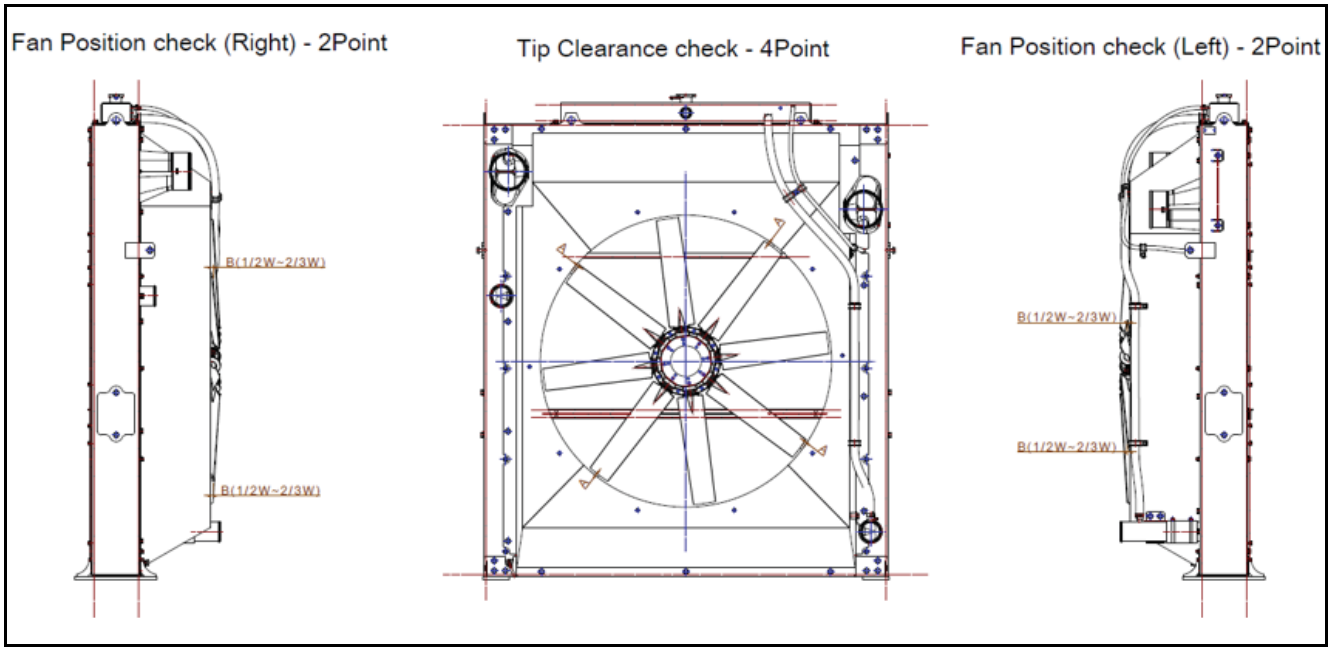


EGN210033

For your reference, HD Hyundai Infracore shrouds are of the box type.

Fan Position Check

In order to check whether the cooling fan has been mounted correctly, check the distances in the places shown below.



EGN210034

5. Cooling System

Evaluating Engine Cooling Performance

Pre-test Installation Inspection Items

After the generator set has been mounted and installed in the field, perform a cooling performance evaluation to check the suitability of the installation (engine room ventilation, intake/exhaust system, radiator and CAC performance, fuel system, etc.) and the power performance.
Since generator engines are usually tested and operated in enclosed spaces, it is important to satisfy the following installation conditions.

- If the engine room is not ventilated sufficiently, the ambient temperature increases, which may worsen cooling performance.
- The temperature of air entering the air cleaner must be consistent.
- Lagging in the exhaust pipe causes radiant heat from exhaust gas to not enter the air cleaner.
- If the temperature of air entering the air cleaner is high, refer to the derating chart on the specification sheet and test and operate the generator with reduced power.

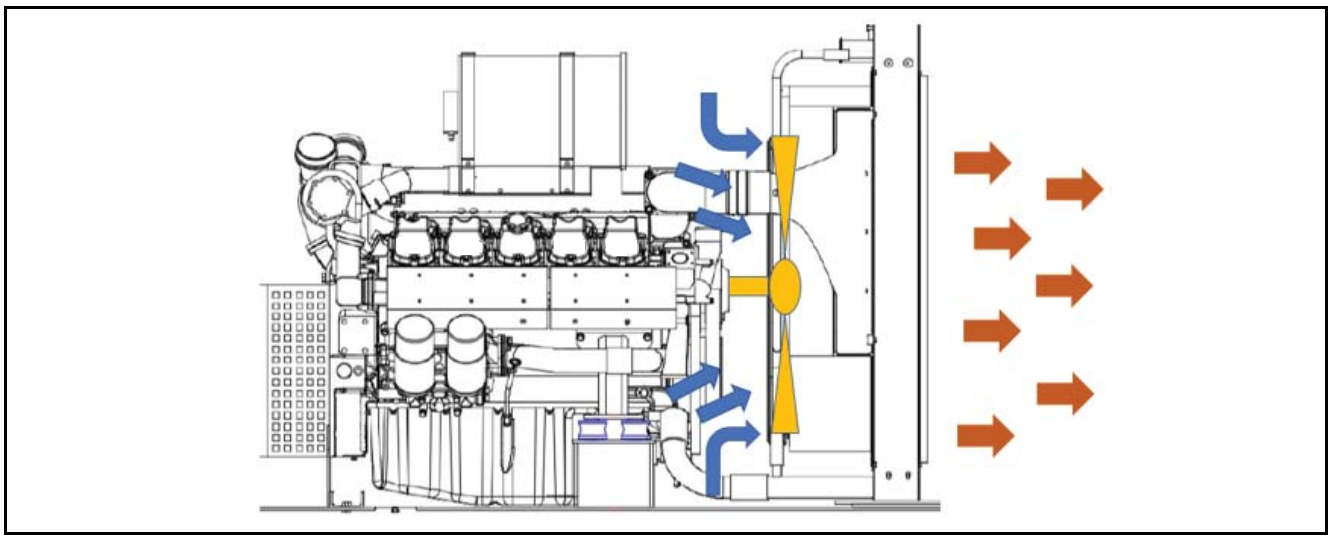
Cooling Test Evaluation

Definition of cooling performance (AOT/ATB)

The cooling performance of the generator set may be defined by ATB (air to boil) and AOT (air on temp.). ATB is defined as the maximum allowable coolant temperature based on ambient temperature conditions, while AOT is the maximum allowable coolant temperature based on the temperature of air entering the radiator to be cooled. The difference between ATB and AOT is that AOT is used as the temperature of cooling air entering the radiator instead of the ambient temperature.

- ATB = max. coolant temp. - engine outlet coolant temp. (TWO) + ambient temp. (T_ambient)
- AOT = max. coolant temp. - engine outlet coolant temp. (TWO) + average temp. supplied to radiator (T_rad)

If a blow-out fan is used together with the generator set, cooling air used to cool the radiator is first heated by the radiant heat from the engine; then, its temperature rises above the ambient temperature. Hence, in order to ensure correct cooling performance of the generator set, the cooling performance must be assessed based on AOT.



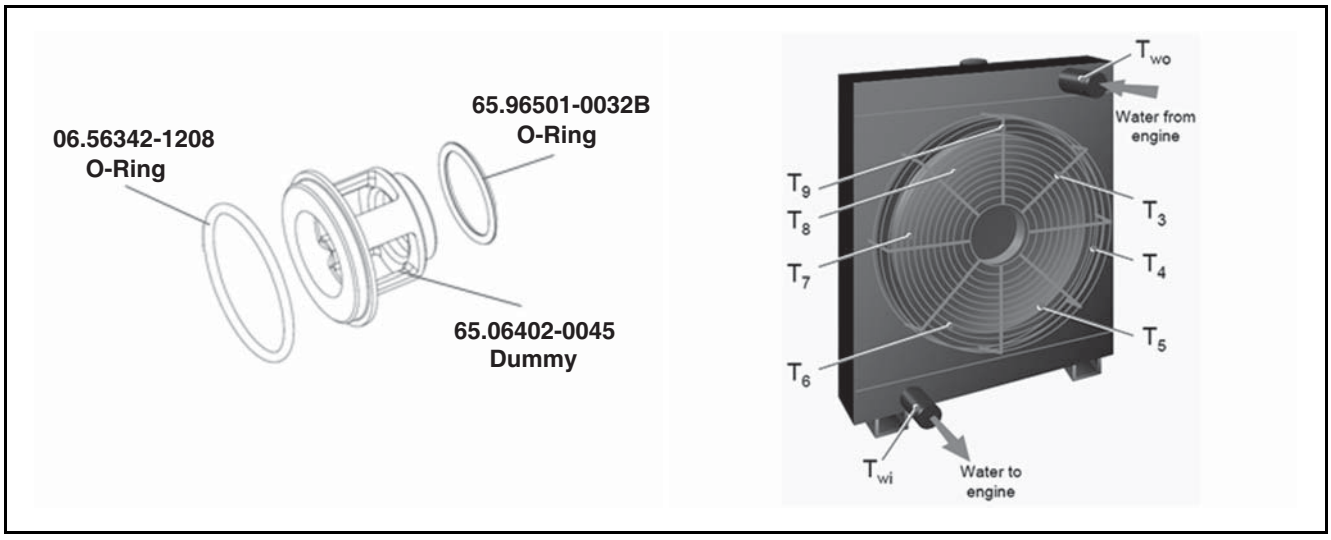
EGN230005

Intercooler outlet temperature conditions

- The pressure difference between the intercooler inlet and outlet must be less than 120 mbar (12 kPa).
- Intercooler outlet temperature < average temperature supplied to radiator (T_rad) + 25°C
- → This may coincide with the engine derating conditions depending on the intercooler outlet temperature.
- (The information above may vary depending on the engine.)
- In the case of an open generator set, the average temperature supplied to the radiator (T_rad) is similar to the atmospheric air temperature.
- In the case of a canopy-type generator set, the average temperature supplied to the radiator (T_rad) should be the atmospheric air temperature + 10°C.

Items to prepare for evaluating cooling performance

- Replace the thermostat with a dummy for the cooling evaluation (DV2213357A)
- Intake air filter upstream temperature
- Radiator cooling air intake temperature (at least four places: T3, T5, T6, T8) (DV2213358A)
- Radiator coolant inlet (TWO) and outlet temperature (TWI)
- If an intercooler (air-to-air intercooler) is used, intercooler upstream/downstream temperature and pressure (optional)



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Cooling performance evaluation sheet

In order to check the maximum and average values during the cooling performance evaluation, it is recommended that the values at the measurement points be recorded in realtime.
After running the engine in the rated engine operating conditions for at least 30 minutes, perform the measurements after the coolant and air temperatures have stabilized.
The list of measurement data is provided below. For information on the allowable limits, refer to the allowable **AOT standard*** for each generator set.

Time	Power	Radiator inlet air temperature (°C)				Water Temp (°C)		AOT
hh:mm	kWe	T3	T5	T6	T6	Two	Twi	
:								
:								
:								
:								

5. Cooling System

* The AOT-based temperatures provided by HD Hyundai Infracore are for open-type generator sets. In the case of canopy-type generator sets, the ambient temperature/pressure conditions differ from the temperature/pressure inside the canopy, so the AOT performance provided by HD Hyundai Infracore may be different. Hence, when using a canopy-type generator set, the canopy must be set up in consideration of the difference in ambient temperature inside/outside the canopy, and the cooling performance must be checked by means of an actual evaluation after the canopy has been created.

6. Lubrication System

General Information

Engine oil is a general term for lubricating oils used in internal combustion engines. Engine oils are made of a combination of a base oil and additives, and they perform the following functions.

- Lubrication: Engine oil reduces the friction between metal parts and creates an oil film on moving engine parts, thereby enhancing their durability.
- Preventing oxidation: At high temperatures, metal oxidizes easily, thereby damaging engine parts, so engine oil serves to prevent the oxidation of metal parts.
- Cleaning characteristics: Engine oil effectively removes carbon, sludge, etc. which accumulates within the machine, thereby keeping it clean.
- Anti-corrosion: Engine oil protects not only cylinders but also bearings and other parts from corrosion which may be caused by moisture and acid produced as a result of explosions during combustion.
- Preventing bubbles: Oil splashed around the crank case forms air bubbles which degrade lubrication performance. The anti-bubble additives in engine oil prevent this type of degradation of lubrication performance.
- Cooling function: Engine oil lowers the overall temperature by absorbing both the frictional heat produced during engine operation and the thermal energy produced during combustion.
- Sealing function: Engine oil helps the engine produce maximum power by forming a seal between the piston and the combustion chamber.

Engine Oil Specifications

Selecting the right engine oil for the intended engine application is very important both technically and economically, and since the appropriate oil specifications vary depending on the engine operating conditions, the types of engine oil need to be classified.
To this end, standard oil grades have been established, such as the SAE (Society of Automotive Engineers) grades which classify oil according to its viscosity; the American API (American Petroleum Institute) classification which classifies oil based on the engine operating conditions; and the European ACEA (European Automobile Manufacturers Association).
Oil used in HD Hyundai Infracore generator engines is limited to API and SAE standards.

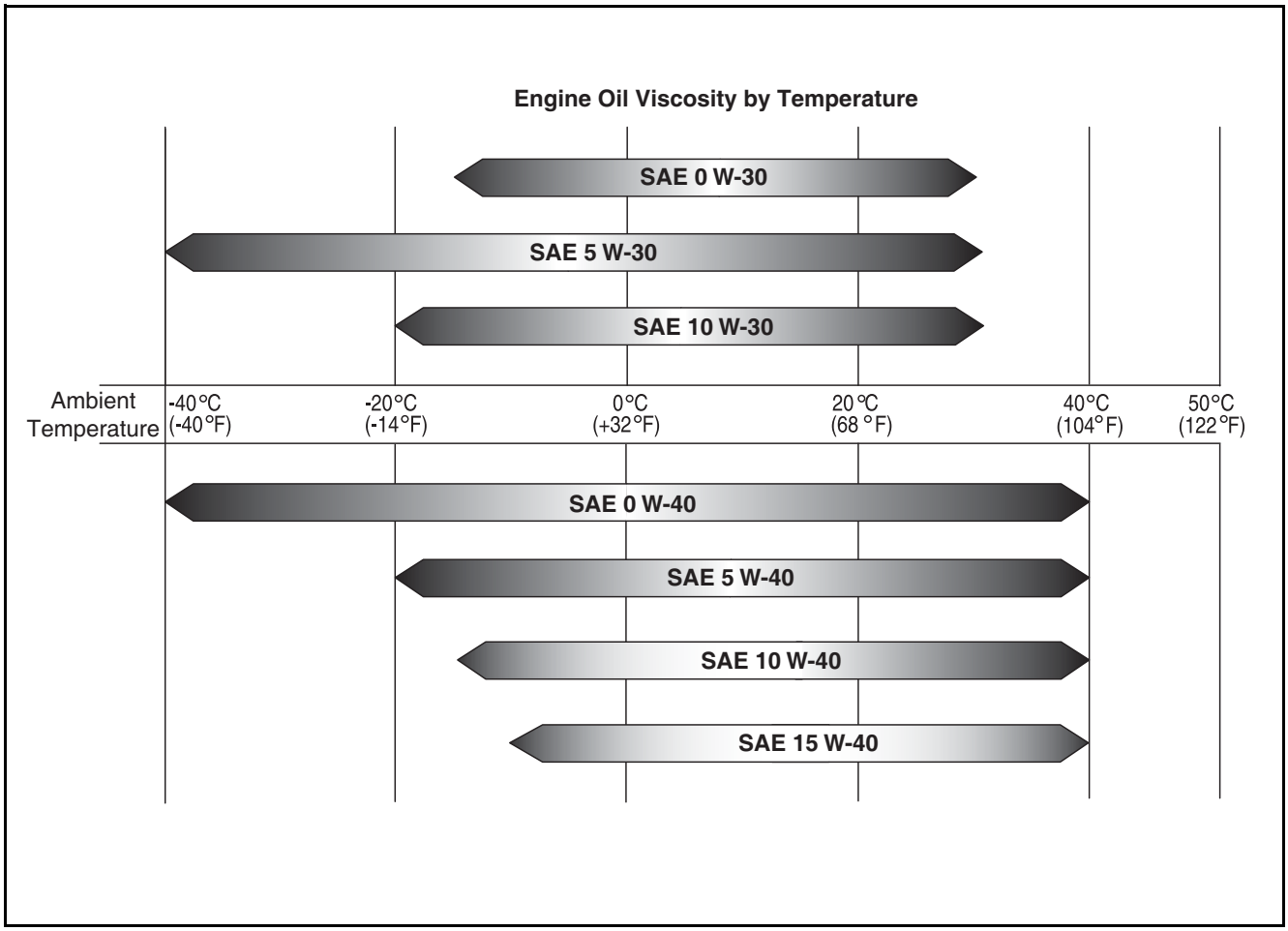
API Oil Grades

The table below is a brief description of API grade engine oils. HD Hyundai Infracore recommends the use of oils graded CI-4 or higher. In order to ensure the correct replacement intervals for each model, make sure to use the correct oil grade according to the service manual.

Grade	Description
CI-4	Standard introduced on 2002.9.5. Engine oil of this grade is suitable for high-temperature, high-load diesel engines and is capable of withstanding the harsh conditions of EGR (exhaust gas recirculation) systems installed to satisfy emissions standards in particular.
CJ-4	Following the enactment of more stringent emissions regulations, this standard was introduced in October 2006 to be applicable to all high-speed 4-stroke diesel engine fuels (with a sulfur content of less than 500 ppm). It is excellent at protecting filters, preventing engine wear, protecting pistons, and stabilizing heat/oxidation.
CK-4	Introduced in 2017, CK-4 oil is suitable for high-speed 4-strike diesel engines. Although its overall physical properties and performance are equivalent to CJ-4, it is around 10% more effective in terms of oxidation stability (OIT). This enhanced oxidation stability allows engine oil replacement intervals to be longer than for previous oil specifications.

SAE Oil Grades

SAE grades classify oil according to its viscosity index. Make sure to use oil of a suitable grade for the ambient temperature.



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Periodic Engine Oil Inspections

Running the engine continuously without sufficient engine oil may cause moving parts in the engine to seize up, leading to engine failure. Hence, check the oil level with the engine oil level gauge and add more if necessary. The oil level should be checked after the engine has stopped. However, wait 5-10 minutes after stopping the engine to allow the engine oil to flow into the oil pan; then, check the oil level.
The oil level must lie between the upper and lower limits on the oil level gauge. If the oil is below the minimum level, add more; engine oil must be replaced according to the replacement intervals.

The engine oil added when the engine is first released from the factory is high-quality engine oil for engine break-in. Oil consumption may be higher during the initial 50-hour break-in period, so the oil level must be checked frequently.

Changing Oil

In order to keep the engine oil clean, the engine oil must pass through the cartridge in the oil filter. The oil filter bypass valve ensures that engine oil can continue to be supplied even if the oil filter element exceeds its service life and becomes clogged. Make sure to check the oil pressure and check for leaks, and replace the oil filter if necessary.
When changing oil, make sure to replace the oil filter cartridge with a new one as well.

Instructions for Replacing Engine Oil

1. Unscrew the oil drain plug and drain the engine oil.
2. Replace the oil filter cartridge with a new one.
3. Clean the other parts thoroughly as well and use a new gasket during reassembly.

There is a risk of burns if the oil is replaced in an engine which has just been driven, so do not touch the oil drain valve with bare hands. In addition, oil is a cause of environmental contamination, so make sure to handle it in accordance with the regulations.

⚠CAUTION

1. **When refilling engine oil, do not exceed the upper limit line on the oil level gauge. Adding engine oil past the upper limit line may damage the engine.**
2. **Be careful not to allow foreign matter to enter the engine while adding engine oil.**
3. **Dispose of used engine oil according to the regulations of local public institutions. Engine oil can cause severe environmental contamination if it is spilled on the ground, in drains, sewers, rivers, or seas.**
4. **When replacing the oil filter cartridge, make sure to use a genuine HD Hyundai Infracore cartridge.**

Cautions for Handling Engine Oil

If engine oil comes into contact with skin over a long period of time, the skin can become contracted and dry, causing inflammation. When replacing engine oil, make sure to wear protective clothing and gloves; if engine oil comes into contact with skin, wipe it off completely.

- Avoid repeated or prolonged contact with used engine oil.
- Apply protective skin cream or wear gloves.
  If your skin comes in contact with engine oil, rinse it off thoroughly.
- Rinse your skin thoroughly with soap and water.
- Do not use gasoline, diesel fuel, thinner or solvent as a cleaner.
- After washing your skin, apply lotion for protection.
- If oil gets on your clothes or shoes, change them.
- Do not put oily rags in your pocket.

6. Lubrication System

Oil Pressure Monitoring

Warning and Shut Down Values

Oil pressure must be monitored by sensor/gauge and engine should be controlled by below values to keep safety operation.

Protection values (Oil pressure, Bar)	V-Type Engines (DP158/DP180/DP222/P158/P180/P222)		In-Line Type Engines (P086/P126/DP126)	
	1,500 rpm (50Hz)	1,800 rpm (60Hz)	1,500 rpm (50Hz)	1,800 rpm (60Hz)
Warning	2.1	2.5	2.5	2.8
Shut down	1.7	2	2	2.3

7. Intake System

General Information

The air intake system may have a direct impact on engine power, fuel consumption, emissions and engine life, so it requires the most careful consideration when being installed on the engine. Accordingly, at the very least the engine must be designed to supply clean, dry and cool air. The system must be designed to withstand shocks, loads, and a variety of working conditions while also providing a stable seal and durability.

Air Inlet System

The air inlet system has three main components.

- Dust side duct
- Air filter
- Clean side duct

Dust Side Duct

The location of the air inlet must satisfy the following conditions.

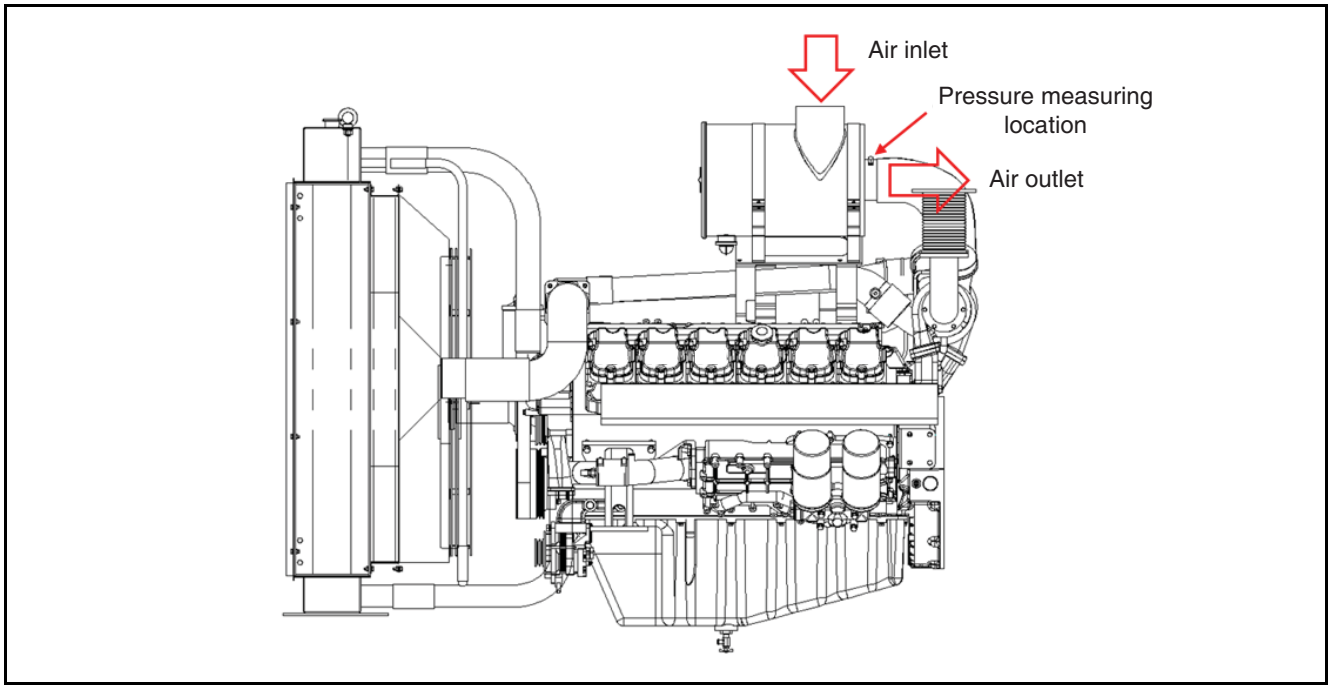
- Must be near the ambient temperature.
- Must be protected from dust, foreign matter, snow, rain, etc.
- Must be far from where exhaust gas is produced (to prevent it from entering).
- The intake pipe must be designed to minimize pressure drops (low pressure drops extend the air filter's service life).
  In order to reduce the amount of pressure drops, it is best to use a large diameter pipe over a short distance with a minimal bend radius.
- There must be a moisture trap installed at the bottom of the pipe capable of draining water.

7. Intake System

Air Filter

The air filter protects the engine from contaminants in the air. The air filter must be of an appropriate size; a filter that is too large or too small will increase the amount of pressure drops, leading to a loss of power. The allowable negative pressure of the air cleaner is affected by the turbocharger; the reference standards are provided below.

- When mounted initially: 2.2 kPa or less
- When replacing the filter: 6.0 kPa or less
- Measuring location of intake side negative pressure



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Clean Side Duct

Pipes passing through the air filter must have proper fittings to provide a stable seal and minimize pressure drops. Pipes must also be kept clean (genuine HD Hyundai Infracore parts provide a stable seal, are kept clean, and are certified against pressure drops).

The surface must be treated to prevent corrosion; galvanization or yellow chromate are suitable treatment methods.

In order to minimize restrictions in the system, pipes should be as short as possible, while the minimum bend radius and number of bends must also be taken into consideration.

The cross-sectional area of all pipes must not be smaller than that of the intake manifold inlet, and the pipe must gradually increase in size until it reaches the turbocharger inlet.

- Aluminum pipes: Must be smooth on the inside and free of defects in any circumstances. When used together with a hose, the pipe must be machined at least 50 mm from each connection to create a smooth finish, while the thickness of the pipe wall must be sufficient to withstand deformation under the pressure of the hose clamp. All pipes must have corrugated sections to prevent hoses from falling out.
- Hoses: Should be used only to connect aluminum pipes at close distances and with hardly any movement. When connecting parts which are not in a straight line, use a formed hose; when this is not available or when connecting parts which move differently from one another, a flexible hose may be used. This type of hose must be durable and must be designed and certified to withstand a minimum negative pressure of 6.5 kPa in order to prevent twisting or bending of the hose. In the case of a CCV type which sends blowby gas back to the engine, make sure to use a hose made of an oil-resistant material.

8. Exhaust System

General Information

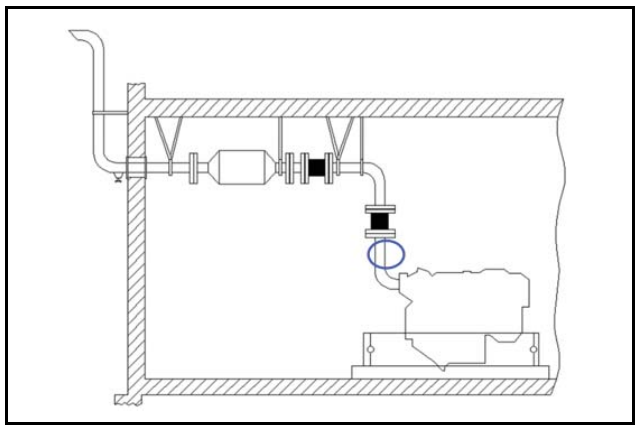
Everything about the exhaust system must be planned from the time of the initial installation. The main requirements are as follows.

- The allowable back pressure of the exhaust pipe is a maximum of 5.9 kPa.
- Support any additional exhaust pipes to prevent a load from being applied to the exhaust manifold and turbocharger.
- Take thermal expansion and contraction into consideration when designing the system.
- Install an exhaust silencer to reduce noise from exhaust.

Back Pressure

The exhaust system creates a certain resistance to the flow of exhaust gas. This resistance or back pressure must be maintained within a specified limit (5.9 kPa). Excessive back pressure causes a loss of power, worse fuel consumption, and high exhaust temperatures. These conditions cause overheating and excessive smoke in the machinery while also shortening the engine life.

- How to measure back pressure: The pressure must be measured at the engine's maximum rated power; as shown in the figure below, it must be measured on the straight section of the pipe. If a special hole must be drilled in order to measure the pressure, the hole must be as small as possible. In order to obtain stable results, the measuring location must be 100 mm or more from the turbocharger outlet (if the measurement is performed at a point right after passing the turbocharger, a maximum error of 2 kPa may occur).



EGN210064

Calculation of Back Pressure

The allowable back pressure of the exhaust pipe is 5.9 kPa. Before designing the exhaust pipe, use the formula below to calculate the theoretical back pressure for the exhaust system; then, design the pipe so that the result of the calculation does not exceed 75% of the allowable back pressure.

Theoretical back pressure

- $\Delta P = \Delta PR \times L + \Delta Pk \times nk + \Delta Ps$
- ΔPR: Back pressure per 1 m of exhaust pipe
- L: Length of exhaust pipe (m)
- ΔPk: Back pressure per 90° elbow in exhaust pipe
- nk: Number of 90° elbows in exhaust pipe
- ΔPs: Back pressure of silencer

For example, if an exhaust pipe is installed on an engine with a displacement of 2,000 kg/h as shown below, the back pressure is as follows.

140 mm diameter, 5 m exhaust pipe, two 90° elbows, 5 mbar silencer back pressure

- $\Delta P = 3.6 \times 5 + 7.3 \times 2 + 5 = 37.6$ mbar (3.76 kPa)

Hence, since this is lower than 4.4 kPa - i.e. 75% of 5.9 kPa, the reference back pressure - this is an acceptable design.

8. Exhaust System

For the back pressure per 1 m of exhaust pipe and back pressure per 90° elbow, refer to the table below.

Exhaust gas mass flow	**Diameter in mm**						
(kg/h)	80	100	120	140	160	180	200
200	0.7	0.2	0.1	-	-	-	-
300	1.6	0.5	0.2	0.1	-	-	-
400	2.8	0.9	0.3	0.1	0.1	-	-
500	4.4	1.3	0.5	0.2	0.1	0.1	-
600	6.3	1.9	0.7	0.3	0.1	0.1	0.1
700	8.6	2.6	1	0.4	0.2	0.1	0.1
800	11.2	3.4	1.3	0.6	0.3	0.2	0.1
900	14.2	4.3	1.6	0.7	0.4	0.2	0.1
1,000	17.5	5.3	2	0.9	0.4	0.2	0.1
1,100	21.2	6.5	2.5	1.1	0.5	0.3	0.2
1,200	25.3	7.7	2.9	1.3	0.6	0.3	0.2
1,300	-	9	3.4	1.5	0.7	0.4	0.2
1,400	-	10.5	4	1.8	0.9	0.5	0.3
1,500	-	12.5	4.6	2	1	0.5	0.3
1,600	-	13.7	5.2	2.3	1.1	0.6	0.3
1,700	-	15.5	5.9	2.6	1.3	0.7	0.4
1,800	-	17.3	6.6	2.9	1.4	0.8	0.4
1,900	-	19.3	7.3	3.2	1.6	0.8	0.5
2,000	-	21.4	8.1	3.6	1.8	0.9	0.5
2,100	-	23.6	9	3.9	1.9	1	0.6
2,200	-	25.9	9.8	4.3	2.1	1.1	0.7
2,300	-	-	10.7	4.7	2.3	1.2	0.7
2,400	-	-	11.7	5.2	2.5	1.4	0.8
2,500	-	-	12.7	5.6	2.8	1.5	0.8
2,600	-	-	13.7	6	3	1.6	0.9
2,700	-	-	14.8	6.5	3.2	1.7	1
2,800	-	-	15.9	7	3.5	1.8	1.1
2,900	-	-	17	7.5	3.7	2	1.1
3,000	-	-	18.3	8	4	2.1	1.2
3,100	-	-	19.5	8.6	4.2	2.3	1.3
3,200	-	-	20.8	9.2	4.5	2.4	1.4
3,300	-	-	22.1	9.7	4.8	2.6	1.5
3,400	-	-	-	10.3	5.1	2.7	1.6
3,500	-	-	-	11	5.4	2.9	1.6

<Average back pressure in mbar per 1 m pipe elbow>

Exhaust gas mass flow	Diameter in mm						
(kg/h)	80	100	120	140	160	180	200
200	0.7	0.3	0.1	0.1	-	-	-
300	1.5	0.6	0.3	0.2	0.1	-	-
400	2.7	1.1	0.5	0.3	0.2	0.1	-
500	4.3	1.8	0.8	0.5	0.3	0.2	0.1
600	6.2	2.5	1.2	0.7	0.4	0.2	0.2
700	8.4	3.5	1.7	0.9	0.5	0.3	0.2
800	11	4.5	2.2	1.2	0.7	0.4	0.3
900	13.9	5.7	2.8	1.5	0.9	0.5	0.4
1,000	17.2	7	3.4	1.8	1.1	0.7	0.4
1,100	20.8	8.5	4.1	2.2	1.3	0.8	0.5
1,200	24.8	10.1	4.9	2.6	1.5	1	0.6
1,300	-	11.9	5.7	3.1	1.8	1.1	0.7
1,400	-	13.8	6.6	3.6	2.1	1.3	0.9
1,500	-	15.9	7.6	4.1	2.4	1.5	1
1,600	-	18	8.7	4.7	2.7	1.7	1.1
1,700	-	20.4	9.8	5.3	3.1	1.9	1.3
1,800	-	22.8	11	5.9	3.4	2.2	1.4
1,900	-	-	12.3	6.6	3.9	2.4	1.6
2,000	-	-	13.6	7.3	4.3	2.7	1.8
2,100	-	-	15	8.1	4.7	3	1.9
2,200	-	-	16.4	8.9	5.2	3.2	2.1
2,300	-	-	18	9.7	5.7	3.6	2.3
2,400	-	-	19.6	10.7	6.1	3.9	2.5
2,500	-	-	21.2	11.5	6.7	4.1	2.8
2,600	-	-	23	12.4	7.3	4.6	3
2,700	-	-	-	13.4	7.8	4.9	3.2
2,800	-	-	-	14.4	8.4	5.3	3.5
2,900	-	-	-	15.4	9	5.6	3.7
3,000	-	-	-	16.5	9.7	6	4
3,100	-	-	-	17.6	10.3	6.4	4.2
3,200	-	-	-	18.8	11	6.9	4.5
3,300	-	-	-	20	11.7	7.3	4.8
3,400	-	-	-	21.2	12.4	7.8	5.1
3,500	-	-	-	22.5	13.2	8.2	5.4

<Average back pressure in mbar per 90° pipe elbow>

8. Exhaust System

Exhaust Bellows

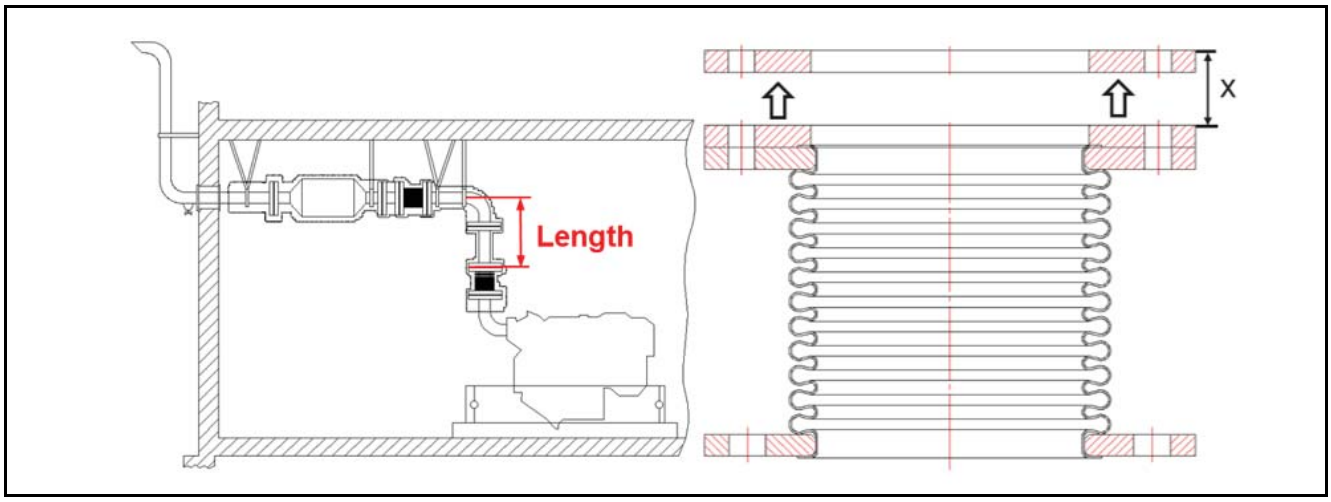
The exhaust pipe is separated from the engine by a connection with the exhaust bellows. Installed near the engine's exhaust outlet, the bellows prevent vibrations and excessive weight, compensate the thermal expansion of the exhaust pipe, and calibrate for lateral movement when starting and stopping the engine (if the engine is equipped with an anti-vibration unit).
The bellows adjust for small radial movements but are weak against torsional or axial movements, so they must be installed vertically and without any bending.
To account for the thermal expansion of the exhaust pipe, the exhaust bellows must be lengthened by 0.5 mm per 1 m of exhaust pipe length and per 100°C of exhaust temperature. The system creates a certain resistance to the flow of exhaust gas. This resistance or back pressure must be maintained within a specified limit (5.9 kPa). Excessive back pressure causes a loss of power, worse fuel consumption, and high exhaust temperatures. These conditions cause overheating and excessive smoke in the machinery while also shortening the engine life.

- X (mm) = 0.5 x exhaust temperature (°C)/100°C x length of exhaust pipe (m)

For example, in the case of a 4 m exhaust pipe with an exhaust temperature of 500°C, the bellows must be installed with a space of 10 mm.

- 0.5 x 500/100 x 4 = 10.0 mm

Incorrectly aligned bellows may lead to damage.



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Condensate Drain

If rain or condensate enters the engine, it may cause severe damage. Hence, the long exhaust line must be equipped with a drain, and the drain must be located close to the engine.

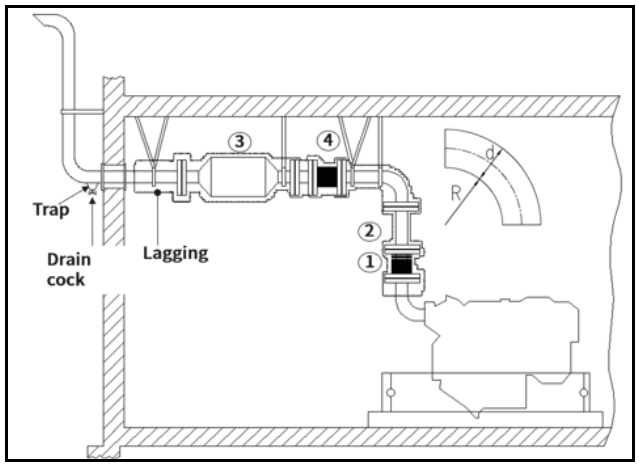
Silencer

The silencer must be installed as close to the exhaust manifold as possible in order to prevent the occurrence of noise in the pipe. When a particular noise needs to be blocked, the silencer is generally mounted in a straight line directly behind the source of the noise. When the silencer is mounted at the tip of the exhaust line, there must only be a short tailpipe (1 m or less) on top of the silencer. An exhaust pipe with a long line affects the back pressure, so the diameter of the exhaust pipe must be increased.

Exhaust Pipe Lagging Guide

The exhaust pipe must have lagging. However, a turbocharger should not have lagging.

No.	Part Name
1	Expansion pipe
2	Y-pipe
3	Silencer
4	Pipe mounting support (must be as close as possible)



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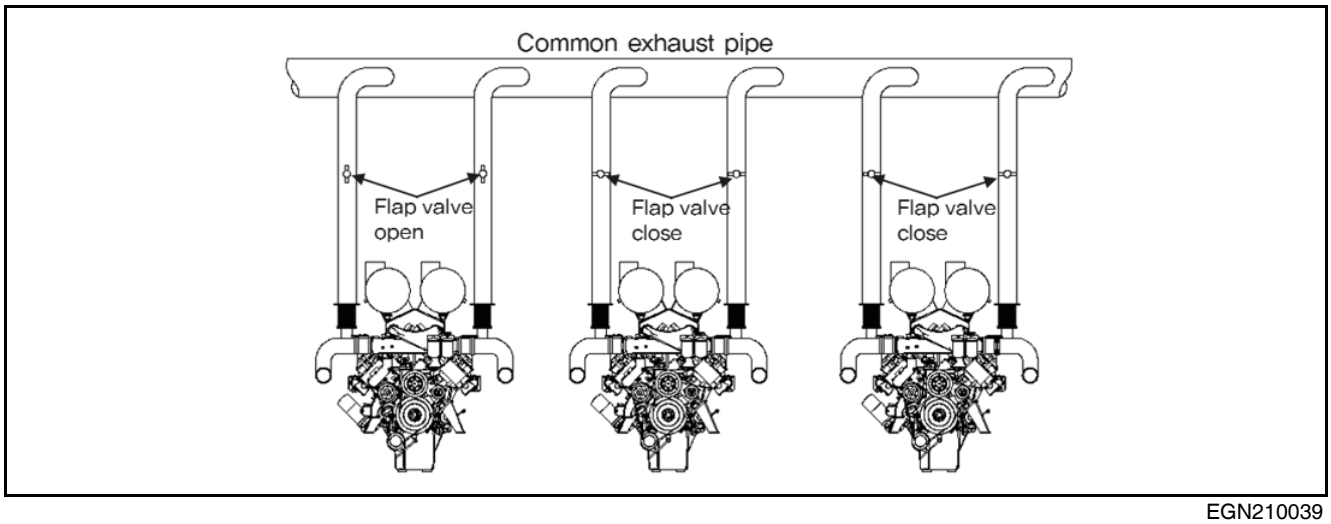
Multiple Exhaust Systems

When more than one engine is installed as a complex assembly, all of the exhaust pipes from the engines must not be connected to a single pipe (if one of the engine stops, the concentrated carbon enters the cylinder and may severely corrode the latter).
If a flip valve with guaranteed performance is installed on each line, it is possible to connect the exhaust pipes from several engines to a single pipe.
The formula for determining the diameter of the exhaust pipe is as follows.



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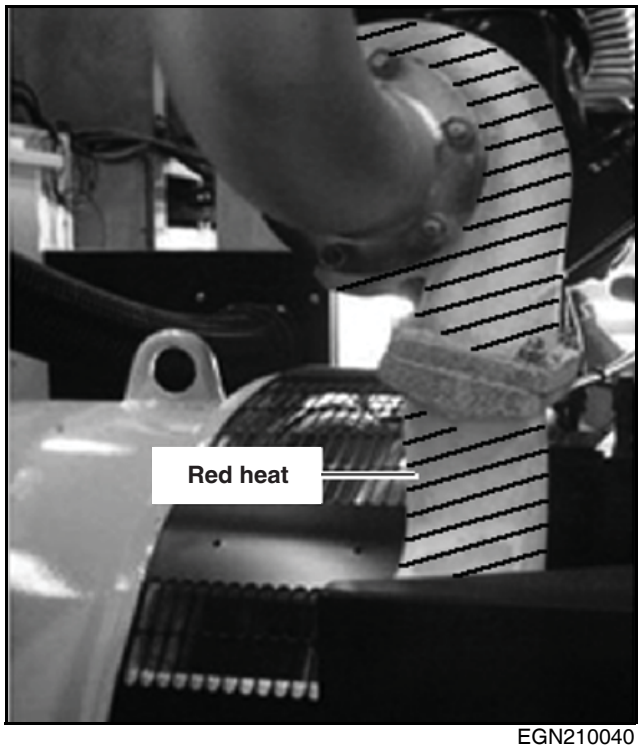
- D (Total) = D x K
  D: diameter of each engine exhaust manifold
  K: constant (see table)

Number of engines	Factor K
2	1.32
3	1.55
4	1.74
5	1.90
6	2.05

- Factor K= $\sqrt[5]{(\mathrm{numberofengines})^2}$

Red Heat Phenomenon of Exhaust

In general, turbocharger diesel engines operate with high exhaust gas temperatures, and the temperature varies depending on the engine load factor. When the exhaust temperature is high, the exhaust manifold and turbine housing begin to turn red, and this can even appear as dark red when operating under a full load. The darker the color, the more clearly visible it is to the naked eye. This is known as the "red heat phenomenon." In general, this begins to appear when the temperature of the exhaust manifold upstream of the turbine passes around 500°C and spreads to the turbine as the load increases. The red heat phenomenon is normal in turbo-charged diesel engines and has no impact whatsoever on the reliability or durability of the engine.



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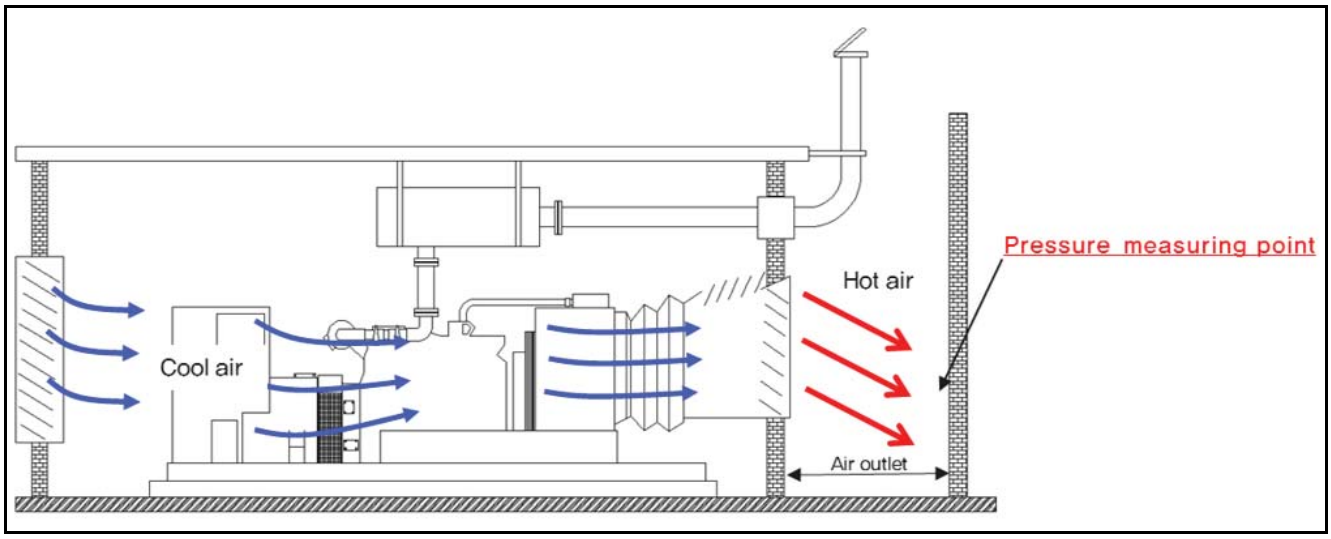
If the exhaust temperature is abnormally high, the following items may need to be checked and corrected (Refer to the exhaust temperatures on HD Hyundai Infracore engine specification sheet).

- High intake temperature, high intake negative pressure, high exhaust back pressure, engine overload, intake/exhaust gas leak

9. Engine Room Ventilation System

Induction System

1) The length of the air outlet must be greater than the height of the radiator core.
2) The direction of the inlet/outlet dampers must be such that airflow is directed downwards in order for air to pass by the engine.
3) The maximum allowable pressure at the air outlet is 12.7 mmH20, which should be measured at the end of the wind wall as shown in the figure. If the allowable pressure standard is not satisfied, cooling performance may be degraded.
4) The temperature in the engine room must be designed to satisfy the following requirement: air cleaner intake air temperature ≤ ambient temperature 10°C.



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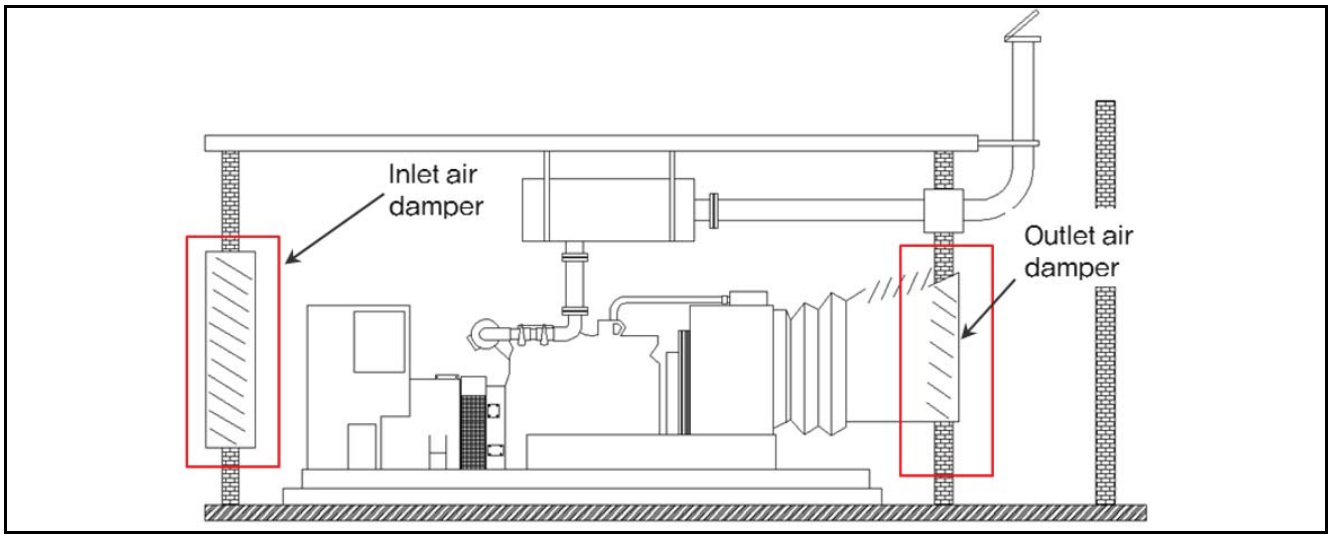
Ventilation

1) The cross-sectional area of the air inlet/outlet dampers must be 25% greater than that of the radiator.
2) When a grill is mounted on a damper, choose one with a size calibrated to 80%.
3) In the event that a 1 m^2 radiator is used, if a 1 m^2 x 1.25 = 1.25 m^2 grill is installed, the damper must have a surface area of at least 1.25/0.8 = 1.56 m^2.



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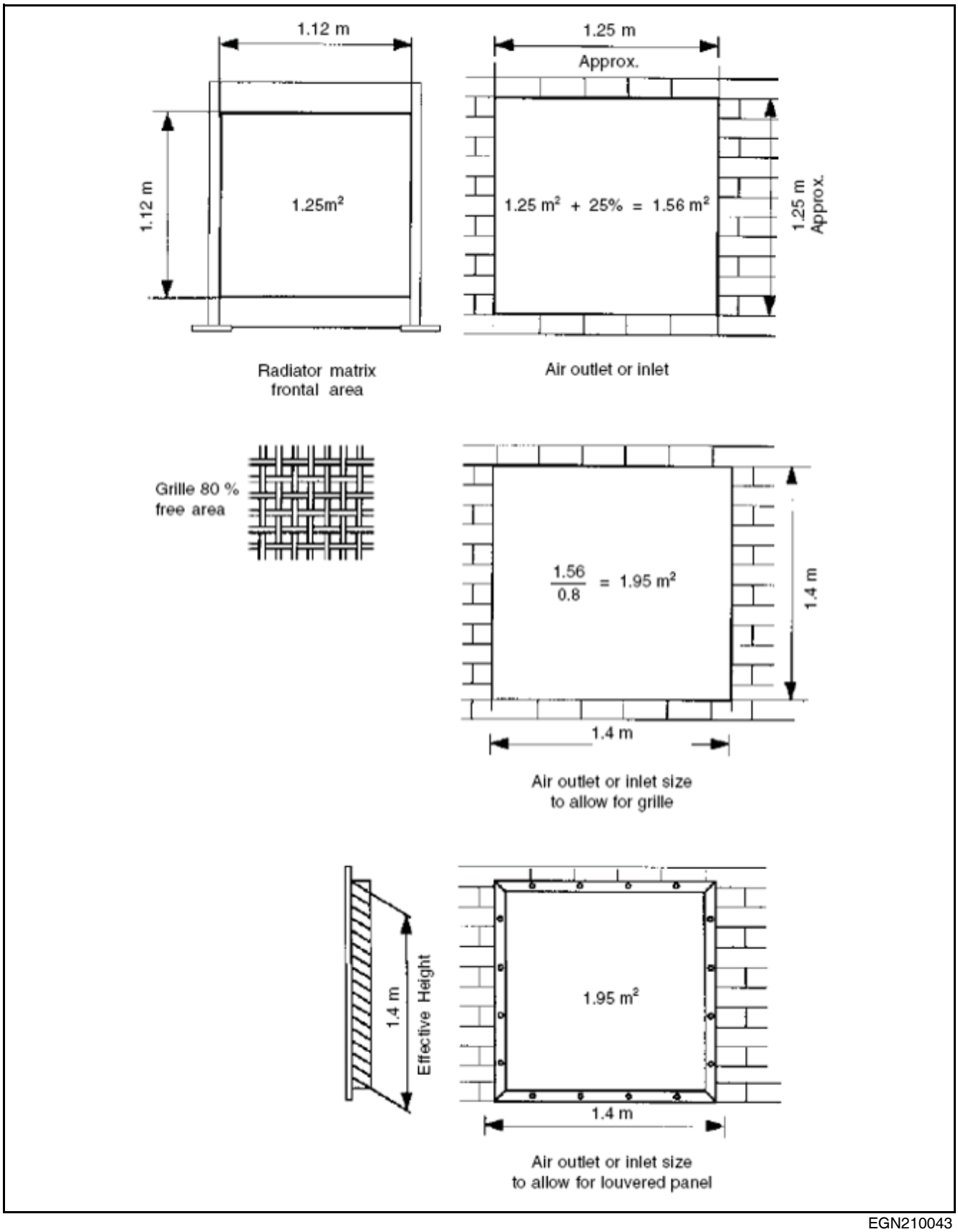

1.12 m
1.12 m
1.25m²
Radiator matrix
frontal area
1.25 m
Approx.
1.25 m² + 25% = 1.56 m²
1.25 m
Approx.
Air outlet or inlet
Grille 80 %
free area
1.56
0.8
= 1.95 m²
1.4 m
1.4 m
Air outlet or inlet size
to allow for grille
1.4 m
Effective Height
1.95 m²
1.4 m
Air outlet or inlet size
to allow for louvered panel

EGN210043

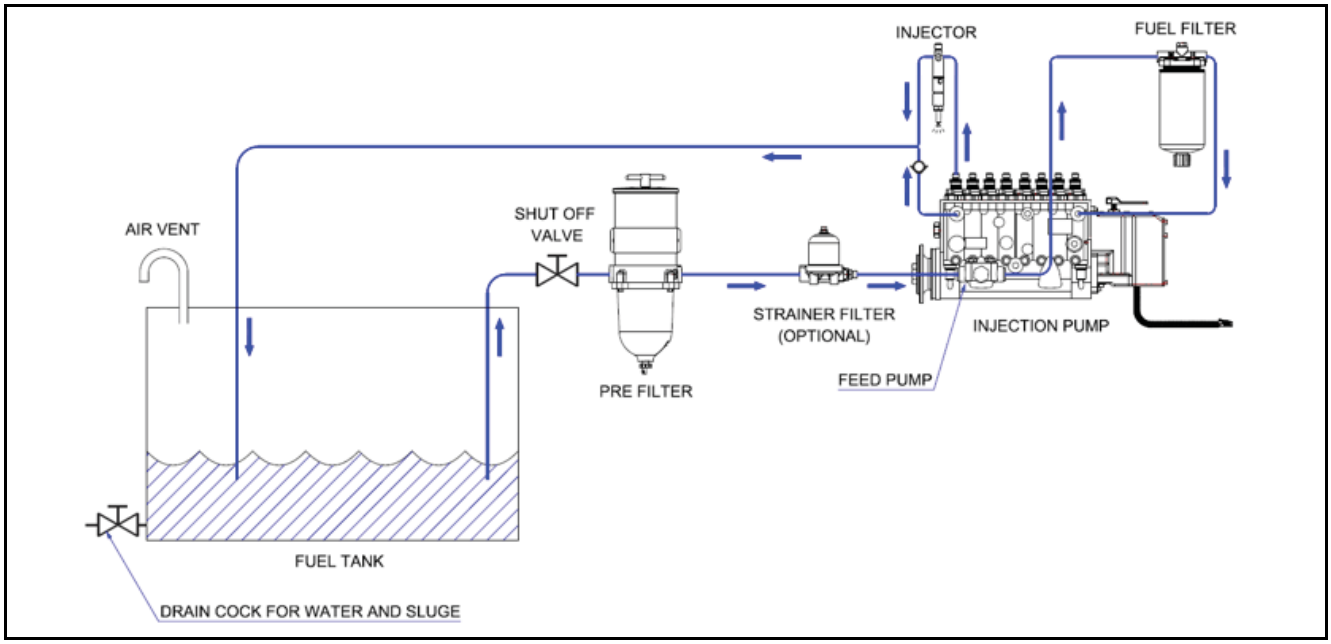
10. Fuel System

General Information

- Fuel supplied to the diesel engine injection system (FIE system) must be free of impurities such as foreign matter, moisture and air in order to protect the components of the injection system. The fuel must always be kept clean. These impurities cause severe malfunctions and shorten the life of injection system components, so in order to prevent the malfunction of these components and to maintain engine power, the use of high-quality fuel and regular maintenance and service (replacing filters, cleaning the fuel tank, etc.) are essential. During service work and inspections, make sure that the work-space is clean before performing any work to prevent foreign matter from entering the fuel system; keep any unnecessary removal and installation to a minimum; and in the case of parts which must be reused during removal and installation, take the necessary measures to prevent foreign matter from entering the parts after removing them and clean them before reusing them for installation.
- All connections within the fuel system may cause a fire and/or environmental contamination in the event of a leak, and if air enters the system, it may cause unstable performance and damage the injection system components, so make sure to follow the specified installation and assembly instructions when installing each connector.
- Parts which come into contact with liquid fuel within the fuel system must not include any zinc (Zn), copper (Cu), lead (Pb), sodium (Na), or calcium (Ca). These materials react to fuel and produce a viscous material (sludge) and other acidic components which may cause abnormal premature wear in the fuel filter and oil-water separator as well as wear and damage in the injection system.
- The reference temperature of fuel supplied to the engine is 40°C (100% power), and a power drop of 1% occurs for every 5°C increase. The fuel temperature must not exceed a maximum of 65°C (95% power) in consideration of the engine's normal power range. In addition, as the fuel temperature increases, the fuel's kinematic viscosity decreases, causing wear and damage in injection system components, which may result in a drop in engine power and high maintenance costs, so make sure to comply with these requirements.
- Any faults resulting from noncompliance with the installation manual are not covered by the engine warranty.

Fuel Circuit

As fuel is drawn from the tank by the feed pump and passes through the oil-water separator and strainer, foreign matter and moisture are removed; following this, the fuel passes through the fuel filter where small particles of foreign matter are finally filtered out; then, the clean fuel is sent to the high-pressure injection pump. The feed pump supplies the fuel necessary for combustion and lubricating/cooling the injection system components. Fuel used for lubrication and cooling returns to the fuel tank by means of the return pipe.



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10. Fuel System

Fuel Tank

The fuel tank must be able to store fuel cleanly and safely and must be structured to satisfy the following requirements so as not to affect the components of the engine injection system.

Maintaining Temperature

The temperature of fuel supplied to the engine must be between a minimum of -15°C and a maximum of 65°C in order to ensure a normal power range. Hence, make sure that the fuel tank is not exposed to direct sunlight to prevent the temperature from increasing, and install the tank in a place with minimal change in ambient temperature (daily temperature change). In addition, when the engine is in operation, the temperature within the tank increases continuously due to return fuel, so the surface of the fuel tank must be structured so as to permit smooth heat transfer with air around the tank. Make sure that the temperature does not exceed 65°C even when the tank's fuel gauge indicates the minimum level.

-15°C $\leq$ fuel temperature in fuel tank $\leq$ 65°C

Cleaning Port for Blocking and Draining Foreign Matter

When fuel is delivered to the engine, a reduction in pressure equivalent to the volume occupied by the fuel in the tank occurs, leading to a fluctuation in the volume of fuel as a result of a change in the fuel temperature. Hence, if the fuel tank is an enclosed structure, excessive static/negative pressure is formed, causing abnormal engine operation. Accordingly, the fuel tank must be equipped with an air intake/discharge system to constantly maintain atmospheric pressure, while the ports through which air is drawn in or discharged must be connected by means of extension hoses or tubes to a clean space with minimal dust, moisture, insects, etc. or if a clean space is not available, a suitable air filter must be installed to prevent foreign matter from entering the system. When air inlets and outlets are installed in extremely dusty or humid areas, the fuel in the fuel tank becomes contaminated and the service life of the oil-water separator, strainer and oil filter is severely reduced, while wear and corrosion of injection system components are accelerated, resulting in a shortened service life and high maintenance costs.

On the bottom of the fuel tank, foreign matter such as moisture entering through the air inlet and outlet ports as well as condensate on the inner wall of the tank resulting from a difference in temperature between the fuel and the ambient air form deposits continuously. Accordingly, the air inlet and outlet ports of the fuel tank must be installed in locations with as little humidity as possible and where it is difficult for moisture to enter. The tank must also have a cleaning port for removing and cleaning out condensate and foreign matter periodically in order to prevent foreign matter and condensate which accumulate at the bottom of the tank from entering the engine fuel system. When the engine is stopped after it has been running, the tank is cooled by the cold ambient air and condensate forms on the wall inside the tank, allowing various microbes to reproduce and causing oxidation of the fuel. Hence, make sure to keep the fuel tank full of fuel after the engine is stopped.

Make sure to install a device to block foreign matter (air filter) and a drain/cleaning port for foreign matter

Stable Materials Which Do Not React to Fuel

Zinc (Zn), copper (Cu), lead (Pb), sodium (Na) and calcium (Ca) cause chemical reactions with water in fuel and biodiesel, thereby forming various corrosive acids, sludge and viscous substances. When this occurs, it causes premature clogging of the oil-water separator, strainer and fuel filter, seizure of injectors, corrosion and wear of injection system components, leading to high maintenance costs resulting from engine failure. Hence, when the use of these materials cannot be avoided, make sure to apply a phosphate film or trivalent chromium plating to parts which come into direct contact with fuel in order to prevent degeneration of the fuel due to a chemical reaction.

Prohibited materials: Zinc (Zn), copper (Cu), lead (Pb), sodium (Na) and calcium (Ca)

Fuel Inlet In Tank

1) The fuel inlet in the tank should be located in a place where foreign matter such as moisture accumulated on the bottom of the tank cannot enter.
   Maximum accumulation height of foreign matter (around 50 mm for inline models, 40 mm for V models) < height of inlet < min. level of fuel tank
2) The fuel return port in the tank must be at the same height as the inlet, and the return power should not be facing the bottom of the tank. If it is facing the bottom of the tank, condensate and foreign matter accumulated on the bottom of the tank may be sprayed by impacts during engine operation, mixed with return fuel, and easily enter the inlet.
   Maximum accumulation height of foreign matter (around 50 mm for inline models, 40 mm for V models) < height of return port < min. level of fuel tank
   Direction of return port: Facing the top of the tank (by default)
   Facing the farthest wall when installed sideways
3) Relative positions of fuel inlet and return port
   The temperature of fuel supplied to the engine while the engine is running must always be kept within the range of -15°C to 65°C. Below are the recommendations for normal conditions. These may change depending on the engine operating region, the installation location and state of the fuel tank, the ambient temperature, and the daily temperature change, so it is the responsibility of the customer performing the final installation to evaluate the engine operating environment and make an appropriate selection.
   - Tropical regions
     Leave a space of at least 500 mm from the inlet in order to enable sufficient heat exchange between the high-temperature return fuel and the fuel in the tank to take place before the fuel enters the inlet.
   - Temperate regions
     The basic setup is the same as that for tropical regions.
     However, in order to avoid unstable engine rpm and power due to low-temperature fuel in winter, either connect the external fuel return line on the fuel tank directly to the fuel suction line or install a three-way valve on the fuel return line so that the fuel return line can be changed easily in summer and winter.
     When running the engine for the first time after directly connecting the fuel return line and completely bleeding the air in the system, idle the engine for at least 30 minutes to completely remove the air in the fuel line before using the engine.
     When operating with a load, make sure to satisfy the specified fuel temperature range before using the engine.
   - Cold regions
     Same requirements as those for temperature regions and winter.

Selecting Tank Capacity

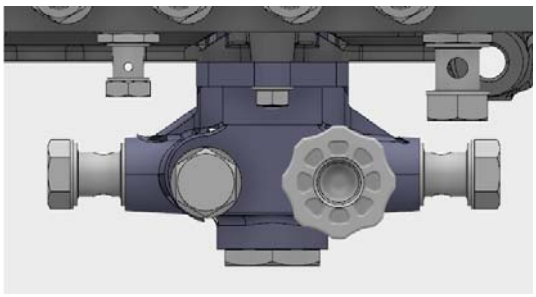
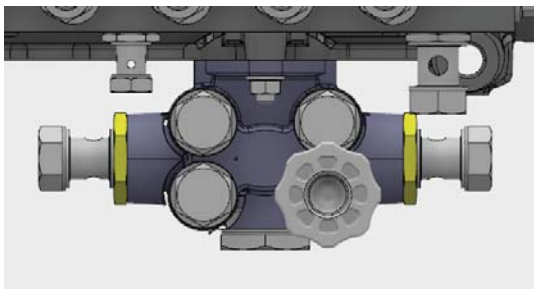
When selecting the capacity of the fuel tank, make sure to consider the engine power, fuel consumption, engine operating time, and refueling intervals, and select a capacity with enough reserve fuel.

Fuel tank capacity (liter) = Fuel consumption (liter/hr) x Running time (hr)

Fuel Tank Location

Although it is advisable to install the tank at roughly the same height as the engine, if this is not possible, make sure to take the allowable height of the fuel feed pump inlet into consideration.
For reference, the allowable height from the fuel tank to the fuel feed pump is as follows for mechanical fuel pumps.
(For more information, contact a HD Hyundai Infracore sales representative)

Inline engine (engine with single-acting feed pump)	Max. 1 m
Inline engine (engine with double-acting feed pump)	Max. 3 m
DV15/DV18/DV22	Max. 3 m

Single-acting feed pump	Double-acting feed pump
	

Installing Fuel Lines

- Fuel lines may cause a fire and/or environmental contamination in the event of a leak, and if air enters the system, it may cause unstable performance and damage the injection system components, so make sure to follow the specified installation and assembly instructions during installation.
- he number of bends in fuel lines should be kept to a minimum without any unnecessary bends. Make sure to use and install fuel lines with the specified inside diameter. For fuel lines connected to the engine, HD Hyundai Infracore recommends using lines (fuel hoses) which are flexible and fire-resistant to prevent damage due to relative motion.
- When several engines are used in parallel, make sure to install separate fuel lines to prevent mutual interference due to the flow of fuel.

1) Keep fuel lines away from rotating or vibrating parts.
2) Fuel lines should be installed away from places with excessively high or low temperatures.
3) A high flow resistance may cause a decrease in power or fluctuations in rpm, so avoid any unnecessary bends and make sure that there are no twists or sudden bends in the lines.
4) The number of connections should be kept to a minimum to prevent leaks and fires.
5) For fuel lines installed in places with relative motion such as between the engine and frame or indoor lines, make sure to use lines (fuel hoses) which are flexible and fire-resistant.
6) Fuel lines must not adjoin/touch/intersect with electrical wires.

Fuel Lines

- Make sure to select fuel lines with suitable specifications to avoid creating resistance in the fuel flow, and use materials which are both fuel-resistant and fire-resistant. The lines for each engine model must satisfy the specifications in the table below.

	DE08/DL11/DX12	**DV15/DV18/DV22**
Fuel line I.D.	> Ø10 mm	> Ø12 mm
Pressure/temperature inside engine fuel delivery lines	0.2 – 1 bar (abs) / -15 – 65°C	
Pressure/temperature inside engine fuel return lines	1 – 1.8 bar (abs) / -15 – 70°C	

Pressure Loss in Fuel Lines

- Fuel lines must be positioned so as to have minimum resistance within them, and the fuel lines must be installed in order to satisfy the fuel flow rate and allowable pressure loss requirements for each model below.

Model	Flow rate		Allowable pressure loss (bar)	
	liter/hr	liter/min	Supply	Return
Inline single-acting	198	3.30	0.12	0.6
Inline double-acting	315	5.25	0.12	0.6
DX12/DV15	315	5.25	0.135	0.6
DV18/DV22	630	10.50	0.135	0.6

Fuel Filter

- The fuel filter is an important component which prevents malfunction and damage in the fuel injection system by filtering out the foreign matter in fuel and supplying only clean fuel to the fuel injection system. Hence, make sure to use a genuine HD Hyundai Infracore fuel filter. Non-genuine fuel filters do not satisfy the performance required by injection system components. Since the warranty does not cover any malfunctions, faults, shortening of service life, or premature wear of injection system components as a result of using non-genuine parts, high maintenance costs may occur.

Oil-Water Separator

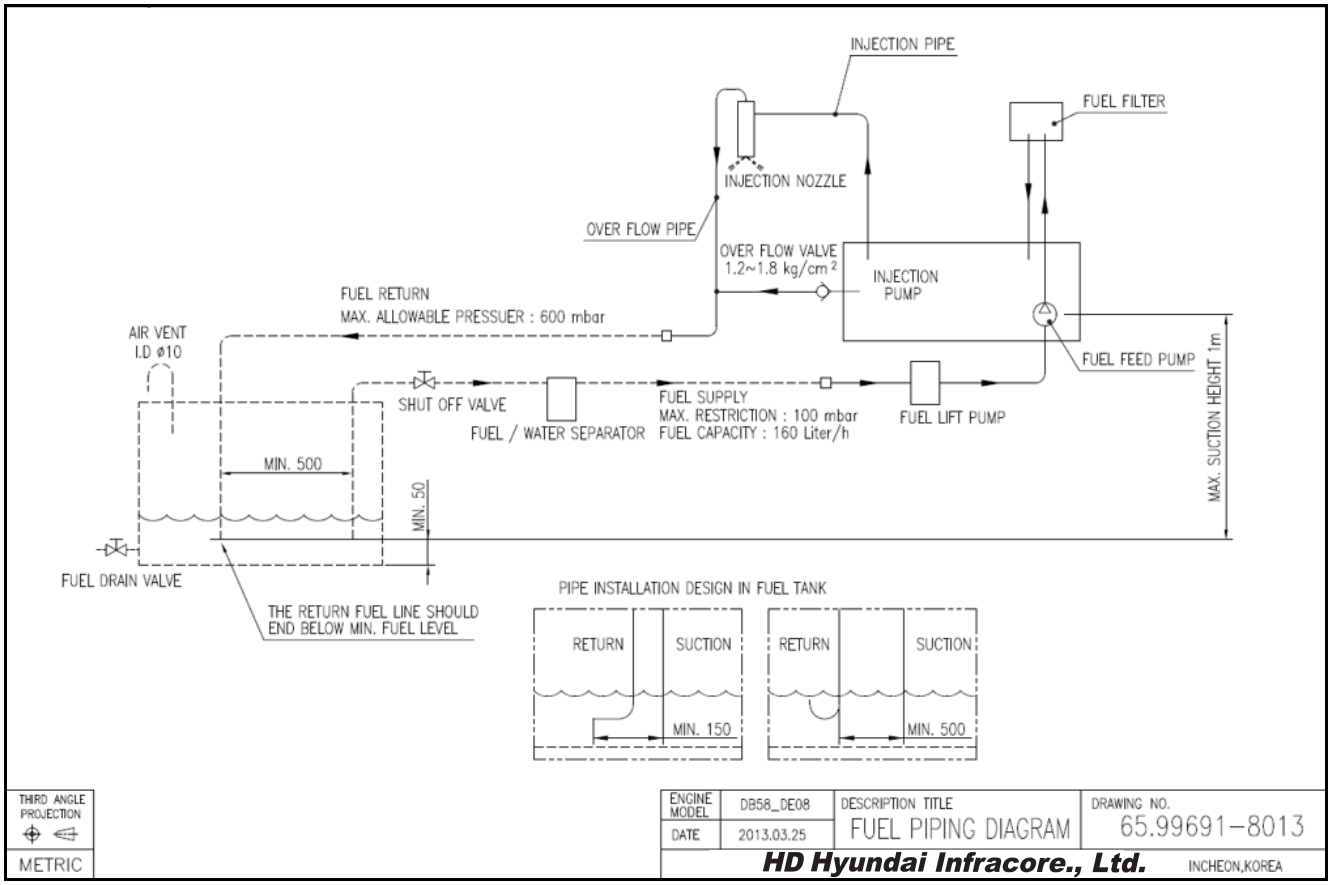
- With regard to the lubrication and cooling of fuel injection system components, fuel must be supplied to the engine in a clean state without any air or moisture, and if fuel containing moisture enters the engine, it can drastically reduce the service life and cause high maintenance costs due to wear and corrosion of injection system components, so the following type of oil-water separator must be installed between the fuel tank and the engine. The oil-water separator installed should be either the Parker 900 FH or Parker 1,000 FH depending on the model as follows.

EGN210047

Parker Model Name	Part No.	Flow Rate (LPH)	Filter	Applicable Model
900 FH	400403-00558	341	30 micron	Inline & V8
1,000 FH	400403-00557	681	30 micron	V10, V12

Fuel Line Circuit Diagrams

- DE08



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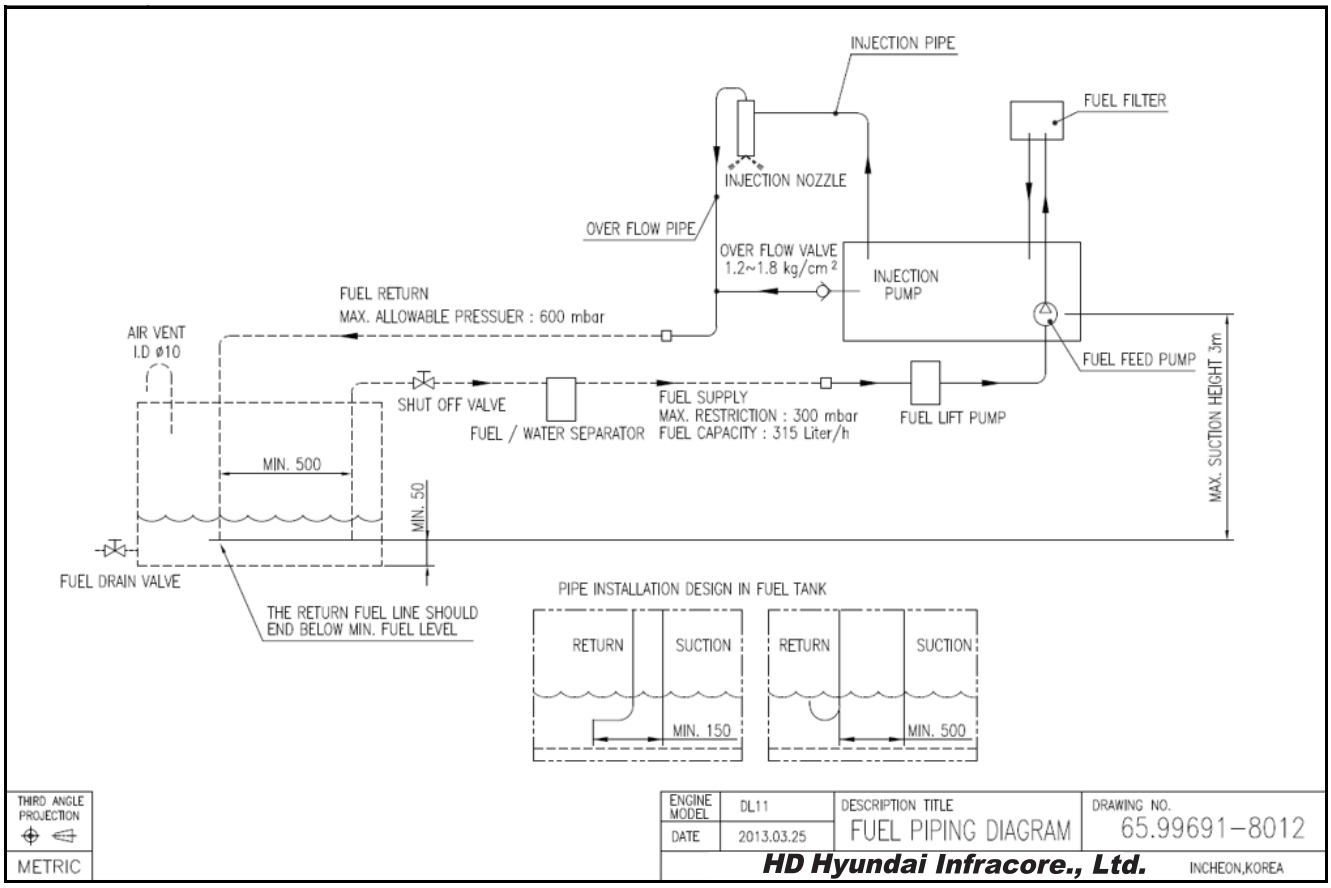
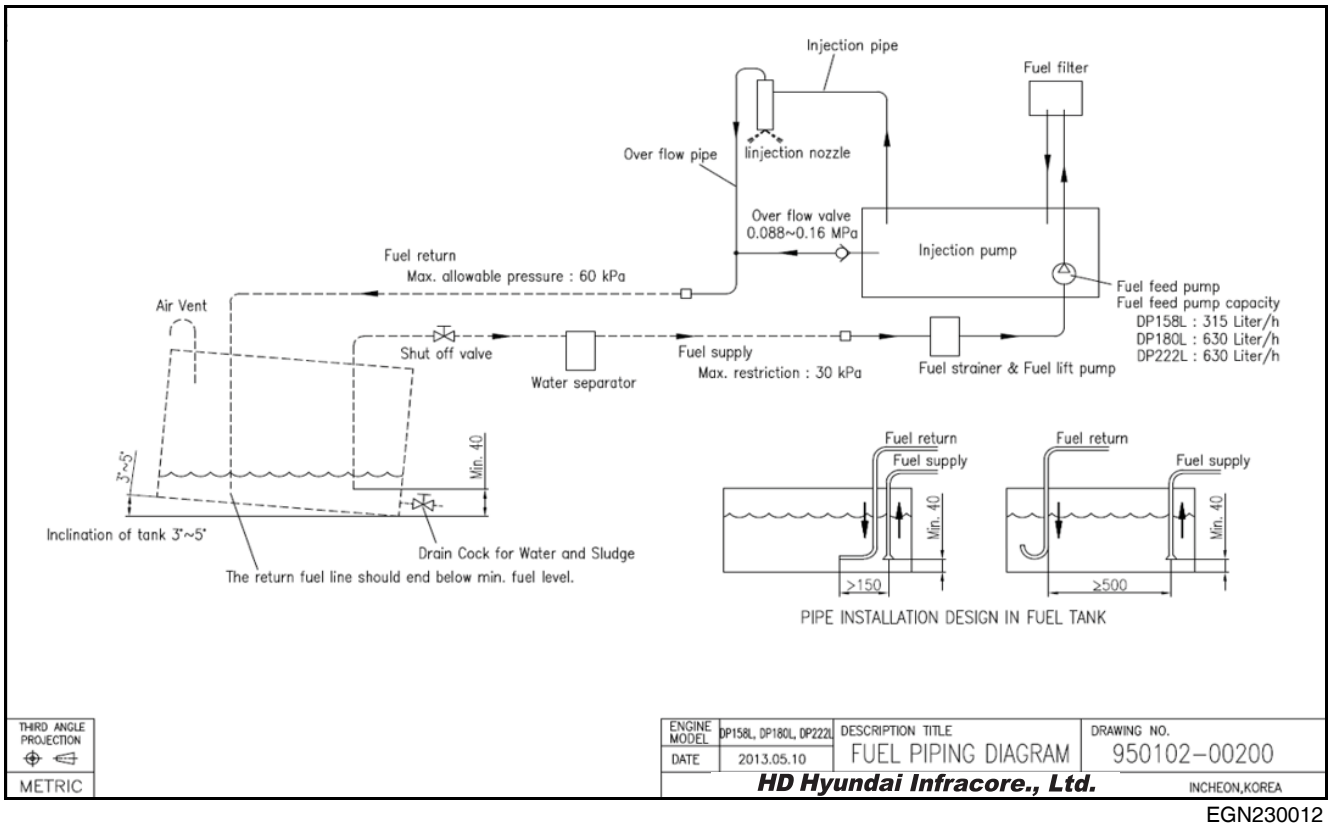
- DL11



EGN230011

- DV15/18/22



EGN230012

10. Fuel System

Fuel Quality and Functions

Fuel Requirements

Malfunctions and faults in injection system components resulting from the use of unapproved fuel are not covered by the engine warranty.

Allowable Fuel Under Warranty

1) Korea: Article 115 Schedule 33 'Ultra-Low-Sulfur Diesel' of the Clean Air Conservation Act
2) Europe: EN590:2013 AC:2014, EN16734:2016
3) North America: ASTM D975-15C Grade 1D or 2D
4) Japan: JIS K2204:2007 (lubricity $\leq$ 520μm, FAME max. 5%)
5) China: GB252:2015 and GB19147:2013
6) India: IS 1460 2005 Amm. 10 BS III or BS IV
7) Brazil: ANP69/2014
8) Russia: GOST R32511-2013 (excluding Articles 3 and 4)

Water and Foreign Matter in Fuel

The fuel and fuel tank must be kept free of moisture. Water in fuel causes the following problems.

1) Incomplete combustion
2) Nozzle clogging
3) Injection pump damage
4) Piston damage

Moisture also accelerates the growth of mold or microbes in the fuel tank, thereby clogging the fuel filter. In winter, moisture can freeze and block the delivery of fuel.

11. Electrical System

General Information

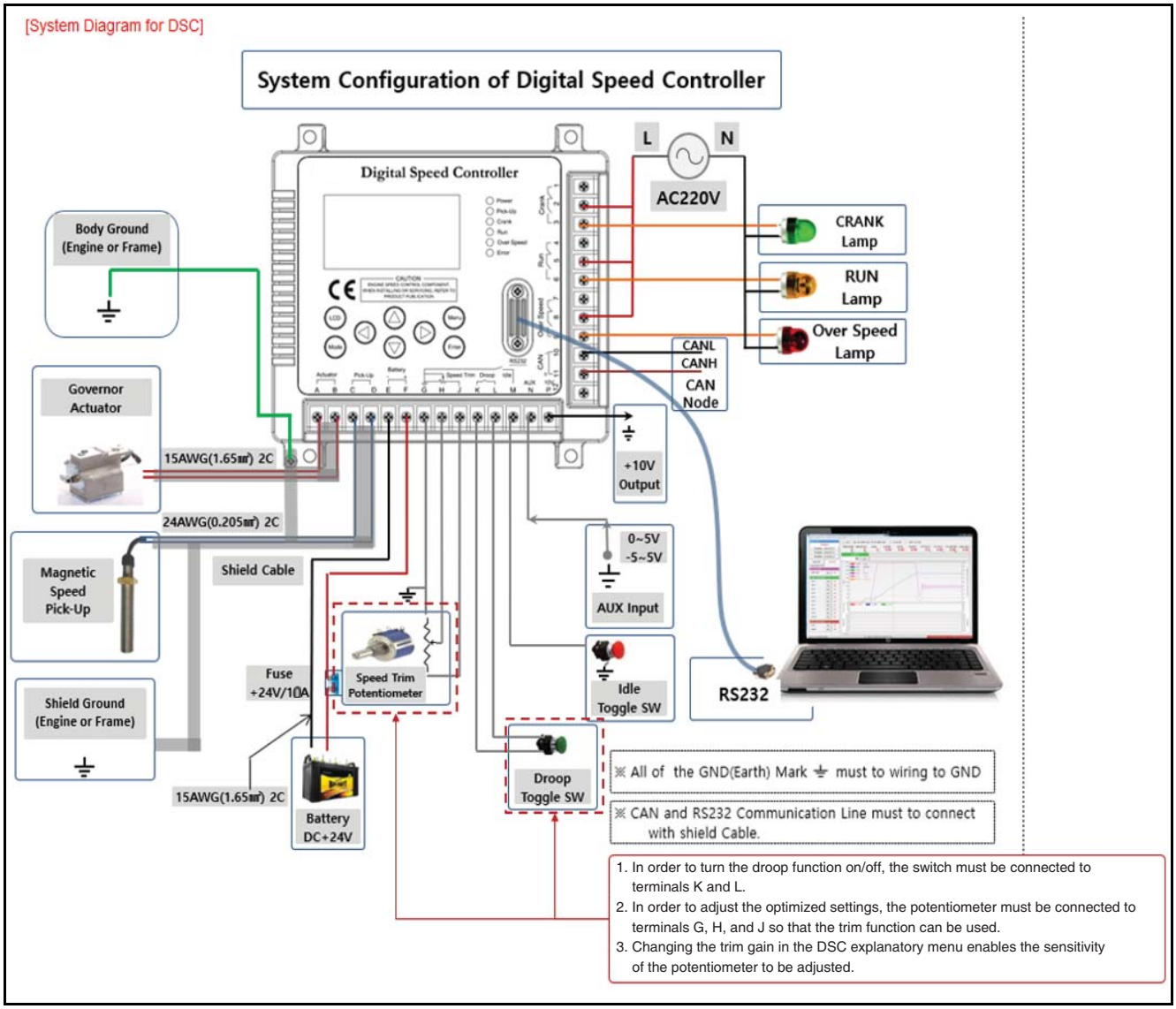
Cautions for Grounding

The electrical system of the generator engine and the drive system must be grounded suitably. A suitable ground is necessary for obtaining optimal performance and reliability. Incorrect grounding creates an unreliable flow of electricity. An uncontrollable electrical flow can damage the main bearings, the surface of the crankshaft journals, and aluminum parts. It can also cause electrical faults which may degrade the electrical performance of the generator set.
The engine and generator frame must be grounded to the negative terminal of the battery.
The ground terminal connected directly to the negative battery terminal may be used as a shared ground for a single engine system.
The engine's ground cable must be sufficiently large enough to convey the alternator's maximum charging current and the starter motor's maximum drive current.
All ground cables should be installed at the optimal length and must be insulated to prevent corrosion.

Digital Speed Controller Installation Guide

1. Cautions regarding installation location
- Install the controller perpendicularly to the face of the control panel, away from water or moisture, and make sure that heat from heating elements near the controller is not transferred to it.
- Do not rely solely on the actuator function of the electronic governor to prevent overspeeding. Use a separate, independent auxiliary fuel shutoff solenoid mechanism.
- When performing welding or charging the battery near the controller, make sure that the controller battery terminal is disconnected.

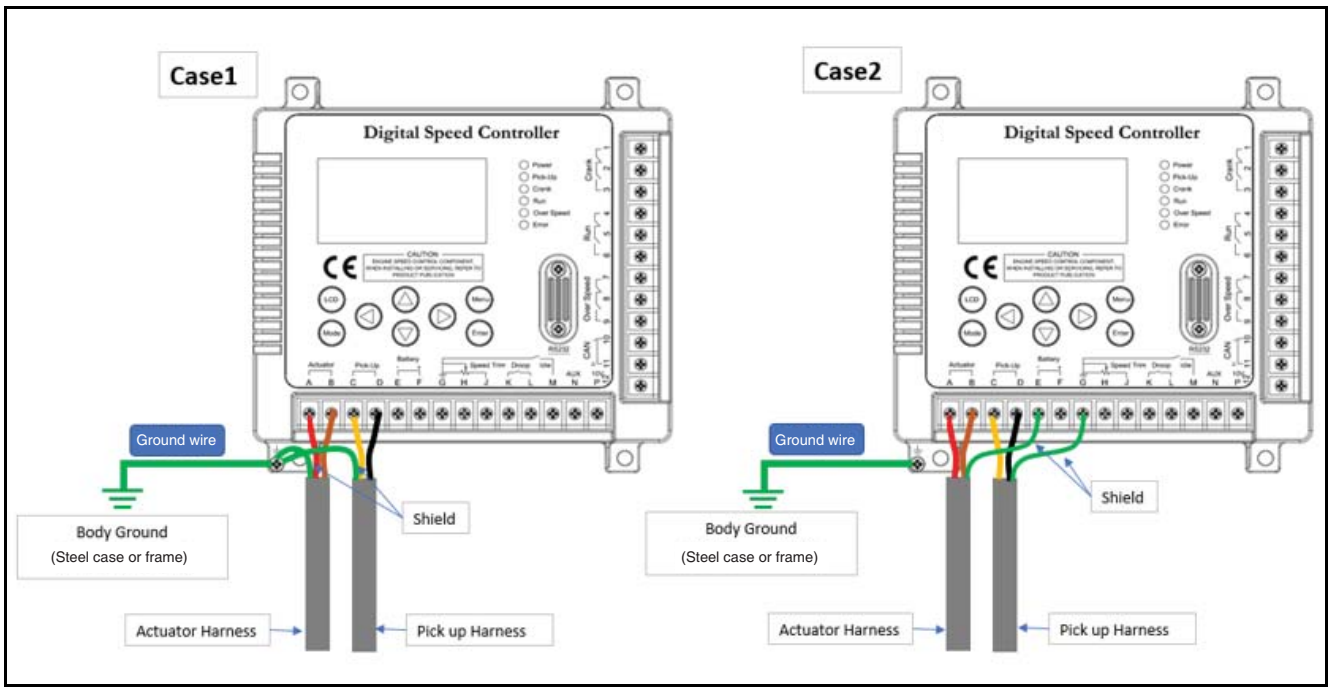
2. Cautions for connecting the battery
- The total length of the actuator (15AWG), pick-up (24AWG_Shielded Cable) and battery (15AWG) connecting cables must be less than 10 m each.
- Connect the circuit with reference to the system diagram and check the type of cables.
- Incorrectly assembled wiring may cause critical damage to the controller, so make sure to inspect it before use.
- A fuse (10A) for protecting the circuit must be installed upstream from battery input terminal "F."
- Do not split the wiring of a single pick-up sensor in order to use it for multiple parts. If additional rpm information is necessary, install another pick-up sensor(s).
- Product malfunctions resulting from noncompliance with the installation manual are not covered by the warranty.


[System Diagram for DSC]
System Configuration of Digital Speed Controller
Digital Speed Controller
L
N
AC220V
CRANK Lamp
RUN Lamp
Over Speed Lamp
CANL
CANH
CAN Node
Body Ground (Engine or Frame)
Governor Actuator
15AWG(1.65㎟) 2C
24AWG(0.205㎟) 2C
Shield Cable
Magnetic Speed Pick-Up
Shield Ground (Engine or Frame)
Fuse +24V/10A
Speed Trim Potentiometer
15AWG(1.65㎟) 2C
Battery DC+24V
+10V Output
0~5V
-5~5V
AUX Input
Idle Toggle SW
Droop Toggle SW
RS232
※ All of the GND(Earth) Mark ⏚ must to wiring to GND
※ CAN and RS232 Communication Line must to connect with shield Cable.
1. In order to turn the droop function on/off, the switch must be connected to terminals K and L.
2. In order to adjust the optimized settings, the potentiometer must be connected to terminals G, H, and J so that the trim function can be used.
3. Changing the trim gain in the DSC explanatory menu enables the sensitivity of the potentiometer to be adjusted.

EGN250001

Grounding the Digital Speed Controller

The shielded cables of the actuator and pick-up sensor must be grounded to eliminate noise.
To ground the system, either use the ground cable on the controller case or connect them to terminals D, E and/or G.
If the ground cable on the controller case is used, the body of the controller must be grounded to a metal part of the chassis, such as the control box or generator frame.
Even when the system is connected to terminals D, E and/or G,
it is recommended to ground it to an external frame in order to prevent accidents due to short circuits with the case.

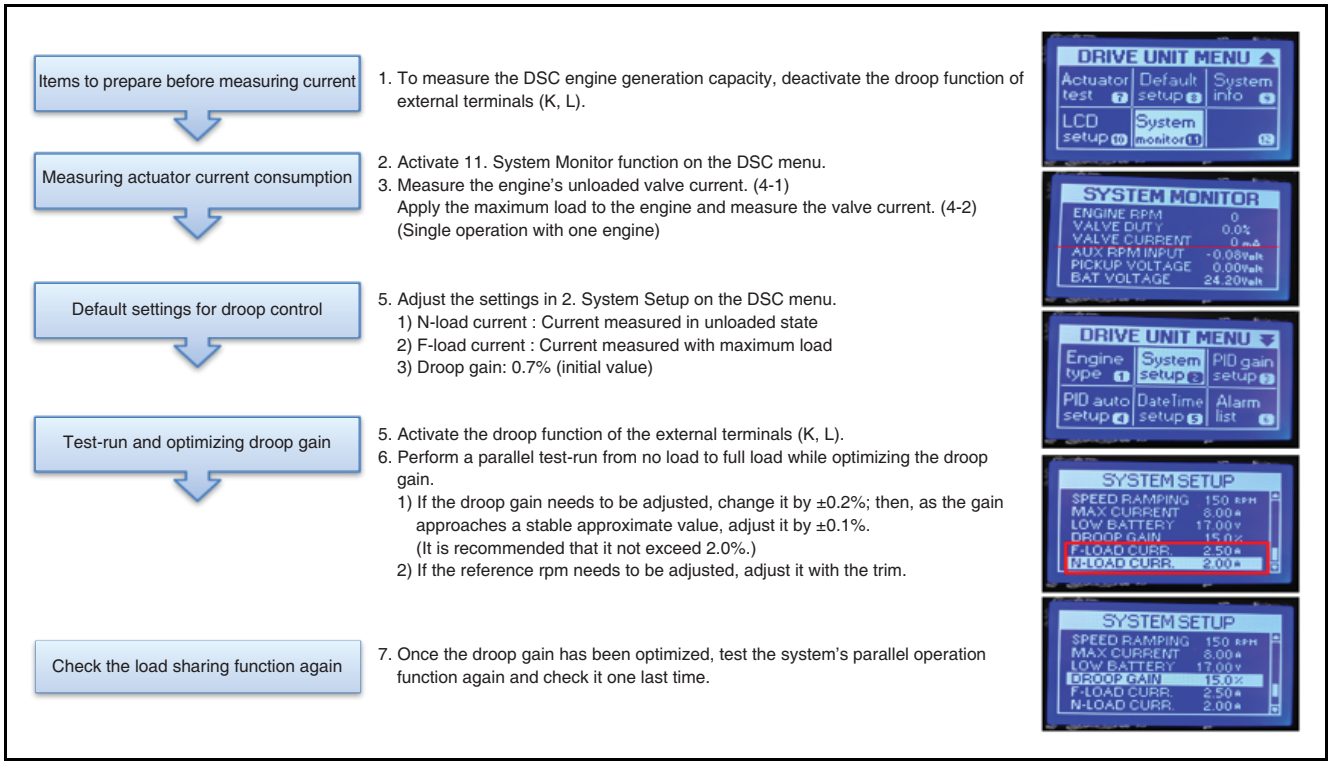


EGN210052

If the controller case or wire shield is not grounded correctly, unnecessary nearby electromagnetic noise is not canceled by the ground terminal and can affect engine operation by causing hunting or abnormal pick-up signals.

Configuring and Using Droop Function on Digital Speed Controller

The droop function is used when several generators share their load without using a separate controller for parallel operation. In order to use the controller's droop function, complete the basic setup and perform a test-run while optimizing the settings. Refer to the instructions below to use the function.

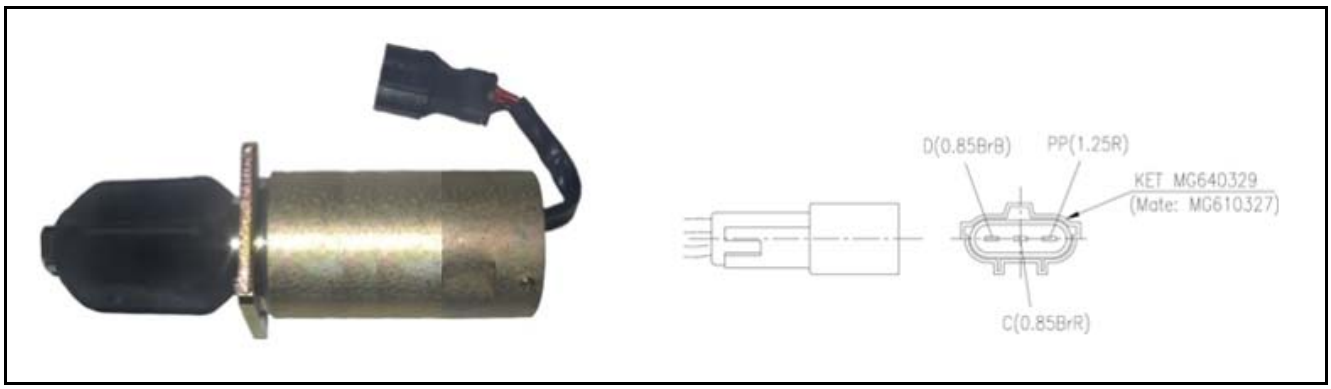


EGN210053

Fuel Shutoff Solenoid (Mechanical Governor)

The fuel shutoff solenoid is used to stop the engine. Only the "energized to stop" type of solenoid is provided by HD Hyundai Infracore, i.e. the engine stops when electrical power is supplied. To use an energized to run solenoid (the engine stops when electrical power is cut off), the fuel shutoff solenoid system must be upgraded by a specialized company.

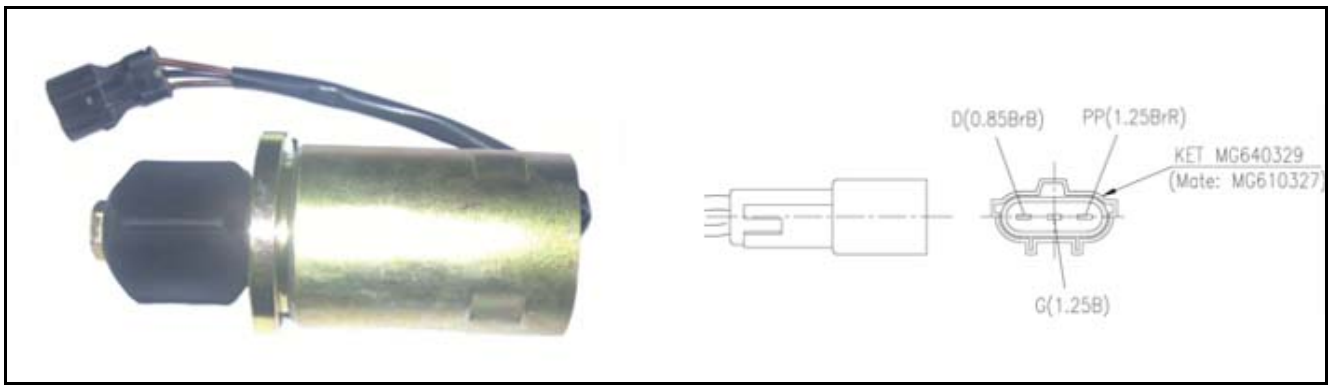
1. Small solenoid (pulling force: 4.0 kg or more)
   Used in 11 liter (DL11) or smaller HD Hyundai Infracore generator engines. The power supply and control logic for using the solenoid must be installed by the manufacturer of the generator system.



EGN210054

- PP (Red): VCC
- G (Brown/Black): GND
- D (Brown/Red): Signal (-)

2. Standard solenoid (pulling force: 8.0 kg or more)
   Used in medium-size/large emergency marine generators for HD Hyundai Infracore generator engines. The power supply and control logic for using the solenoid must be installed by the manufacturer of the generator system.



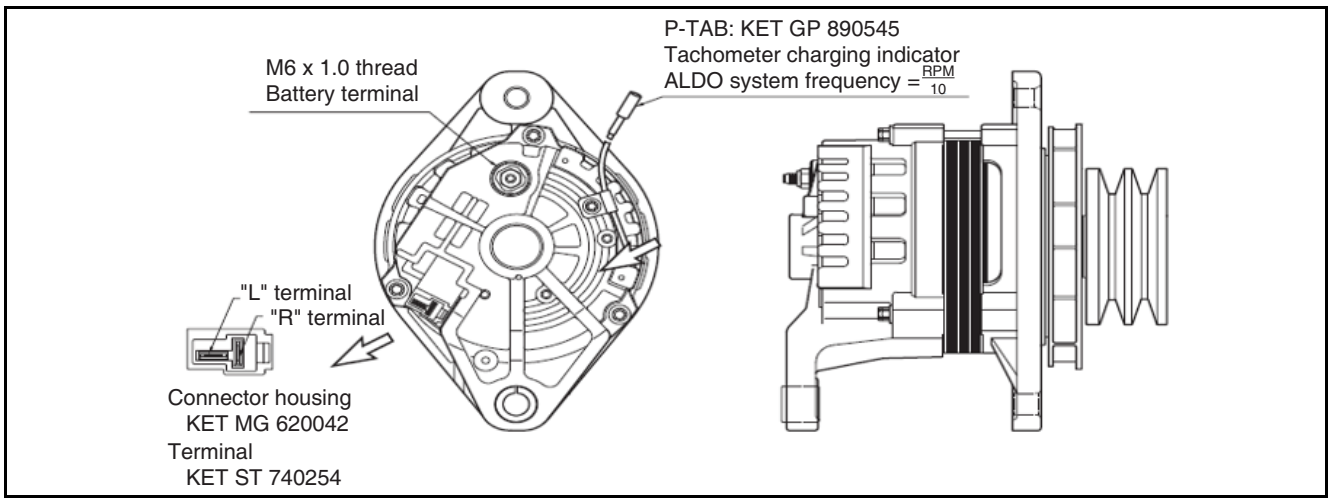
EGN210055

- PP (Brown/Red): VCC
- G (Black): GND
- D (Brown/Black): Signal (-)

11. Electrical System

Alternator

The alternator is equipped with an internal silicon rectifier. The voltage regulator installed in the body of the alternator consistently adjusts the voltage generated inside and supplies it to the battery. In order to prevent damage to the rectifier and regulator, do not run the alternator unless the regulator and battery are connected to the circuit.

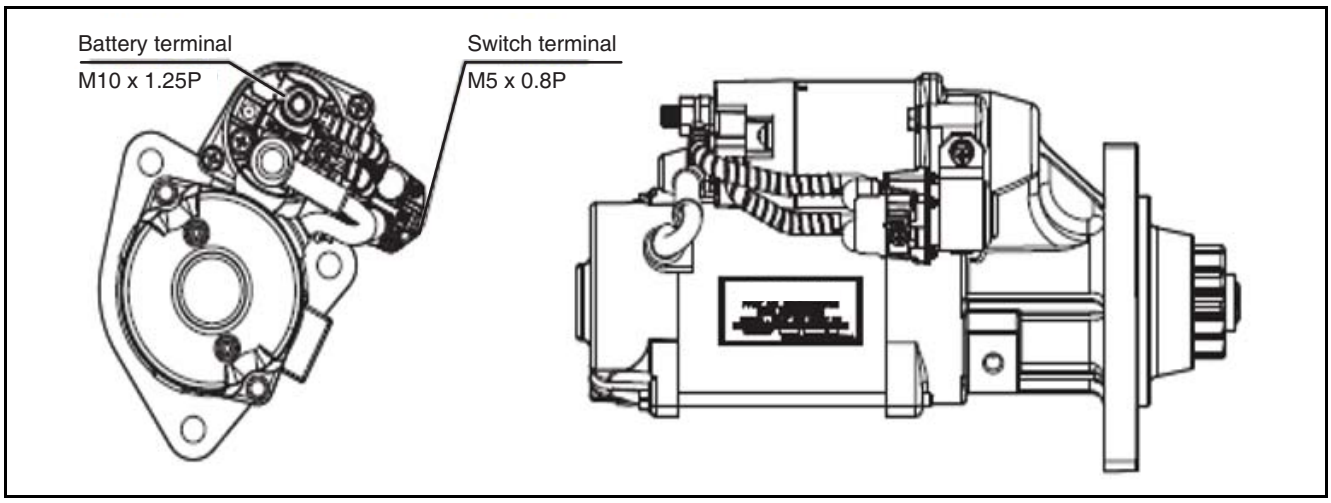


EGN210056

The alternator does not require maintenance, but it must be protected from dust, moisture and water.

Starter Motor

The starter motor is an earth return type which acts as the negative (-) terminal. Either the starter motor body or the engine body must be grounded to the negative battery terminal. The positive (+) terminal of the starter motor must be connected to the positive battery terminal, and the ground cable and power cable must be sufficiently large enough to convey the maximum drive current.



EGN230009

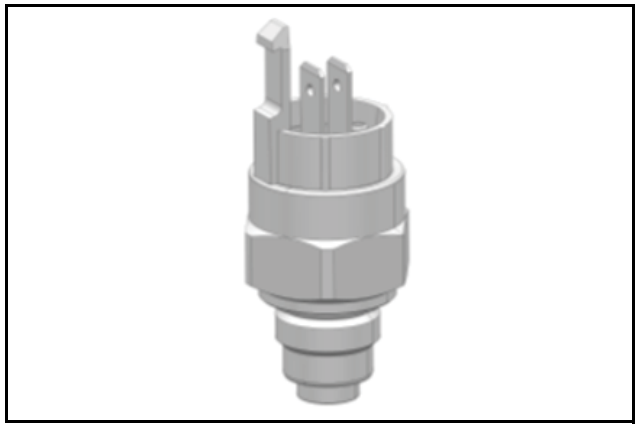
In order to prevent damage to the starter motor, the control panel system must be designed so that the starter motor does not turn on while the engine is running and the ignition signal is cut off between 400 - 600 rpm.
Damage from reactivation of the starter motor generally occurs when the motor is restarted before it has stopped completely, so make sure to restart the engine only once the engine has stopped completely.
The starter motor should not run for more than 10 seconds. Continuously restarting the starter motor causes it to heat up, which may degrade its performance. Hence, do not restart the starter motor more than three times in a row; allow the motor to rest sufficiently before restarting it again.

Sensors

Coolant Temperature Switch

This temperature switch measures the coolant temperature. The switch is used as an alarm. It measures the coolant temperature, and when the temperature reaches a certain level, the switch is activated. It is a resistive-type switch, so it has no polarity.

1. Operating temperature: ON: 103 ±3°C, OFF: 96°C or more
2. Current capacity: DV12V, 9A
3. Switch type: Normal open (—o o—)
4. Insulation resistance: 10MΩ or more
5. Durability: 50,000 times (subsequent temperature changes must be less than ±4°C of the initial value)
6. Thermal resistance: Must be free of faults at 130°C, 100 hr.
7. Tightening torque: 3.5 ±0.5 kgf.m



EGN210058

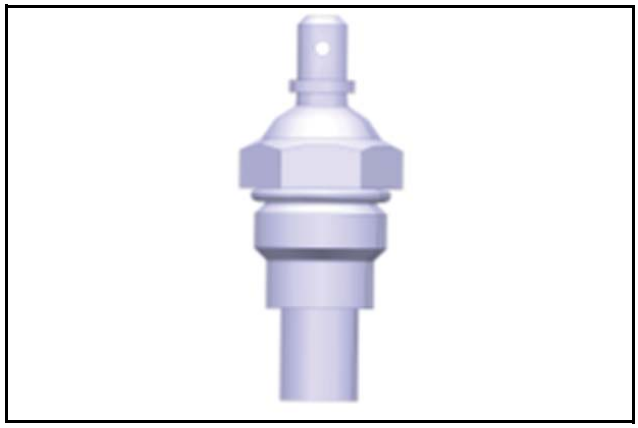
Coolant Temperature Sensor

This temperature sensor measures the coolant temperature. It is used for display purposes. The resistance changes depending on the coolant temperature. It is a resistive-type sensor, so it has no polarity.

Opposite terminal: KET MG630063

Resistance

Temperature (°C)	50	80	100	120
Resistance (Ω)	(153.9)	51.9 $^{+6.1}_{-4.4}$	27.4 $^{+3.9}_{-1.2}$	(16.1)



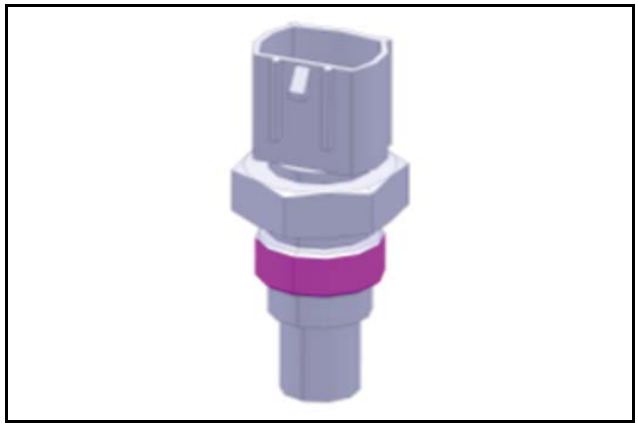
EGN210059

Coolant Temperature Sensor (For Controlling the Air Heater)

This temperature sensor measures the coolant temperature. It is used for controlling the air heater. The resistance changes depending on the coolant temperature. It is a resistive-type sensor, so it has no polarity.

Opposite terminal: MG640461

Temperature (°C)	**7V 55Ω Gauge**		**7V 25Ω Gauge**	
	Resistance (Ω)	**Current (mA)**	**Resistance (Ω)**	**Current (mA)**
50	226 $^{+33.6}_{-36.6}$	24.9 $^{+3.7}_{-2.6}$	-	-
115	26.4 $^{+1.71}_{-2.21}$	86.0 $^{+2.4}_{-1.8}$	24.3 $^{+2.68}_{-3.68}$	142 $^{+11.5}_{-7.8}$

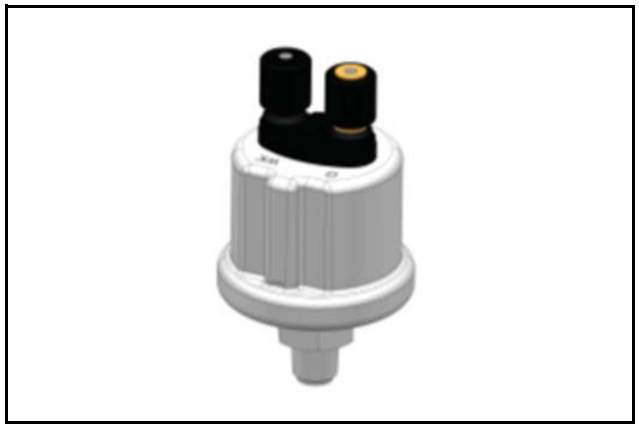


EGN210060

Oil Pressure Sensor

This pressure sensor measures the oil pressure in the main oil gallery. The resistance changes depending on the oil pressure. It is a resistive-type sensor, so it has no polarity.
Opposite terminal: M4 Rig Terminal (Torque: Max 1.0 N.m)

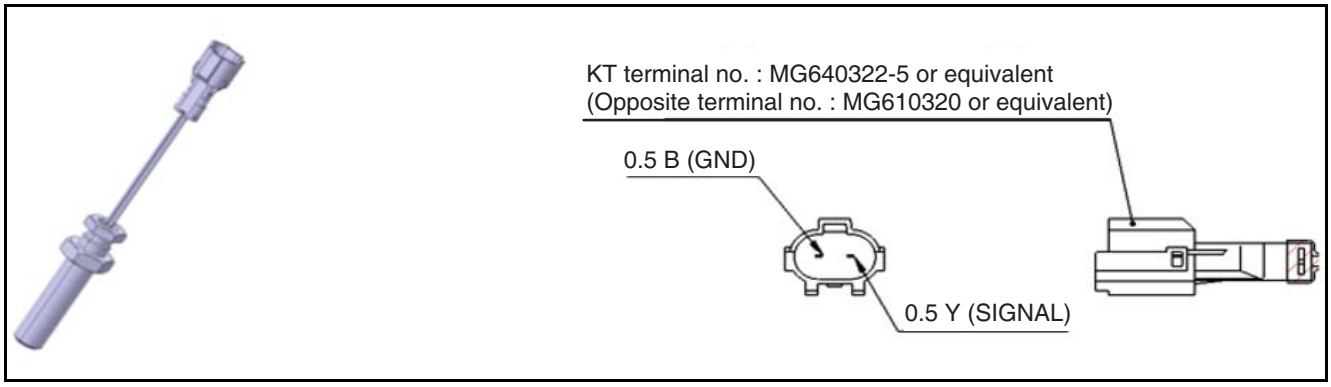
Pressure (bar)	0	2	4	6	8	10	Warning pressure (bar)
Resistance (Ω)	10 ±5	52 ±5	88 ±5	124 ±5	155 ±7	184 $^{+8}_{-7}$	



EGN210061

Magnetic Pick-up Sensor

This sensor measures the engine rpm. The voltage output changes depending on the rpm. In order to obtain an accurate output value, the air gap must be adjusted to 1.0 ±0.1 mm.



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Battery

A battery with suitable specifications for the engine and generator load must be selected.
The recommended battery specifications for each model are as follows.

Engine	Voltage (V)	AH	CCA	Quantity
DB58/DE08/GL08	12	100	750	2
DL11/DX12/GL11	12	150	950	2
DV15/DV18/DV22/DX22	12	200	1,000	2