HYUNDAI INFRACORE

950106-163001EN

Installation Guide

GAS 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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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

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

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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.

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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

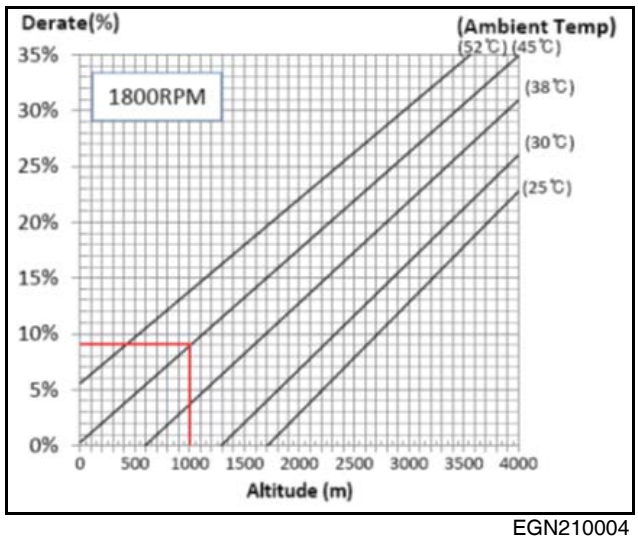
HD Hyundai Infracore generator engines have various power ratings depending on the intended purpose of the engine determined at the time of sale; these power ratings conform to ISO 8528.

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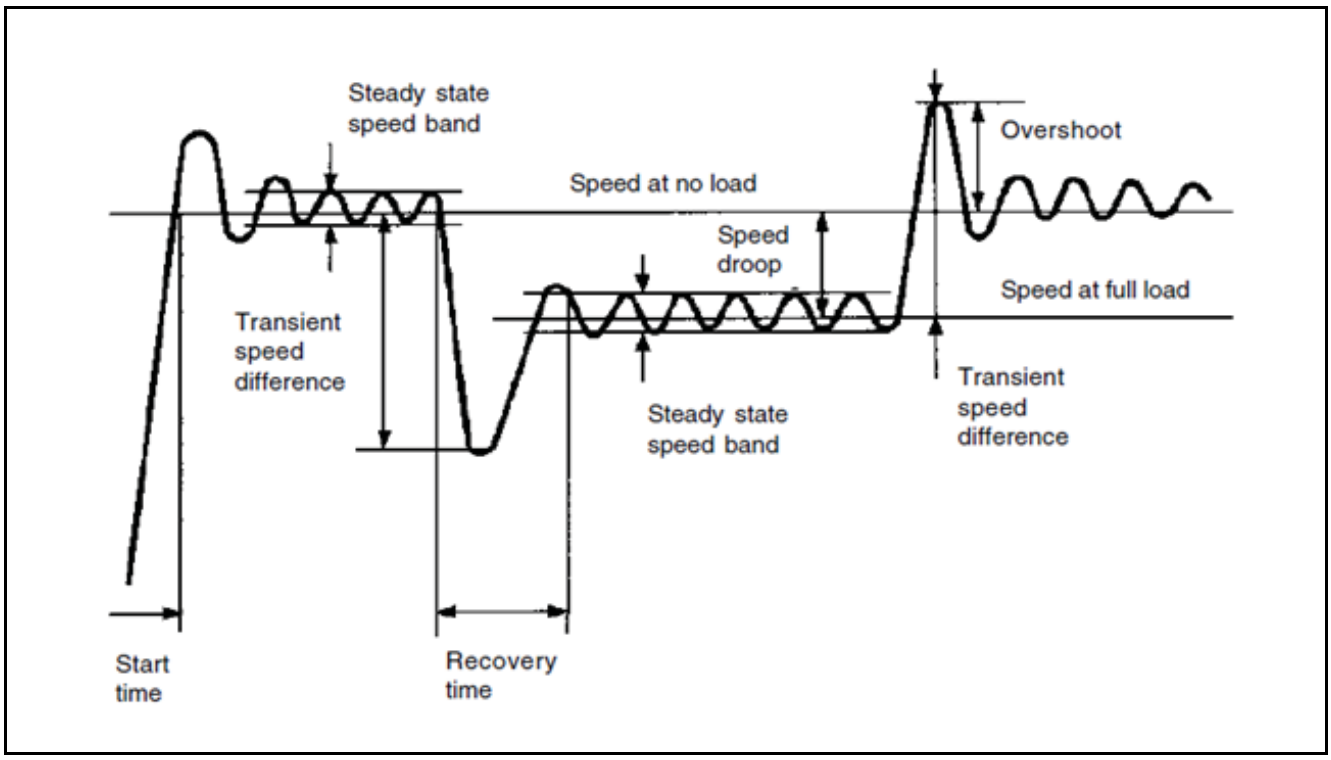
Power derating must be performed daily when operating under the same conditions; failing to perform derating may result in the following phenomena.

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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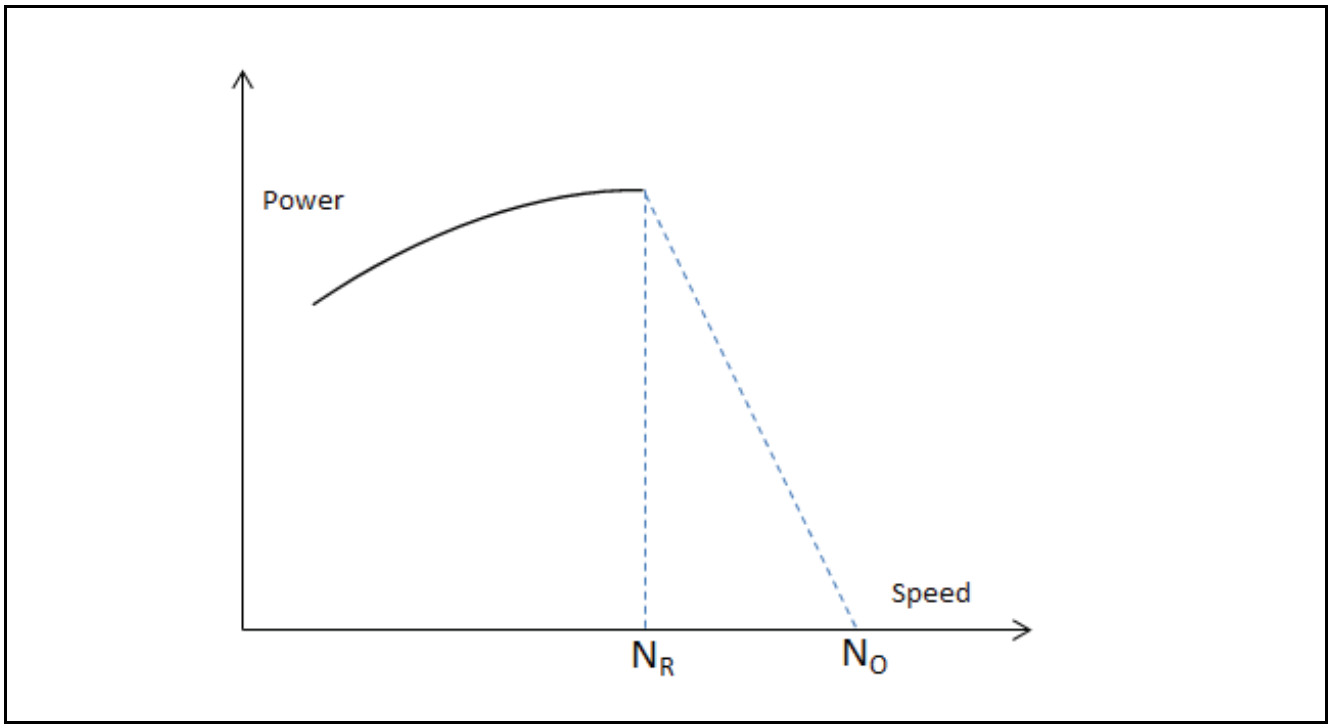
Engine Speed Control

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%

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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

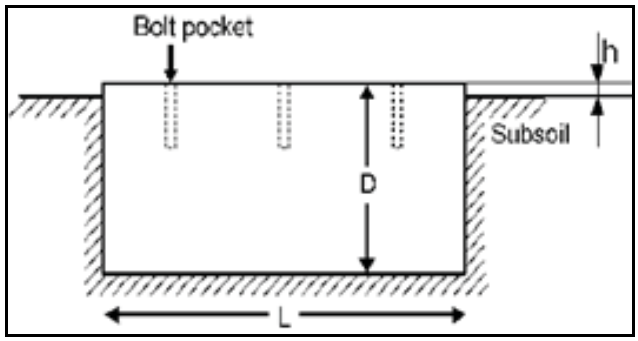
The generator set's foundation must be strong enough to withstand both its own weight and the vibrations and external forces which occur while the engine is running. Take particular care to ensure that harmful vibrations from engine operation do not affect other machines or buildings. In addition, make 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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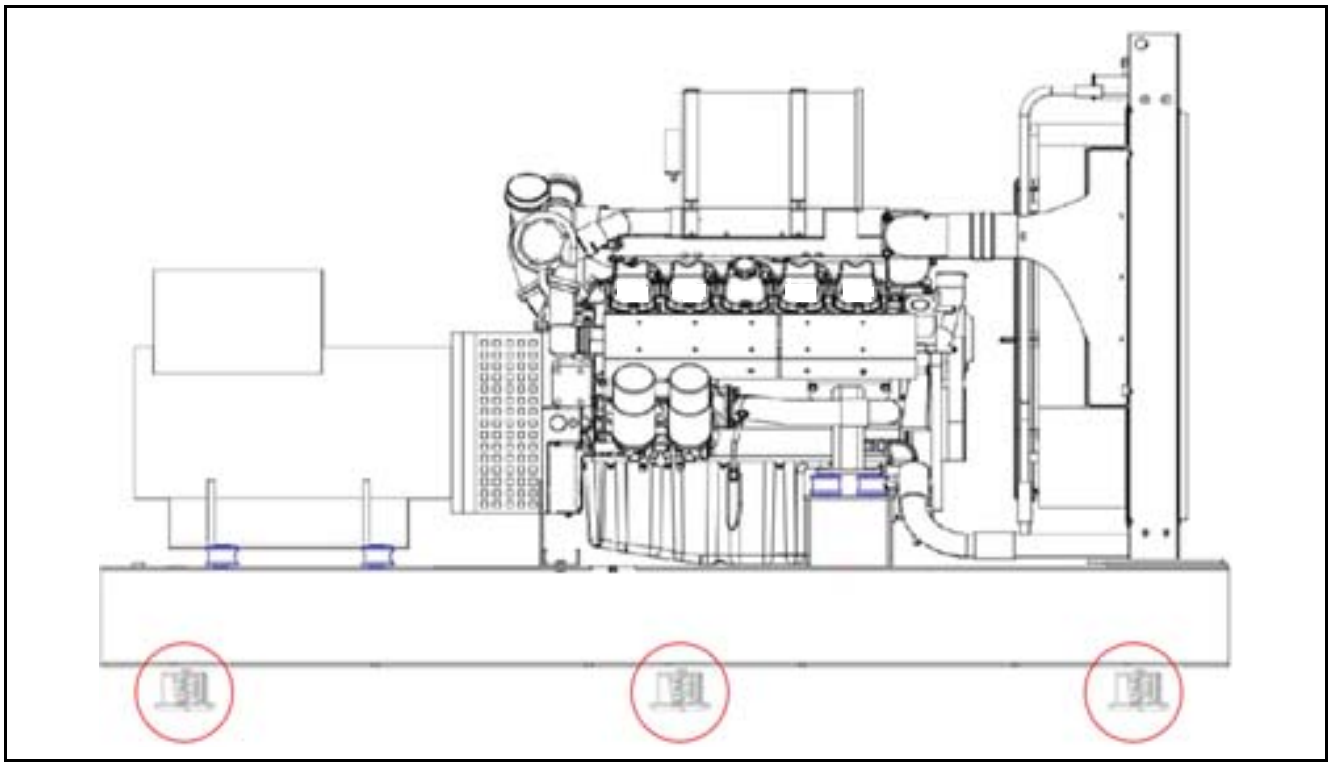
When generator sets are operated in parallel, the foundation must be made firmer than when an individual generator is operated in order to prevent the generator sets from going out of sync with one another as well as the withstand torque rebound.

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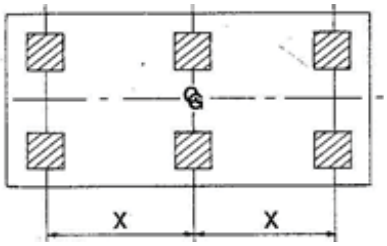
The foundation must be stronger than the anti-vibration unit when such a unit is installed. Otherwise, the foundation acts as another spring. In addition, all pipes, cables and ducts must be flexible in order to respond to deformation caused by vibrations when an anti-vibration unit is installed.

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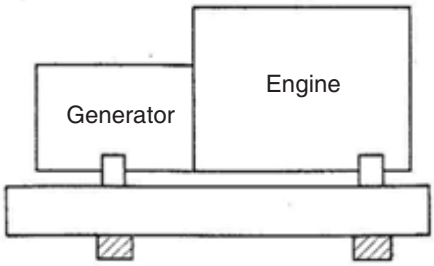
- When supporting four points (small engine)
  Both the engine and the generator unit require a pair of mounting points.



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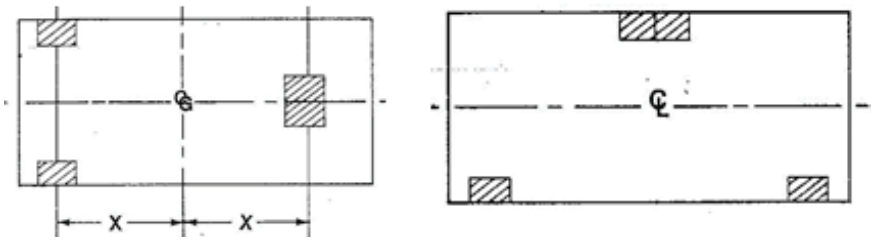
- When supporting three points
  Three mounting points with an equal load distribution are required.



EGN210011

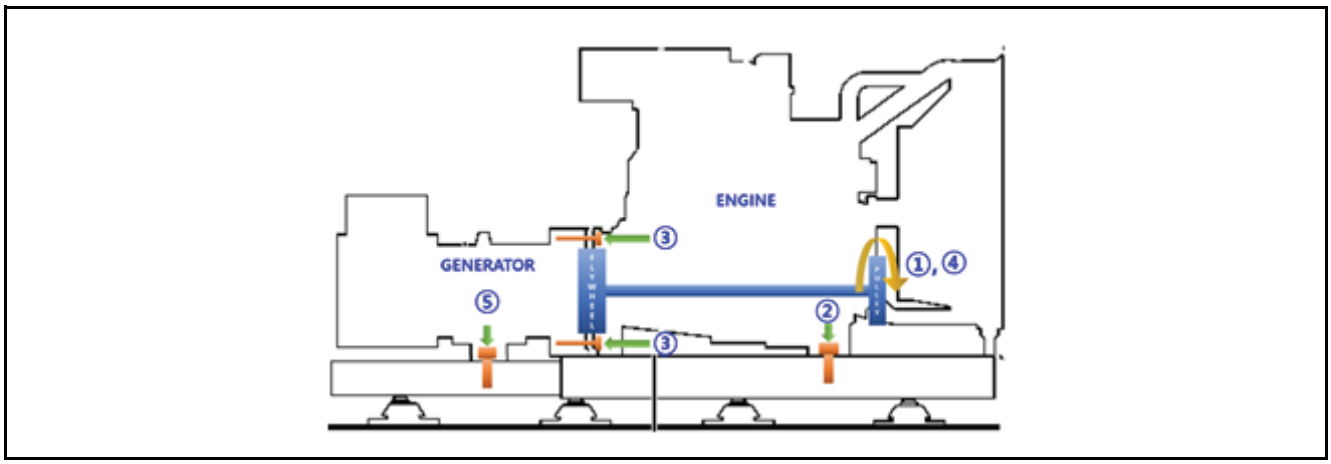
3. Generator Mounting

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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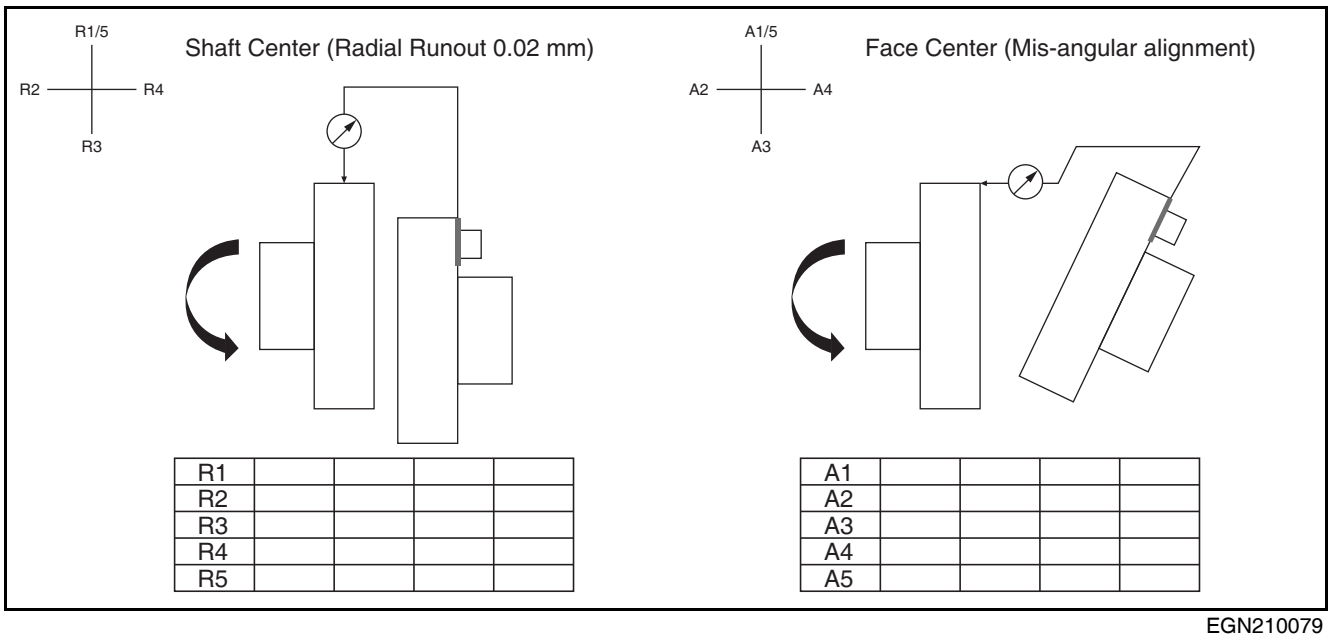


R1				
R2				
R3				
R4				
R5				

A1				
A2				
A3				
A4				
A5				

EGN210079

⚠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.

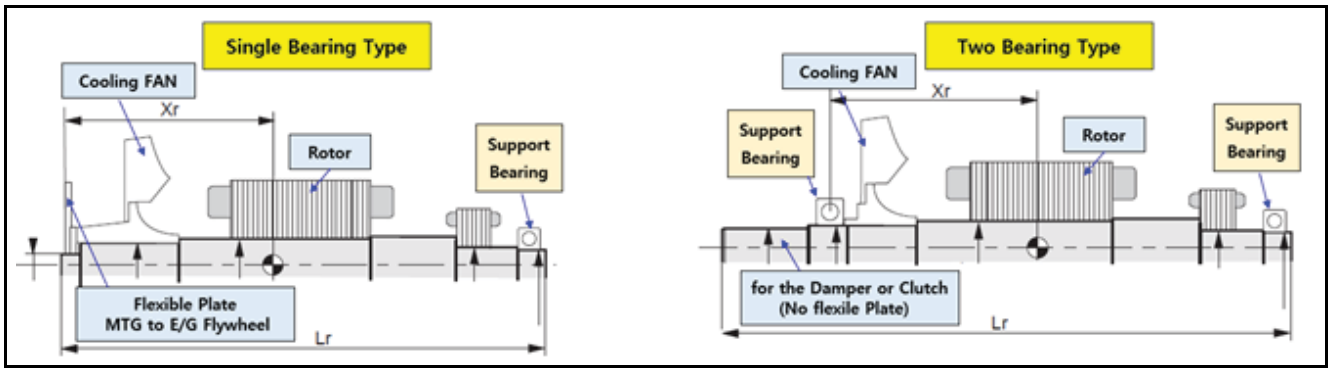
Engine and Generator Mounting

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.

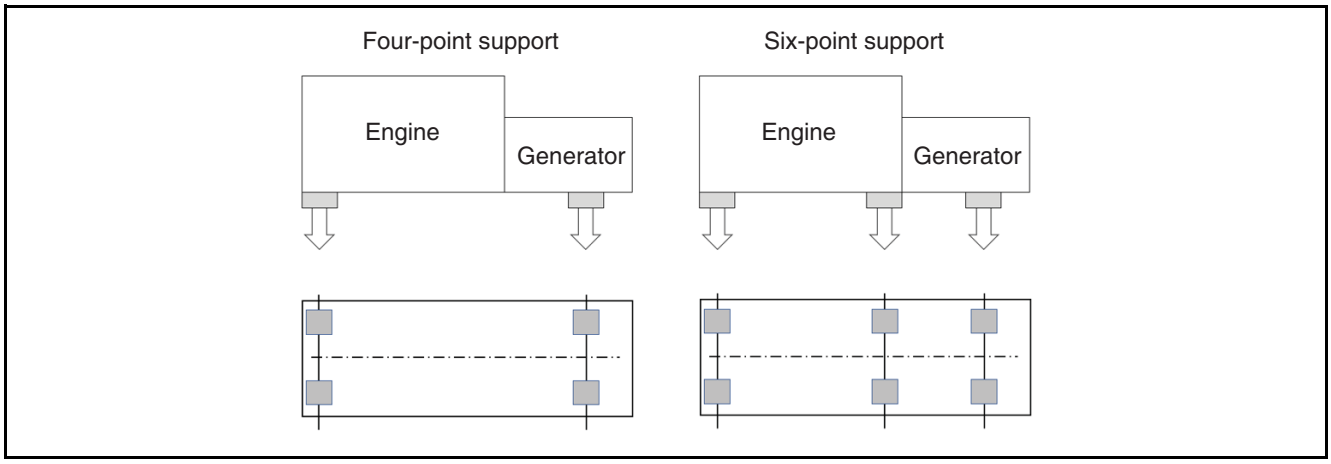
Make sure to install a mounting cushion between the engine and the frame in order to insulate the engine vibrations. If a mounting cushion is not installed, the engine parts or the radiator may be damaged.

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.



EGN210013



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.

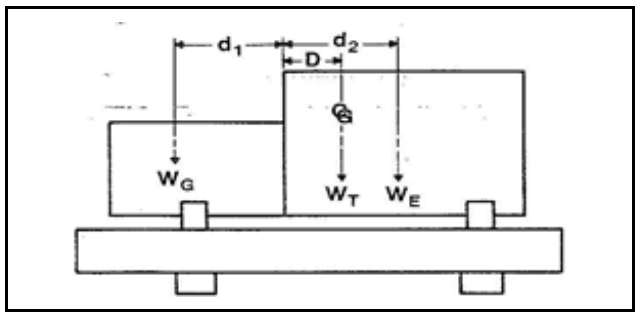
3. Generator Mounting

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.

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

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

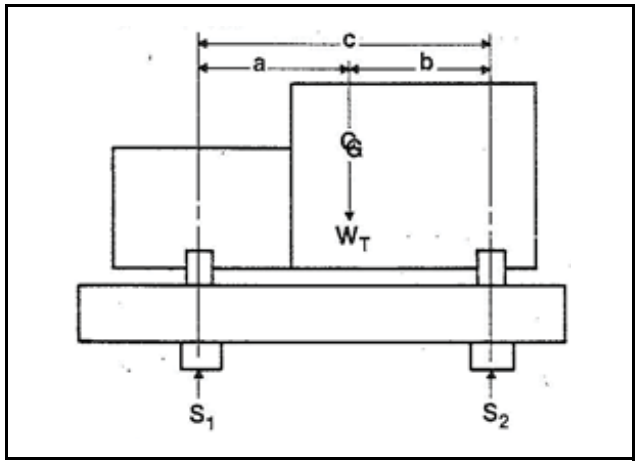


EGN210015

- 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

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Ground and Foundation 27
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Maximum Usable Limit of Front of Engine Power Takeoff (maximum F.P.T.O.) 31
Maximum Allowable Power Takeoff in Open State 32
Belt-Driven 34

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

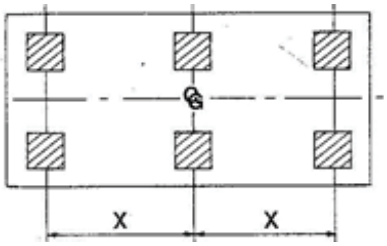
In general, when a power unit set is installed in a building, it is recommended to install a rubber plate or vibration isolator between the bed frame and foundation in order to reduce the vibrations conveyed to the base of the foundation or transmitted from the outside.
The anti-vibration unit must be 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

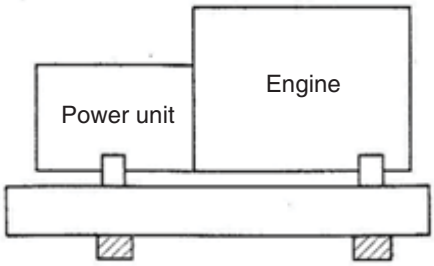
Installation Location of Anti-Vibration Unit

- 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.



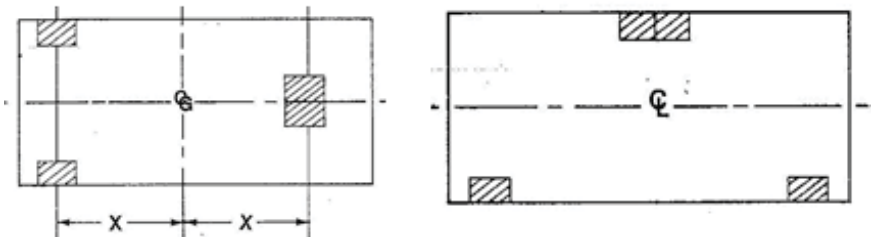
EGN210009

- 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.



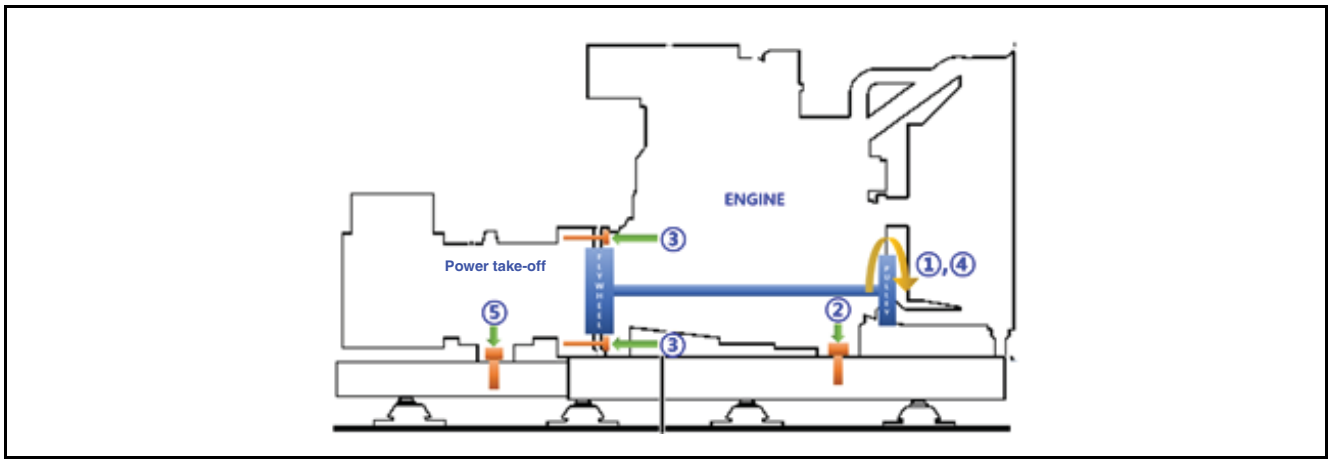
EGN210011

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.

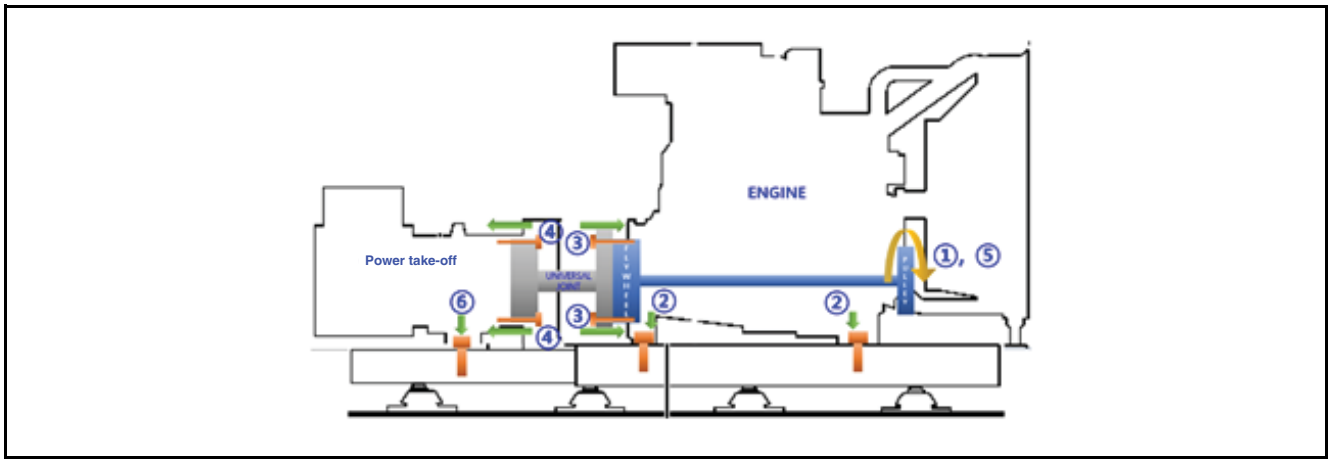


EGN210018

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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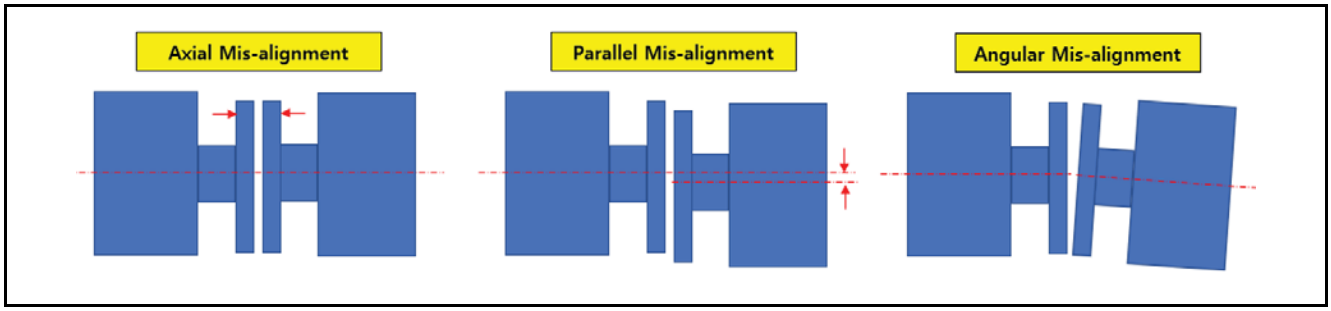
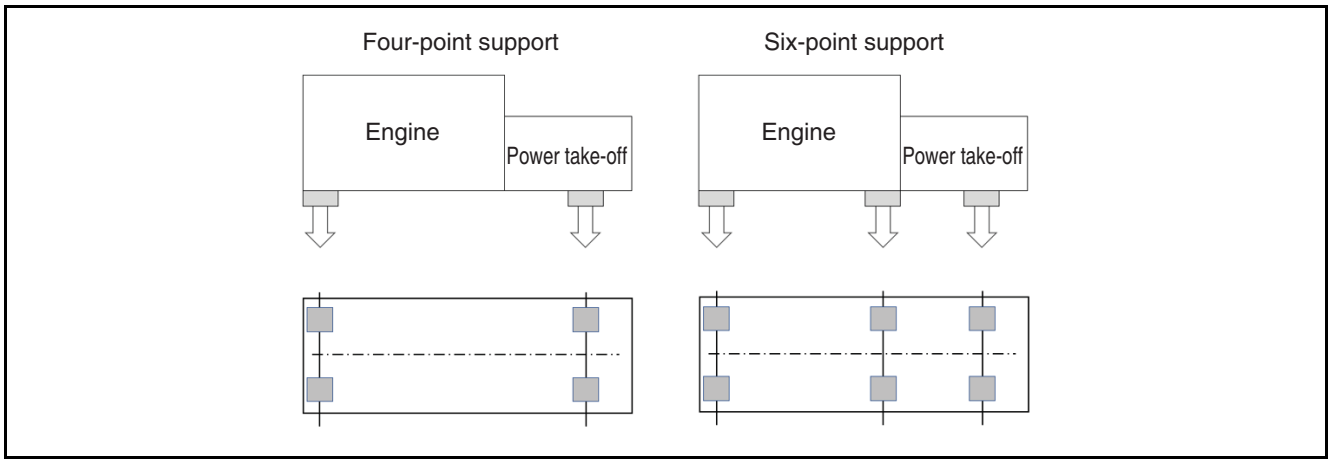


EGN210020

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.



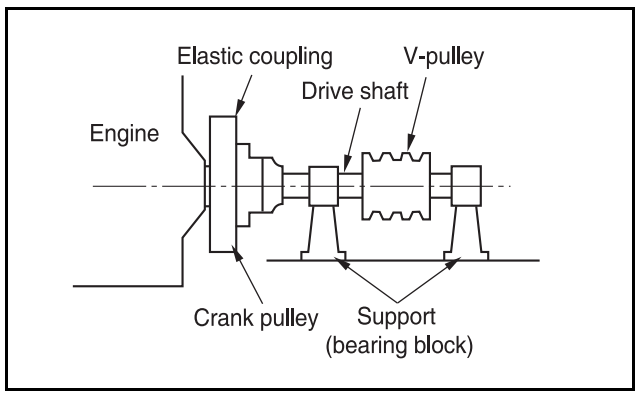
EGN210063

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>

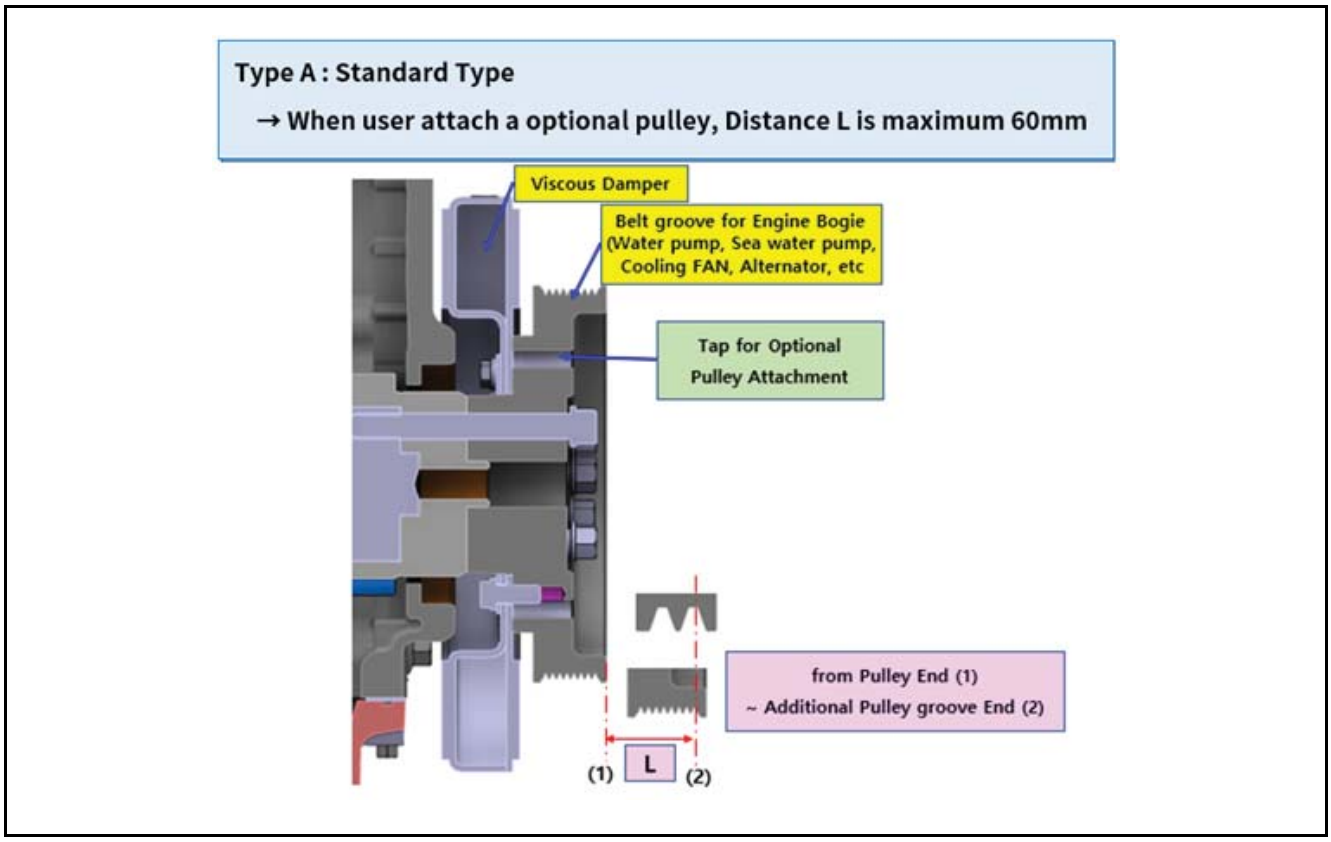
Engine Model	Rotational torque (kg.m)
D1146/PU086/GE08	60
PU126/GE12	80
PU158/180/222/GV22	140

⚠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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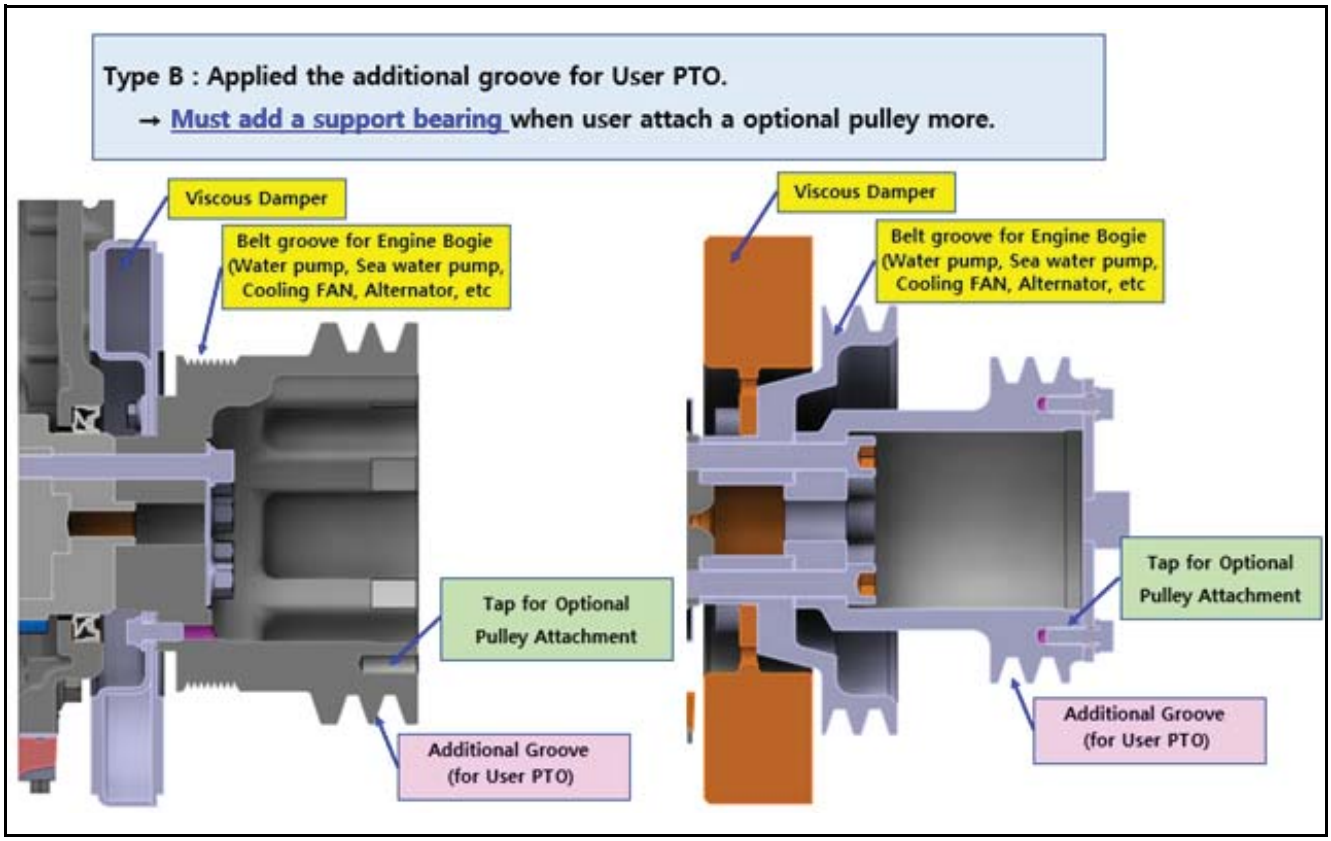


EGN210022

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

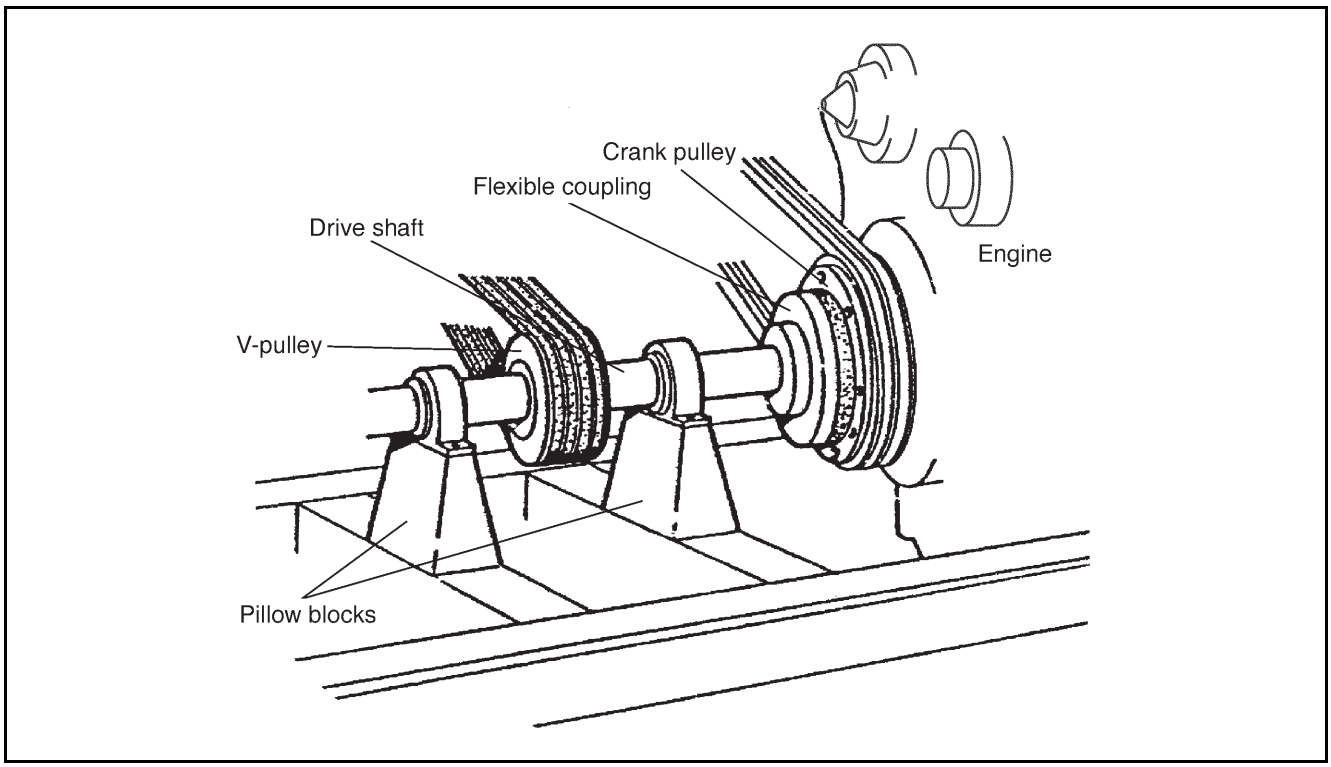
Engine Model	Rotational torque (kg.m)
D1146/PU086/GE08	60
PU126/GE12	80
PU158/180/222/GV22	140

⚠ 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.

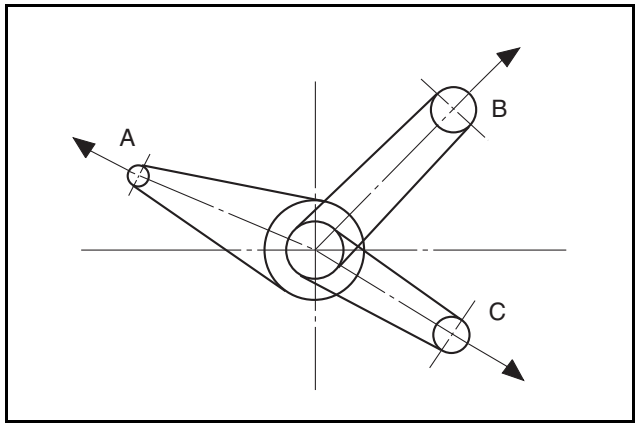


EB0O3002

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.



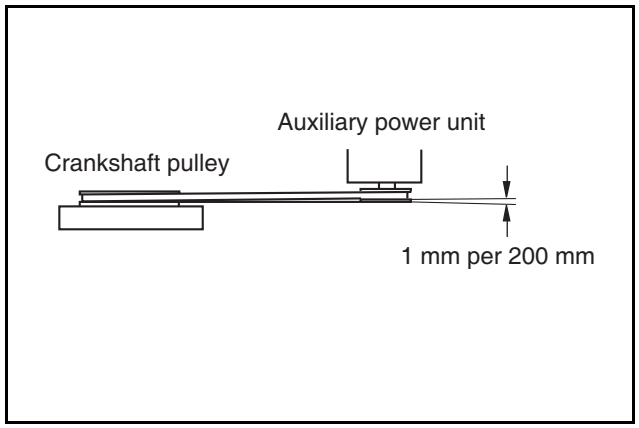
EB0O3003

⚠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

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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)

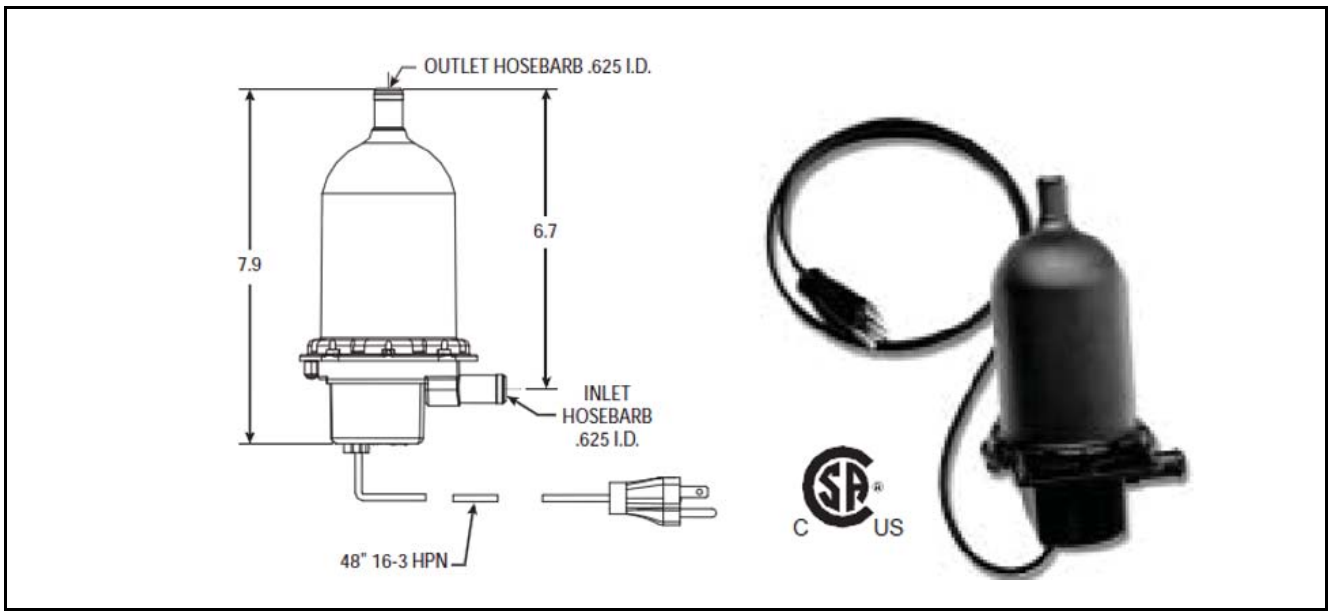
The engine heater is a device which heats the engine coolant. If the engine heater is run when the ambient temperature is cold, startability improves and the amount of white smoke decreases.

- 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)

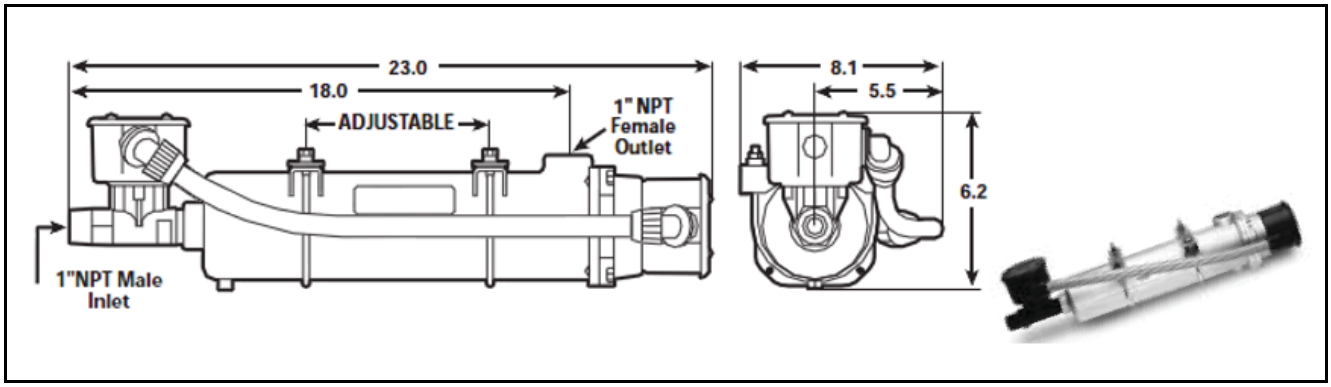
- Recommended for 11 liter (DL11) or smaller HD Hyundai Infracore generator engines models.
- Uses 1,000 to 1,500 watts depending on the size of the engine.
- For more details, HD Hyundai Infracore recommends contacting the heater manufacturer.



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.



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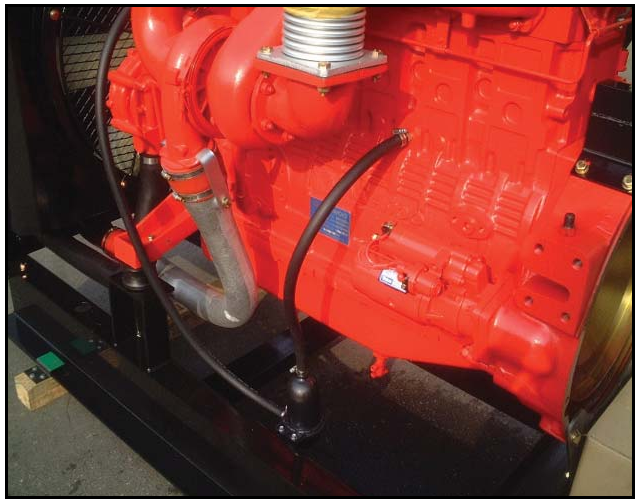
Ex.) Picture of engine with block heater installed



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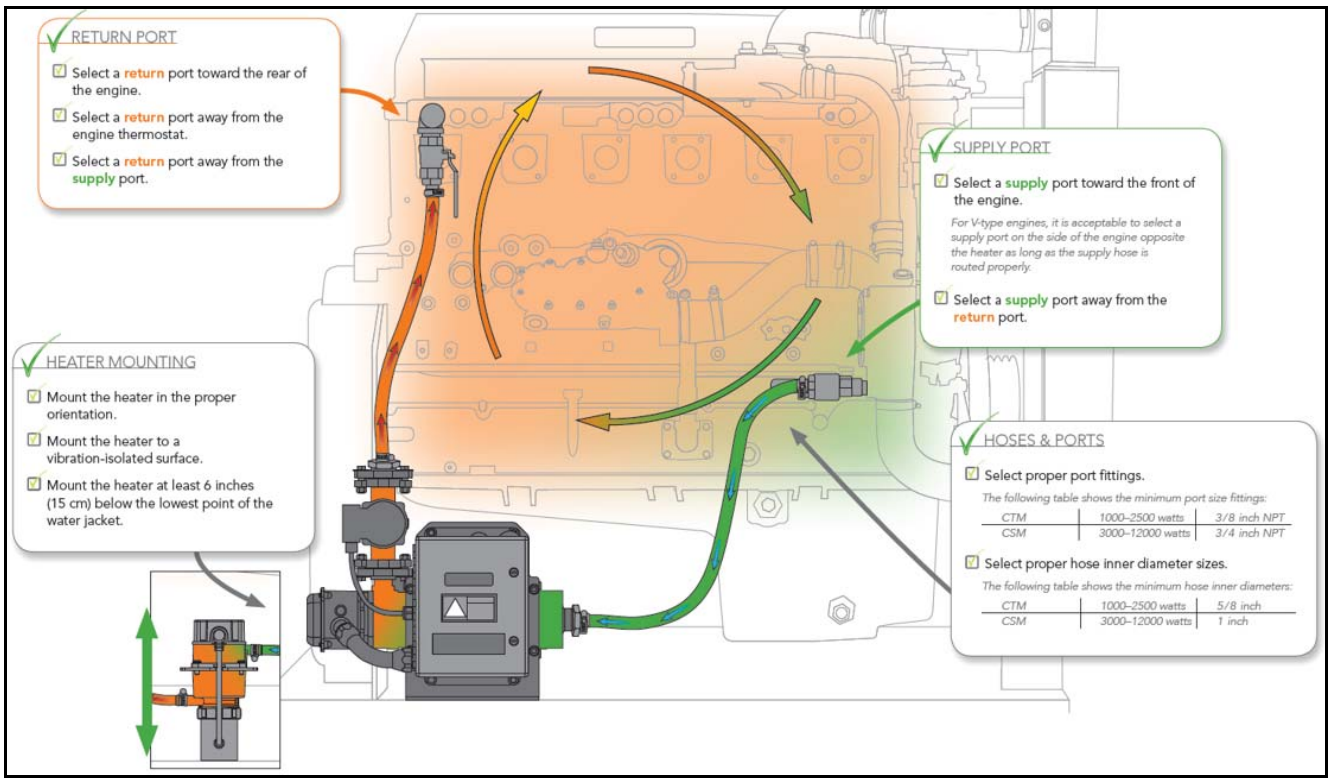
Mounting check points and best/worst practices (information provided by HD Hyundai Infracore supplier Hotstart.)

- Best Practices



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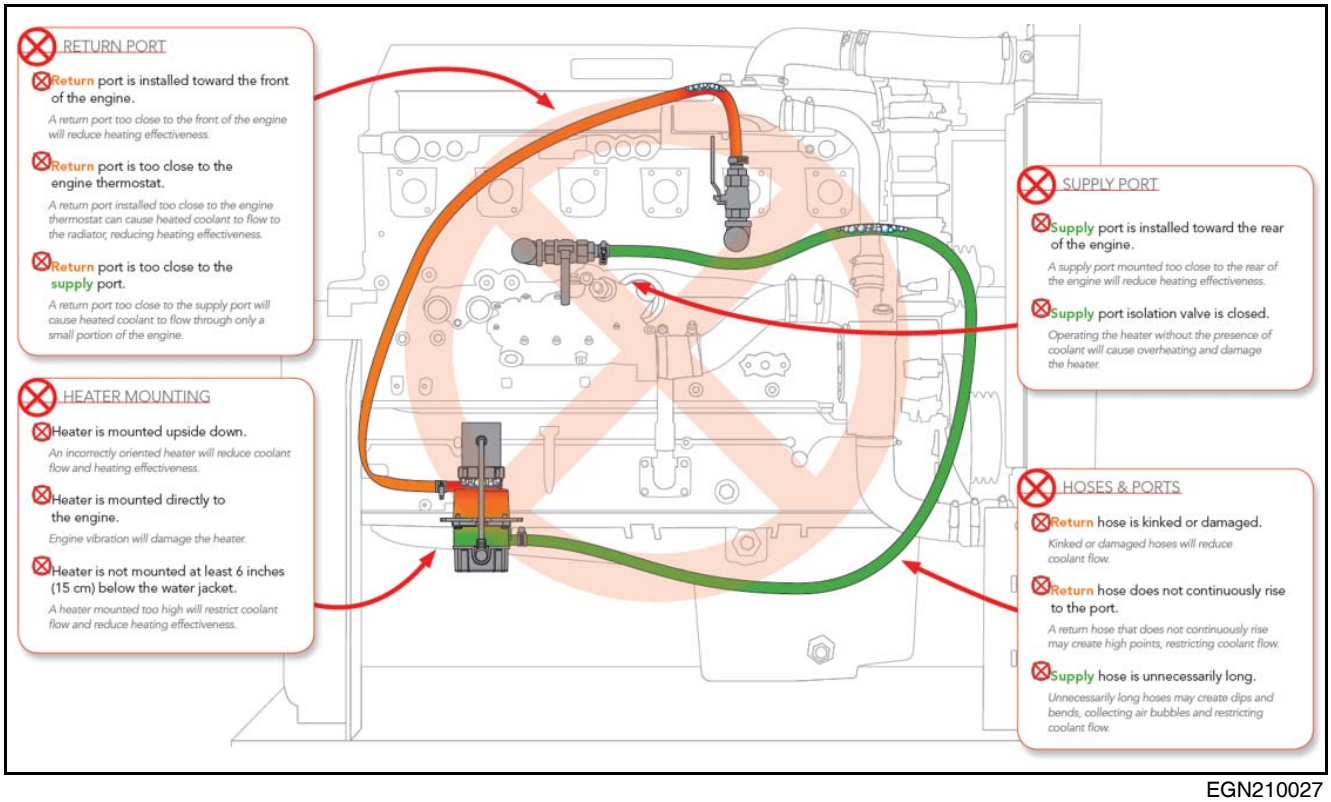
- Worst Practices



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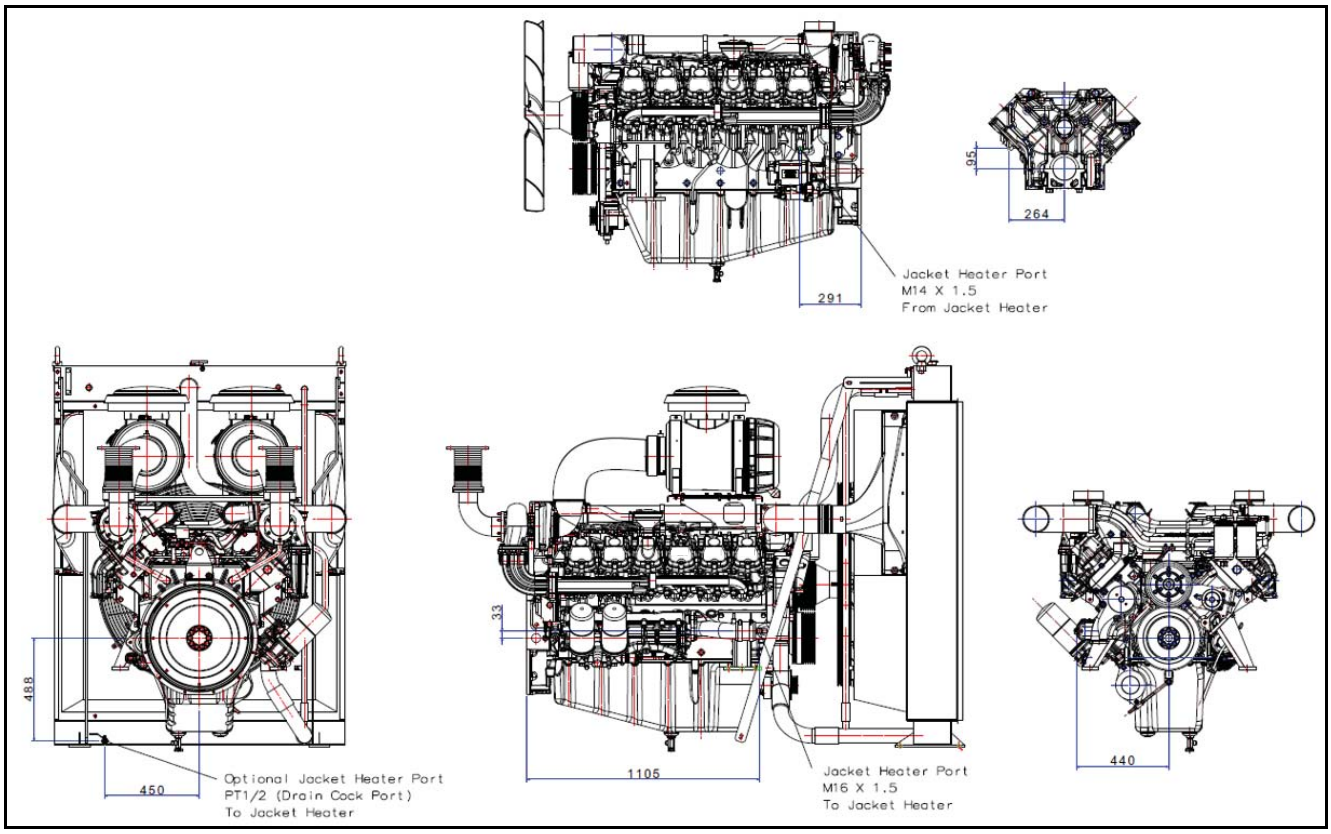
Examples from HD Hyundai Infracore (locations of in/out ports)

- DP222/GV22



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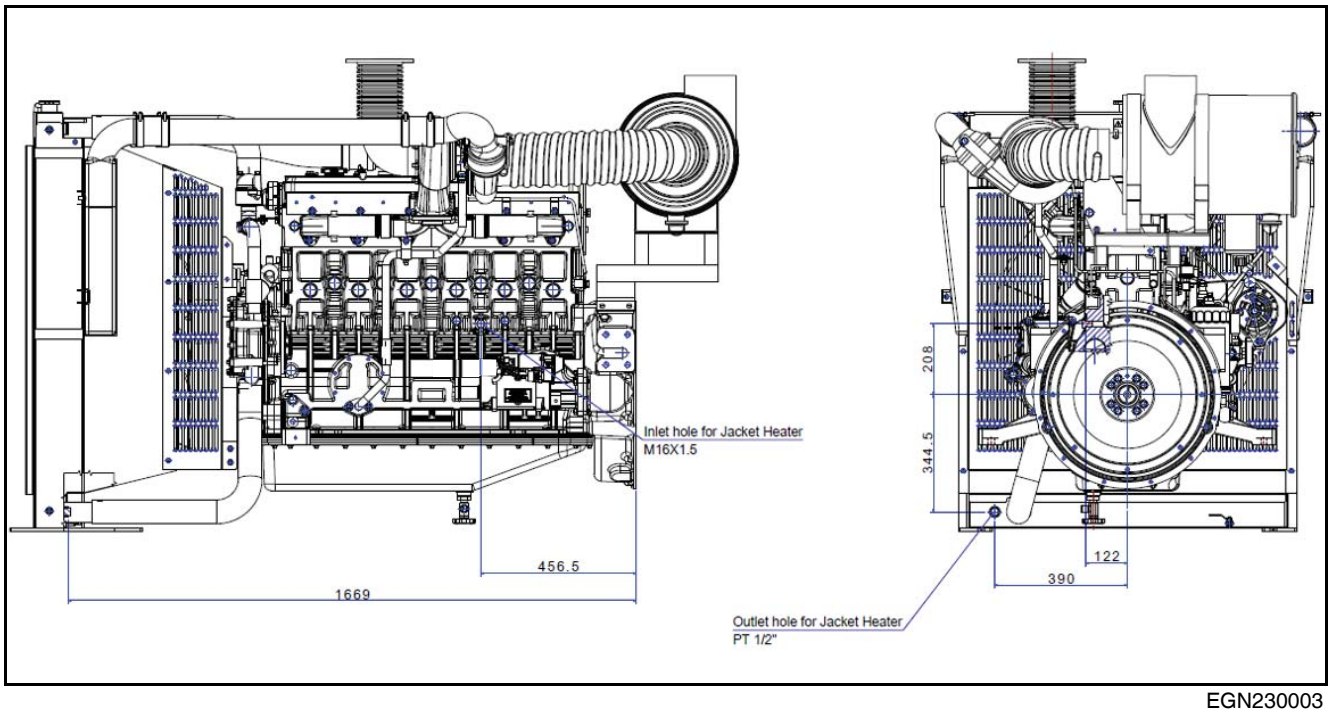
- P126TI/GE12



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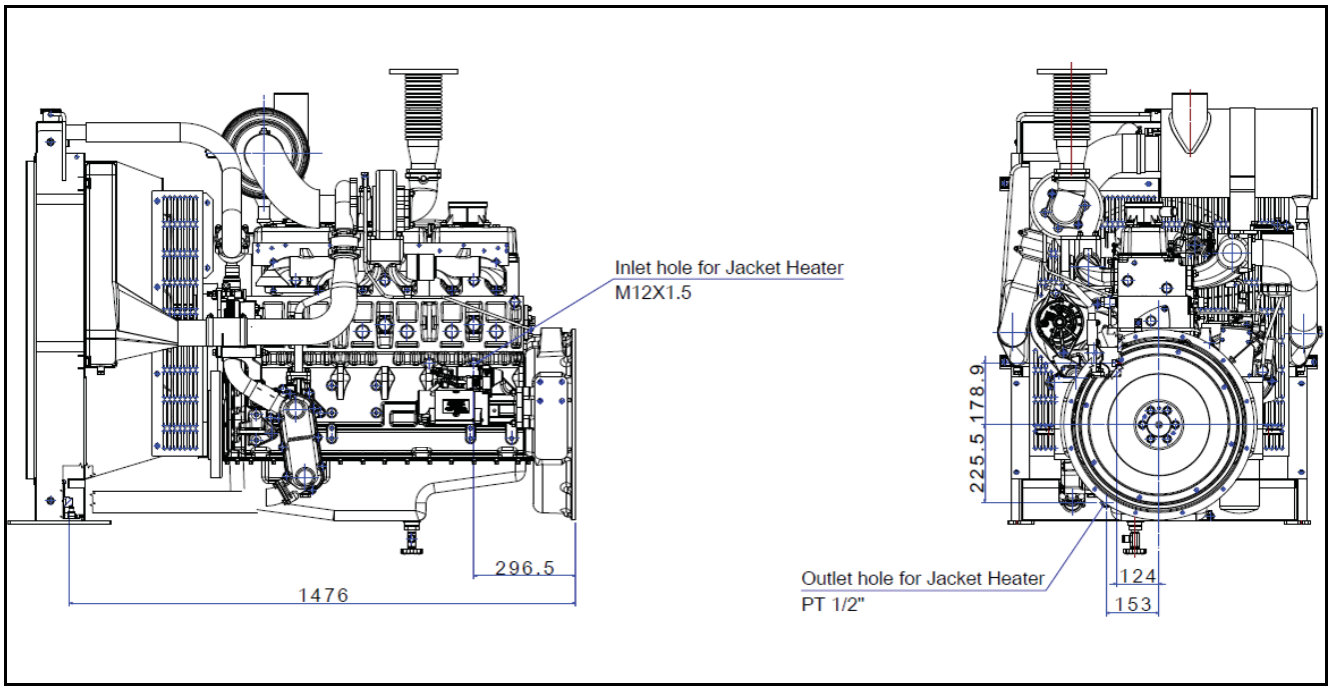
5. Cooling System

- P086TI/GE08



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°.

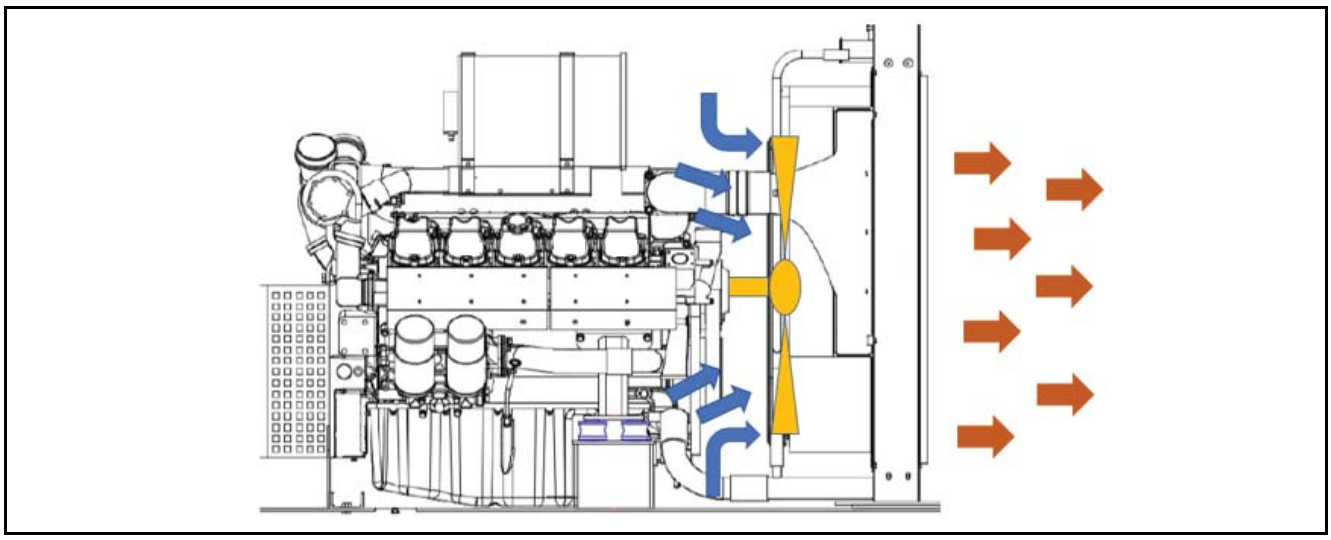
Cooling Fan

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.



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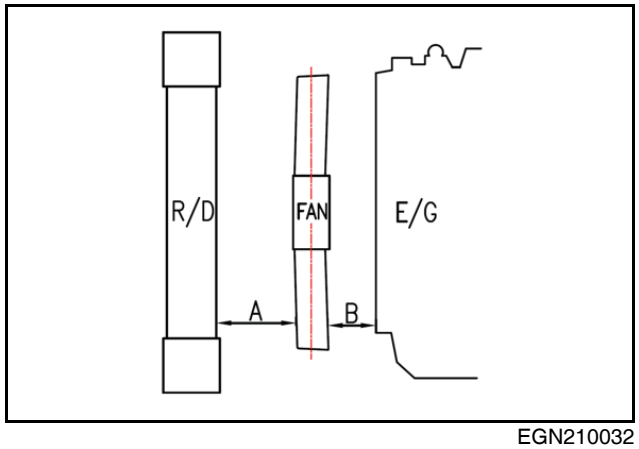
Installation Location of Cooling Fan

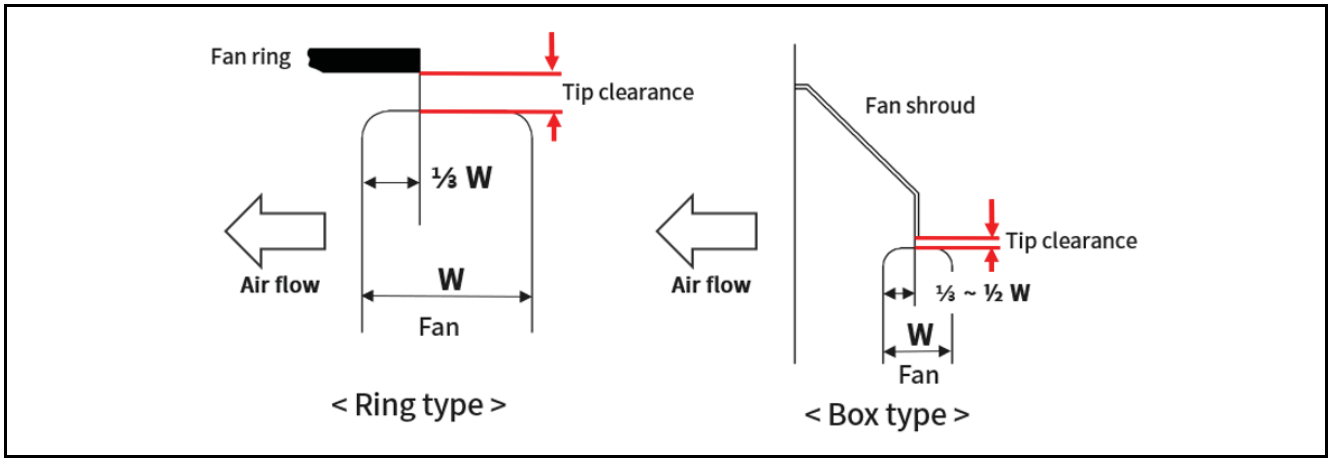
When the cooling fan is being installed, "A" (the distance from the radiator core to the cooling fan) must be at least 2 inches (50.8 mm), and if possible, a distance of 4 inches (101.6 mm) must be maintained.

"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.



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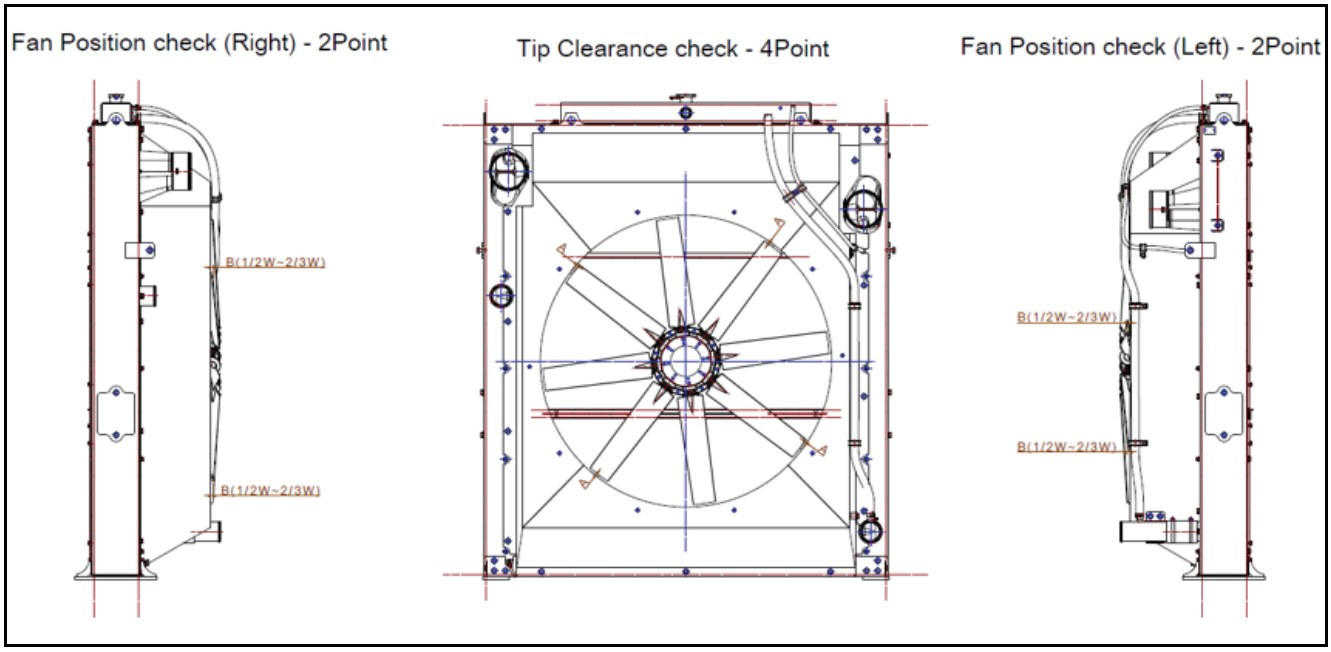
For your reference, HD Hyundai Infracore shrouds are of the box type.

Fan Position Check

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



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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.

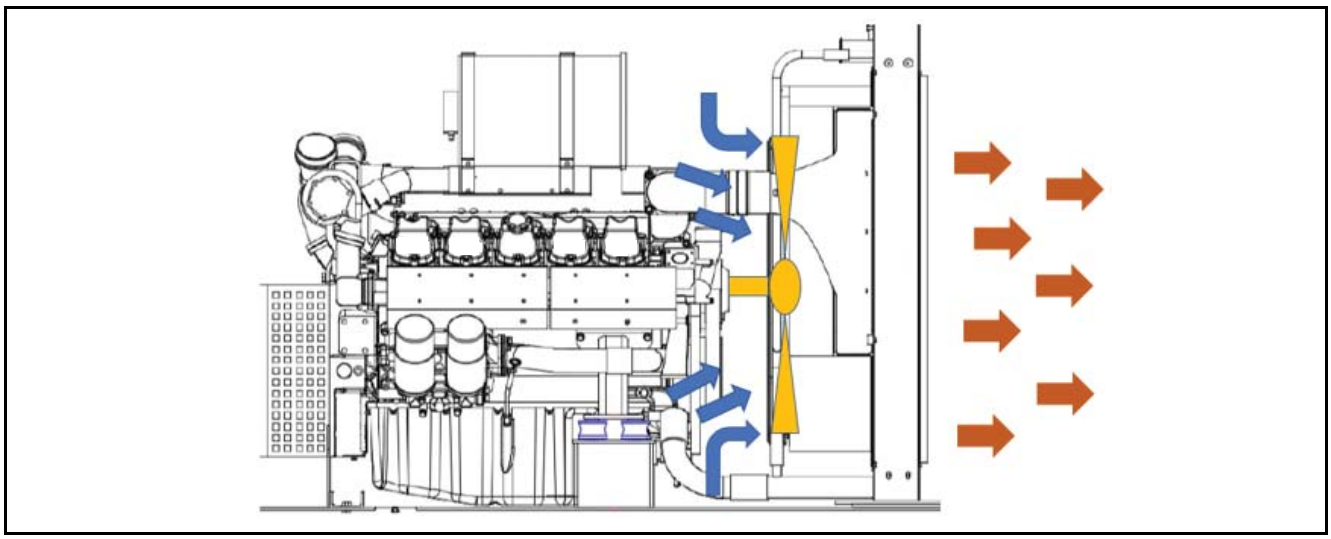
Cooling Test Evaluation

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.



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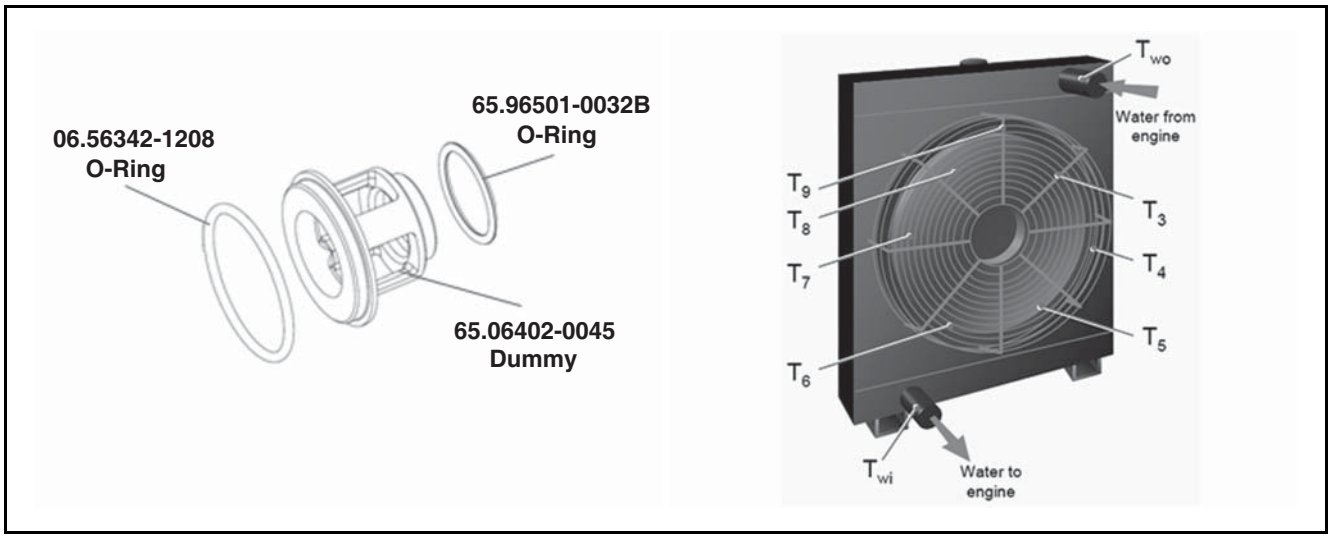
Intercooler outlet temperature conditions

- 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

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Engine Oil Specifications 55
API Oil Grades 55
SAE Oil Grades 56
Periodic Engine Oil Inspections 57
Changing Oil 57
Instructions for Replacing Engine Oil 57
Cautions for Handling Engine Oil 57
Oil Pressure Monitoring 58
Warning and Shut Down Values 58

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.

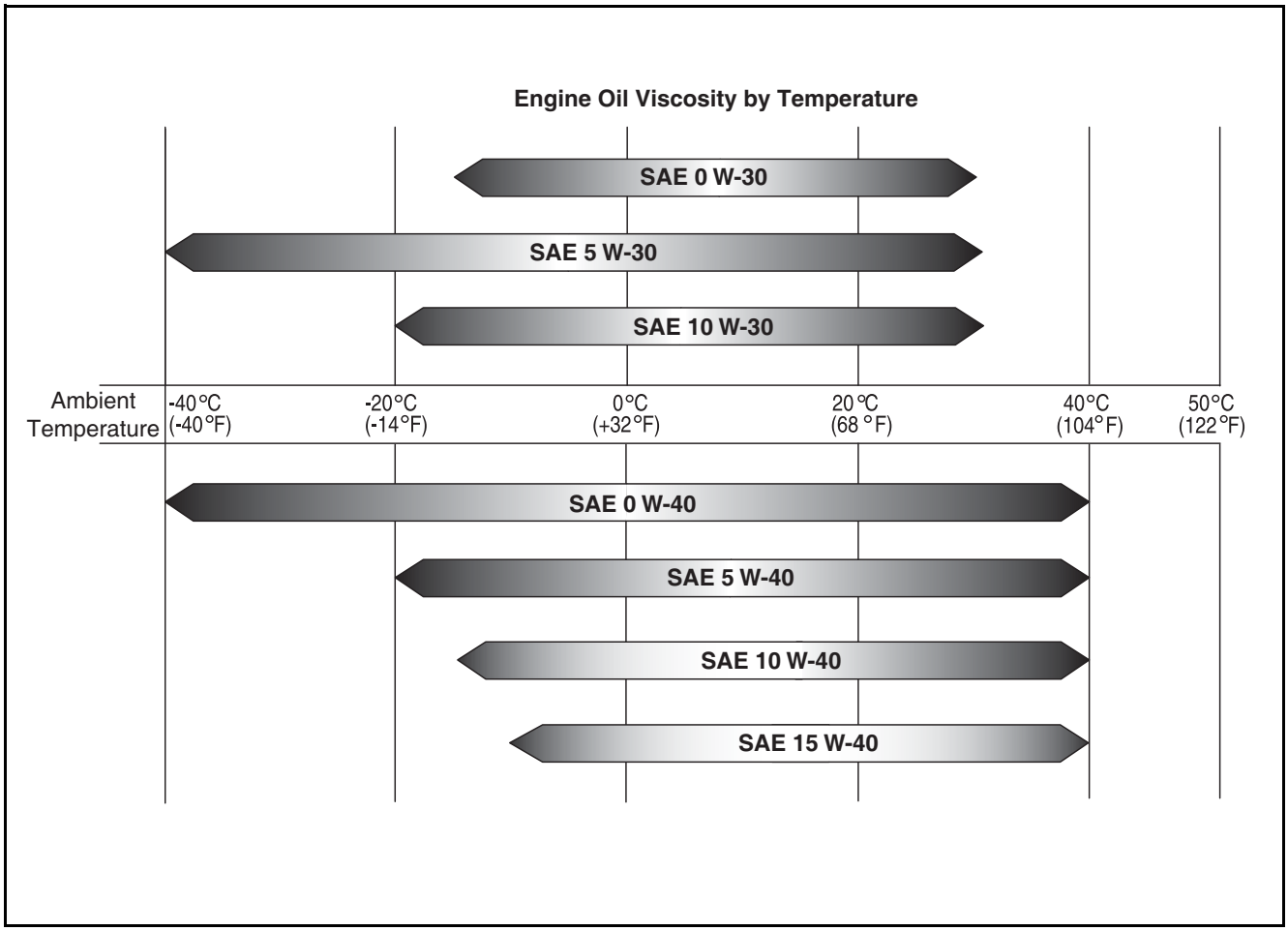
API Oil Grades

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 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 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 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, 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

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Air Inlet System 61
Dust Side Duct 61
Air Filter 62
Clean Side Duct 62

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.

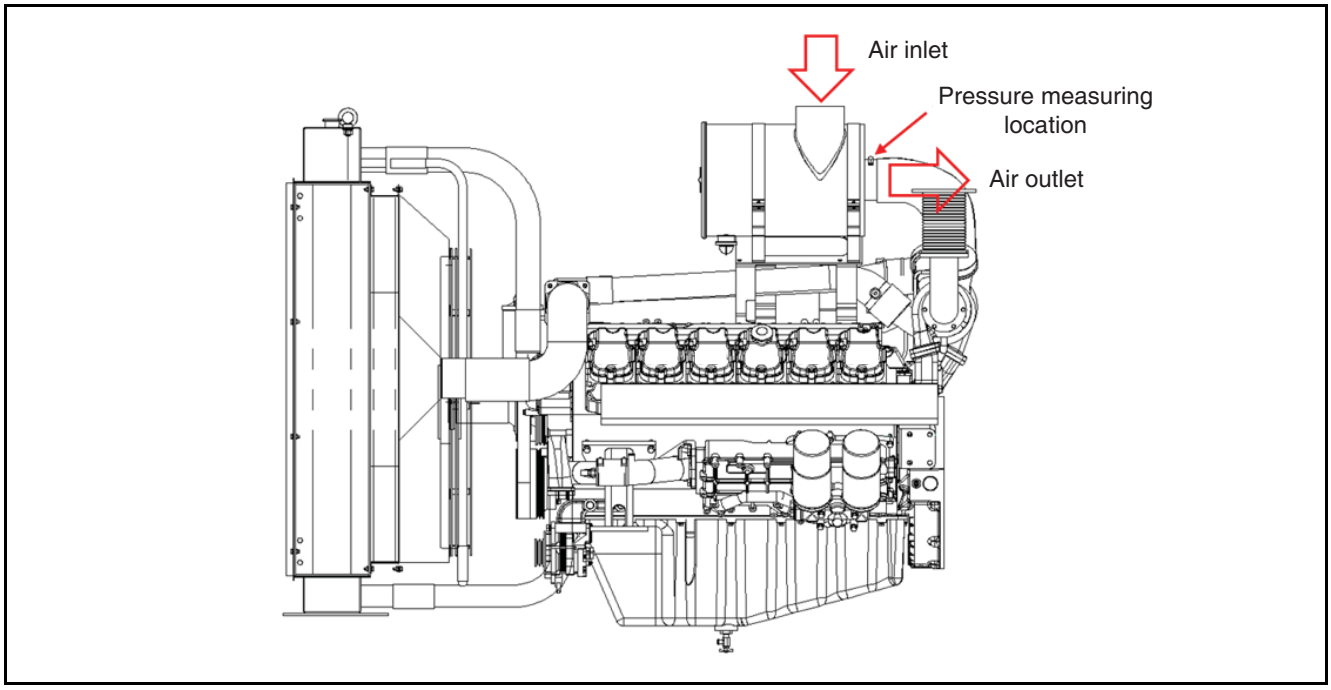
- Must be near the ambient temperature.
- Must be protected from dust, foreign matter, snow, rain, etc.
- Must be far from where exhaust gas is produced (to prevent it from entering).
- The intake pipe must be designed to minimize pressure drops (low pressure drops extend the air filter's service life).
  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



EGN230006

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

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General Information

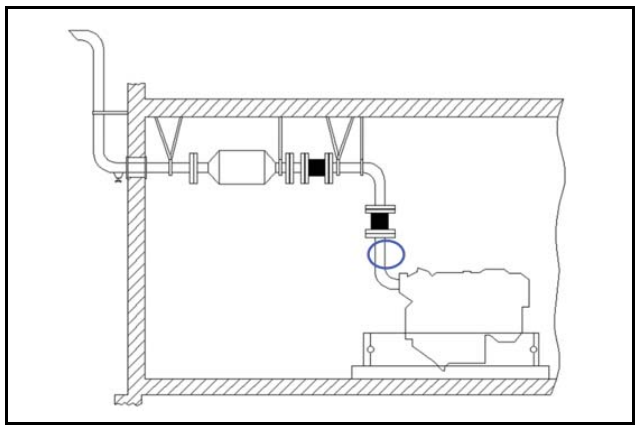
Everything about the exhaust system must be planned from the time of the initial installation. The main requirements are as follows.

- 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).



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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

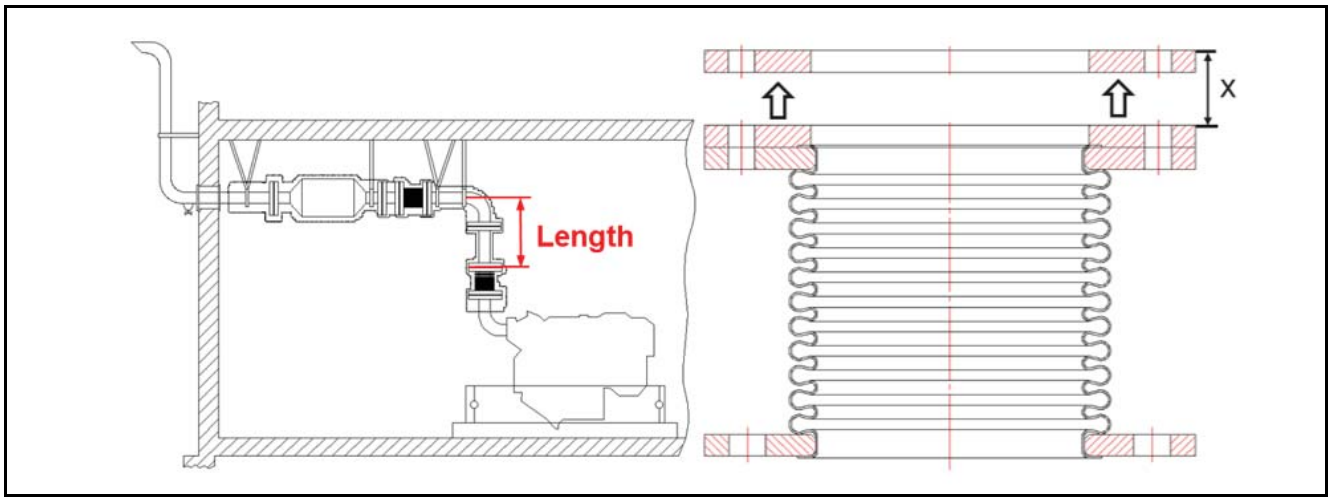
The exhaust pipe is separated from the engine by a connection with the exhaust bellows. Installed near the engine's exhaust outlet, the bellows prevent vibrations and excessive weight, compensate the thermal expansion of the exhaust pipe, and calibrate for lateral movement when starting and stopping 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.

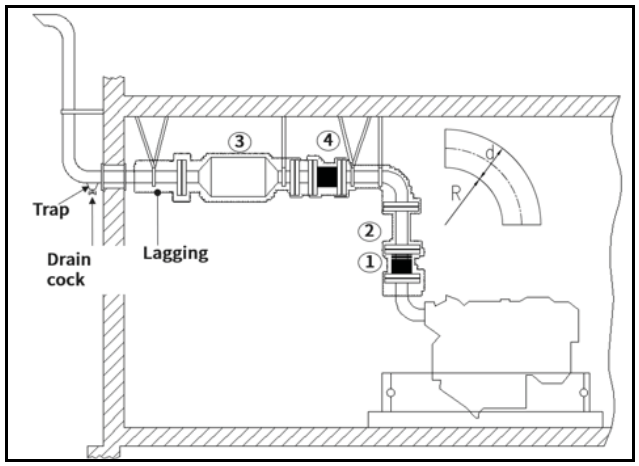
Silencer

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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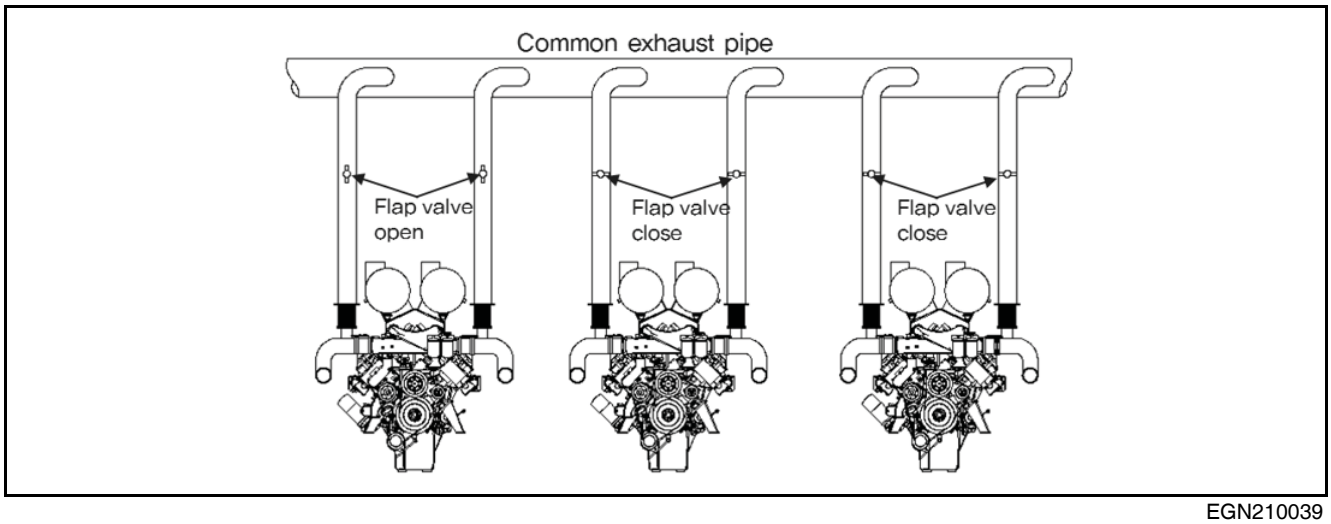
Multiple Exhaust Systems

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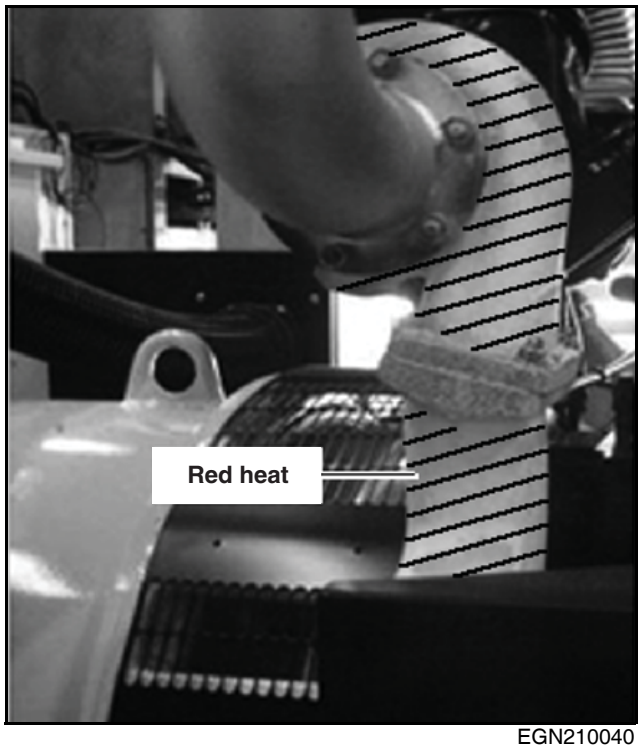
- D (Total) = D x K
  D: diameter of each engine exhaust manifold
  K: constant (see table)

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 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 turbocharged engines and has no impact whatsoever on the reliability or durability of the engine.



EGN210040

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

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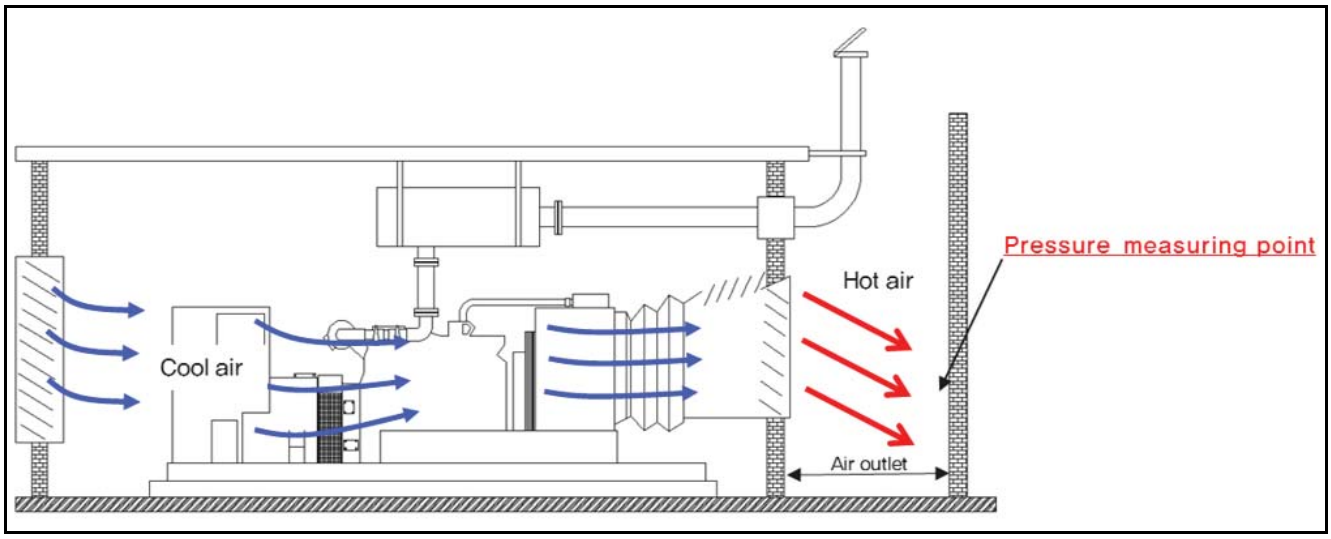
Ventilation 73

Induction System

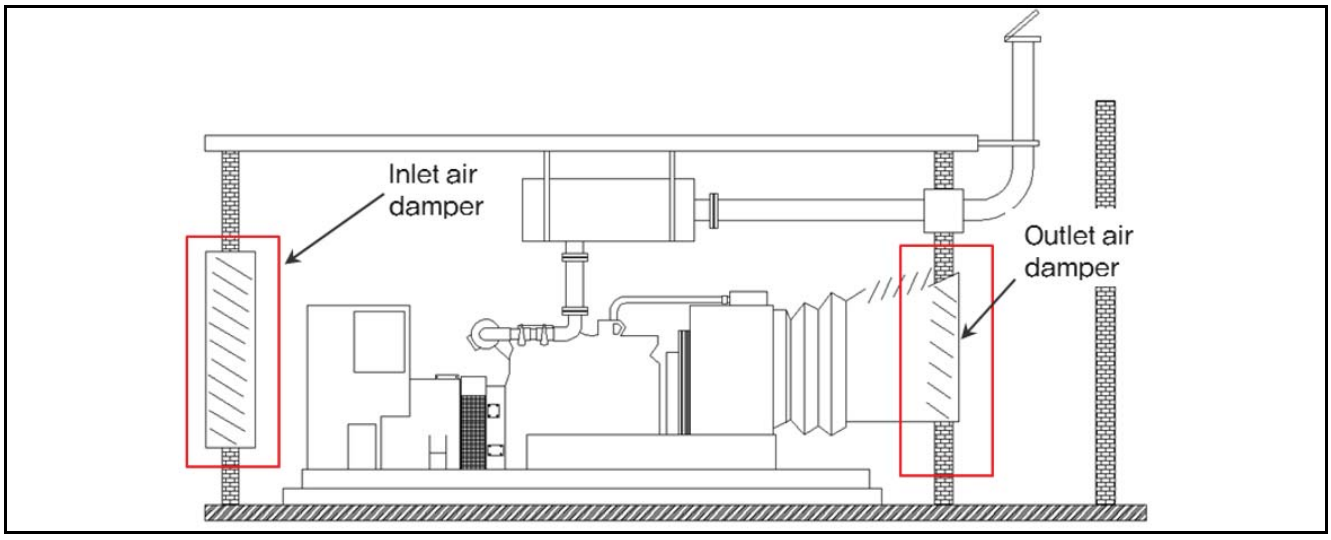
1) The length of the air outlet must be greater than the height of the radiator core.
2) The direction of the inlet/outlet dampers must be such that airflow is directed downwards in order for air to pass by the engine.
3) The maximum allowable pressure at the air outlet is 12.7 mmH20, which should be 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.



EGN210041

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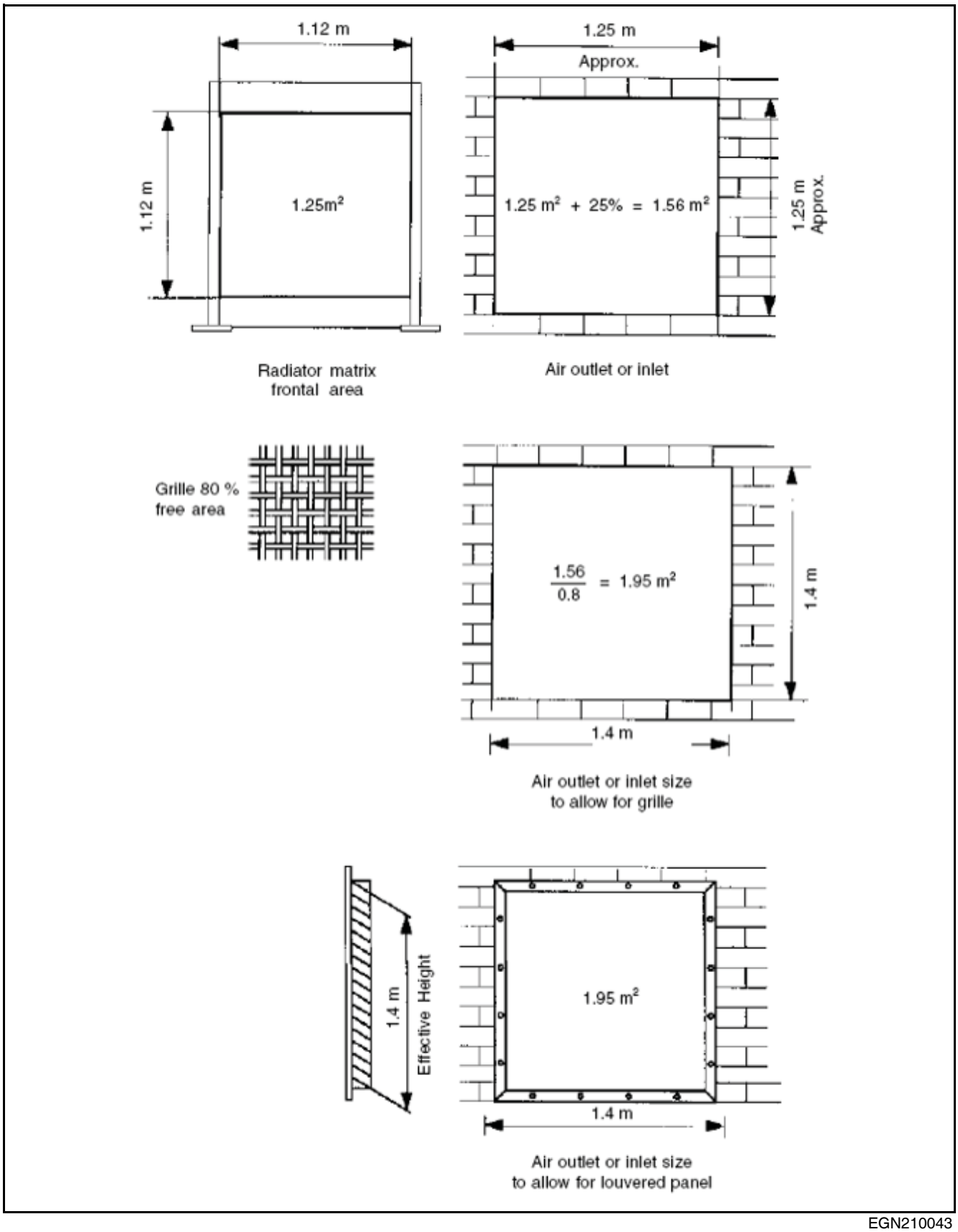
1.12 m
1.12 m
1.25m²
Radiator matrix
frontal area
1.25 m
Approx.
1.25 m² + 25% = 1.56 m²
1.25 m
Approx.
Air outlet or inlet
Grille 80 %
free area
1.56
0.8
= 1.95 m²
1.4 m
1.4 m
Air outlet or inlet size
to allow for grille
1.4 m
Effective Height
1.95 m²
1.4 m
Air outlet or inlet size
to allow for louvered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

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10. Fuel System

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Gas shut off valve 78
Gas filter or strainer 78
Gas select valve 78
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Fuel Line Circuit Diagrams 79

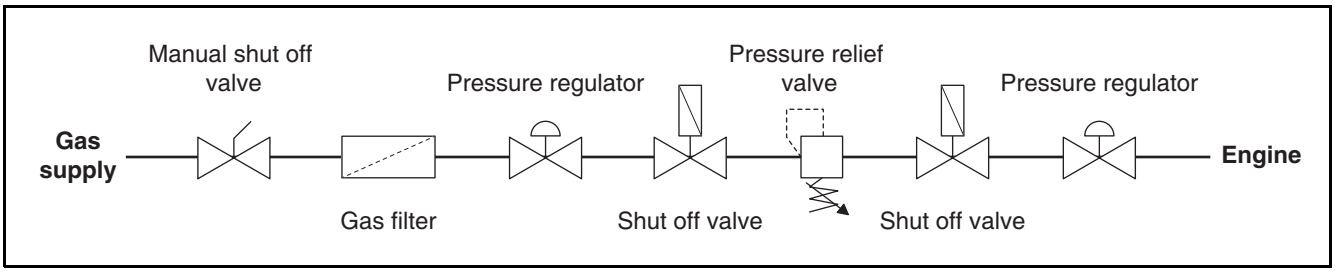
General Information

- GV22PU engine is compatible with the following fuels:
  - Natural gas (Pipeline gas)
  - Propane gas
  - Biogas (Over 900Btu/ft3)
  - Wellhead gas (Over 900Btu/ft3)
- Fuel supplied to the gas engine injection system (FIE system) must always be kept clean to prevent contamination with oil mist and foreign substances to protect the injection system components.
  These impurities cause serious failure and shortened life of injection system components, so the use of high-quality fuel and the installation of gas filters in the gas supply line are essential to prevent failure of injection system components and maintain engine output.
- When performing maintenance and inspection, always work in a clean environment to prevent foreign substances from entering the fuel system. Minimize unnecessary removal and installation as much as possible. When removing and installing parts that require reuse, take measures to prevent foreign substances from entering the parts after removal, and then reuse them when installing.
- All connections within the fuel system pose a risk of fire and contamination if there is a leak. Therefore, when installing each connection, the specified installation and assembly methods must be followed, and the presence of leaks must be checked using bubble tests, etc.
- Defects caused by failure to follow the installation instructions are not covered by the engine warranty.

Fuel Circuit

Fuel must be delivered to the engine through a suitable gas train. The gas train must contain the following components:

- Gas train have a following components.
  - Manual shut off valve
  - Pressure regulator (If gas pressure needs to be reduced to meet the engine gas inlet pressure)
  - Gas shut off valve
  - Gas select shut off valve (If more than two types of gas supply lines are connected)
  - Gas filter or strainer
  - Pressure gauge
  - Flame arrester (If biogas or wellhead gas is used as a fuel and there is possibility of oxygen in)
  - Pressure relief valve (If gas supply pressure is more than 12 KPa)
  - Leak detecting device
- Gas train



EGN250002

Manual shut off valve

- Manual shut off valve must be installed in an easily accessible location to shut off the fuel supply to the engine in an emergency.

Pressure regulator

- The gas pressure supplied to the GV22PU engine must satisfy 1 to 5 kPa regardless of the installation location and altitude. A pressure regulator with appropriate specifications must be selected so that the gas supply pressure can be maintained.

Gas shut off valve

- In the case of the gas shut off valve, it is supplied with the engine as a loose part. After installing the gas shut off valve on the gas supply line, refer to the maintenance manual and connect it to the generator panel.

Gas filter or strainer

- Mist components and foreign substances in gas fuel directly affect the life of fuel injection system components. Fuel injection system components must be protected by installing appropriate filters and strainers.

Gas select valve

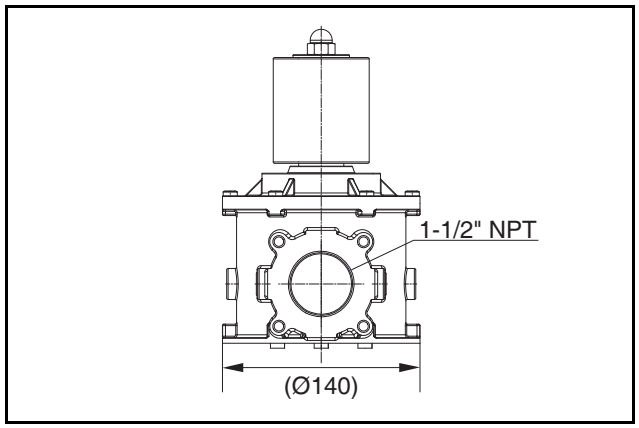
- If two or more fuels are connected, a gas select valve must be installed to select the fuel.

In addition, if necessary, install pressure gauge, flame arrestors, pressure relief valves, leak detection devices, etc., appropriately on the gas train.

Fuel Pipe

From the gas train to the gas shut off valve, recommend using steel piping, and from the gas shut off valve to the EFR, recommend using a hose for natural gas.

- Steel pipe assembly specifications for gas shut off valve
  : 1-1/2" NPT



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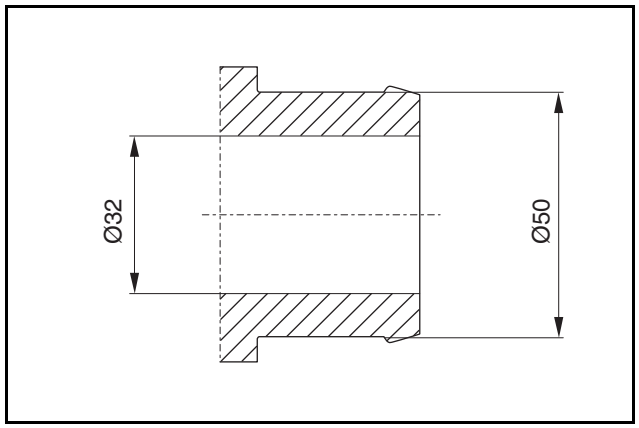
- For the rear end of the gas shut off valve, connect to the EFR with a hose using the adapter provided with the shut off valve.
  : Hose I.D Ø50 mm



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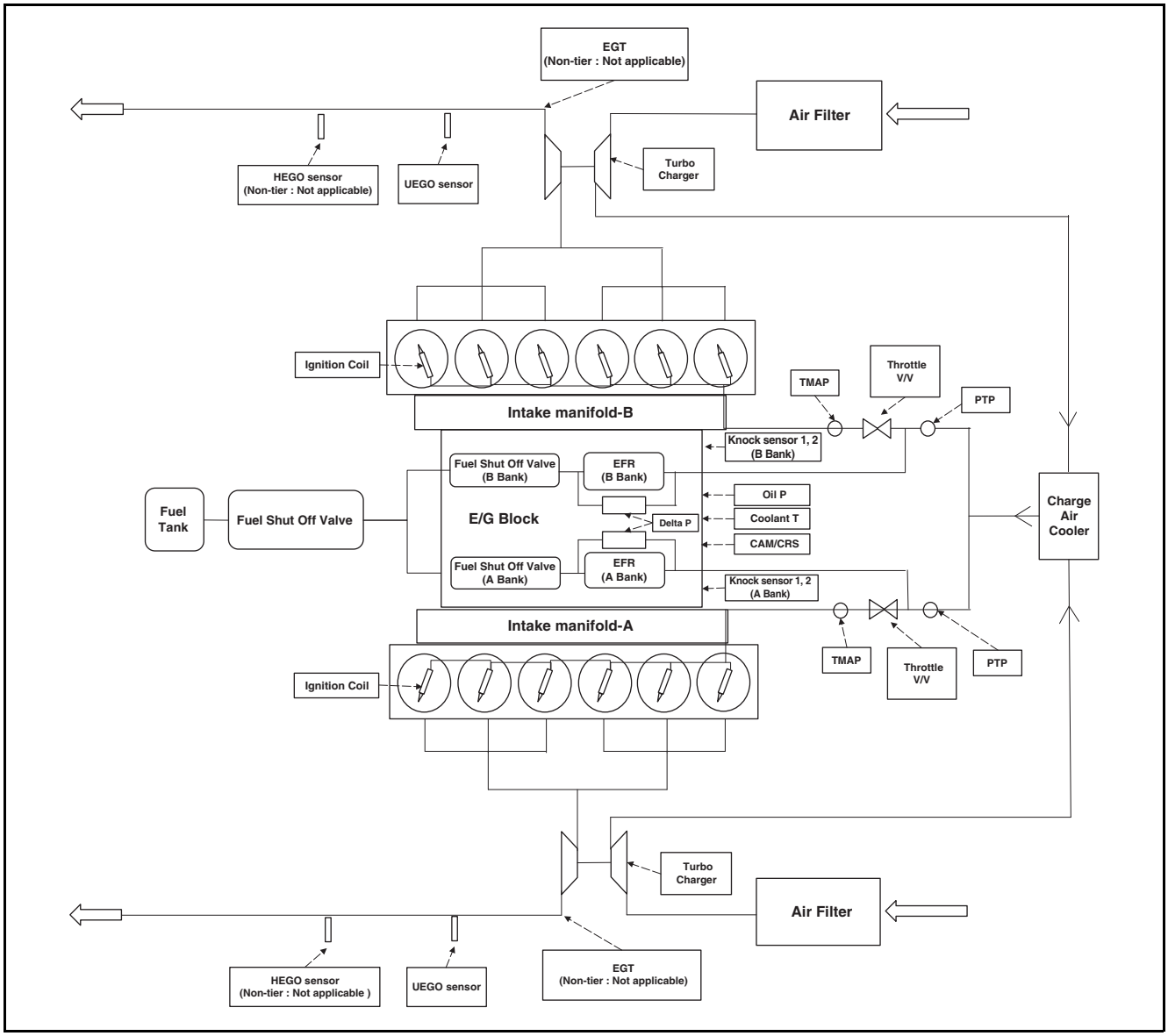
After installation, perform a bubble test on all pipes to check for leaks.

Fuel Line Circuit Diagrams



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10. Fuel System

11. Electrical System

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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.

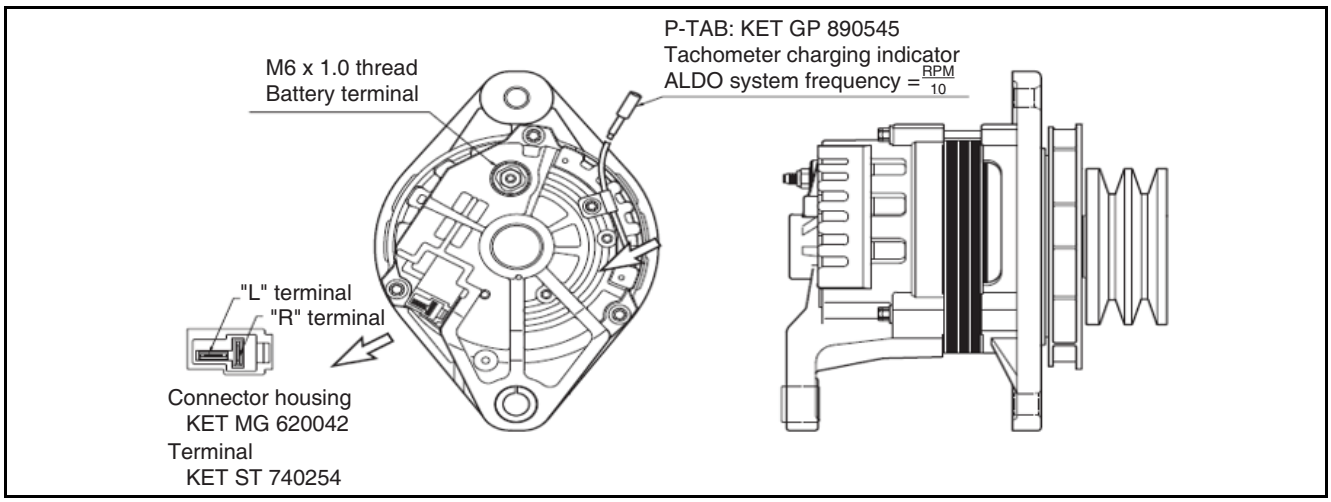
The ground terminal connected directly to the negative battery terminal may be used as a shared ground for a single engine system.

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.

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.



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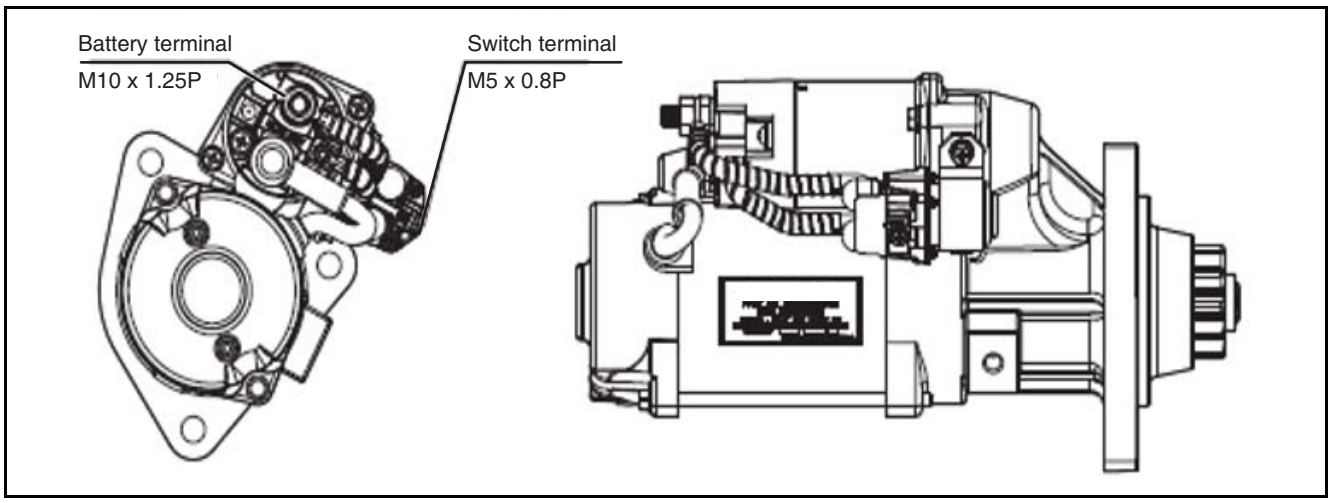
The alternator does not require maintenance, but it must be protected from dust, moisture and water.

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.



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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.

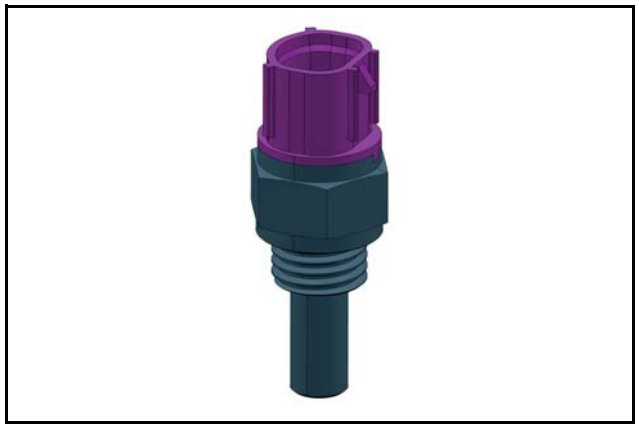
Sensors

Water Temperature Sensor

Measures the temperature of the coolant and transmits it to the engine control unit (ECU). It is a resistance type sensor and has no polarity.

- Operation temperature: -40 ~ 140°C
- Resistance table

Temperature (°C)	-40	0	20	80	140
Resistance (Ω)	48085	5878.3	2507	328.16	66.817

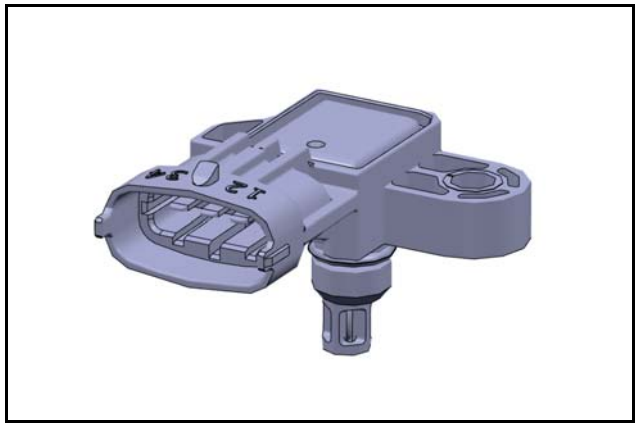


EGN250007

T-MAP Sensor

Measures the pressure/temperature inside the intake pipe and transmits it to the engine control unit (ECU).

- Operation temperature: -40 ~ 130°C
- Operation pressure: 20 ~ 300 kPa

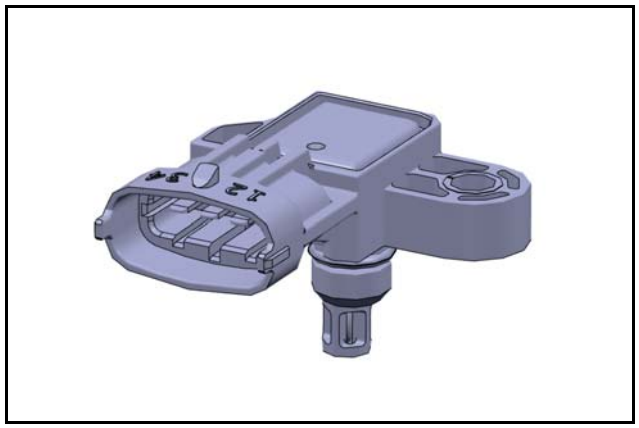


EGN250008

PTP (Pre Throttle Position) Sensor

Measures the pressure/temperature inside the intake pipe ahead of the throttle and transmits it to the engine control unit (ECU).

- Operation temperature: -40 ~ 130°C
- Operation pressure: 20 ~ 300 kPa



EGN250008

Crank Shaft Position Sensor

Magnetic VR type sensor recognizes the concave or convex part of the flywheel and transmits it to the engine control unit (ECU), which then determines the piston position information.

EGN250009

Camshaft Position Sensor

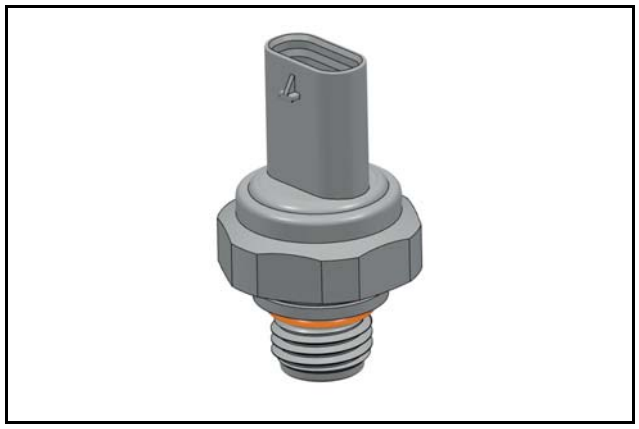
Camshaft position sensor is a magnetic hall effect type sensor that controls the engine intake and exhaust valves. Rotating at half the speed of the crankshaft, this sensor determines whether the camshaft is in the compression stroke or exhaust stroke when the piston moves towards TDC.

EGN250010

Oil Pressure Sensor

Measures the pressure inside the oil cooler or oil filter tube and transmits it to the engine control unit (ECU).

- Operation temperature: -40 ~ 135°C
- Operation pressure: 0.5 ~ 10 BarA



EGN250011

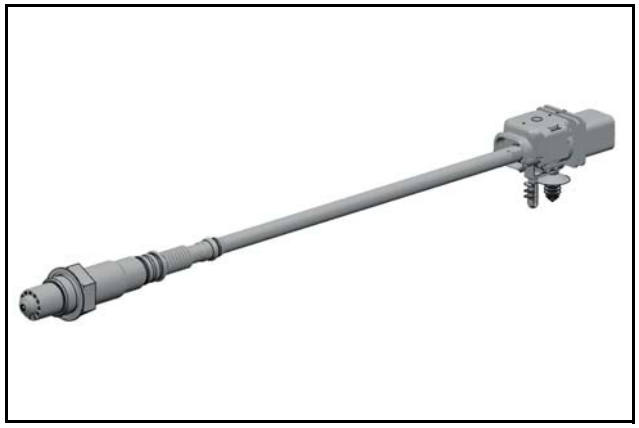
EGT Sensor

Located in the exhaust pipe and measures the temperature of the exhaust gas and transmits it to the engine control unit (ECU).

EGN250012

UEGO Sensor

Mounted at the rear of the turbocharger, it measures the amount of oxygen in the exhaust gas. By measuring the oxygen concentration, it plays an important role in maintaining the efficient operation of the catalytic converter.

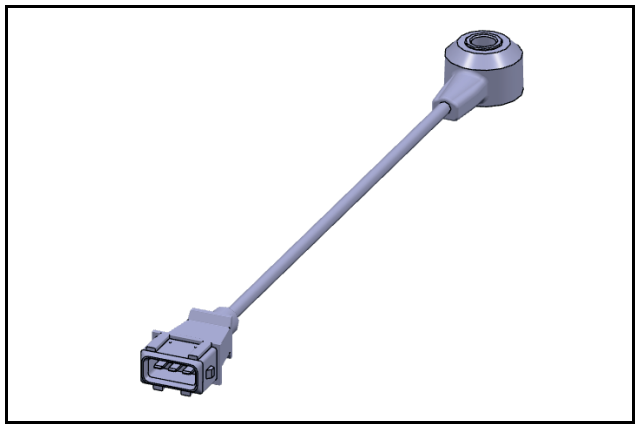


EGN250013

Knock Sensor

Detects abnormal noise caused by incomplete combustion inside the engine and transmits it to the engine control unit (ECU).

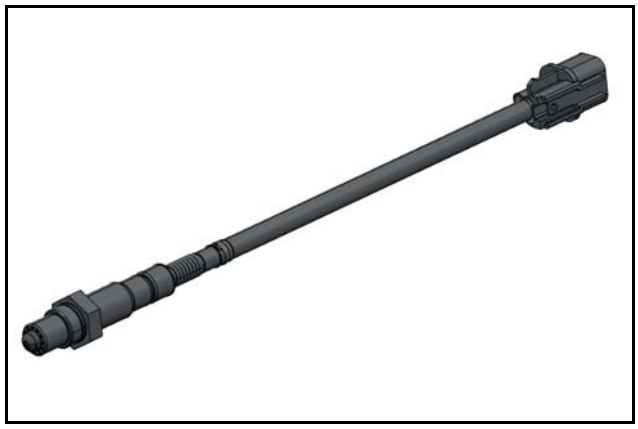
- Operation temperature: -40 ~ 150°C



EGN250014

HEGO Sensor

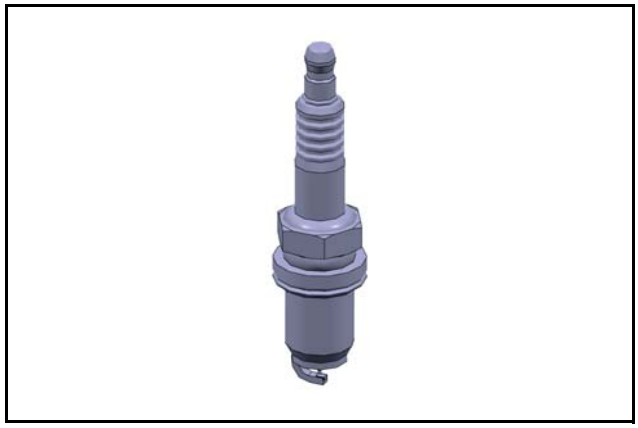
Along with the UEGO sensor, it measures the amount of oxygen in the exhaust gas. It plays an important role in controlling the oxygen to fuel ratio by measuring the oxygen concentration.



EGN250015

Spark Plug

This is a component that generates a spark for an explosion inside the combustion chamber and needs to be replaced/maintained periodically.



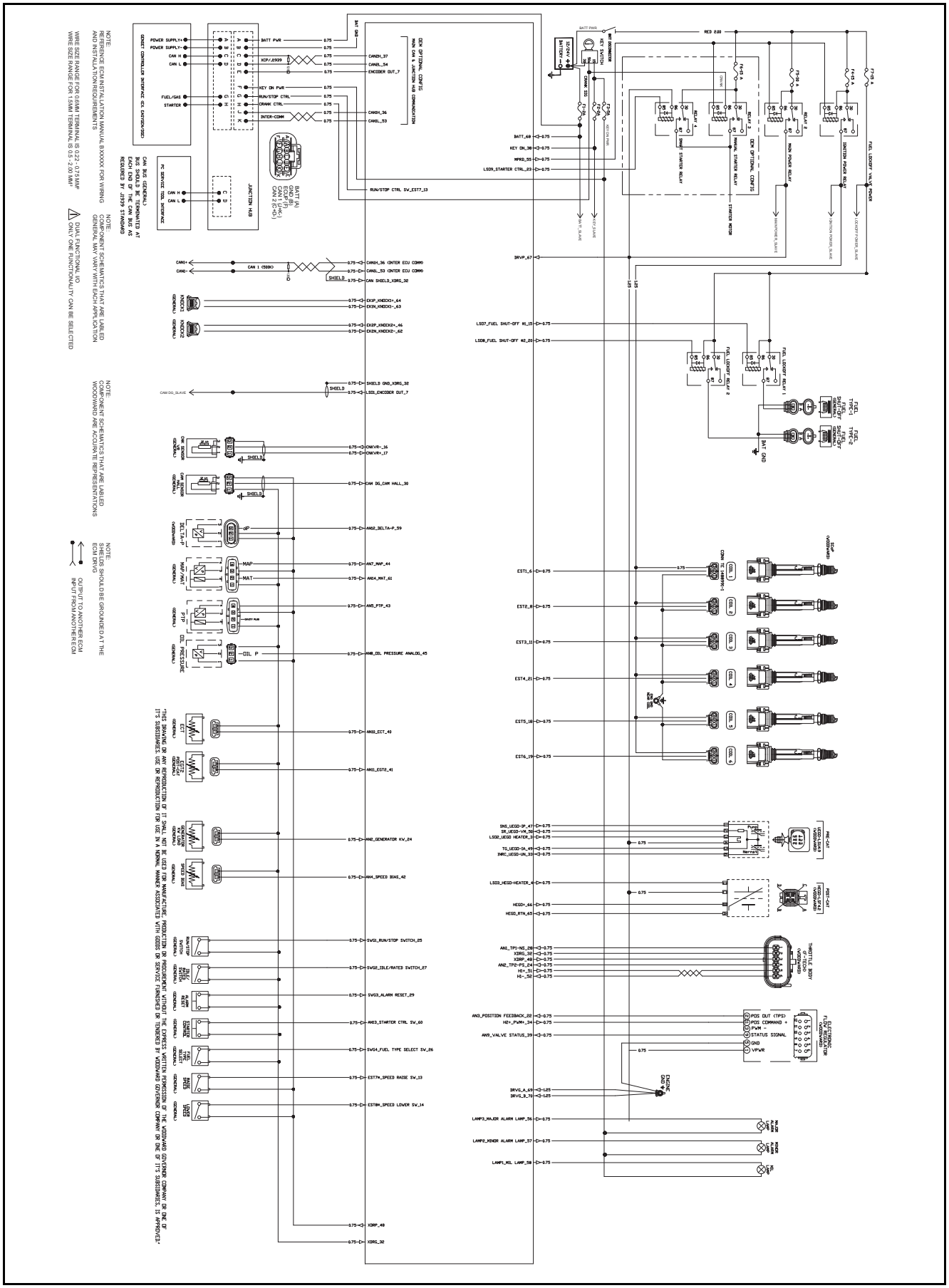
EGN250016

Ignition Coil

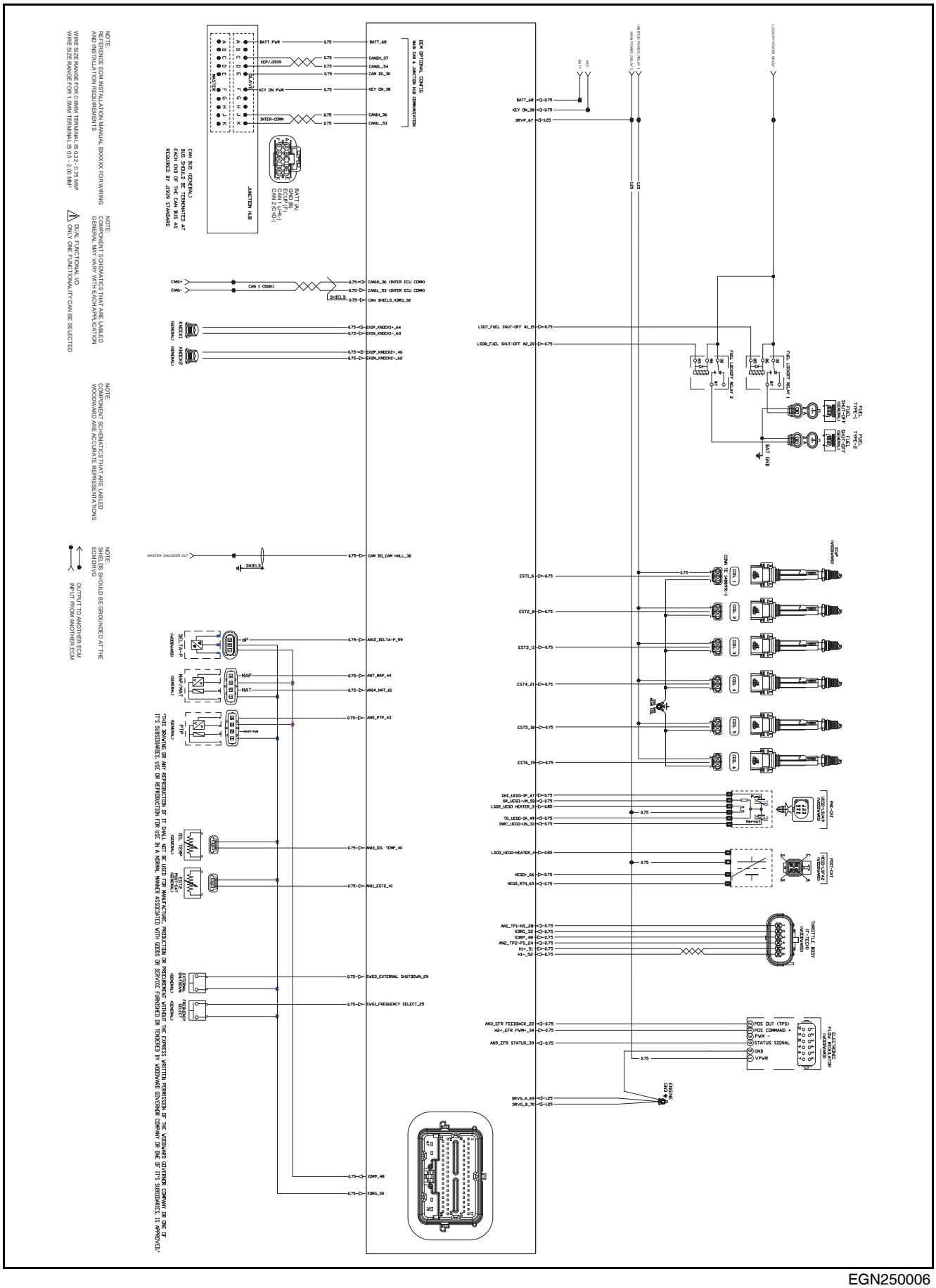
It is responsible for transmitting ignition energy and ignition signals to the spark plug and needs to be replaced/checked periodically.

EGN250017

Electrical Wiring Diagram



EGN250005



EGN250006

12. Aftertreatment System

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Introduction

The exhaust system products supplied by HD Hyundai Infracore Co., Ltd. (hereafter referred to as 'HDI') are composed of catalytic muffler device which reduces harmful emissions to the levels required to meet emissions legislations and various parts or components such as mounting brackets, pipes, flanges, bolts, etc.

Supply Scope and Responsibility

Beyond the HDI products, the entire exhaust system of machine (or equipment) may include parts from the machine manufacturer. The machine manufacturer takes full responsibility for these parts and for any failure of the HDI products caused by the parts from the machine manufacturer. In this case the machine manufacturer has no warranty claim.
HDI is not responsible for any defect and/or functional difficulty in the HDI products resulting from non-compliance with the ‘Installation Guide’ which is provided from HDI. Therefore, in this case, the warranty of the HDI products will no longer be valid. Each of HDI and the machine manufacturer should verify or validate each of their products respectively. HDI is not responsible for the verification or validation of the parts that are supplied by the machine manufacturer.

Mandatory Requirements

General Requirements

- The engine must be installed and operated with the aftertreatment system that has been matched to the engine.
- All joints, clamps and pipes used between the engine and aftertreatment must be industry standard, leak tight and must be durable.
- Only all sensors and accessories supplied by HDI must be used.
- Mounting clamps or bolts should be tightened as standard (or suggested) torque. It is not allowed that loosened the clamps or mounting bolt for any purpose.
- Additional welding, painting or insulation onto the aftertreatment is prohibited.

Aftertreatment Hardware Requirements

- The exhaust system temperature drop and backpressure must meet the guideline which provided in the "System Specification (94 page)". The maximum drop in exhaust pipe temperature and exhaust backpressure is determined based on the application and the rated power and speed.
- The exhaust pipe length from turbo to aftertreatment inlet must be designed to meet under 2 m. If customer want the exhaust pipe to be longer, customer should contact application engineer.
- The exhaust stack must be designed to prevent water and dirt ingress into the aftertreatment.
- In case of aftertreatment is mounted on chassis or ISO-mounted on engine, flexible pipe (e.g., bellows pipe) between turbo and aftertreatment inlet should be applied. The machine manufacturer is responsible for flexible pipe.
- Gaskets, V-clamps and exhaust pipes must be properly installed to prevent leakage, and there must be no malfunction of gaskets and V-clamps due to errors during installation. Gasket and V-clamp are not reusable component.
- The exhaust pipe should avoid touching or passing close to the air cleaner, fuel and lubricating oil filters, fuel tank or piping, injection or lift pumps, radiator and also, alternator, starter motor wiring or any electronic components.
- The inlet and outlet pipe must be adequately supported to minimize the joint load, prevent induced stress, avoid vibration and resonance.

12. Aftertreatment System

Aftertreatment Mounting Requirements

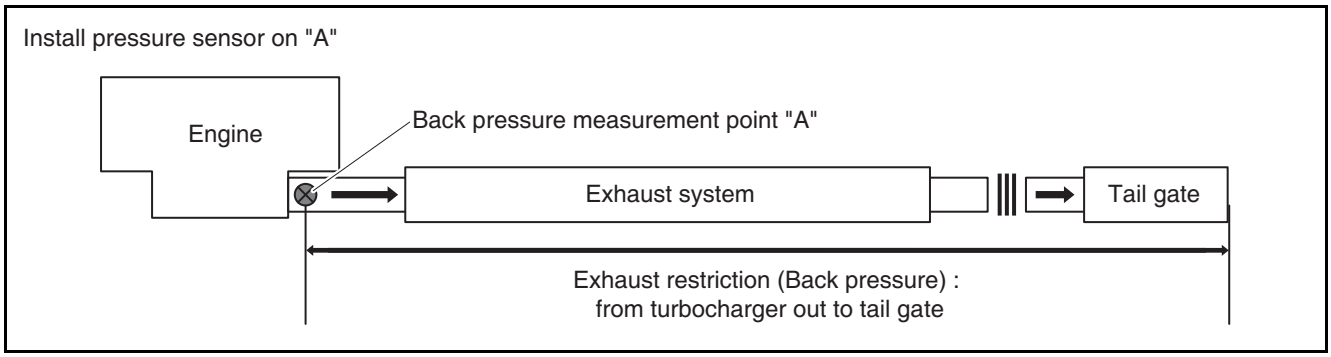
- The aftertreatment must not be mounted on the application or the engine system without HDI approval.
- The aftertreatment must be mounted to a structure that will provide sufficient rigidity to support the aftertreatment mass and be capable of withstanding the maximum loading during a worst-case work cycle (including shock loading) for that application. (For worst-case work cycle of application, customer provides information to HDI application engineer and is responsible for the information.)
  The detail requirement provided in "Mounting (95 page)" of "Aftertreatment System Mandatory Requirements".
- Any brackets, bolted joints, mounts, welds or other structural elements supporting the aftertreatment which provided by customer must be able to withstand all mechanical loads seen during operation. The engine and aftertreatment failure occur due to abnormal vibration caused by deformation or cracking of the support is not allowed.
- The orientation of the inlets and outlets must not be adjusted during the installation process.
- Aftertreatment location should be easy to access, without major component removal, for any service and maintenance requirements.

Environmental Requirements

- The aftertreatment should be located where air circulation around the canister is allowed and be protected from debris or damage from outside the system.

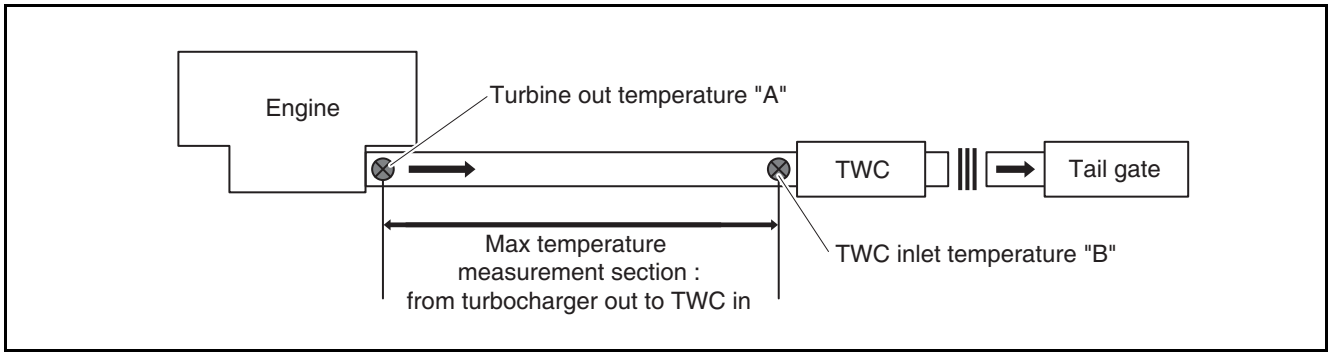
System Specification

- The maximum exhaust back pressure is determined based on the application and the rated speed.
- Make sure that the measured back pressure is lower than 15 kPa for any engine operating condition. Measuring point is "A" which describe below figure.



EGN250018

- Make sure that the measured temperature difference between turbine out "A" and TWC inlet "B" is lower than 15°C for any engine operating condition.



EGN250019

Aftertreatment System Mandatory Requirements

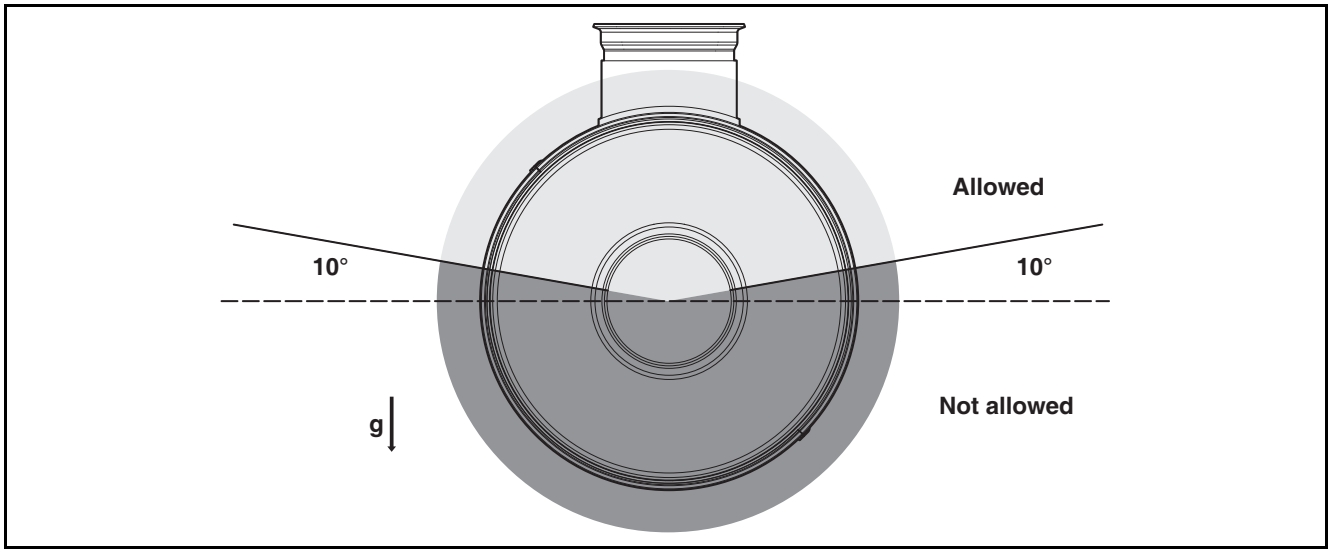
HD Hyundai Infracore After-Treatment System consists of Three Way Catalyst (TWC).
The GV22 engine must be equipped with HD Hyundai Infracore TWC for meeting the emission regulations.

Safety

- The converter must be designed to ensure that the exhaust temperature from the tail pipe does not cause property or physical injury to bystanders.

Mounting

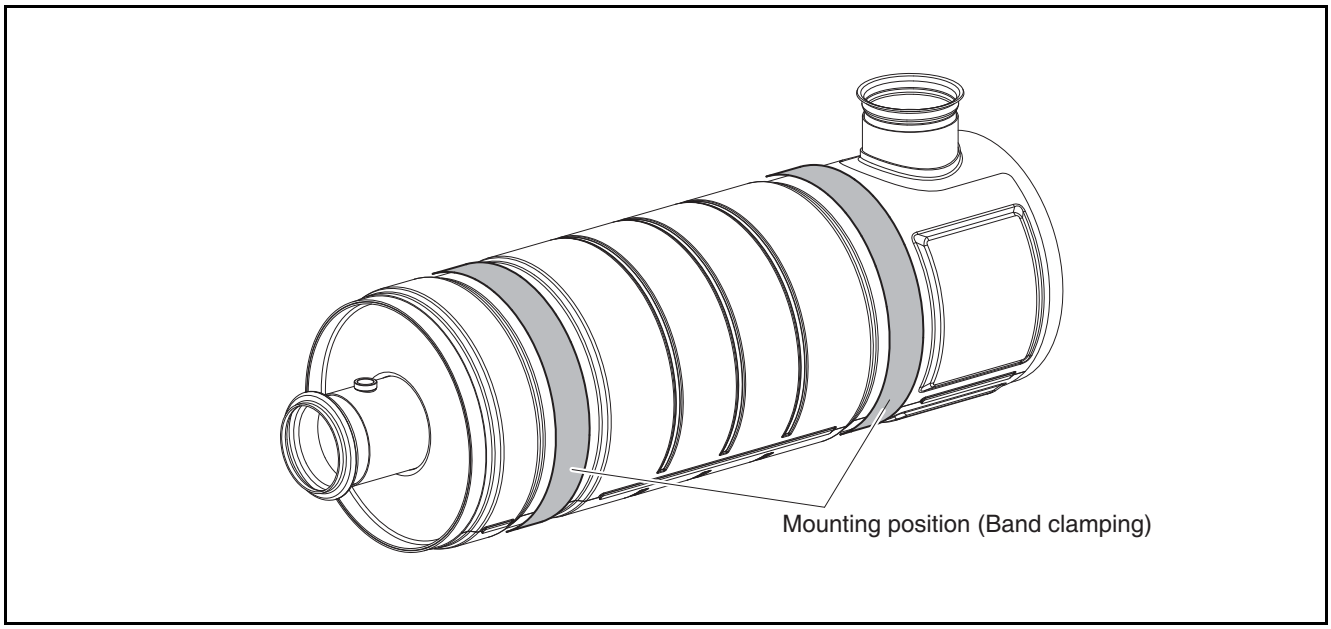
- ATS system must be located to minimize heat loss.
- Mounting must prevent the entire exhaust system from contacting adjacent equipment components. (25 mm minimum clearance)
- ATS system that is designed for horizontal orientation must be installed in the designed orientation.
- The exhaust pipe connected to the inlet of the after-treatment system cannot be used to support the aftertreatment system because it induces a bending moment.
- For chassis-mounted after-treatment systems, flexible connections are required between the turbocharger and the after-treatment system to prevent motion constraints between the engine and the machine frame.
- When the HEGO sensor is installed on the TWC that is designed for horizontal orientation, the HEGO sensor must be installed in the proper orientation as shown in the following Fig.



EGN250020

- If parts from the machine manufacturer are assembled in addition to ATS supplied by HDI, the machine manufacturer must prepare and follow the appropriate overall assembly guidelines, including assembly guidelines for parts supplied by HDI.
- If inlet or outlet pipe which is provided by the machine manufacturer is additionally connected to the aftertreatment system supplied by HDI, the machine manufacturer must assemble it with aligning along its center line. Otherwise, some problems such as gas leakage, abnormal noise, excessive pre-stress or flow resistance, etc. may occur.
- If a connection pipe is installed between the turbocharger and the after-treatment system, it should be done in such a way as to prevent any leakage.
- The ATS muffler could be mounted according to the customer needs. However, the vibration requirement for the ATS muffler specified in "Vibration (96 page)" of "Aftertreatment System Mandatory Requirements" must be satisfied.

- HDI recommends that the ATS muffler is mounted using band clamps as shown in the Fig. below.



EGN250021

Vibration

- The vibration load to the ATS muffler must be measured in all relevant states of equipment operation including worst-case vibration conditions. Acceleration sensors should be installed on the center and top of the ATS muffler. The vibration load should not be exceeded 4.5 Grms under normal operating conditions and not be exceeded 6 Grms during over 10% of equipment operation time.