



Hyundai Infracore

G2 Engine Installation Guide

Engine Model : DM01 / DM02

Three / Four Cylinder Diesel Engines

July, 2024 rev18

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Revision history

For further details on the previous revision history, refer to **Engine Installation Guide Rev.9**

Rev	Date	Name	Description
10	2020.08.25	CH Cho	Overall change of Engine Installation Guide : Numbering of chapter, Form of document.
10	2020.08.26	JH Kang	Chapter2, 2-5: Added NOx sensor controller installation torque
10	2020.08.26	JO Park	Chapter8,2: Added block heater hole dimension Chapter16: Added Engine mounting system chapter
10	2020.08.26	JW Kim	Chapter3, 3-4: Vibration guide of radiator change
10	2020.09.09	Jihun Song	Chapter11-1 : minimum load for DPF graph change
10	2020.09.16	DH Kim	Chapter2, 12 : Added IP grade for Starter
11	2020.10.29	DS Cha	Chapter1-6.6 Add CAUTION for fuel return line
11	2020.11.02	DH Kim	Chapter2, 12 : Modified IP grade for Starter
11	2020.11.02	JY Kim	Chapter5-3 : Modified Engine Oil ACEA Grade
11	2020.11.12	CH Cho	Chapter1, 2-1: Updated fuel standard Added fuel requirement and management 3-1: Added fuel filter system guide 7-9: Updated interface connection information
11	2020.11.18	JH Kang	Chapter2, 2-1: Added operating temperature of temp. sensor 8-4: Modified alternator L-terminal permission current.
12	2021.02.01	DU Jin	Chapter 11. Minimum load requirement 11.2 Minimum load requirement at cold condition graph update
12	2021.02.01	DU Jin	Chapter 2. Electrical System 1-3) ECU terminal diagram – Battery disconnect time update 120s → 150s
12	2021.02.05	SK Hwang	Chapter4, 2-2: Modify tail pipe mass in case of ATS mounting
12	2021.02.22	CG Kim	Chapter2, 8-4 : Added comment of alternator's L terminal installation.
12	2021.03.22	JH Kang	Chapter2, Added 13. Mating Wire Guide (Reference)
12	2021.03.30	DY Kim	Chapter3, picture 3-3 updated Chapter3, 7-2 : Cooling fan rpm ratio added
12	2021.03.30	DS Cha	Chapter1, 7-8 picture updated
12	2021.04.01	SG Lim	Chapter14-2 Spec. table updated
12	2021.04.01	CH Cho	Chapter1, 7-9: Updated interface connection information
13	2021.06.21	JH Kang	Chapter6, Added 4-3) Guide for customers who do not conduct MAF sensor calibration test with DI and modified 4-7) Air System Proposal Design. Chapter2, Added temperature measuring points of the aftertreatment sensors. (2-2) / 3-3) / 5-2))
13	2021.06.23	DU Jin	Chapter4. Exhaust System, 1. System Specification : Add picture of sensor installation point (Back pressure limit / Temperature drop limit) Chapter7. Charging Air cooling System, 2. Additional design considerations : Add picture of sensor installation point (CAC out temperature limit)
13	2021.07.28	JY Kim	Chapter 16. Engine Mount system 1. Added content of Engine mount bracket which DI are supplying to customer for option. 2. Added mount position recommendation in case of using DI mount bracket.
13	2021.08.31	YS Jeong	Chapter 6. Air intake system 1. Added installation guide for air cleaner
13	2021.09.01	H Choi	Chapter2, 1-3: Added comment of customer specific ECU TD.

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			Chapter2, 11: Added comment of standard engine accelerator pedal must be satisfied the specification #1. Chapter2, Added 1-4) Guide for SCR heater feedback wiring of SCR-equipped engines. Chapter2, 8-1: Added comment of SCR-equipped engines.
13	2021.09.06	SA Han SK Hwang	Chapter4, 3,4,5: Added installation guide of ATS system above 56kW of DM02 engine Chapter4, 2-4: Added installation guide of remote DP sensor Chapter4, 2-6~7: Added comment of flow uniformity index and welding guideline for canned DOC
13	2021.09.08	JW Kim	Chapter3-2 Added the heat rejection by E/G power Chapter3-4 Modified the Vibration guide
13	2021.09.24	CH Cho	Chapter1, 3-1: Added comment of additional filter system guide for maintenance period.
14	2022.02.15	DH Kim	Chapter2, 14 : Added Operation Voltage for Starter Solenoid
14	2022.02.17	DH Kim	Chapter2, 8-4 : Added Starter counter connector Chapter2,12-3 : Added JHEECO Starter
14	2022.03.10	SH Oh	Chapter3, added heat rejection unit
14	2022.03.15	DS Cha	Chapter1. 7-3), 7-8) Pressure 0.5 → 0.35
14	2022.03.29	H Choi	Chapter2. 1-3, 1-5 : Added comment of wait to disconnect lamp Chapter2. 5-4 : Added comment of power source of NOx sensor Chapter4. 4-3 : Updated the comment of battery (+) line
14	2022.03.31	SK Hwang	Chapter4.: Added introduction, supply scope and responsibility, Mandatory requirements Chapter4. 2-2): Updated mounting requirements Chapter4. 2-3): Updated vibration guideline of PSD Chapter4. 2-4): Updated guideline of remote DP sensor Chapter4. 4-4): Added guideline of breather filter
14	2022.04.05	JH Kang	Chapter2.: Added descriptions and requirements for DEF sensor assy.
15	2022.11.21	DH Kim	Chapter2, 16: Mandatory requirement of starter control Chapter2, 17: Mandatory caution of starter control
15	2022.12.12	SB Choi	Chapter6 1-1: Deleted Air cleaner type (G070020, G070018)
15	2022.12.13	JY Kim	Chapter5 6: Updated Oil Schematic
15	2022.12.14	JH Kang	Chapter2 : Yellow shading for items applied HP engine only Chapter2, 2&3 : Updated applied engine specifications
15	2022.12.16	JH Han	Chapter4 : Added maximum exhaust back pressure and temperature drop table for DM02HP
15	2023.02.13	SK Hwang	Chapter4. Deleted contents for DM02 HP only
15	2023.02.20	CH Cho	Chapter1 2-1): Updated Included Fuels
15	2023.02.24	H Choi	Chapter2, 1-3): Updated requirement of LED and DPF switch
15	2023.02.27	JH Kang	Chapter2 : Deleted items applied HP engine only
16	2023.05.30	JW Kim	Chapter3 3-2) Generator cooling capacity update
16	2023.07.10	DU Jin	Chapter7 Charge Air Cooling System – Air mass table update
16	2023.07.14	DJ Kim	Chapter2, 14: Mandatory Requirement of Ring Gear and Starter Pinion Gear
16	2023.07.21	DJ Kim	Chapter, 7: Relay for Starter update
16	2023.08.01	JW Kim	Chapter 3 CI Change
17	2023.12.15	SK Hwang	Chapter4, 2-2): Updated first fixation point guideline for tail pipe chassis mounting
17	2023.12.21	SM Choi	Chapter14. PTO Permissible external thrust load update
18	2024.03.06	DJ Kim	Chapter2. 5-2): Updated starter counter connector
18	2024.07.04	JW Kim	Chapter 3, 6-5) : Added the installation of reservoir tank
18	2024.07.08	DU Jin	Chapter 7, 1) : Update CAC out temperature guide

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18	2024.07.08	JO Park	Chapter5, 1) update Maximum Oil Temperature
18	2024.07.12	SA Han	Chapter4, 2-2) Update machine(or vehicle) tail pipe design guide

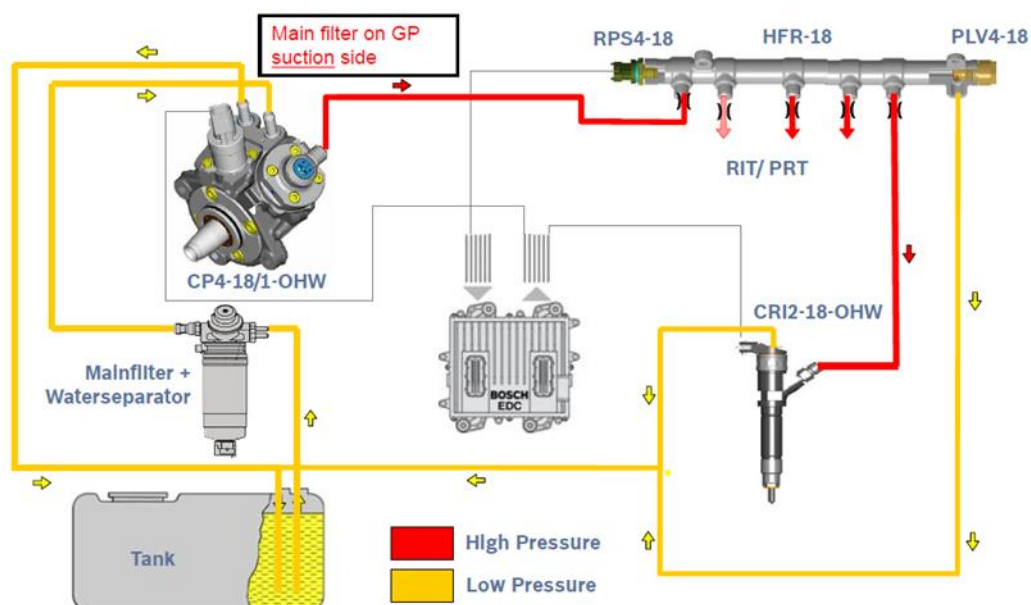
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Chapter 1. Fuel System

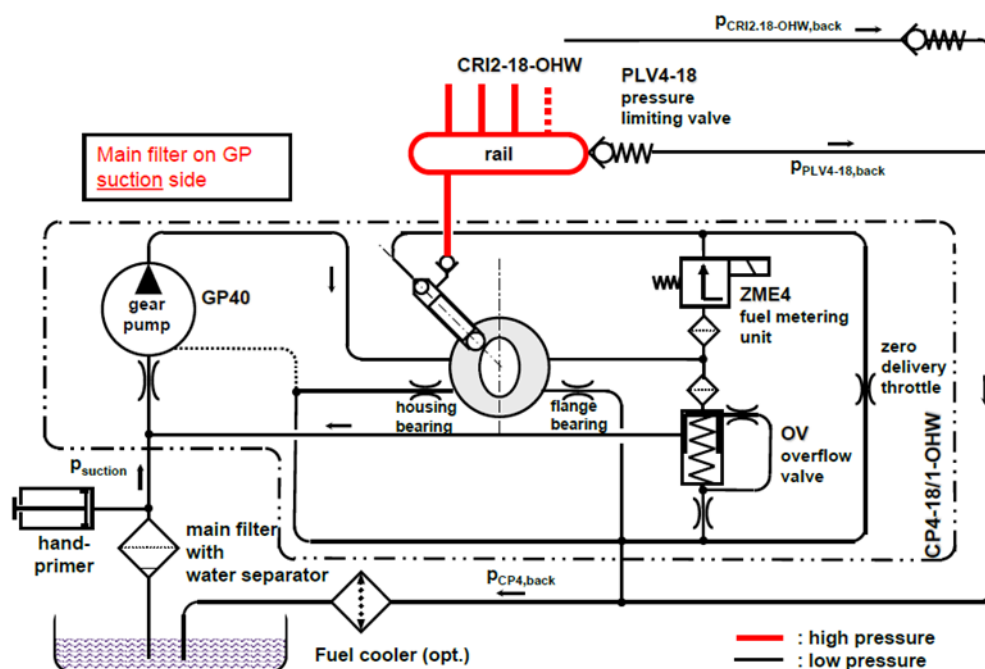
1. Fuel System Diagram

1-1) Schematics of the fuel system configuration

The application guideline deals with the fuel system configurations visualized.



< picture 1-1.



< picture 1-2.

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2. Diesel Fuel

2-1) Included Fuels

The design layout is done for fuel fulfilling all requirements of at least one of the following standards.

- EN590:2013/AC:2014
- EN16734:2016
- ASTM D975C-15 Grades 1D or 2D, with the restrictions regarding paraffinic fuels and FAAE as indicated below
- JIS K2204:2007 with a lubricity (HFRR test, per test method ISO12156-1) $\leq 520\mu\text{m}$ and acc. To the Japanese legal regulations with the restrictions regarding paraffinic fuels as indicated below This includes up to 5% of FAME acc. To JIS K2390:2008.
- GB252:2015 and GB19147:2013
- IS1460 2005 Amm. 10 BSIII or BSIV
- ANP69/2014
- GOST R32511-2013 except it's arctic classes 3 & 4
- EN15940:2016 +A1:2018+AC:2019

The standard fuels must meet the requirements below

- FBT(Filter Blocking Tendency) : < 2.5 per IP 387
- MG(Mono Glyceride) : Must comply with EN14214(within 0.7%), ASTM D6751(within 0.4%)

- First Fill

For the first fuel fill, the following additional requirements are strongly recommended.

- Lubricity $\leq 400\mu\text{m}$ HFRR
- No blends with fatty acid methyl esters (i.e. biodiesel) to avoid premature fuel aging in the vehicle tank.

- Paraffinic fuels

Paraffinic material (synthetically produced hydrocarbon, hydro-treated vegetable oil, and fats) hold promise as a blend component in conventional diesel fuel. The use of paraffinic blended fuel is covered by this data sheet, provided that the final fuel fulfills an allowed fuel standard as indicated by this data sheet.

NOTE: ASTM D975 and JIS K2204 specifications do not exclude neat or pure paraffinic fuels. Neat paraffinic material characteristics can differ substantially from fuels described in this datasheet and therefore additional validation for such material is necessary.

- Fatty Acid Alkyl Ester (FAAE) as blend component

Due to market availability, validation of such blend components has only been done with fatty acid

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methyl esters (FAME). Fuels according to ASTM D975 could contain other non-validated FAAEs according to ASTM D6751.

- Specification gaps in the fuel standards

Fuel standards are not comprehensive technical specifications. Consequently, fuels which comply with a standard, yet are placed in service under boundary conditions unintended or unanticipated by the standard (or application or market) may incur additional uncertainty regarding the fuel fitness for use. Examples are metal contaminations, high-molecular biogenic components (filter blocking), additive incompatibilities or process chemicals from fuel production.

- Aftermarket admixtures and additives

Use of fuels with aftermarket admixtures and/or additives (e.g. usage of fuel borne catalyst) are not included fuels. Under special boundary conditions (e.g. usage of additives to support the diesel particulate filter) the usage of such additives can be tolerated. In the event supplementary aftermarket admixtures and/or additives are used, consequential FIE damage from such usage are the exclusive responsibility of those marketing and/or using it.

- Fuel requirements

- The properties of diesel fuels can easily change by various factors, under different conditions used by customers. (Particles in atmosphere, moisture in air, temperature change, storage periods, local fuel quality, dirty storage condition, etc..)
- Biodiesel (BD) is derived from natural oils, and can thus, deteriorate. The deteriorated BD contains acid, sticky substances (sludge), diesel fungi, and etc., which can increase in fuel.
- These contaminated and deteriorated fuels can cause critical engine troubles, thereby leading to higher maintenance costs. (e.g. fuel filter early clogging, wear/damage of fuel injection equipment, injector inner deposit, piston melting due to injector clogging)
- 0% BD fuels must be used for emergency generator after a long stand still. (Engine dose will not start due to fuel line and filter plugging, caused by deteriorated BD.)
- Do not use BD after 3 months from the date of its manufacture.
- Any problems or risks associated with the use of unsuitable fuels will not be covered by HDI's warranty. (Such claims will not be covered by HDI's warranty)

- Day fuel tank and fuel storage tank(for operation site) system requirements

- An air breathing device (the pressure/vacuum relief valve or air vent port) should be installed at the clean side of the day fuel tank and the fuel storage tank.
 - (i) The end of the air inlet should be protected from dirt/mud/water intrusion.
 - (ii) A suitable air/moisture filter system should be included in the tank breathing system.
- A day fuel tank and a fuel storage tank should be included in the water drain and the contamination cleaning port.
 - (i) Drain/clean the sludge, contamination, condensed water inside the fuel tank on a weekly basis.
 - (ii) Check the contamination status of the fuel tank and flush with clean diesel on a monthly basis.
- The amount of condensed water, created due to the difference in temperatures, must be minimized inside the storage tank.
 - (i) The fuel tank should be positioned at least 30cm above the ground.

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- Avoid the entry of air in the fuel tank by adequately designing and installing the tank (e.g. swirl pot).
- The fuel storage tank (operation site) should have a dirt/water separation filter in the dispensing nozzle. (e.g. 10micron rating filter)
- Do not paint the inner surface of the fuel tank when biodiesel is used. (Biodiesel will strip the paint, which will plug the filter and fuel line)

2-2) Exempted Fuels

The FIE components must be operated at all engine application conditions with fuels according to this document so that potential impairment of the components caused by fuel effects is minimized (e.g. as a consequence of aged fuel, supplemental additives or admixtures, contamination, or unconventional non-validated fuels).

Exempted fuel includes the use of pure or intermixtures with gasoline, kerosene-type fuels and other fuels potentially available in some markets but not compliant to the fuel standards mentioned above.

Fuel ageing may lead to FIE malfunction by restriction of moving parts throughout the Low- pressure circuit and the FIE. Operation of the FIE with aged fuel is exempted in this document by HDI.

An applications' fuel ageing reserve depletion is decisively influenced by the specific low- pressure circuit layout as well as environmental and other operational conditions. Extended engine standstill periods, especially with diesel/FAME-blends, can lead to depletion of the fuel ageing reserve. To reduce the potential for resultant aged fuel FIE damage, it is highly recommended to take appropriate measures based on specific customer/application use case assessment by the OEM. Some examples are given in the table below.

Use case	Measure	Example
Foreseeable long standstill	Fill up, preferably with biodiesel-free branded fuels	Seasonal equipment (motor homes, winter services, agricultural), new vehicles (especially export), emergency gensets
During service, if applicable before placing into operation	Additional check of aging reserve of the fuel in the tank, if necessary, replace fuel and thoroughly flush the fuel system by engine operation	Emergency gensets, vehicles with extraordinary long standstill due to overseas export or fabrication completion at 3rd party plant

2-3) Boundary Conditions

- Fuel filtration

The requirements on fuel cleanliness regarding water and particles are defined independently from this characteristic data sheet in this guide.

- Avoidance of materials

All component surfaces in direct contact with the fuel must not contain copper (Cu), zinc (Zn), lead (Pb), sodium (Na) & calcium (Ca), as far as technically possible. Copper-containing materials in particular catalytically accelerate the ageing process of diesel fuel. The resulting fuel ageing, especially with admixtures of FAME, can lead to deposit formation and corrosion inside the FIE. Zn or Pb dissolved into the fuel from materials may lead to increased deposit formation. FAME increases the risk of dissolving such elements out of materials or surfaces.

Sodium & Calcium lead to deposit problems. Usually, these elements get into the fuel due to contamination. But if the customer is using parts which have surfaces which are also covered with

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/ made of such metals and they are in contact with fuel, this can also lead to deposit problems.

2-4) Responsibility

The fuels according to this document must be fully represented in the customer's engine and (where relevant) application validation program prior to usage of the series product by the end-user. It is recommended the OEM informs the end-user about appropriate measures for maintaining the fuel quality as described in this characteristic datasheet until consumed. The liability of HDI is excluded in case of damages caused by fuel.

3. Filtration System

3-1) Fuel filter system guide

Continent	Country	Extra Pre-Filter	Pre-Filter	All in One Filter
ASIA	Korea/Japan	N/A	Recommend	Mandatory (DI)
	The rest of the country	Recommend	Mandatory	
Europe	EU Union / Turkey	N/A	Mandatory	
	Russia	Recommend	Mandatory	
North/South America	All	Recommend	Mandatory	
Africa	All	N/A	Mandatory	

*Refer to the Operation & Maintenance Manual for the period of the fuel filter replacement

3-2) Fuel filter specification

- General remarks

In the modern common rail system (CRS), the necessary filtration efficiency for the particles depends on the used components (high and low-pressure system), the vehicle based influencing factors (like e.g. filter mounting position, tank ventilation...), and the basic contamination of the used fuel.

Due to the several influencing factors (fuel properties, mechanical vibration, volume flow, number of starts, pressure, and volume pulsations...), the efficiency achieved by the fuel filters during vehicle operation is mostly less than the efficiency measured in the laboratory according to the standard.

Filter Particle Size	$\geq 4\mu\text{m}\odot$	$\geq 6\mu\text{m}\odot$	$\geq 14\mu\text{m}\odot$
Efficiency	$\geq 99.6\%$	$\geq 99.9\%$	$\geq 99.9\%$

※ The given values are valid for initial efficiency according to ISO 19438 (2003) at a volume flow of 120 l/h.

3-3) Definition water trap

- General remarks

CRS components are partially sensitive against water contaminated fuels, because these fuels may cause corrosion problems and excessive wear due to the modified lubricity of the fuel.

With the application of efficiently working and regularly serviced water traps it is possible to largely extract the undissolved (free) water out of the fuel and by this to inhibit damages and minimize water-

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related incidents on CRS components.

- Definition water trap

The target is to avoid undissolved water inside CRS. Required minimum water separation efficiency for Common Rail injection system.

The water separation efficiency always $\geq 93\%$ within whole project specific flow rate from minimum to maximum measured acc. to ISO/TS 16332 (2006) with standard conditions, but fuel with the interfacial tension (IFT) 11~15 mN/m, DSEP (Diesel micro separometer) < 50 (see hints) and droplet size.

- $\leq 10\mu\text{m}$ if there are any emulsifying devices upstream of the water separator, e.g. pre-delivery pump
- $\leq 150\mu\text{m}$ if there are no emulsifying devices upstream of the water separator at all. Alternatively, SAE J1488 Revised OCT 2010 can be used, but with a fuel with the interfacial tension 11~15mN/m and DSEP (Diesel micro separometer) < 50 .

If the customer installs an e-feed pump, the pre-fuel filter must be applied.

- The pre-fuel filter can protect the e-feed pump and improve durability.
- The water in fuel must be removed from the pre-fuel filter before passing through the e-feed pump.

If the customer does not use the pre-fuel filter supplied by HDI, a pre-fuel filter that the customer applies must meet the following specifications.

Dust Filtration Efficiency (Test per ISO 19438)	$\geq 95\%$, $30\mu\text{m}\odot$
Water Separation Efficiency (Test per ISO 16332 or SAE J1488)	$\geq 93\%$ (IFT : 11~15m.Nm, DSEP 50, DSD=50 : droplet size $\leq 150\mu\text{m}$)
Rated flow	180l/h
Max. delta P across filter assembly (Test per ISO 4020)	New filter: $\leq 10\text{kPa}$ Used filter at change interval: $\leq 30\text{kPa}$
Change interval	Maximum 1,000 hours
Prohibition material	All material and surface treatment that contact with fuel must be not contained Na, Cu, Zn, and Pb.
Collapse Pressure (ISO 4020)	$\geq 5\text{bar rel.}$ The fuel filter assembly must withstand below burst pressure without any defect.

Purpose of this requirement

- The test procedure represents a method, which allows a relative or comparative assessment of the water separation function under defined laboratory conditions.
- By obtaining the required separation efficiency, a minimum standard of the water trap is ensured.

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- This should not be interpreted that a certain level of undissolved water is acceptable for use in CRS.

Hints

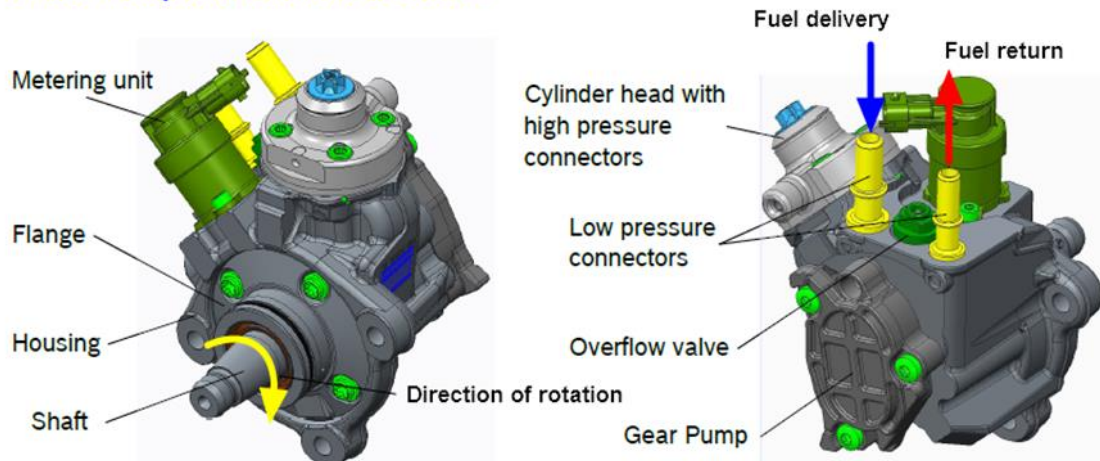
- IFT measurement according to ISO 9101 (1987) or ASTM D2285 (1999), DSEP according to ASTM D7261 (2013).
- Test fuel with required IFT and DSEP shall be produced by mixing ULSD fuel without additives (e.g. by clay treatment, see SAE J1488 appendix A1.1) and B100 made out of organic material acc. to EN14214 or ASTM D6751 to Bx (Blend from mineral fuel and x% biodiesel). A blend rate 5-10% RME (rapeseed methyl ester) can be expected, depending on mineral basic fuel.

4. High-Pressure Pump

4-1) Function description

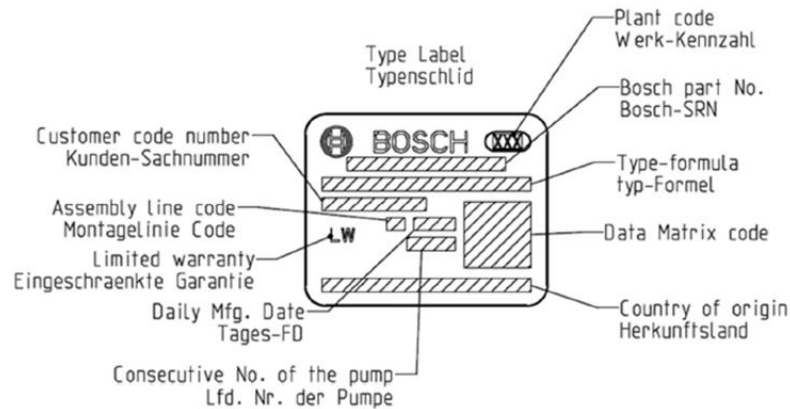
The CP4 is a 1-cylinder radial plunger high pressure pump. It creates the system pressures required by the Common Rail Injection System for all operating conditions of the engine. Possible governing of system pressure: by using the integrated fuel Metering Unit (MeUn).

CP4.1 Pump overview for D18/D24



4-2) Identification and labeling

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5. Common Rail System

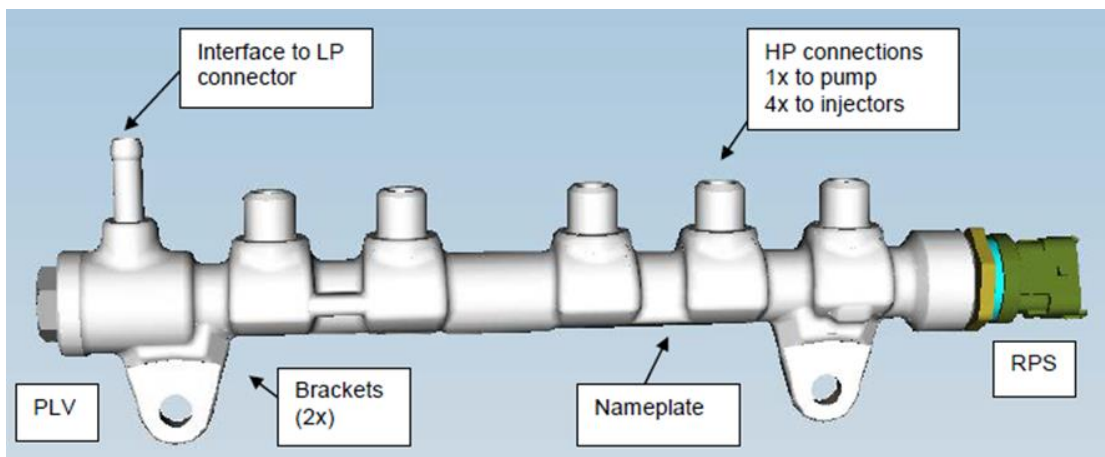
5-1) Function description

The Hot Forged Rail (HFR) is to be used exclusively in Fuel-Injection Equipment (FIE) for diesel engine. The HFR18/OHW is developed for a system pressure of 1,800 bar.

The functions and sub functions of the HFR are (for the functions of rail attached components)

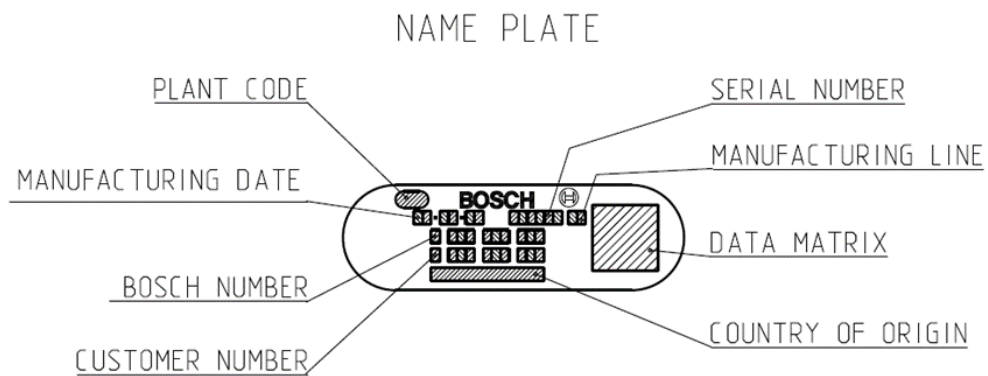
- To store the fuel at required pressure
- To distribute the fuel from high-pressure pump to the injectors
- To ensure the backflow from Pressure Limiting Valve (PLV) to the Low-Pressure Circuit (LPC)

5-2) Interfaces



5-3) Identification and Labeling

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6. Injector

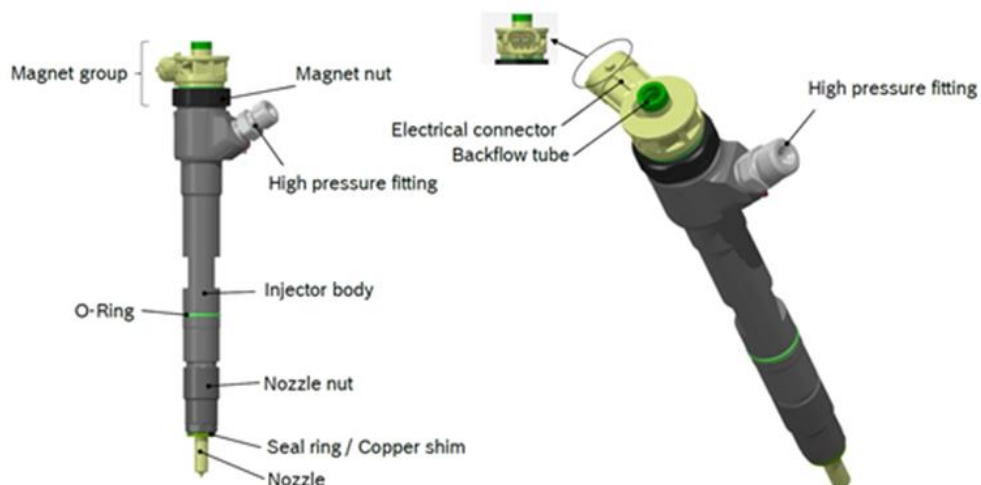
6-1) Function description

For every single combustion cycle, the injectors meter and distribute the diesel fuel into the cylinders of the engine.

6-2) Product identification

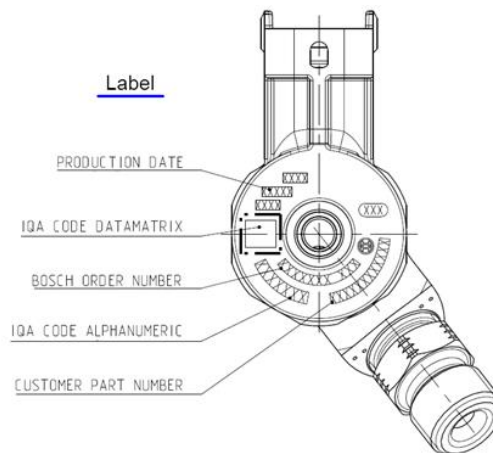
The Common Rail Injector is a part of the direct injection system of a diesel engine. The CRI is arranged between the rail and combustion chamber, in the cylinder head. The task of the CRI is to meter and to atomize the pressurized fuel to achieve mixing of fuel and air in a specific volume of the combustion chamber.

CRI2-18 OHW Injector overview



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6-3) Identification and Labeling



6-4) Safety and Warning notes

The following fundamental misuses are known from customers, field experience, development and testing. The CRI does not have to fulfill its tasks under these circumstances and could be damaged. They are regarded as misuse. An overload of the product could cause heavy damages, e.g. at the engine or the vehicle.

6-5) Shipment, assembly, start and end of operation, storage, service, maintenance, and recycling

- Mounting of injectors to the engine

Any work on the injection system should be carried out only in the load-free and pressure-free condition. During the assembly, disassembly, or cleaning of injectors, cleanliness should be maintained in order to prevent the entry of particle matter into injectors or the engine.

Protective caps should be removed immediately before installation. The damaging of the nozzle tip or its spray holes must be avoided. External seals (O-rings) can be moistened for an easier mounting (e.g. with assembly oil, engine oil, or diesel). Aqueous lubricants or anti-friction agents are not permissible. In order to prevent corrosion on the injectors and on the cylinder head, the customer has the option to lubricate the nozzle retaining nut and the injector body up to the locating flange. This makes the dismounting of injectors easier. Before the assembly, the correct position of the copper sealing washer on the nozzle retaining nut must be checked.

Please pay attention that the injector is introduced into the cylinder head bore without any damage. The application of force on the backflow connector or on the plastic head of the injector is not permissible. It is important that the backflow connector is not damaged by the mounting of the fuel return line. Particles or edges out of the mounting process can cause an incorrect connection of the fuel return line with the injector or leakage.

All plug connections must be safety latched and locked after the assembly.

The nut of the high-pressure connection must be properly fastened before the first operation.

Injector-specific data like the IQA codes should be transferred into the ECU. These serve the purpose of correct actuation of the injectors and with it, the intended operation.

A deflating of the injectors before the first use is not intended.

- Dismounting of injectors from the engine

Injectors must be demounted in a manner similar to that of assembly.

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Open connections must be closed with protective caps.

To loosen the nut of high-pressure pipe, the hexagonal bolt of the high-pressure connector must be fixed firmly. If this inlet connector is loosened, the high-pressure tightness of the injector will no longer be guaranteed.

If the injector is loosened by turning in the cylinder head, for example, the screw connection at the nozzle can be damaged or loosened. Then the tightness of the injector will no longer be guaranteed.

- Re-mounting of injectors to the engine

Every time the injector is demounted, the used copper sealing washer must be replaced by a new one. Before the injector can be remounted a cleaning of the sealing surfaces without damaging is necessary. In order to keep the cylinder-specific correction data in the engine management, the injectors must be installed on the same cylinder, if re-used. The mounting on another cylinder is possible, but the correction data of IQA must be revised in the engine control unit.

The cleaning of injectors is possible with an ultrasonic cleaning device. This might be necessary for the service if some sealing between the injector and cylinder has been not tight. Before cleaning prepare the injectors with protection caps at backflow, high pressure, and the electrical connector. The injectors can be cleaned below the high-pressure connector in a perpendicular position in the ultrasonic bath. The nozzle tip is only allowed to contact the ultrasonic cleaning liquid. Special equipment can be used to fix the positions of injectors in the cleaning liquid during the cleaning process. If no ultrasonic cleaning device is available, the cleaning of the injector shaft is possible by manual brushing. During this brushing process, the injector must be equipped with protection caps at backflow, high pressure, and the electrical connector and additional at the nozzle. Mechanical cleaning of the nozzle shaft is not permitted to prevent damages of the spray holes. The injector should be protected against corrosion (e.g. by grease) after brushing.

Washing of the injector with the permitted fuels is possible to clean the nozzle. It is very important to prohibit contamination of the injector during the washing process.

In order to assure safety no other treatments of the injector are allowed except the here mentioned methods.

6-6) Fuel return line from Injector

The fuel return line collects the fuel return quantity appearing at the injectors and returns this quantity into the tank. For this purpose, the so-called T- and L- return connectors are connected to hose pieces.

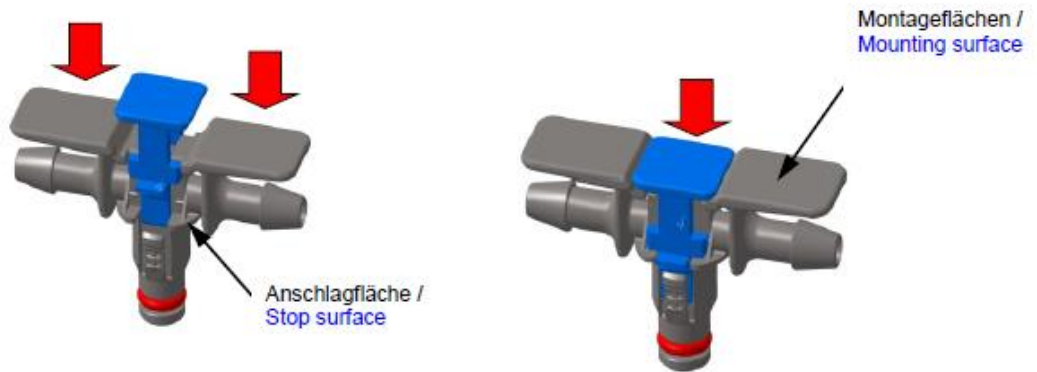
The return connectors have an interface to the injector and are fitted to it. The non-return valve serves to maintain the counter pressure in the fuel return line required by the injector.

- Mounting

Mounting has to be done manually. Insert return connector on injector return connection (up to contact of the stop surface to the injector) (left picture). Subsequently, close the locking clip (clip must lock in place when closed and must be even with the mounting surfaces) (right picture).

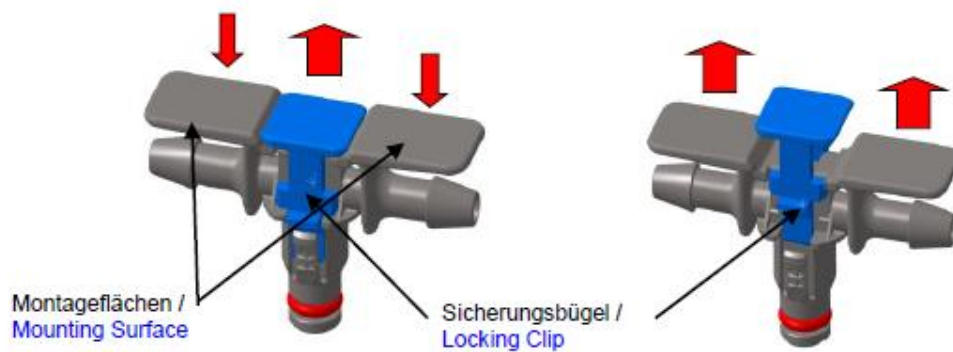
To ensure the function, the return connector should be mounted as per the mounting instructions mentioned above. Otherwise, fuel can leak out.

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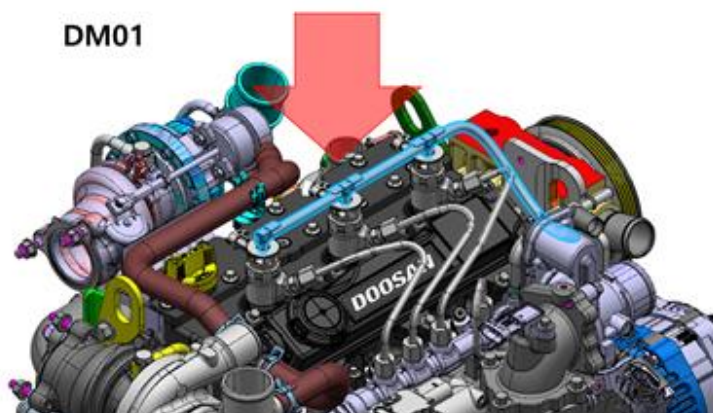
- Demounting

Demounting should be done manually. Open the locking clip. While doing so, press on the mounting surface in the direction of insertion (locking clip must snap-in in the open locking position) (left picture) Subsequently, remove the return connector from the injector return connection (right picture).

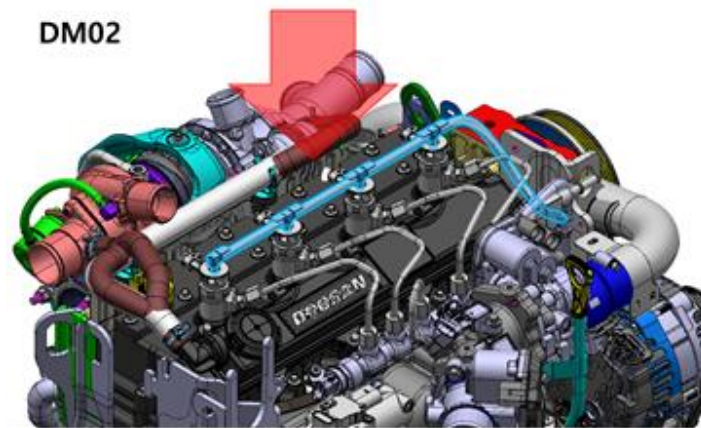


CAUTION.

Be careful to avoid damage for fuel return hose of injector. Don't press on the fuel hose, Don't drop heavy tool like as spanner on engine, Don't step on fuel hose, Don't stand on engine. If the fuel hoses are broken by wrong handling, it is possible fire.



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7. Low-Pressure Circuit

7-1) Introduction

This guideline contains recommendations for the dimensioning of the low-pressure connections and of the tank system and gives an overview of the specifications of the common rail components in the low-pressure circuit. It also describes the initial filling of the high-pressure pump as well as possibilities for the re-start after filter change or after driving tank empty.

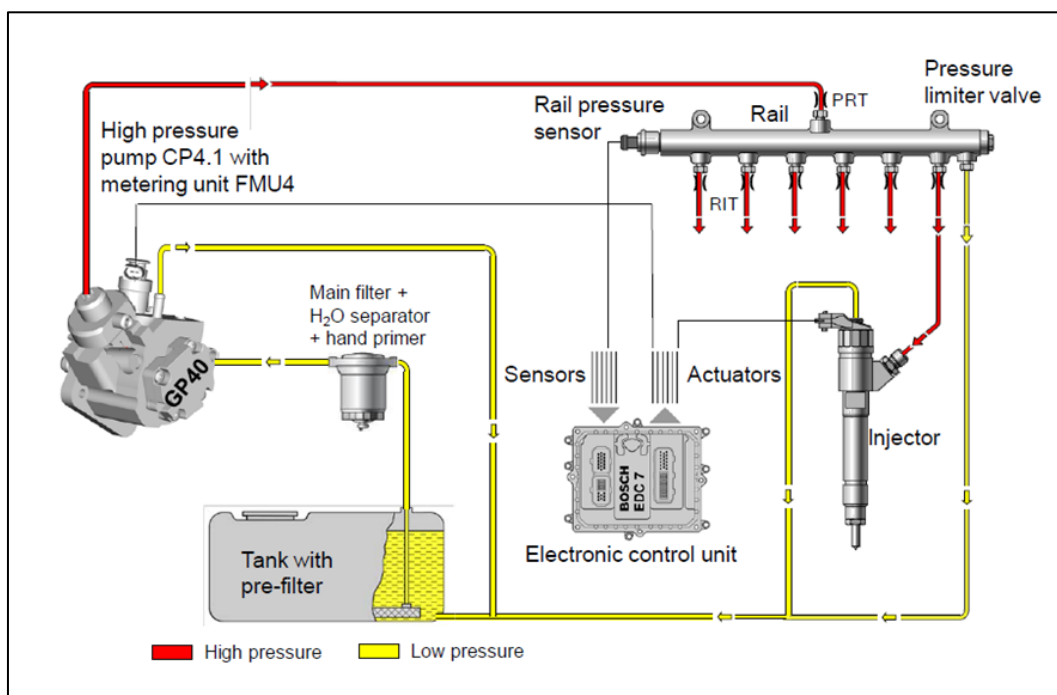
The proposed inner diameters in the low-pressure circuit are typically recommended values. Please note that the pressure specification at the interface with the CR components must be kept. Inner diameters of lines and connectors have to be chosen accordingly.

7-2) General recommendations

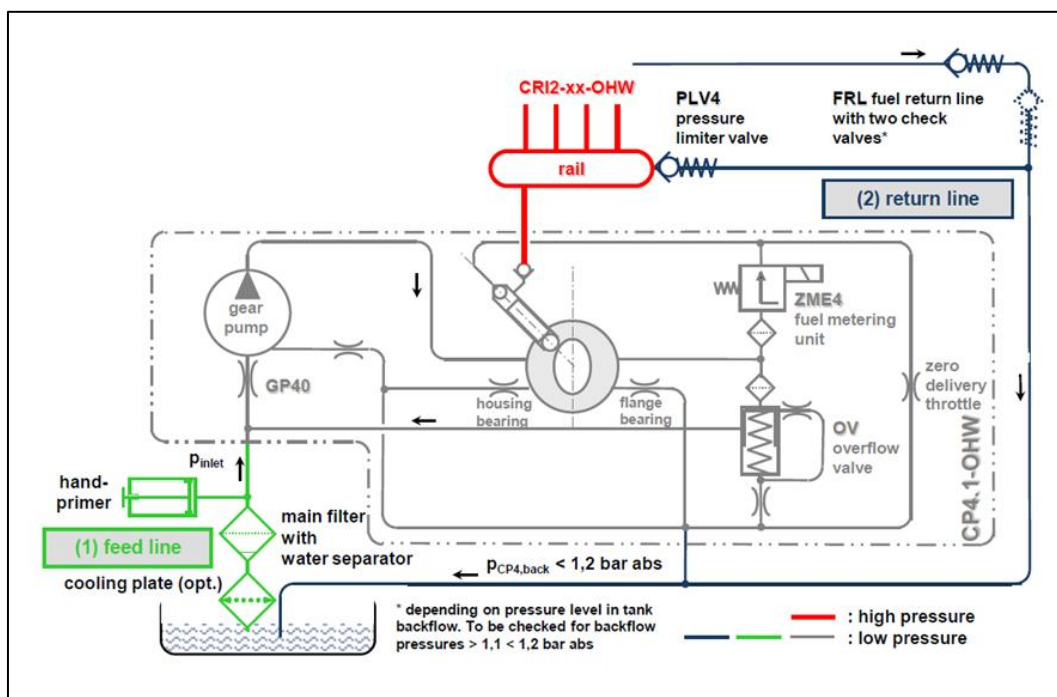
- Do not kink pipes.
- Tighten the connections properly as leakage will not be detected in the suction and backflow area by the system itself. Lines, connections and components must be tight.
- Pipes and connection parts containing copper, zinc, lead, sodium & calcium must be avoided.
- The return flow pipe must end below the minimum fuel level of the tank.
- Lines must withstand the occurring temperatures.
- Lines must withstand the occurring pressures.

Schematics of the system configuration

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Schematics of the low-pressure circuit



7-3) Recommendations for the pressure, temperature, dimensions of pipes, and connectors of the low-pressure circuit.

	Inner diameter	Pressure	Temperature
Fuel Inlet	≥ 8 mm	0.35~1.5 bar _{abs}	max. 80°C
Fuel Return	≥ 8 mm	max. 1.2 bar _{abs}	max. 120°C

7-4) Low-pressure circuit cleanliness

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Cleanliness for inlet to CP4 Pump (LP-area) based on a particle count depending on particle size according to ISO16232

If <u>use</u> the fuel filter supplied by HDI, the cleanliness must be observed.					
Particle size (μm) measured in the greatest particle extension	$50 \leq x < 100$	$100 \leq x < 200$	$200 \leq x < 400$	$400 \leq x < 600$	$x \geq 600$
Fuel tube or hose between main filter outlet and CP inlet	105	27	0	0	0

If <u>not use</u> the fuel filter supplied by HDI, the cleanliness must be observed.					
Particle size (μm) measured in the greatest particle extension	$50 \leq x < 100$	$100 \leq x < 200$	$200 \leq x < 400$	$400 \leq x < 600$	$x \geq 600$
Main fuel filter in clean side, fuel tube or hose between main filter outlet and CP inlet	350	90	5	0	0

7-5) Recommendations for the fuel tank system

The CR-components must be protected against the extreme wear caused by particles present in the fuel by using a suitable filter system. As far as the tank is concerned, it is strongly recommended to design the breathing system with an appropriate air filter system. By doing this it is possible to avoid the pollution of fuel by particles present in the environment. This measure is mandatory for vehicles running in dirty environments or under severe conditions. Fuel pollution produces considerable wear (up to damage) of the CR components and reduces the lifetime of the main filter. Besides this the risk of a breakthrough for the filter elements increases. Another problem can be the sucking of air out of the fuel tank and into the GP (and consequently into the CRS). This should be avoided by an adequate design of the tank or installations.

7-6) Initial filling and operation of CP pump

- General consideration
 - A dry run of the CP pump is forbidden
 - The system bleeding requires an external fuel lift pump, e.g. an electric feed pump
 - For the first filling, it is strongly recommended to use the fuel with a FHRR value $\leq 400 \mu\text{m}$
 - For the first filling, the usage of fuels with biodiesel content is not recommended.

The filling time of the CP Pump and the Fuel Injection System depends on the air content in the pump and the system and on the capacity of the external fuel lift pump. The completion of the pump and system filling with fuel is detected via a visual check of the return flow at the pump low-pressure return connection. In case of the usage of non-transparent backflow pipes, it is the customer's responsibility to ensure a sufficient filling time.

7-7) Re-start after than empty drive or after fuel filter of CP change in service

- Tank empty drive

In case that the low- and high-pressure circuits of the CRS get filled with air, a restart can be

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problematic. As a first step the usage of the hand primer is necessary to ensure the filling of the LPC. Please activate the hand primer until the encountered resistance is big enough. If possible, check the presence of fuel backflow from the CP.

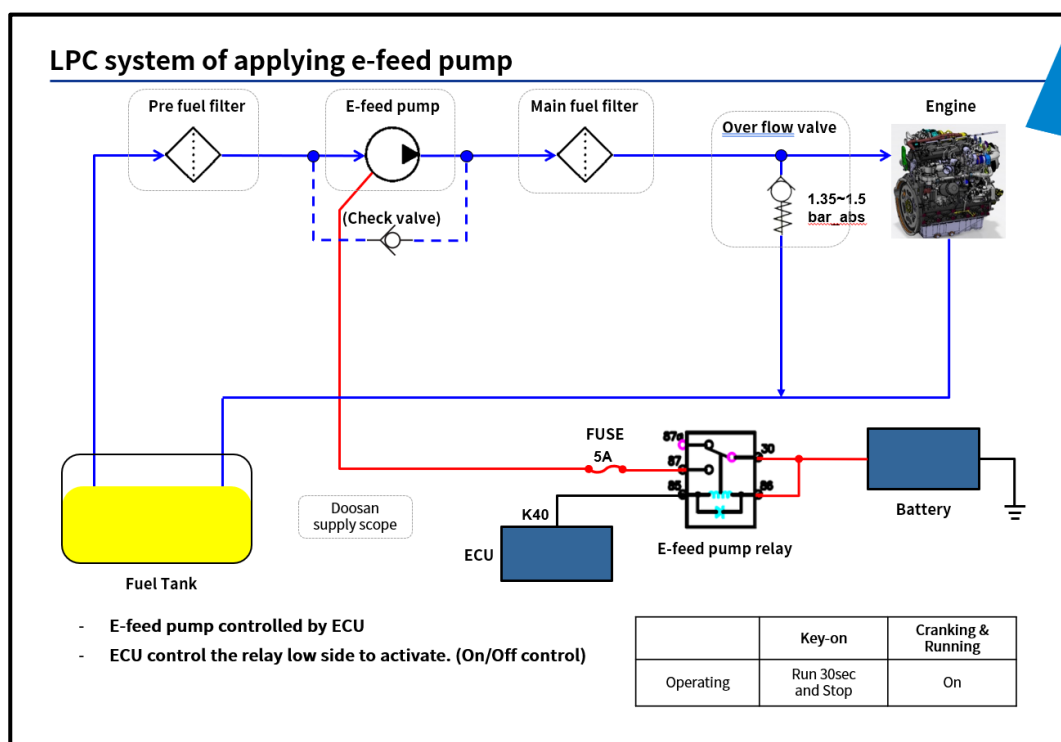
- Fuel filter or CP change

After a fuel filter or CP change and before an engine restart, it is necessary to use the hand primer in order to fill the CRS low pressure circuit with fuel. The hand primer should be used until the fuel comes out from the CP backflow and the resistance encountered by activating the hand primer is big enough. In case of usage of non-transparent pipes, we recommend disconnecting the CP backflow connector in order to check the fuel flow. The time needed to fill the low-pressure circuit is dependent on the specific customer configuration.

7-8) CP pump inlet pressure requirement and LPC Installation guide

The CP pump inlet pressure should be maintained at 0.35-1.5 bar (abs). To meet pump inlet pressure 0.35-1.5 bar (abs) up to altitude 2000m, the LPC allowable maximum resistance pressure must be within $\Delta 30\text{kPa}$. The requirement is the same when adding a pre-fuel filter. If the requirement is not met, a feed pump can be applied between the tank and the pump to meet the requirements. (high altitude, pressure loss due to a long hose, filter differential pressure, etc.)

See the below picture regarding applying the electric feed pump supplied by HDI. If to get more information about the electric feed pump, contact HDI Infracore or its dealers.



The pressure of the main filter supplied by HDI is less than 10kPa (Test per ISO 4020, rated flow: 180l/h), and the recommended change interval is maximum 1,000 hours. The required change interval depends on the filter surface, fuel consumption and fuel quality by country and region

In extreme conditions, it can happen sooner than the expected lifetime of the Filter. If there is a large amount of impurities in the fuel, the total LPC resistance before reaching the replacement cycle may reach 30kpa. Therefore, the total resistance needs to be controlled so as not to exceed 30kpa.

HDI does not guarantee the loss of power or damage of the FIE system, which occurs when the LPC resistance exceeds 30kpa before the fuel filter change interval.

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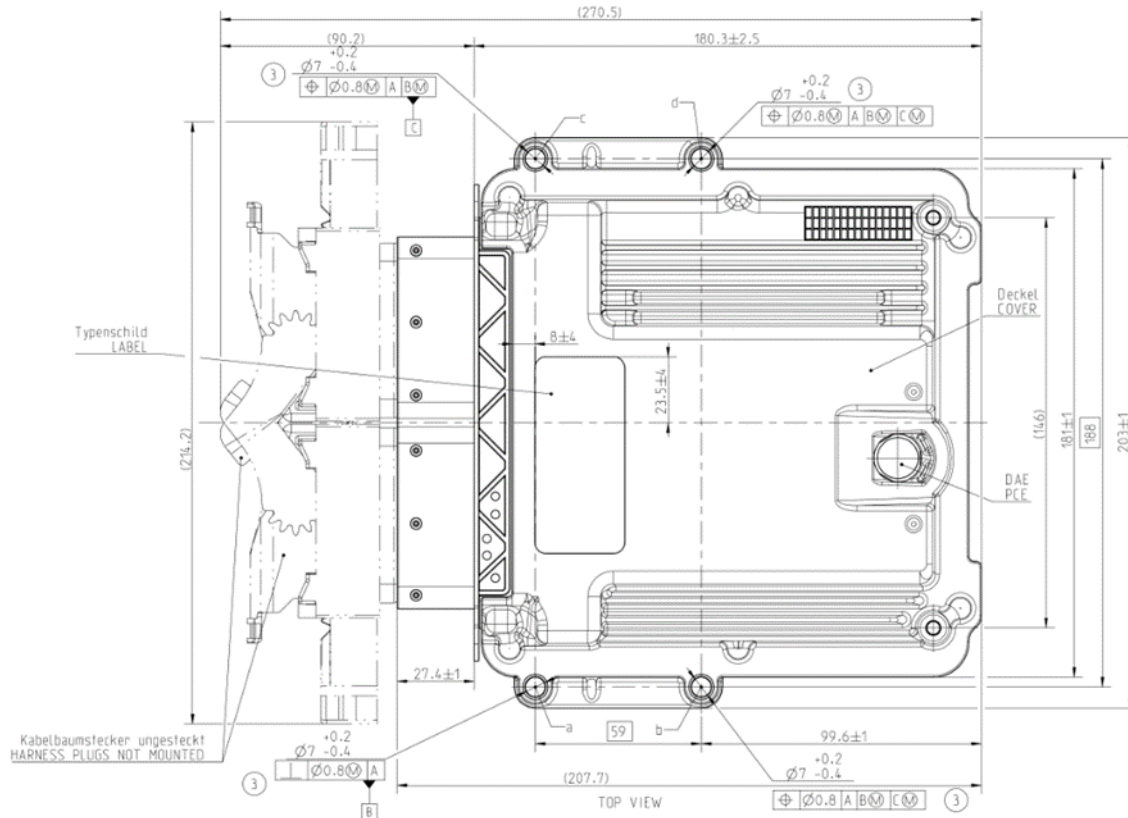
7-9) Interface connection information

- CP Pump inlet port: SAE J2044 O.D \varnothing 11.8 Quick Connector type
- Fuel return port: SAE J2044 O.D \varnothing 10 Quick Connector type
- Fuel filter in/outlet port
 - Hose and Clamp type: JASO M 101-94 Bulge shape for \varnothing 10 outer diameter
 - Quick connector type: SAE J2044 for \varnothing 10 outer diameter
- Fuel filter
 - WIF sensor matching connector: DEUTSCH DT06-2S
 - Fuel heater voltage: 12V(Gray) / 24V(Black)
 - Fuel heater matching connector: DELPHI 15300027
 - Fuel temperature sensor matching connector: TYCO 936248-2
 - Fuel pressure sensor matching connector: FCI F519600
 - The minimum distance required for fuel filter removal : 30mm
- Electric feed pump
 - E-feed pump inlet port : JASO M 101-94 Bulge shape for \varnothing 10 outer diameter
 - E-feed pump outlet port : JASO M 101-94 Bulge shape for \varnothing 9.52 outer diameter
 - E-feed pump matching connector : DEUTSCH DT06-2S
- OFV(Over Flow Valve)
 - OFV in/outlet port : JASO M 101-94 Bulge shape for \varnothing 12.7 outer diameter
 - OFV return port : JASO M 101-94 Bulge shape for \varnothing 9.52 outer diameter

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Chapter 2. Electrical System

1. ECU



1-1) Operational requirements

[Supply Voltage]

- Functional range*1 6V– 16V
- Starting condition (actuation of the starter relay) 4.5V - 6V
- Limited operation with increased tolerance*2 6V – 10 V and 16V – 18V
- Full functional range 10V – 16V
- Limited operation impact on lifetime 16V - 18V for max. 1h at Ta = 23°C

(With increased tolerances)

- Jump Start 18V - 24V for max. 60s at Ta = 23°C

If other restrictions of the functional range result from the normative requirements (e.g. LIN-specification), these are also applicable without explicit naming. For operating voltages <6 V without activation of the starter the ECU can switch off for protection. When returning to normal operation or to the functional range, the defined function is resumed again.

*1 Limited diagnosis functionalities from 6V to 10V

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*2 Increased tolerances are mainly available in the injection system and the power stages. Functional restrictions are possible by calibration.

[Power Consumption]

The power consumption and power dissipation of the control unit are dependent on the connected components and the operating state.

Table 4 illustrates the possible power dissipation of the control unit for three operating points. The values specified within the table are not intended to be complete. Furthermore, power dissipation strongly depends on the properties defined in the application (e.g. activation of specific actuators, injections, etc).

	Idle	Partial load	Full load
Engine speed (1/min)	800	1500	3000
Number of injections	5	5	4
Total Pv [W]	14,5	19.5	24.12

Table : power dissipation illustrated for three operating points

The power consumption during DPF regeneration increases up to 5W depending on the operation mode. The operation mode "DPF regeneration" is permitted for cycles of maximum 30minutes, followed by a return to steady state in normal operation or engine off according to the service life profile.

[Operating Temperature]

Ti = ECU inside air temperature on one reference measurement point

Th = ECU housing temperature on one or more reference measurement points

Tmax = +125°C, it is not allowed to exceed this temperature even if ECU is passive.

Ta = + 105°C, ECU ambient temperature, operating range: Tamin < Ta < Tmax

Tamin = -40°C, It is not allowed to fall below this temperature even if ECU is passive.

[Storage Temperature]

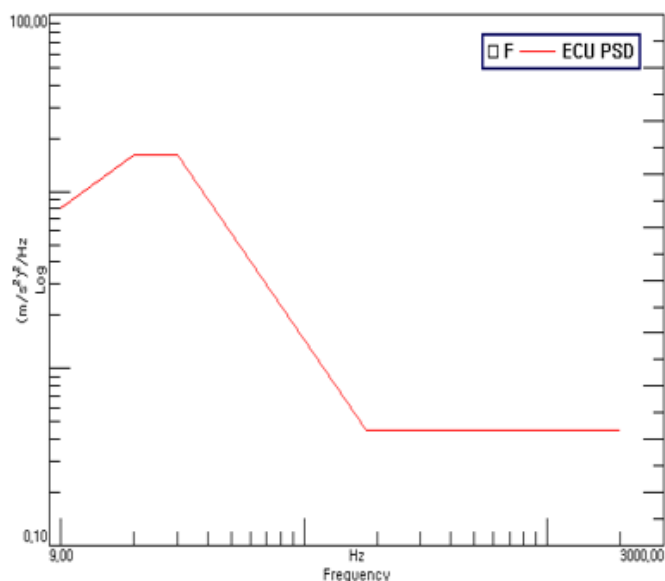
Storage conditions	Temperature	Storage time	
Temperature	-40°C ... 10°C	<0.1%	100 h
	10°C ... 25°C	70%	92,000 h
	25°C ... 30°C	20%	26,300 h
	30°C ... 40°C	<10%	12,900 h
	40°C ... 90°C	<0.1%	98 h
	90°C ... 130°C	<0.0015%	2 h
	Total	100%	131,400 h
	30 ... 60 % r.F.	90%	118,300 h
	≤ 80 % r.F.	<10%	12,900 h
Humidity	≤ 85 % r.F.	<0.2%	200 h
	Total	100%	131,400 h

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[Vibration]

The permissible vibration loads in the frequency domain is shown below.

Frequency [Hz]	PSD [$((m/s^2)^2)/Hz$]
10	8.000
20	16.000
30	16.000
180	0.444
2000	0.444



1-2) Installation requirements

[Mounting of ECU]

The ECU has to be tightly fastened to avoid any friction or abrasion against other parts or connecting elements. Where there is any deviation from the drawing, the admissible interface and the resulting load on the cover and the bottom would have to be discussed and determined with HDI. The ECU should be mounted on the chassis and connector orientation can be performed if there is no standing water inside the ECU and the connector.

[Fastening]

The ECU has to be fastened from 4 points (a, b, c, and d).

The maximum tightening torque for the ECU (M6-screws) is 10Nm. This torque applies to screw connections without washer. If a washer is used, the required torque should be determined accordingly. The minimum tightening torque for screw connection depends on the mounting location, which shall be the customer's responsibility. The minimum gap between the bottom and the screw-on surface of the vehicle is 1mm. Even surface of customer's screw-on surface between the points a, b, c, d: 0.5.

In the event of any deviation, a prior approval of HDI is required. The mating area and the mounting location should be defined by the customer.

[Wiring harness plug]

A wiring harness plug is not included in the scope of delivery and must be ordered separately. The wiring harnesses must be supported mechanically at the ECU mounting position (Distance < 150mm) in a way that the excitation of the ECU is in phase (e.g. at the ECU screw-on plate).

Vehicle side ECU counter connector supplier Part No. : BOSCH 1928405452

The maximum permitted number of mating cycle is 20.

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1-3) ECU terminal diagram (full version)

Customer specific ECU TD will be defined after interface meeting with customer based on full version. Please refer the customer specific ECU TD in the check sheet.

The positive supply end (K01/03/05) and the negative supply end (K02/04/06) should be directly connected to the battery. If you want to disconnect the power between the ECU and the battery with a switch, it should be done after the following time:

- Without SCR (No after-treatment, DOC only, DOC+DPF) : 60 seconds
- With SCR : 150 seconds

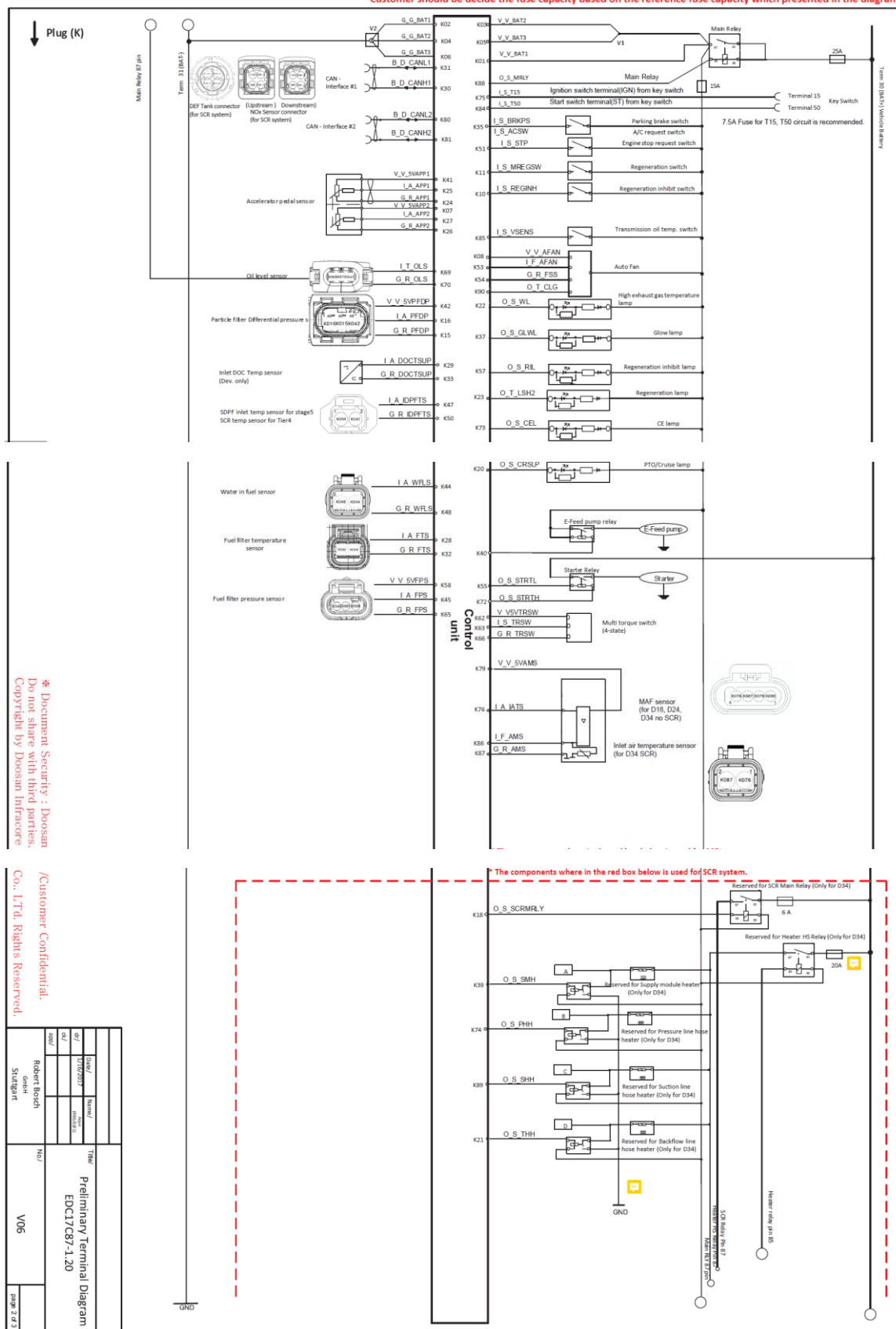
If customer want to provide the warning to user before disconnect the ECU power, please refer the '1-5) Wait to disconnect lamp wiring (Optional)'.

Hardwired LED and DPF Regen/Inhibit Switch should be meet the requirement as below.

- LED : Rated current consumption around 20mA. Parallel resistance needed to prevent mild glowing.
- DPF Switch: Self return (Momentary) type switch should be used.

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* Customer should be decide the fuse capacity based on the reference fuse capacity which presented in the diagram.

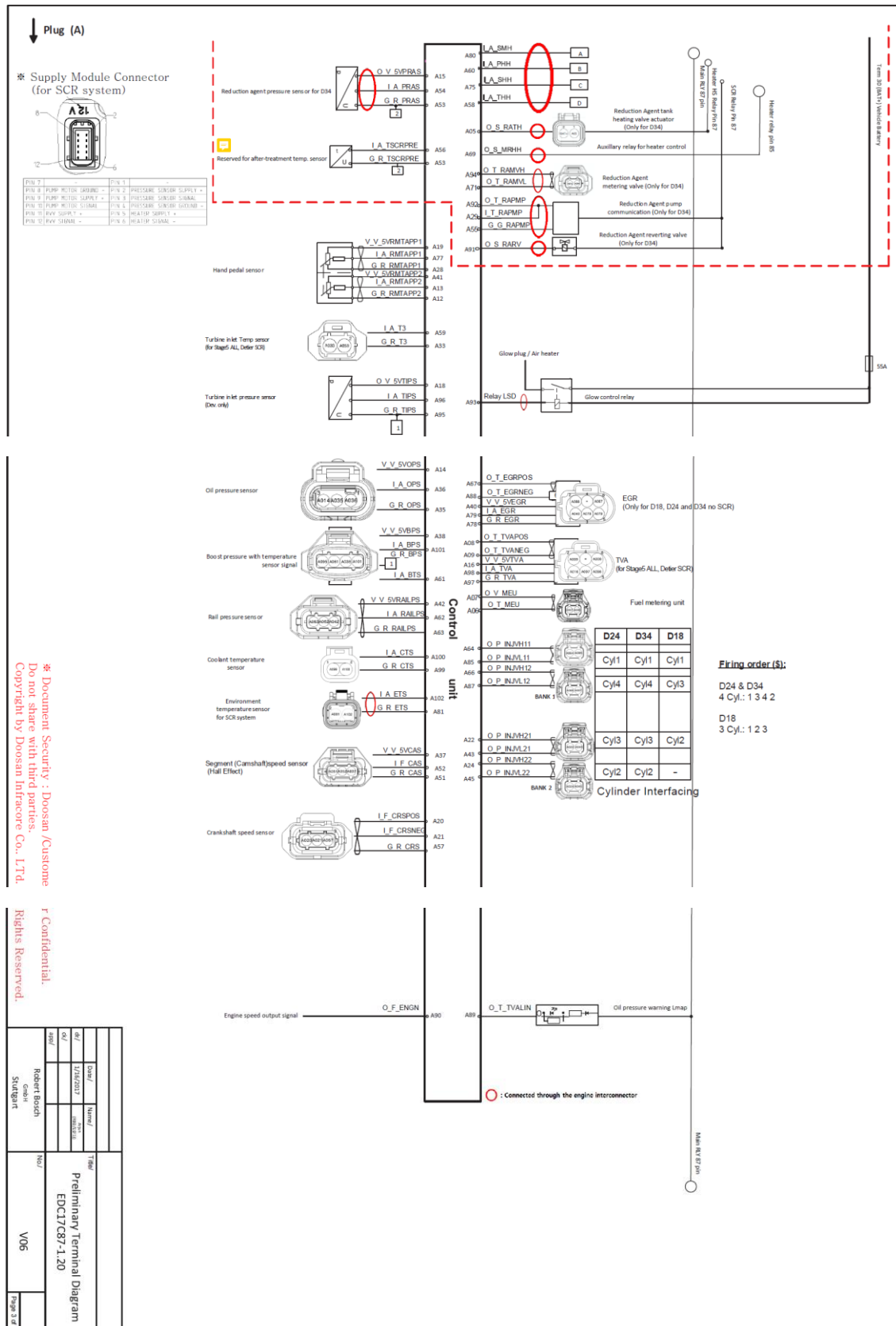


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Robert Busch General Manager		Title V06
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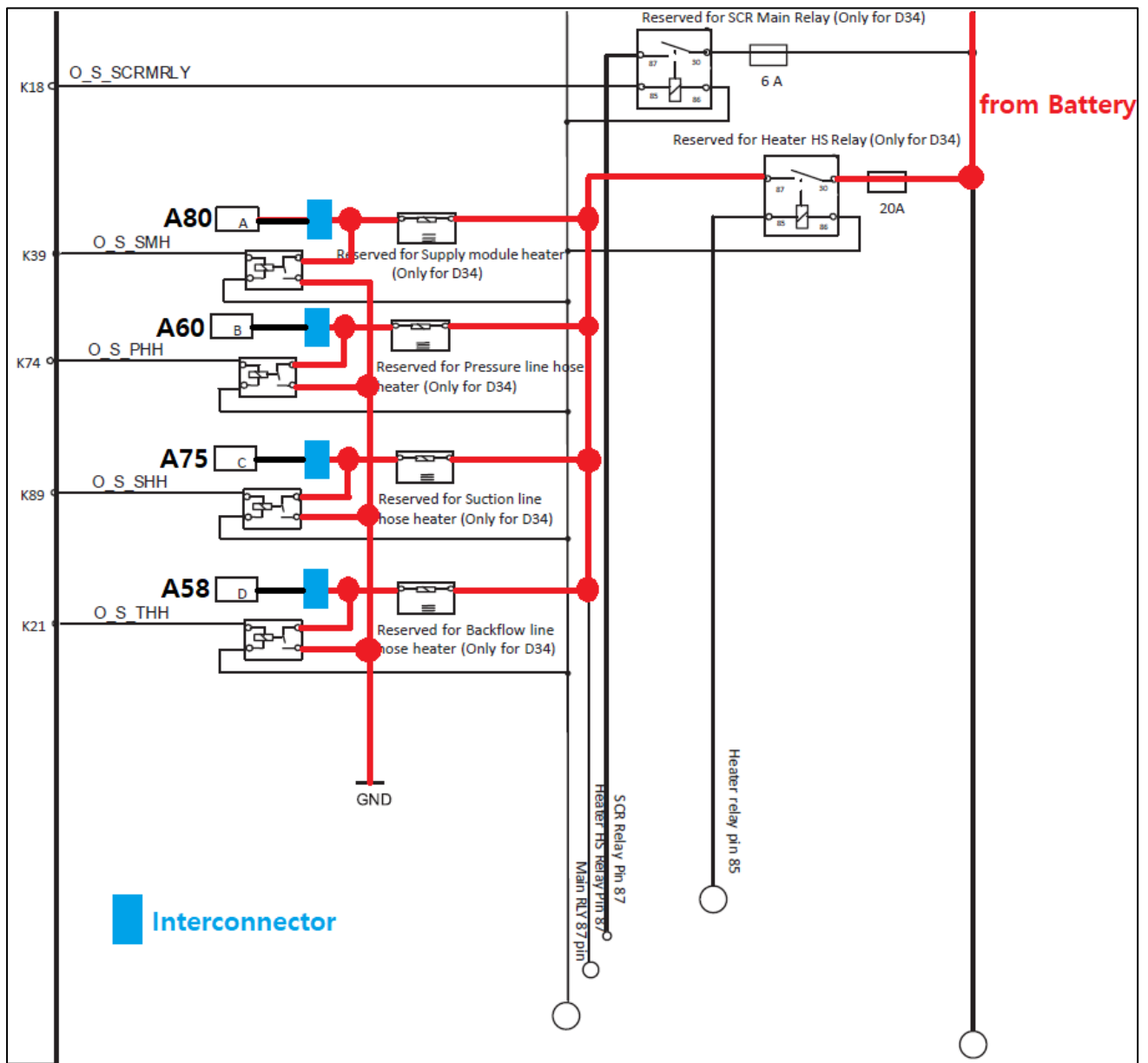
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1-4) SCR heating feedback line wiring (SCR-equipped engines only)

The wire size, which marked as red, should be used with 1.5mm². The voltage drop should be lower than 1.5V between heater feedback pins (A80, A60, A75, A58) and ground.

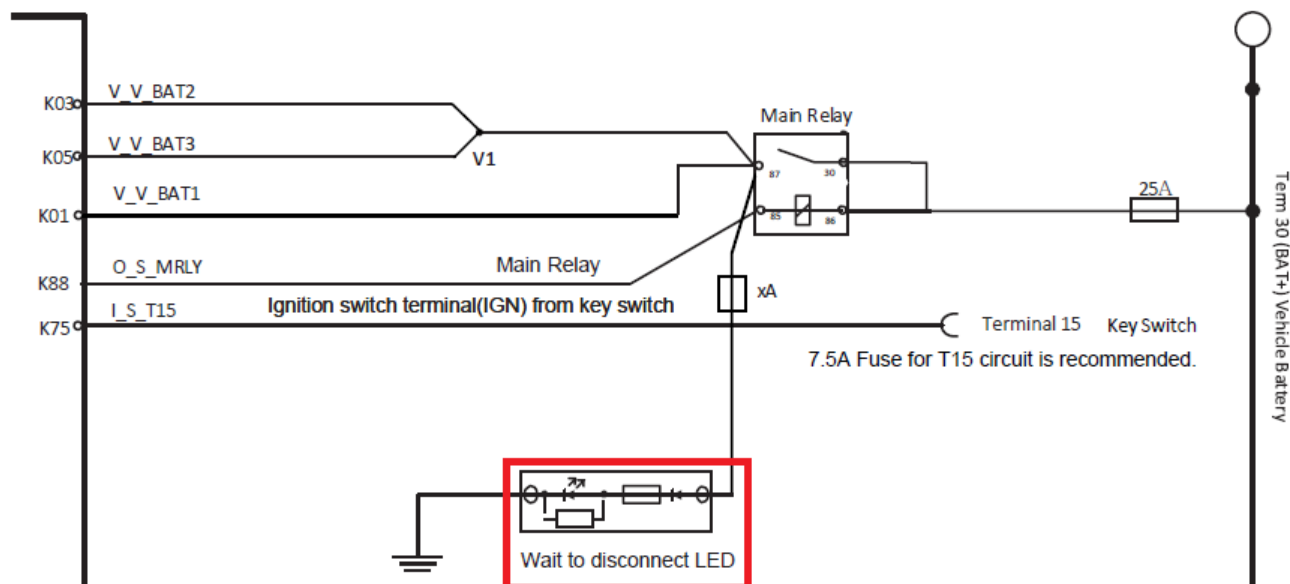


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1-5) Wait to disconnect lamp wiring (Optional)

To prevent the disconnect the ECU power before ECU ready to power off, customer can use LED lamp which indicating the ECU power should not be disconnected during lamp ON status. Please refer the recommend configuration below.

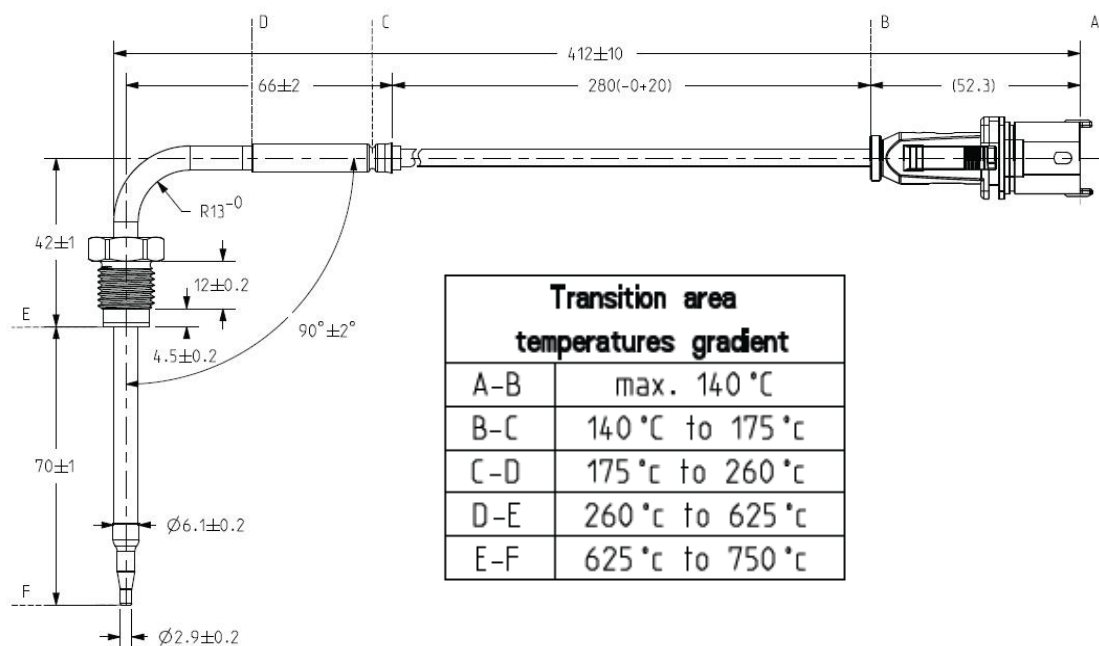
(Recommended LED Spec. : 12V, 20mA @nominal)



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2. DPF Inlet Temperature Sensor (DPF-equipped engines only)

2-1) Operating temperature



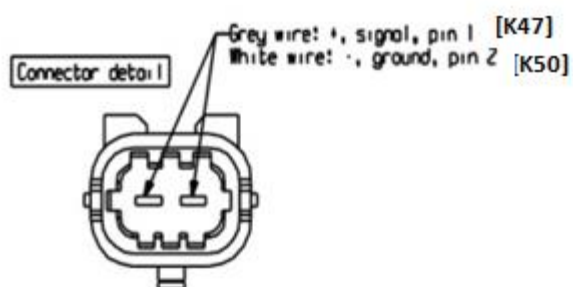
2-2) Temperature measuring point

- Sensor cable of nearest to aftertreatment canning
- Limit temperature: 175°C



2-3) I/O description

- Counter connector: DELPHI 15397337 or AMP936059-1



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2-4) Sensor cable

6.1.2 Cable outgoing at sensor grommet

Angle between outgoing cable and longitudinal axes of the sensor: $0 \pm 15^\circ$
Cable bent radius $> 20\text{mm}$

6.1.7 Cables/Varnish tube Temperature range: -40° to 200°C

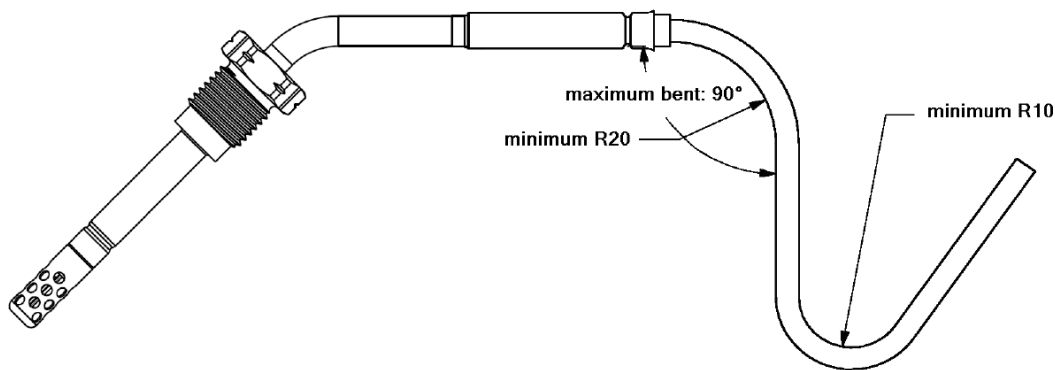
Varnish tube: flexible fiberglass silicon tube

Min. cable bending radius

each single wire:	$r > 3,5 \text{ mm}$
cable bundle:	$r > 20 \text{ mm}$

Bending radius flexible cable

- The cable should not be bent more than 90° and with a bending radius of minimum 20mm at the point where the cable exits the rear of the sensor.
- The bending radius for the free flexible cable is 10 mm minimum.



Fixation points flexible cable

Fixation points for the flexible cable should be placed:

- between 150 and 250 mm behind the fixation nut
- between 150 and 250 mm before the connector
- depending on routing and applied conductors, additional cable fixation points have to be foreseen

Overlength of the cable has to be secured to the car body (with for example cable ties) to avoid friction or abrasion of the cable against other car-parts.

Depending on the application, the sensor cable needs to be protected with an extra sleeve.

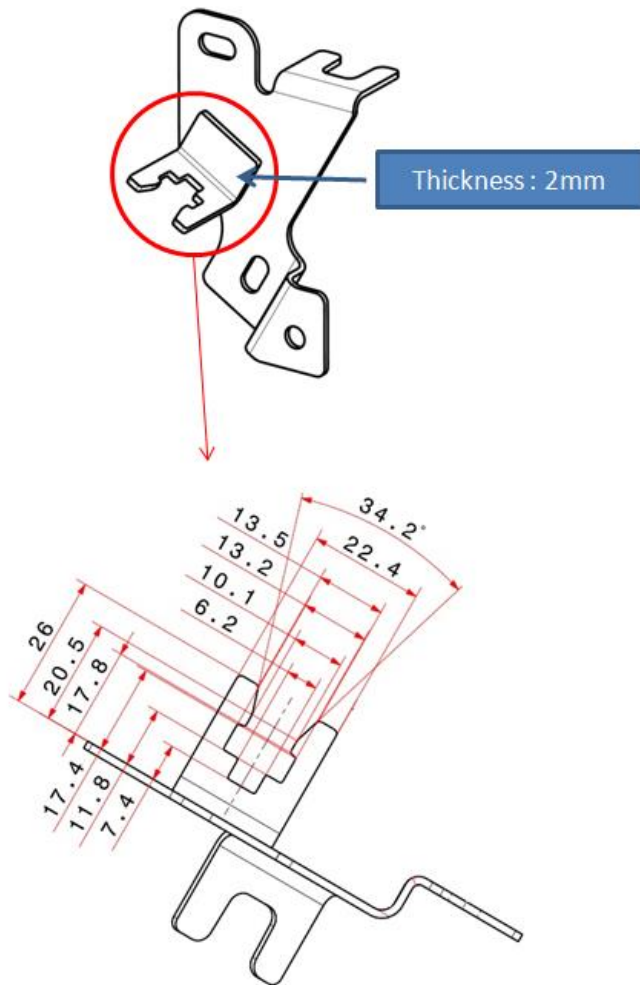
Position of the connector

Connector should be placed in such a position that possible water intrusion is reduced to a minimum.

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2-5) Sensor connector

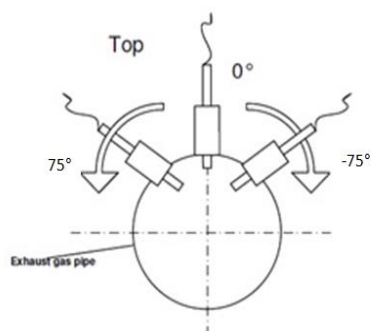
- Position of sensor connector: Mounted to the vehicle chassis
- Sensor connector bracket reference



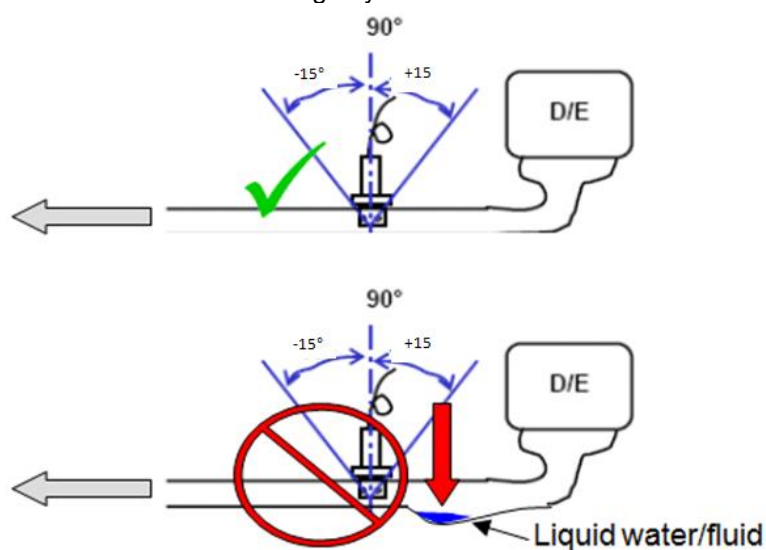
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2-6) Sensor installation

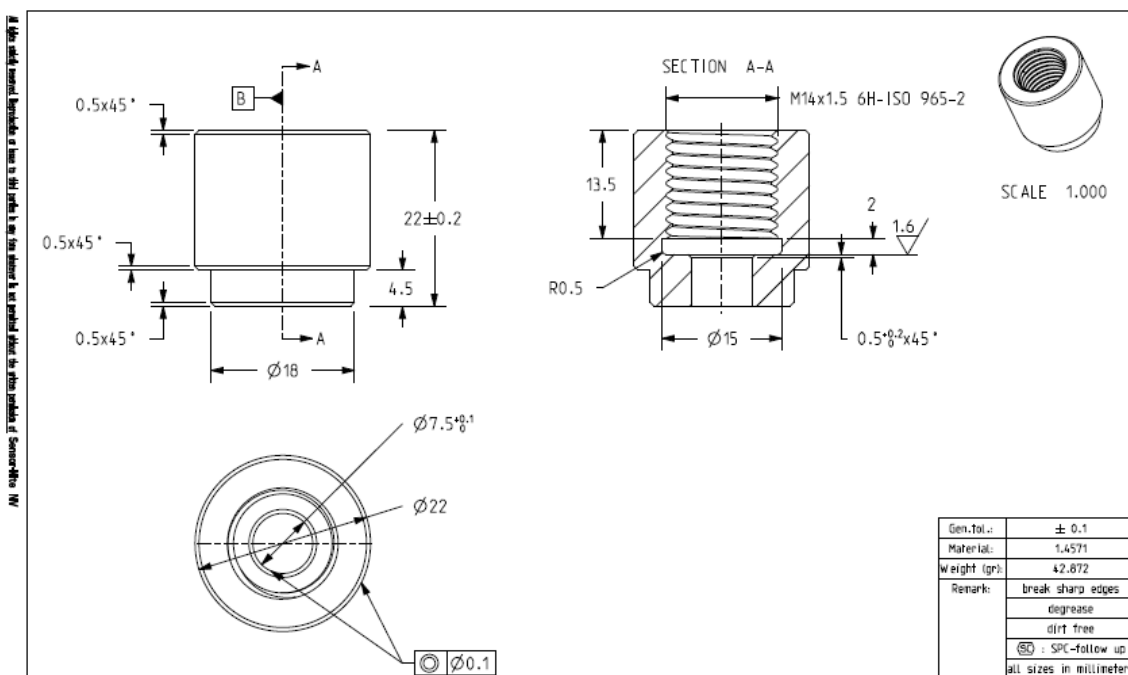
The sensor has to be mounted in a way, that no condensed water is collected inside the protection tube of the sensing element.



Avoid sensor element damage by water intrusion



2-7) Boss

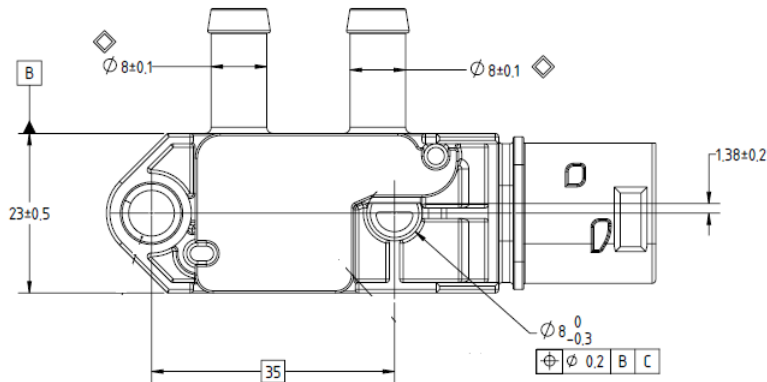


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2-8) Recommended installation torque : $45 \pm 5 \text{ Nm}$

3. DPF Differential Pressure Sensor (DPF-equipped engines only)

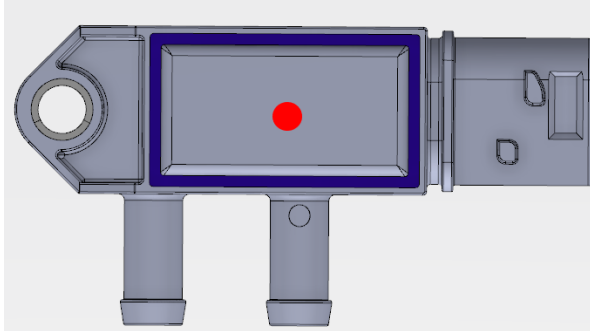
3-1) Sensor 2D drawing (dimension)



3-2) Operating temperature: $-40^{\circ}\text{C} \sim 130^{\circ}\text{C}$

3-3) Temperature measuring points

- Middle surface of the sensor.
- Limit temperature: 130°C



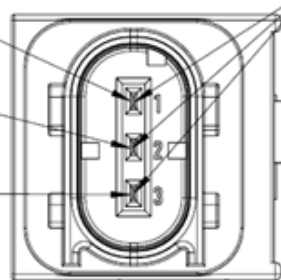
3-4) I/O description

- Counter connector: Tyco C-1418448 REV B1 CODE A

PIN 1: Vs [K42]

PIN 2: GND [K15]

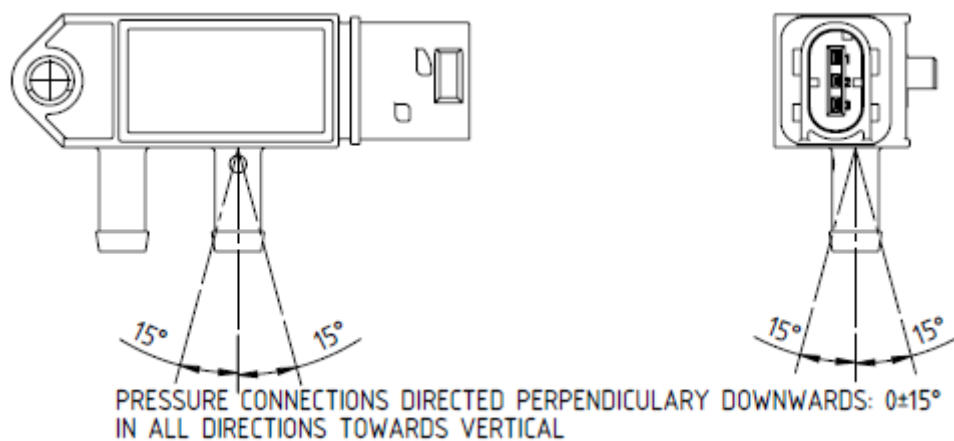
PIN 3: Vout [K16]



3-5) Sensor installation

- Torque of M6 Bolt for sensor installation: $8 \pm 2 \text{ Nm}$
- Install the pressure ports vertically, facing towards the bottom.
- Install the sensor above the pressure ports.
- Mounting angle: less than $\pm 15^{\circ}$

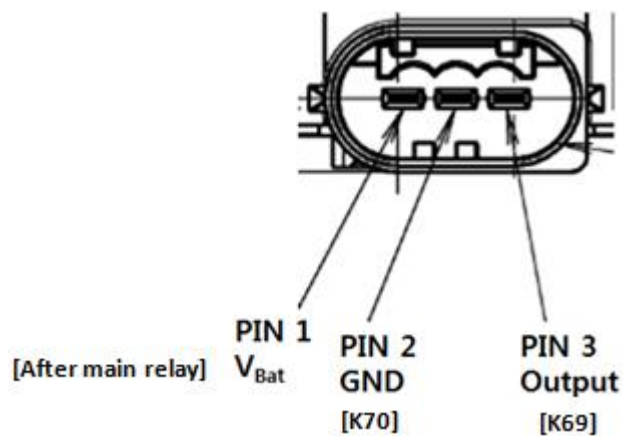
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4. Oil Level Sensor

4-1) I/O description

- Counter connector: KOSTAL 09 4413 82





4-2) Input voltage(V_{bat}) : 6 ~ 16V

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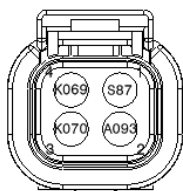
5. Counter connector for wiring harness, starter, alternator and glow plug

5-1) Wiring harness counter connector

- DM01, DM02 (Directly connected to the ECU with engine harness)

Engine Side	Vehicle(Machinery) Side
	
DEUTSCH_DTM04-4P	DEUTSCH_DTM06-4S

- Pin assignment

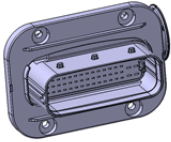
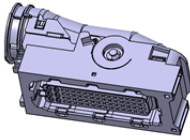
DEUTSCH	DEUTSCH_DTM04 - 4P
	
INTER	

CIRCUIT	WIRE SIZE	COLOR	INSULATION	CIRCUIT DESCRIPTION	FROM	PIN	T	TO	PIN	T	REMARK1
S87	0.75	R	FLR91X-A	VBAT	INTER	1		OIL_LEVEL	1		@CUSTOMER OPTION
K070	0.75	B	FLR91X-A	GROUND	INTER	3		OIL_LEVEL	2		@CUSTOMER OPTION
K069	0.75	G	FLR91X-A	SIG	INTER	4		OIL_LEVEL	3		@CUSTOMER OPTION
A093	0.75	LGr	FLR91X-A	PREHEATER RELAY RETURN	INTER	2		ECU	93		

※ S87, K070, K069: Oil level sensor option circuits

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- DM02 (Connected to the ECU with extension harness)

Engine Side	Vehicle(Machinery) Side
	
TYCO_1-1718324-1 (62Way)	TYCO_1-1418883-1 (62Way)





- Pin assignment

TYCO	TYCO_1-1718324-1		

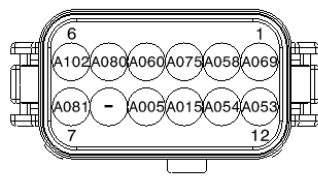
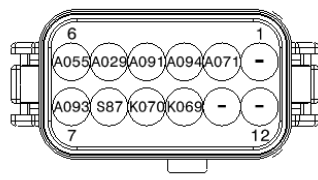
CIRCUIT	WIRE SIZE	COLOR	INSULATION	CIRCUIT DESCRIPTION	FROM	PIN	TO	PIN	REMARK1
A063	0.75		FLR91X-A TWIST01	GROUND-	RPS	1	* INTER	18	
A062	0.75		FLR91X-A TWIST01	SIG(OUT)	RPS	2	* INTER	14	
A042	0.75		FLR91X-A TWIST01	POWER+(5V)	RPS	3	* INTER	15	
A040	0.75		FLR91X-A	POWER+(5V)	EGR	1	* INTER	28	
A088	1.0		FLR91X-A TWIST02	H-Bridge(NEG)	EGR	2	* INTER	44	
A078	0.75		FLR91X-A	GROUND_RETURN	EGR	3	* INTER	32	
A079	0.75		FLR91X-A	SIG(POSITION)	EGR	5	* INTER	36	
A067	1.0		FLR91X-A TWIST02	H-Bridge(POS)	EGR	6	* INTER	40	
A016	0.75		FLR91X-A	POWER+(5V)	THROTTLE	1	* INTER	25	
A009	0.75		FLR91X-A TWIST03	H-Bridge(NEG)	THROTTLE	2	* INTER	41	
A097	0.75		FLR91X-A	GROUND_RETURN	THROTTLE	3	* INTER	29	
A098	0.75		FLR91X-A	SIG(POSITION)	THROTTLE	5	* INTER	33	
A008	0.75		FLR91X-A TWIST03	H-Bridge(POS)	THROTTLE	6	* INTER	37	
A099	0.75		FLR91X-A	TEMP SIG RETURN	COOLANT TEMP	1	INTER	50	
A100	0.75		FLR91X-A	TEMP SIG	COOLANT TEMP	2	INTER	54	
A007	0.75		FLR91X-A TWIST04	O_V_MEU	MPROP	1	* INTER	10	
A006	0.75		FLR91X-A TWIST04	O_T_MEU	MPROP	2	* INTER	11	
A020	0.75		FLR91X-A BS01	SIG POS	CRANK	1	* INTER	47	
A021	0.75		FLR91X-A BS01	SIG NEG	CRANK	2	* INTER	46	
A057	0.75		FLR91X-A	SHIELD	CRANK	3	INTER	43	SHIELD DRAIN(A020/A021)
A051	0.75		FLR91X-A	GROUND_RETURN	CAM	1	* INTER	31	
A052	0.75		FLR91X-A	SIG	CAM	2	* INTER	35	
A037	0.75		FLR91X-A	POWER+(5V)	CAM	3	* INTER	39	
A095	0.75		FLR91X-A	GROUND_RETURN	T MAP	1	INTER	30	
A061	0.75		FLR91X-A	SIG(TEMP)	T MAP	2	INTER	34	
A038	0.75		FLR91X-A	POWER+(5V)	T MAP	3	INTER	38	
A101	0.75		FLR91X-A	SIG(PRESSURE)	T MAP	4	INTER	42	
A014	0.75		FLR91X-A	POWER+(5V)	OIL PRES	3	INTER	19	
A035	0.75		FLR91X-A	GROUND_RETURN	OIL PRES	2	INTER	23	
A036	0.75		FLR91X-A	SIG(PRESSURE)	OIL PRES	1	INTER	27	
A064	1.5		FLR91X-A TWIST05	High side	INJECTOR#1	1	* INTER	59	Difference twisted length than other twisted wires
A085	1.5		FLR91X-A TWIST05	Low side	INJECTOR#1	2	* INTER	62	Difference twisted length than other twisted wires
A024	1.5		FLR91X-A TWIST06	High side	INJECTOR#2	1	* INTER	58	Difference twisted length than other twisted wires
A045	1.5		FLR91X-A TWIST06	Low side	INJECTOR#2	2	* INTER	61	Difference twisted length than other twisted wires
A022	1.5		FLR91X-A TWIST07	High side	INJECTOR#3	1	* INTER	57	Difference twisted length than other twisted wires
A043	1.5		FLR91X-A TWIST07	Low side	INJECTOR#3	2	* INTER	60	Difference twisted length than other twisted wires
A066	1.5		FLR91X-A TWIST08	High side	INJECTOR#4	1	* INTER	51	Difference twisted length than other twisted wires
A087	1.5		FLR91X-A TWIST08	Low side	INJECTOR#4	2	* INTER	55	Difference twisted length than other twisted wires
A033	0.75		FLR91X-A	RETURN	EGT	1	INTER	22	
A059	0.75		FLR91X-A	SIG(TEMP)	EGT	2	INTER	26	
S87	0.75		FLR91X-A	VBAT	OIL_LEVEL	1	@ INTER	3	
K069	0.75		FLR91X-A	SIG	OIL_LEVEL	3	@ INTER	7	
K070	0.75		FLR91X-A	GROUND	OIL_LEVEL	2	@ INTER	6	

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- SCR-equipped engines only

Engine Side	Vehicle(Machinery) Side
Inter_1 	Inter_1 
DEUTSCH_DT06-12SA-C015	DEUTSCH_DT04-12PA-C015
Engine Side	Vehicle(Machinery) Side
Inter_2 	Inter_2 
DEUTSCH_DT06-12SB-C015	DEUTSCH_DT04-12PB-C015

- Pin assignment

DEUTSCH	DEUTSCH_DT06-12SA-C015	DEUTSCH	DEUTSCH_DT06-12SB-C015
			
INTER_1		INTER_2	

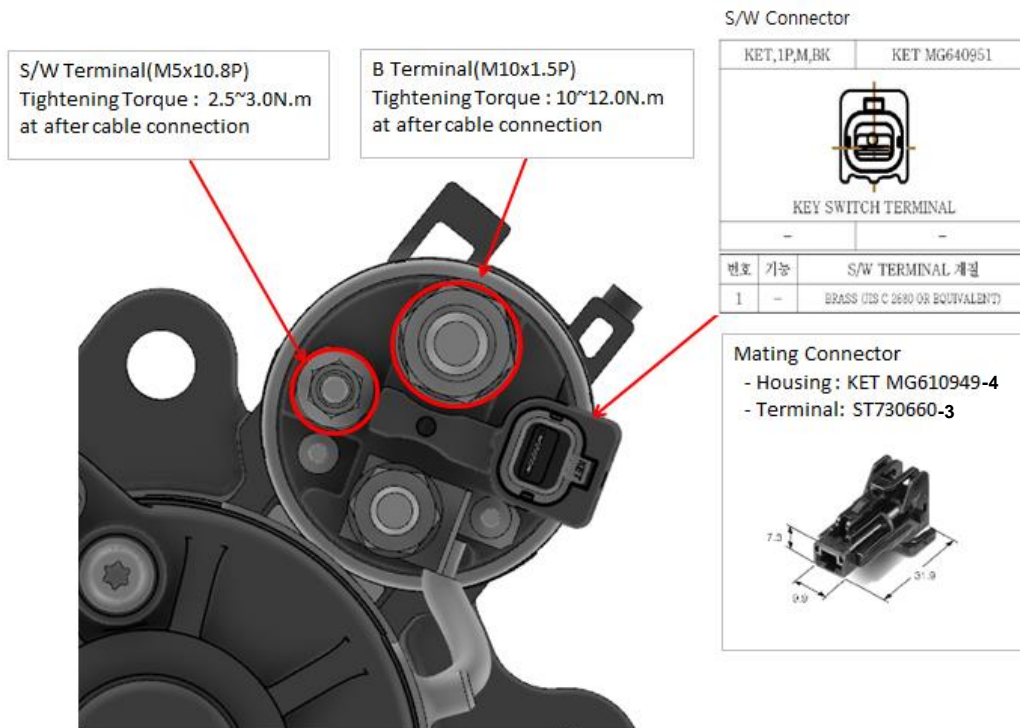
CIRCUIT	WIRE SIZE	COLOR	INSULATION	CIRCUIT DESCRIPTION	FROM	PIN	TO	PIN	REMARK1
S87	0.75		FLR91X-A	VBAT	INTER_2	8	OIL_LEVEL	1	@CUSTOMER OPTION
K070	0.75		FLR91X-A	GROUND	INTER_2	9	OIL_LEVEL	2	@CUSTOMER OPTION
K069	0.75		FLR91X-A	SIG	INTER_2	10	OIL_LEVEL	3	@CUSTOMER OPTION
A069	0.75		FLR91X-A	HEATER RELAY LOW SIDE	INTER_1	1	ECU	69	
A058	0.75		FLR91X-A	BACKFLOW LINE HEATER FB	INTER_1	2	ECU	58	
A075	0.75		FLR91X-A	SUCTION LINE HEATER FB	INTER_1	3	ECU	75	
A060	0.75		FLR91X-A	PRESSURE LINE HEATER FB	INTER_1	4	ECU	60	
A080	0.75		FLR91X-A	SUPPLY MODULE HEATER FB	INTER_1	5	ECU	80	
A102	0.75		FLR91X-A	ENV TEMP SIGNAL	INTER_1	6	ECU	102	
A081	0.75		FLR91X-A	ENV TEMP GND	INTER_1	7	ECU	81	
A005	0.75		FLR91X-A	REDUCTION VALVE ACTUATOR LOW	INTER_1	9	ECU	5	
A015	0.75		FLR91X-A	SM PRESS SENSOR SUPPLY +	INTER_1	10	ECU	15	
A054	0.75		FLR91X-A	SM PRESS SENSOR SIGNAL	INTER_1	11	ECU	54	
A053	0.75		FLR91X-A	SENSOR GND	INTER_1	12	ECU	53	
A055	0.75		FLR91X-A	SM PUMP MOTOR GND -	INTER_2	6	ECU	55	
A029	0.75		FLR91X-A	SM PUMP MOTOR SIGNAL	INTER_2	5	ECU	29	
A091	0.75		FLR91X-A	SM RVV SIGNAL -	INTER_2	4	ECU	91	
A094	0.75		FLR91X-A	RED AGENT METERING VALVE HS	INTER_2	3	ECU	94	TWIST PAIR(A094/A071)
A071	0.75		FLR91X-A	RED AGENT METERING VALVE LS	INTER_2	2	ECU	71	TWIST PAIR(A094/A071)
A093	0.75		FLR91X-A	PREHEATER RELAY RETURN	INTER_2	7	ECU	93	

※ S87, K070, K069 : Oil Level Sensor option circuits

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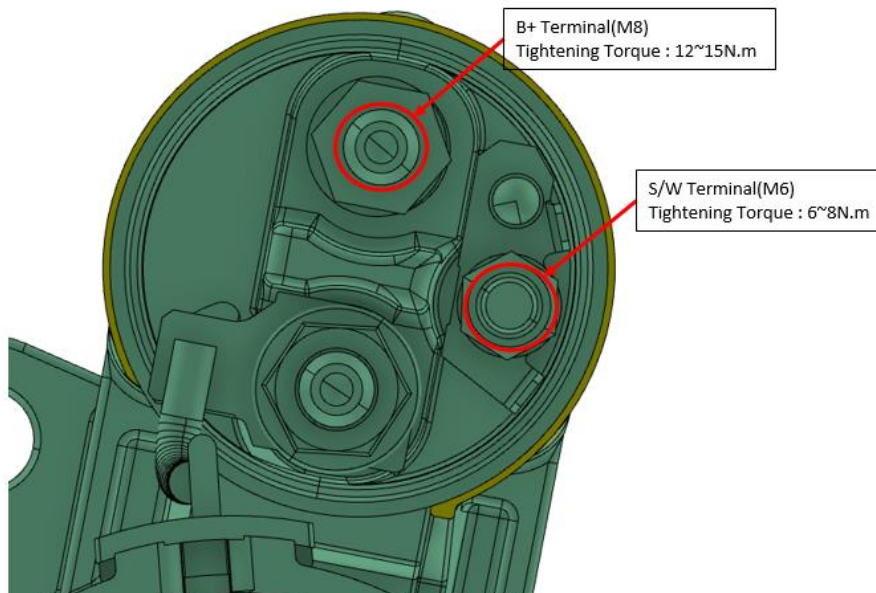
5-2) Starter counter connector (300516-00126X, 300516-00151X, 300516-00119X)

- Customer can choose in between Solenoid Plug in connector or Switch Terminal.
- **B+: M10 Terminal / Switch Terminal: M5 Terminal / Solenoid Plug in connector Mating: MG610949-4 KET**



5-3) Starter counter connector (300516-00152X)

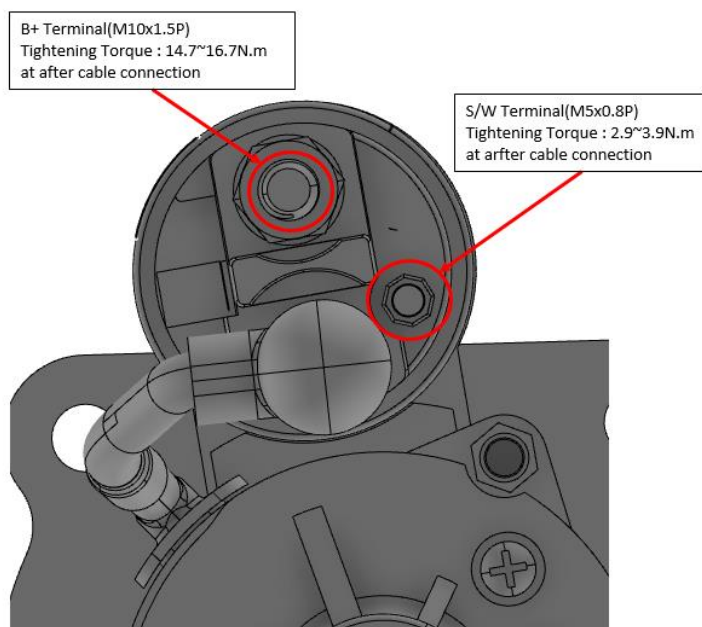
- **B+: M8 Terminal / Switch Terminal : M6 Terminal**



G2 Diesel Engine Installation Guide – DM01, DM02

5-4) Starter counter connector (300516-00120X)

- Customer can choose in between Solenoid Plug in connector or Switch Terminal.
- B+: M10 Terminal / Switch Terminal: M5 Terminal

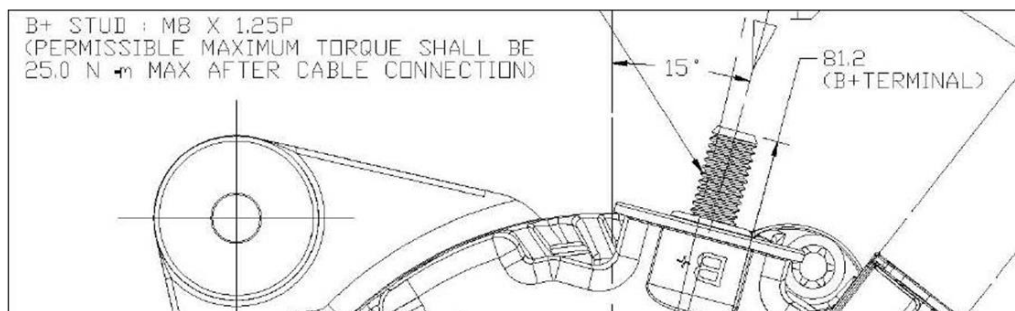


5-5) Alternator counter connector

- Resistance installation may be required to meet the reference values of the alternator's L terminal voltage and current.
- L-Terminal Permission Current: 0.01 ~ 0.5A
- Part Number: 300901-00183X, 300901-00189X, 300901-00219X, 300901-00220X
- L-Terminal Permission Current: Max. 1.2A
- Part Number: 300901-00250X, 300901-00251X

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1. B+ : M8



2. Counter Connector: F6189-0443 SUMITOMO

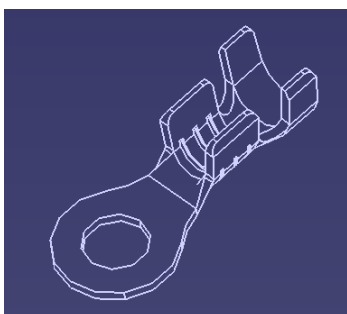
SUMITOMO,3P,M,BK		M6188-0282 EQ
		
REGULATOR CONNECTOR		
-	-	-
NO	FUNCTION	MATERIAL
1	C	STEEL
2	L	STEEL
3	FR	STEEL

CONNECTOR FORM(ALT. SIDE)
M6188-0282(SUMITOMO) EQ
CONNECTOR FORM(W/H SIDE)
F6189-0443(SUMITOMO) EQ

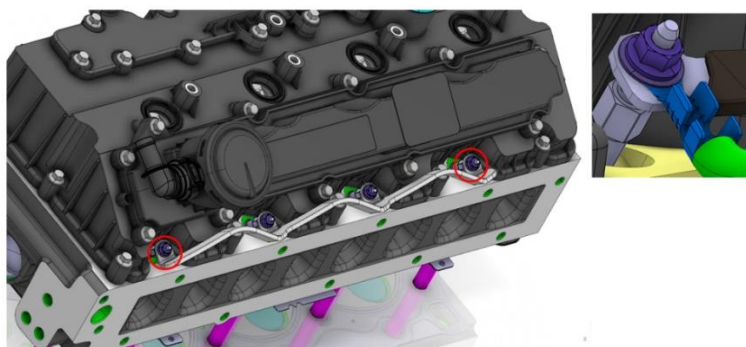
USE TERMINAL "L" ONLY.

5-6) Glow plug connector

- Ring terminal (Hole size: M4)



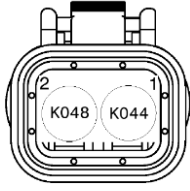
- Wire spec: 5SQ (Type: AEXF)
- Applied position: Connect #1 glow plug or #4 glow plug



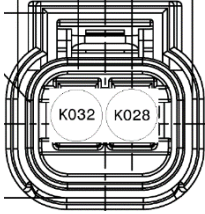
G2 Diesel Engine Installation Guide – DM01, DM02

6. Counter connector for WIF, Fuel temperature, Fuel pressure and Mass air flow sensor

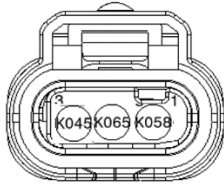
6-1) WIF sensor counter connector: DEUTSCH DT06-2S



6-2) Fuel filter temperature sensor counter connector: TYCO 936248-2



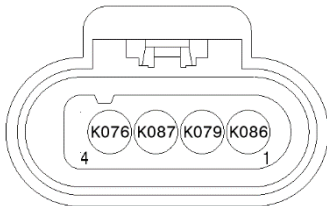
6-3) Fuel filter pressure sensor counter connector: FCI F519600



6-4) Fuel heater counter connector: DELPHI 15300027 (No polarity)

6-5) Mass air flow sensor counter connector

- TYCO 1-1670918-1
- Hirschmann: 872-859-...KD
- F.C.I: F881100



7. Relay for Starter

7-1) Starter relay : HDI K1053575

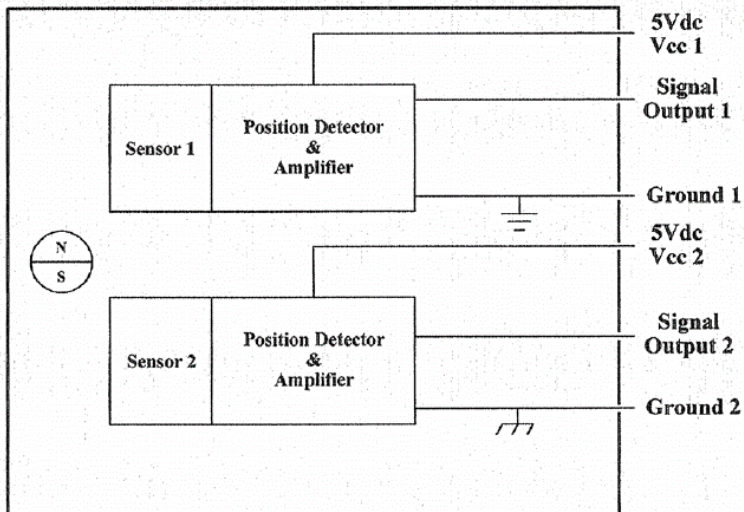
8. Accelerator Pedal

- The voltage at the output pin of the sensor in case of loss of sensor ground is considered as 4.95V.
- The voltage at the output pin of the sensor in case of loss of sensor supply is considered as 0.025V.
- The sensor resistance is considered between 0~0.5Ω.

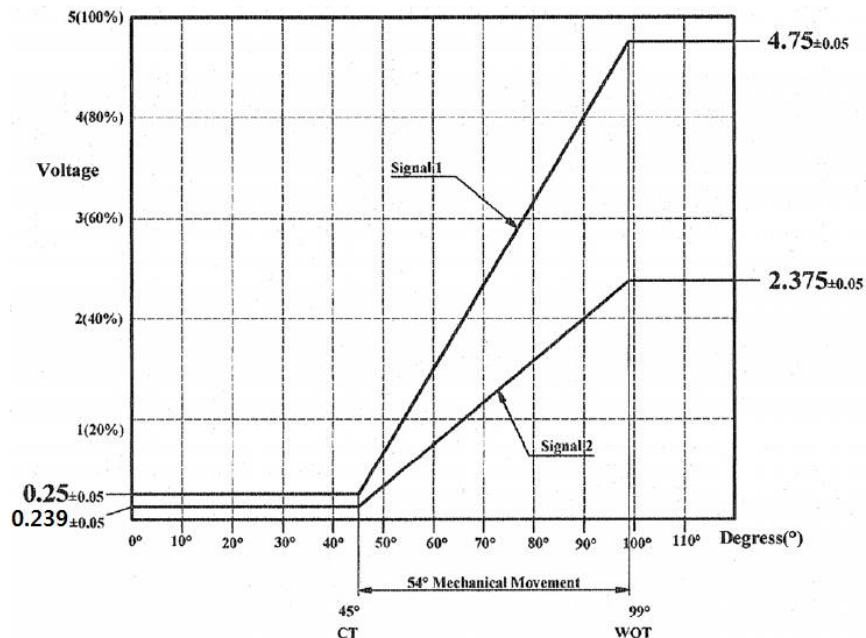
G2 Diesel Engine Installation Guide – DM01, DM02

- Input voltage (Vcc): 5Vdc
- Operation Current(Iop): 9mA (Normal), 10mA (Max) / Channel
- Reverse Polarity: Withstand 10min.(max)
- Electrical Travel: see Fig 2.
- Independent Linearity $\pm 2\%$
- Signal Load: 10k Ω , C=2x4.7nF Tested

Fig 1. Circuit Diagram

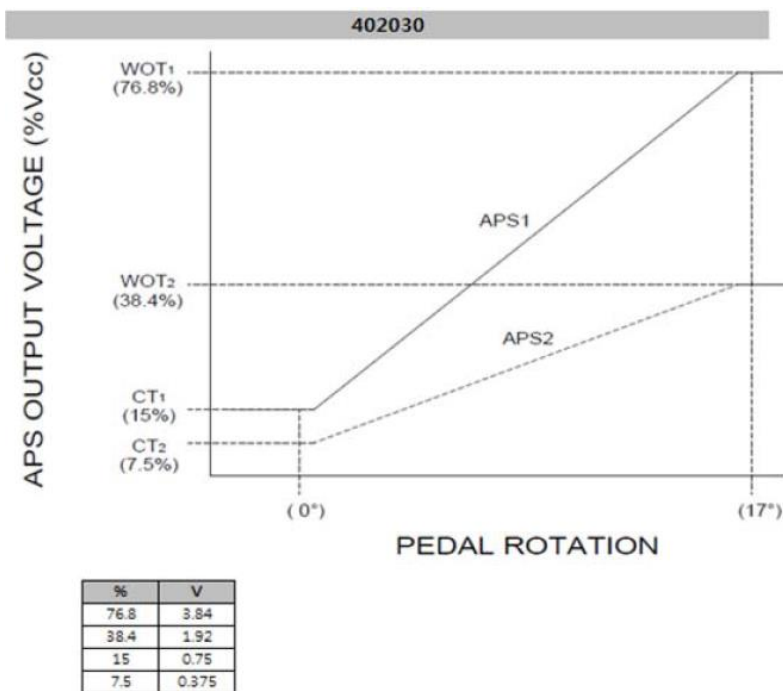


- APP Sensor Spec. #1 – Standard engine must be satisfied the specification #1.

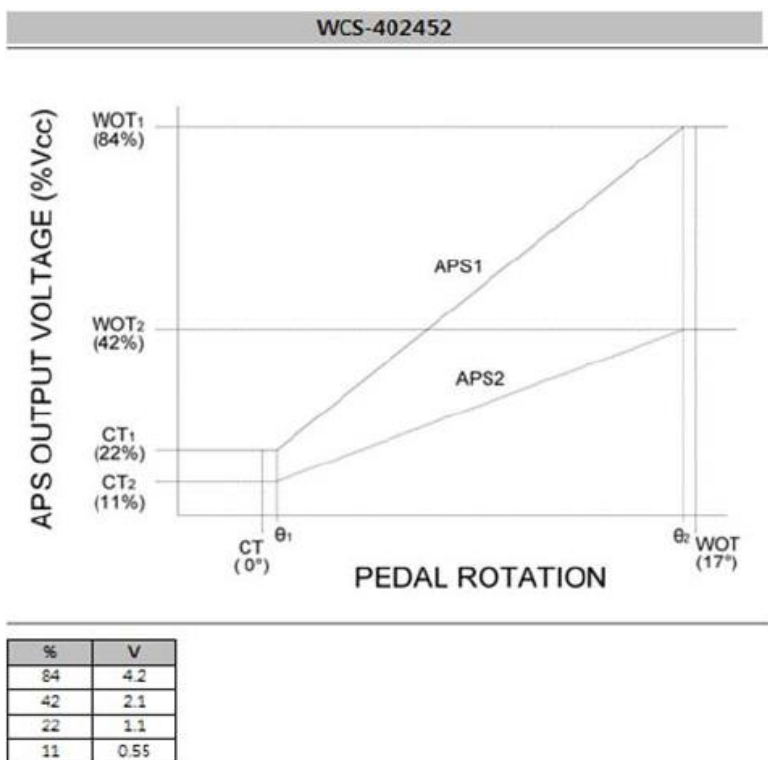


G2 Diesel Engine Installation Guide – DM01, DM02

- APP Sensor Spec. #2

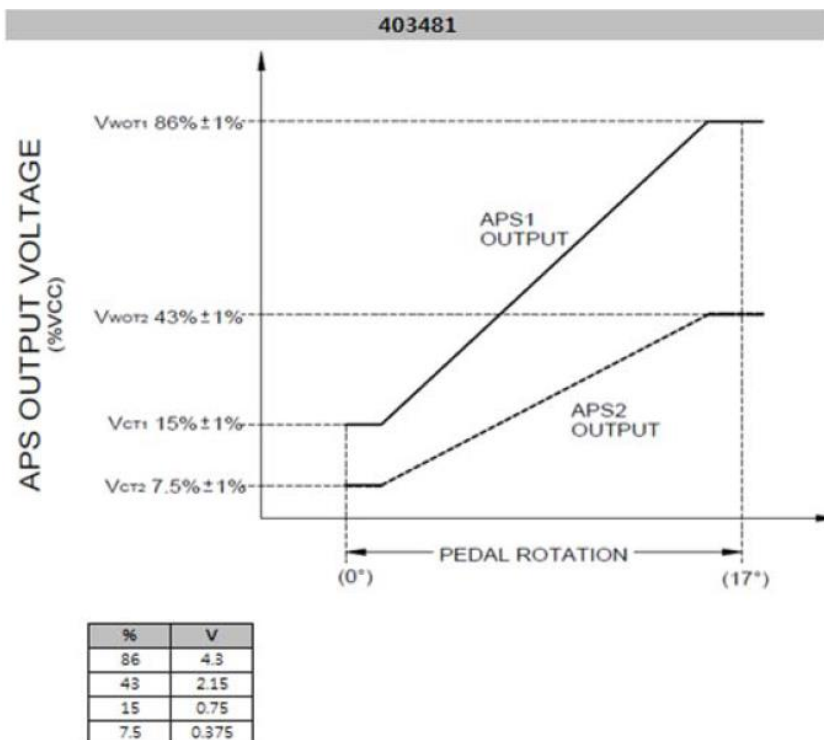


- APP Sensor Spec. #3



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- APP Sensor Spec. #4



9. IP(International Protection) grade for Starter

9-1) Borgwarner Starter (300516-00126X, 300516-00151X, 300516-00119X)

- IP (International Protection) grade
 - Engineering discussion is required if there is an IP grade requested by the customer

9-2) SEG Starter (300516-00152X)

- IP (International Protection) grade
 - Engineering discussion is required if there is an IP grade requested by the customer

9-3) JHEECO Starter (300516-00120X)

- IP (International Protection) grade
 - Engineering discussion is required if there is an IP grade requested by the customer

10. Mating Wire Guide (Reference)

- Fixation: The mating wire is supported mechanically at the mounting position of counter parts of mating wire. (Distance < 150mm)
- Bending radius: $R > 1D$ (D: Branch outlet diameter)

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11. Operation Voltage for Starter Solenoid

- The minimum voltage required to operate the starter solenoid is at least 8.5V(12V System)

12. Mandatory Requirement of Starter Control

- Starter S terminal signal should not be applied even if the start signal is given while the engine is running.

: If starter control is not possible with the VCU or ECU, it is recommended to apply an anti-restart ignition switch.

- Starter S terminal signal should be disconnected or disabled when the engine is below 800rpm.

- Starter S terminal signal is applied after the engine is completely stopped(engine rpm = 0).

: If starter control is not possible with the VCU or ECU, it is recommended to restart after 5 seconds after key off.

13. Mandatory Caution of Starter Control

- Guide the engine not to hold the key over 30 seconds when starting the engine.

: Recommend to try starting after checking the parts related to starting (Battery, Relay, Cable, Etc.) when starting occurred twice continuous fails.

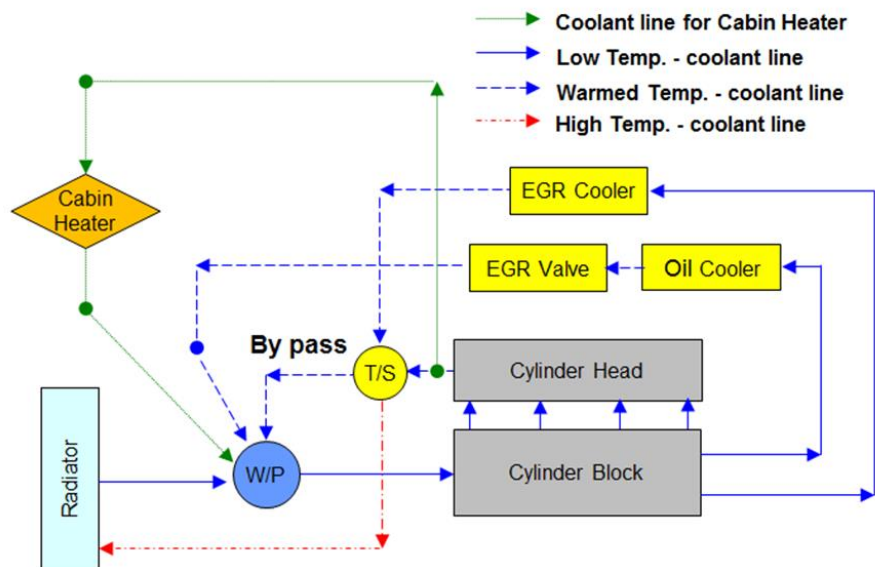
14. Mandatory Requirement of Ring Gear and Starter Pinion Gear

- Distance between ring gear and pinion surfaces face each other should be 3-4mm.

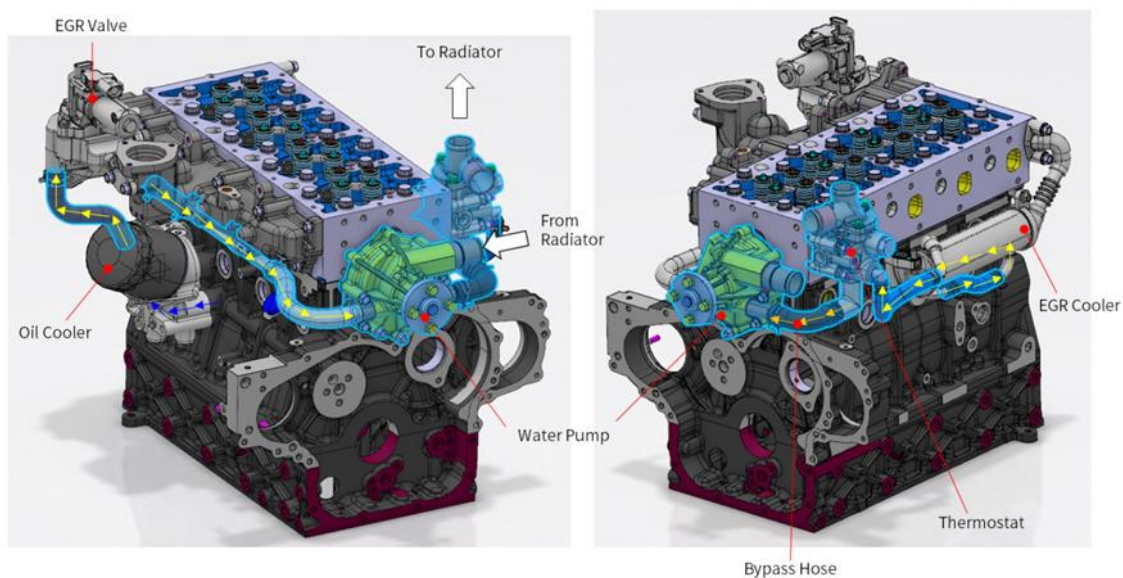
G2 Diesel Engine Installation Guide – DM01, DM02

Chapter 3. Cooling system

1. System Schemes



< picture 3-1. Cooling system diagram >



< picture 3-2. Cooling system description >

G2 Diesel Engine Installation Guide – DM01, DM02

2. Coolant Characteristics

The engine coolant must avoid the freezing or boiling and have corrosion resistance, and it must not generate sludge in response with cooling system component.

Engine	DM01	DM02	DM03	PM02	PM03
Coolant volume	3.0 liters	3.8 liters	4.7 liters	3.9 liters	4.8 liters

Please use the HDI genuine coolant (Ethylene glycol) and pure water or another which satisfies the following recommended specification according to coolant change intervals. If further life of coolant is required, discuss with HDI.

Emission regulation	Global standard	1,200 hours of 1-year interval	6,000 hours or 3-years interval
Tier3 / StageIII	SAE J1034 ASTM D3306 ASTM D6210 JIS K2234	General Coolant	LCC (Long Life Coolant)
Tier4 / StageIV		General Coolant	LCC
Tier5 / Stage V		General Coolant	LCC

Note. Genuine HDI LLC (part number for 200 L drum: 500201-00011, part number for 3 L pail: 500201-00012)

Note. Mixing guide: coolant & pure water = 50 : 50

HDI genuine does not necessary to add corrosion inhibitor, if want to use another that satisfies the recommended specification, check the necessity to add or not.

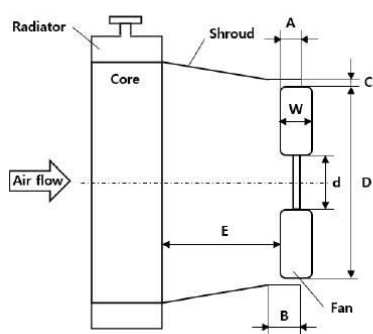
Caution: Do not mix different brands of coolant, otherwise harmful sludge can be formed, it can reduce cooling performance or make overheating.

3. Radiator

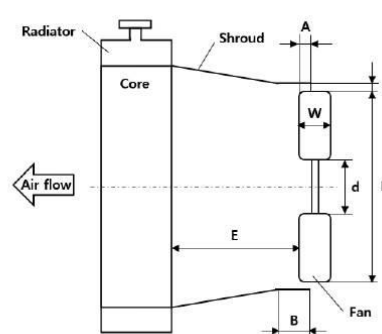
Radiator is important part that serve to release heat from the engine and need to select optimal location and capacity to maintain cooling performance and durability.

3-1) Radiator Position

Position between radiator and fan is closely related to cooling performance. If the radiator is close to the fan, the area which is close to the fan shaft does not be cooled properly. If it's so far, the air flow does not reach the radiator core. Air flow is different from suction and blower type. Determine the location referring to the picture for optimal cooling performance.



< Suction Fan >



< Blower Fan >

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< picture 3-3. Radiator position >

Symbol	Meaning	Suction Fan	Blower Fan
A	Project width	1/2 ~ 2/3W	1/3 ~ 1/2W
B	Shroud width	Approx. 1/2 of W	
C	Tip Clearance	10 ~ 25 mm (0.4~1.0 inch)	
D	Fan Diameter		
E	Core-fan Clearance	d/2 to 25 mm or more	
d	Fan boss diameter		
W	Projected fan width		

NOTE: Radiator should be suitably installed and cleaned to avoid clogging.

3-2) Radiator Capacity

The heat rejection (kW or kcal) indicating the capacity of the radiator is the result under specified test condition. That is not an absolute value. Actual heat rejection is related to coolant flow, ambient temperature, air flow that related to shape of engine room. For selecting optimal radiator, the heat balance test is required. When the cooling system is developed by customer, it should be selected considering heat rejection in below table.(The below are the representative engines of HDI, request to HDI for data on the engine selected by the customer)

DM01 61hp

Engine Speed (rpm)	Power (kW)	Heat rejection of the radiator(kW)	Heat rejection of the intercooler(kW)
2600	45	33	6
2400	44	33	6
2200	44	33	5
2000	44	32	5
1800	42	32	4
1600	34	30	4
1400	27	25	2
1200	23	21	1
1000	17	16	1

DM01 55hp

Engine Speed (rpm)	Power (kW)	Heat rejection of the radiator(kW)	Heat rejection of the intercooler(kW)
2500	41	32	5
2400	41	32	4
2200	40	32	4
2000	38	30	4
1800	35	29	3
1600	32	28	3

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1400	27	25	2
1200	23	21	1
1000	17	16	1

DM01 49hp

Engine Speed (rpm)	Power (kW)	Heat rejection of the radiator(kW)	Heat rejection of the intercooler(kW)
2500	37	30	5
2400	36	27	5
2200	35	27	4
2000	34	26	4
1800	32	26	3
1600	30	27	2
1400	25	22	2
1200	20	19	1
1000	16	16	1

DM01 42hp

Engine Speed (rpm)	Power (kW)	Heat rejection of the radiator(kW)	Heat rejection of the intercooler(kW)
2200	31	26	3
2000	30	25	2
1800	28	25	2
1600	26	22	2
1400	22	20	1
1200	18	16	1
1000	15	15	1

DM01 33hp

Engine Speed (rpm)	Power (kW)	Heat rejection of the radiator(kW)	Heat rejection of the intercooler(kW)
2400	25	22	2
2200	24	21	2
2000	22	20	1
1800	20	18	1
1600	18	16	1
1400	16	14	1
1200	13	11	1
1000	10	9	1

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DM02 74hp

Engine Speed (rpm)	Power (kW)	Heat rejection of the radiator(kW)	Heat rejection of the intercooler(kW)
2600	55	43	8
2400	55	42	8
2200	55	42	7
2000	55	41	7
1800	55	41	7
1600	54	38	6
1400	46	35	5
1200	28	28	4
1000	30	24	2
800	16	16	1

DM02 68hp

Engine Speed (rpm)	Power (kW)	Heat rejection of the radiator(kW)	Heat rejection of the intercooler(kW)
2600	51	41	7
2400	50	38	7
2200	50	37	6
2000	49	37	6
1800	48	35	5
1600	42	32	4
1400	36	29	3
1200	30	24	3
1000	25	23	2
800	16	16	1

DM02 55hp

Engine Speed (rpm)	Power (kW)	Heat rejection of the radiator(kW)	Heat rejection of the intercooler(kW)
2600	41	33	6
2400	41	33	6
2200	41	32	6
2000	40	30	5
1800	38	31	4
1600	34	27	3
1400	29	23	2
1200	24	19	2
1000	19	17	1
800	14	16	1

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DM02 49hp

Engine Speed (rpm)	Power (kW)	Heat rejection of the radiator(kW)	Heat rejection of the intercooler(kW)
2600	36	32	6
2400	36	30	5
2200	36	28	5
2000	35	27	4
1800	34	26	4
1600	29	23	3
1400	25	19	2
1200	21	16	2
1000	17	15	1
800	13	15	1

Generator

Model	Emission	Rpm / Hz	Gross Standby (kWm)	Air mass (L/min)	Coolant (kW)	CAC (kW)
DM01	S5	1500 / 50	30.2	1740	27	3
		1800 / 60	42	2270	32	4
	T4	1500 / 50	30.2	1740	27	3
		1800 / 60	38.1	2230	32	4
DM02	S5	1500 / 50	48.1	2780	37	5
		1800 / 60	55	3140	41	6
	T4	1500 / 50	42.1	2570	32	5
		1800 / 60	50	3030	38	6

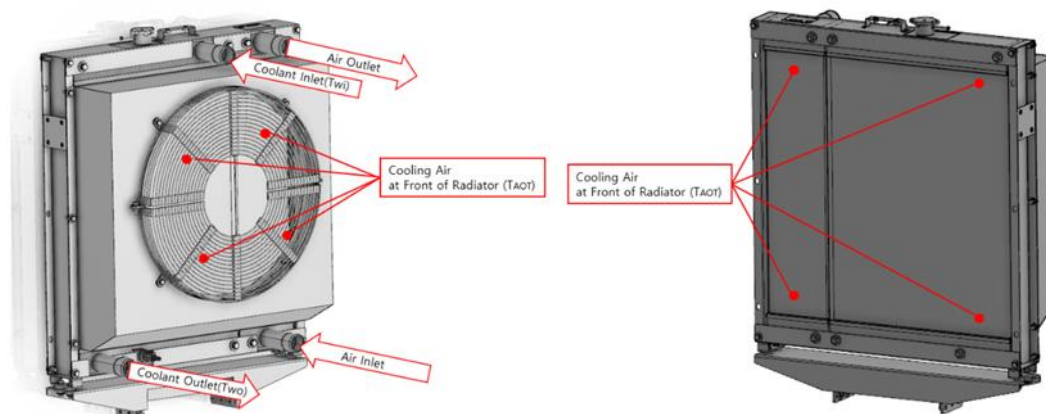
3-3) Heat balance test

Basically, heat balance follows guide of the equipment. HDI presents several guides to follow.

- Preparation for test
 - (i) Conduct test where the air flow is smooth. (Constant ambient temperature)
 - (ii) Measuring instruments and sensors shall be calibrated to prevent errors before testing.
 - (iii) Install the dummy (full opened) thermostat.
 - (iv) Install the protector in the radiator to prevent air recirculation.
- Evaluation for heat balance

The measuring point of the sensor for evaluation heat balance is as follows. In case of AOT, it is recommended to average after measuring four point to reduce errors.

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- T_{wi} : Coolant temperature at the inlet of radiator ($^{\circ}\text{C}$)
- T_{wo} : Coolant temperature at the outlet of radiator ($^{\circ}\text{C}$)
- T_{AOT} : Cooling air temperature at front of radiator ($^{\circ}\text{C}$) (Average value at four points)
- ATB: Coolant usage limits atmospheric temperature ($^{\circ}\text{C}$)
- $ATB = 110 - T_{wi} + T_{AOT}$

Note: Depending on the shape of the engine and fan type, the difference between ambient air temperature and air inlet temperature at front of radiator occur result in inaccurate ATB. Therefore, ATB should be based on the air inlet temperature in front of the radiator.

Coolant temperature		Recommend Difference between radiator in. & outlet ($T_{wi} - T_{wo}$)	Maximum system pressure in pressurized cooling circuit	ATB ($110 - T_{wi} + T_{AOT}$)	
Optimum Temperature (T_{wi})	Max. permissible Temperature (T_{wi})			in moderate climates	in tropical climates
90 ~ 95 $^{\circ}\text{C}$	110 $^{\circ}\text{C}$	8~10 K	0.9~1.5 bar	$\geq 45^{\circ}\text{C}$	$\geq 60^{\circ}\text{C}$

ATB represents the ambient temperature when the coolant is at the highest allowable temperature. That means the maximum available ambient temperature of the equipment. At using general radiator, it is recommended the above guides and at using the standard radiator in HDI, the below guide should be met.

Item	Radiator on Industrial	Radiator on Genset
Guide	$\geq 42^{\circ}\text{C}$	$\geq 52^{\circ}\text{C}$

Note : If ATB is not satisfied, be satisfied by changing the fan size and speed, radiator capacity and air resistance in the engine room.

3-4) Precautions for Installation

- Vibration

To prevent damage to radiator core, it is important to protect against excessive vibration a shock load. Basically, it should be installed considering the vibration of equipment (related with Chapter. 13 Engine Mounting system). And verification in the equipment is required. At using the standard radiator in HDI, be satisfied the vibration guide in all installation conditions.

Item		DM01						DM02					
Vibration Guide	42deg	X Axis		Y axis		Z axis		X Axis		Y axis		Z axis	
		Hz	g	Hz	g	Hz	g	Hz	g	Hz	g	Hz	g

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		10	0.5	10	0.5	10	0.5	10	0.5	10	0.5	10	0.5
		25	2.9	25	1.6	25	1.5	25	2.4	25	1.8	25	2.4
		93	4.4	93	1.5	93	2.1	157	3.6	75	1.2	158	1.4
		154	1.2	154	1.2	154	1.2	190	1.2	300	1.2	190	1.2
		300	1.2	300	1.2	300	1.2	300	1.2	-	-	300	1.2
	52deg	X Axis		Y axis		Z axis		X Axis		Y axis		Z axis	
		Hz	g	Hz	g	Hz	g	Hz	g	Hz	g	Hz	g
		10	0.5	10	0.5	10	0.5	10	0.5	10	0.5	10	0.5
		27	2.4	27	0.8	27	1.1	27	0.8	27	1.1	27	1.4
		91	2.9	91	1	91	1.5	77	2.9	77	1.4	75	1.9
		182	1.2	300	1	182	1.2	151	1.2	151	1.2	151	1.2
		300	1.2			300	1.2	300	1.2	300	1.2	300	1.2

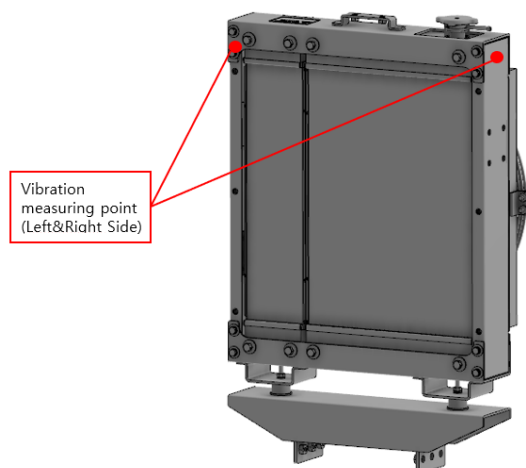
*Hz : Frequency, g : PHV

Vibration guide for HDI standard radiator

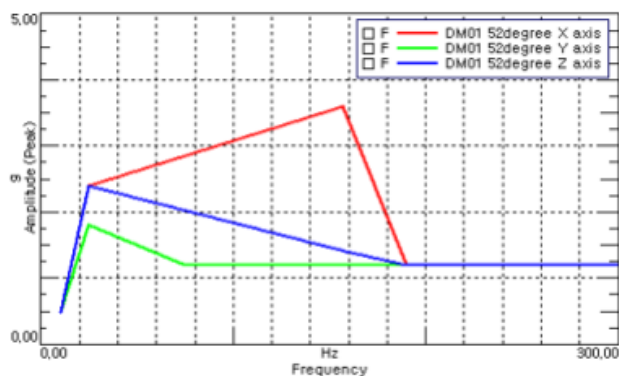
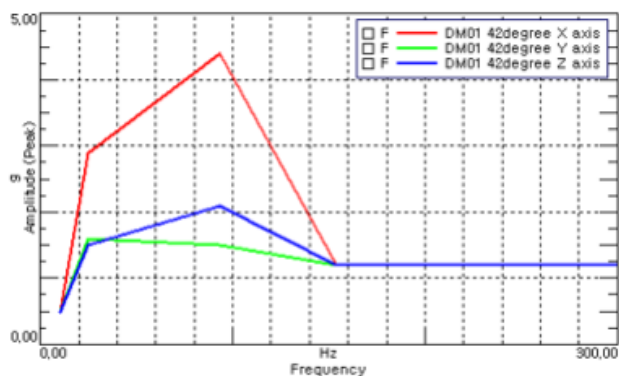
Test Item	Radiator
Averaging	PHV
Scaling	Peak
Resolution	1Hz
Sampling Frequency	>500Hz
Bandwidth	>250Hz

Test method of HDI standard radiator

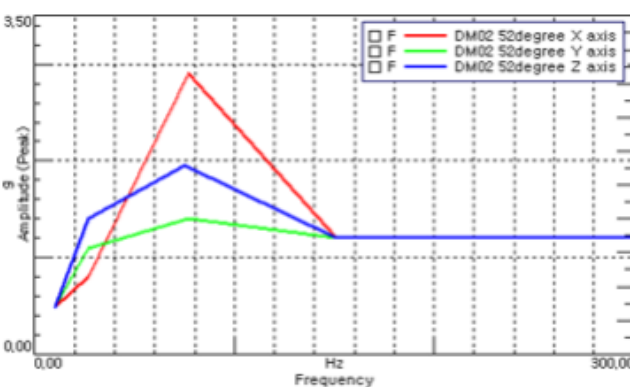
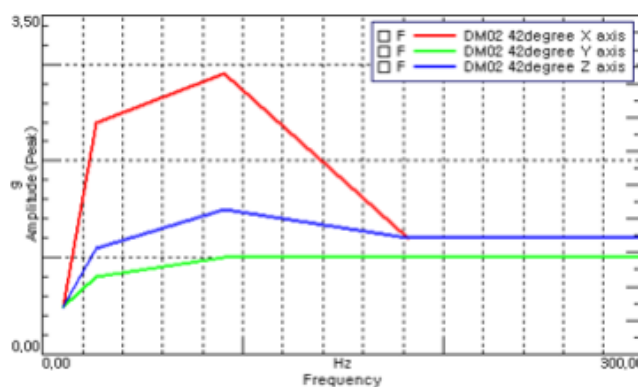
The vibration loads must be measured in all relevant states of vehicle operation, including worst-case vibration conditions. Permissible vibration level in the frequency domain for each 3 axes is shown below.



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DM01 Radiator

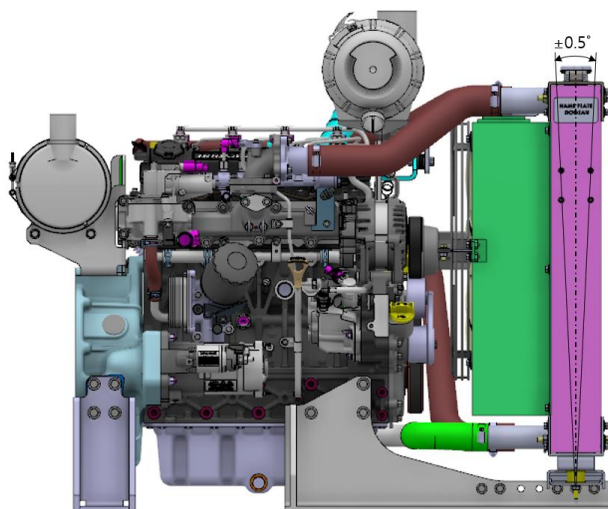


DM02 Radiator

Caution: Installation of optional parts is allowed under limited condition. Refer to 6.6-5.

- Horizon for radiator

The top of radiator should be parallel to the engine to maintain the clearance between the fan and fan guard. If horizon of the engine is right, install the radiator using a jig or level meter. (recommended: within 0.5°degree at the top of radiator)



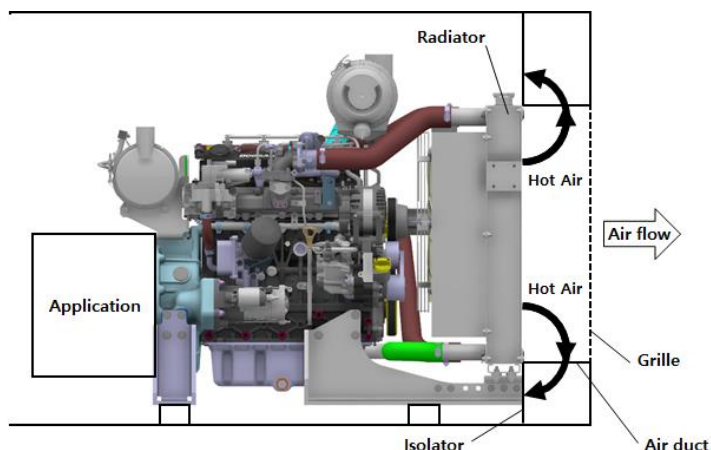
G2 Diesel Engine Installation Guide – DM01, DM02

- Clearance with counter components

The radiator should be isolated to surrounding parts at least 30mm to prevent contacting with the radiator by vibration of the engine and equipment

- Prevention for air recirculation

The radiator should be isolated using air duct or isolator to avoid mixing hot air in the engine room with cold air in outside.



- Intake and Exhaust duct design

For smooth air flow of the radiator, the square area of the inlet and outlet of the engine room should be at least 25% larger than the front area of the radiator.

4. Cooling Hose

4-1) Specification of rubber hose

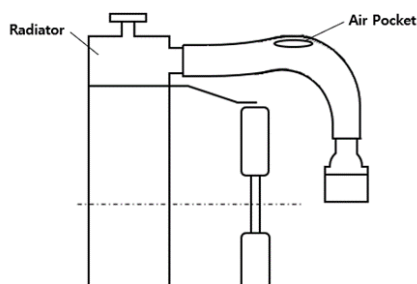
The rubber hose used in the cooling system should be durable to the heat and vacuum pressure and positive pressure of the system. If use the improper hose, it can be leak and deformed by vacuum pressure generated when coolant temperature change from high to low temperature. This interferes with the flow of coolant and causes overheating.

Item	Guide
Thickness	$\geq 5 \text{ mm}$
Pressure resistance	$\geq 5 \text{ bar}$
Operating temperature	$-40 \sim 120 \text{ }^{\circ}\text{C}$
Material	EPDM with 1 or 2 Polynogic Rayon (Middle)

4-2) Precautions for cooling hose

The cooling hose should be installed without contact with external component to avoid damage by contact.

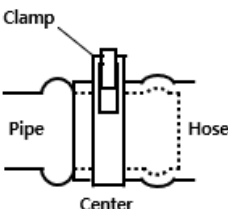
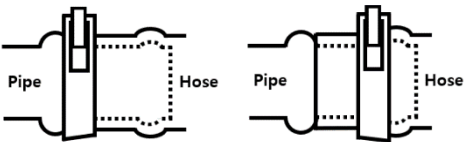
G2 Diesel Engine Installation Guide – DM01, DM02



When connecting the cooling hose to the radiator, it should be installed to prevent flexion. If flexion occurs, air pocket is made, and it makes to reducing the coolant flow and causes overheating.

4-3) Hose clamps

Hose clamps which is available to coolant leakage and damages to the cooling hose after installation should not be used. The mounting position follows the picture below.

	Correct condition	Incorrect condition
Layout		
Description	Locate a clamp at the flat portion to avoid leakage.	Don't locate at the bulge portion

5. Thermostat

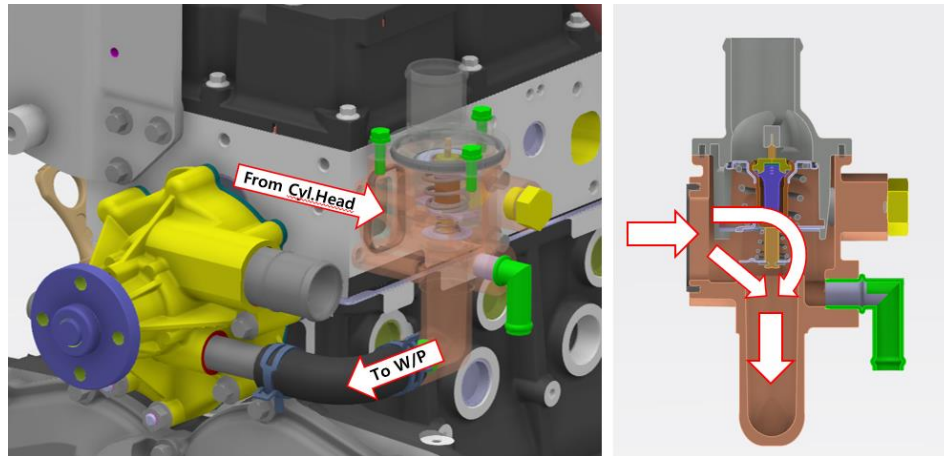
The thermostat is necessary for rapid preheating of the engine and is mainly installed cylinder head-top of the radiator line. The following table shows the thermostat specification of HDI.

Thermostat type	Opening temperature	Full open temperature	Maximum lift
Wax pellet	82°C	97°C	≥ 8 mm

5-1) Operation of thermostat and flow of coolant

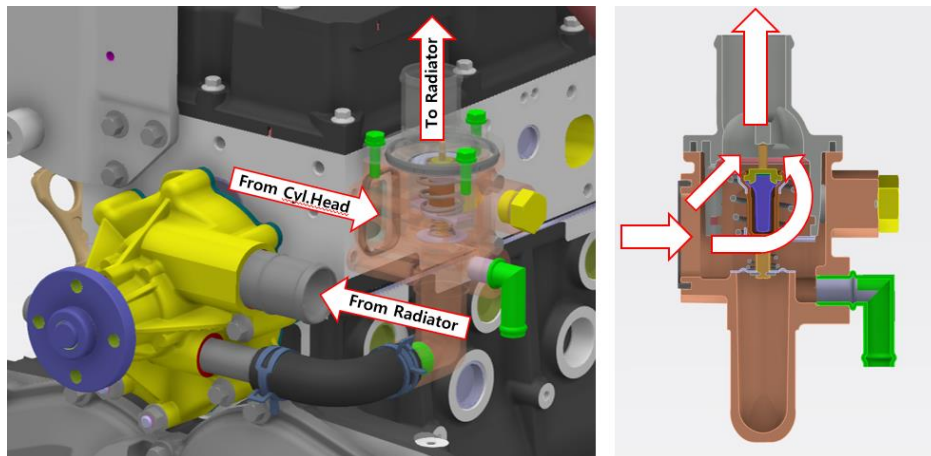
- Under Cold Condition

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The thermostat value is closed until the engine reaches operating temperature. The coolant from the cylinder head enters the water pump via the bypass circuit.

- Under Warm Condition



Once the temperature of coolant reaches the operating temperature of the engine, the thermostat valve is opened and at the same time the bypass valve is closed, the coolant flows to the radiator.

5-2) Cabin heater line

If the cabin heater is to be connected, follow the below guides.

- Inlet and Outlet diameter: $\geq 13\text{mm}$
- Inlet port location: Use the Thermostat service port.
- Outlet port location: Use a T joint from radiator outline

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6. Reservoir Tank

The cooling system consists of a closed circuit, but small amount of coolant is lost through the radiator cap while the engine is running. coolant needs to be checked and replenished periodically; reservoir tank can extend the period of coolant check. At the replenishment of coolant, only reservoir tank needs to be filled. But both radiator and reservoir tank need to be filled at initial coolant charging of the engine.

6-1) Types of reservoir tank

There are two types of reservoir tank and refer to the table below according to the customer's conditions. HDI recommends a pressurized reservoir tank.

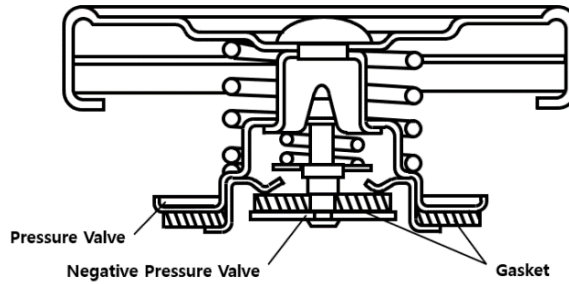
Condition	Pressurized Type	Non-Pressurized Type
Diagram		
Advantage	Easy to deaerate Available to replenish coolant immediately	Easy to design of package
Installation		
Description	Pressurized reservoir tank should be mounted at the highest for deaeration. Use the dummy radiator cap.	It should be installed between top and bottom of the radiator. Overflow hose should reach the bottom of the reservoir tank to be sufficiently submerged in the coolant.

Note : Reservoir tank should be installed where the coolant level can be easily checked. If the cooling circuit is higher than pressurized tank or radiator cap in non-pressurized reservoir tank type, add an auxiliary reservoir tank for deaeration.

6-2) Pressure cap structure

The function of the pressure cap is not only to act as the lid of the filling port but also prevents damage to cooling system by high and vacuum pressure.

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Condition	Warmed up state	Cold State
Engine Condition	Operating State	Stationary State
Diagram		
Operation Valve	Pressure valve	Vacuum valve
Opening Pressure	0.9 ~ 1.5 bar	0.1 bar
Description	When the pressure valve opens, the coolant of the cooling circuit flows into the reservoir tank to release the pressure.	When the vacuum valve opens, the coolant of reservoir tank flows into the cooling circuit to recover the pressure.

6-3) Selection of the Engine coolant reservoir tank capacity

The below conditions are recommended to use the reservoir tank and the volume can be adjusted according to the machine condition. But if volume is too small, replace period of coolant can be shortened.

- Total volume: 18 ~ 20%
- Expansion volume: $\geq 8\%$
- Working volume: Depends on vaporization and replacement period of the coolant
- Minimum volume: Depends on the maximum tilting angle of the application

6-4) Coolant Supplying and Deaeration

All lines should be as vertical as possible to avoid air trap and to be filled the coolant smoothly. And cooling circuit should be completely filled as coolant. If it's not full, the engine will overheat. Follow the below for coolant filling and deaeration.

- After filling the coolant at radiator and reservoir tank, operate the engine for short period to remove the air form the cooling circuit.
- If the coolant level is not just below of the filler, fill the coolant.
- Drive the engine sufficiently to open the thermostat and check that the radiator top is hot.

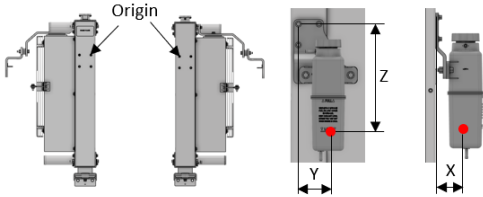
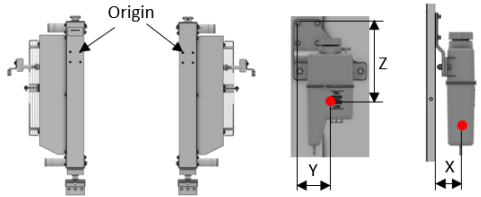
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- (iv) Repeat this process until the coolant level is just below the filler.
- (v) Fill the reservoir tank with the coolant to the proper limit when finished.

Note: Equipment coolant must be included in the total coolant volume and the amount of coolant on equipment should be based on data obtained during design and test.

6-5) Installation of reservoir tank

Reservoir tank or item can be positioned on radiator or machine body. If you want to install to radiator body, follow the below guide.

E/G		DM01/02				DM03			
Application		Industrial		Generator		Industrial		Generator	
Sourcing		Customer	HDI	Customer	HDI	Customer	HDI	Customer	HDI
		Allowed	Not allowed	Allowed		Allowed	Not allowed	Allowed	
Guide	Max. Weight (kg)	2.3		2.3		3.2		3.2	
	Max. COG (mm)	X	Y	Z	X	Y	Z	X	Y
		<65	<40	<160	<80	<40	<160	<80	<40
Layout									

< Installation guide of Reservoir tank or item >

Note : Maximum weight and COG(center of gravity) include mounting bracket and coolant of full level.

7. Cooling Fan

7-1) Role of the cooling fan

In addition to cooling the radiator, the cooling fan helps to cooling several parts by creating cold air flows around the engine.

- Exhaust heat removal
- Lowering the fuel temperature
- Engine surface cooling
- Protecting electrical parts from heat and reducing wire harness voltage drop

7-2) Selection of the cooling fan

At selecting a cooling fan, the heat exchange rate with the radiator, layout of engine room, the fan speed and noise should be considered. Therefore, the fan is selected by predicting the required air flow rate of the radiator and determine it through the test. (Reference: Airflow of HDI standard cooling fan)

	Power unit		Genset
Type	Suction	Blower	Blower

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Part number	210101-00578	210101-00579	210101-00580
Fan rpm (1:1.2)	Air flow rate (m³/min)		
1200	36	34	41
1800	57	54	66
2160	71	68	83
2640	86	82	-
3120	104	100	-

7-3) Blower fan / Suction fan

The characteristics of blower and suction fan type are as follows and it is needed to select the fan suitable for using condition.

Type	Blower	Suction
Generally applied application	Stationary equipment	Moving Vehicle
Advantages	- Reduced engine room temperature - Reduced harness and electric parts temperature	- Increased radiator efficiency - Reduced fan noise

7-4) Material and deformation of the cooling fan

The cooling fan should be controlled to the ambient temperature of cooling fan below 80 degrees and the fan speed below 70m/s to prevent deformation and breakage by overheat and air pressure.

8. Water Pump

8-1) Coolant flow rate

The coolant flow rate is the most important factor for the selection of the radiator, so radiator should be selected based on this, Refer to the coolant flow rate of HDI engine.

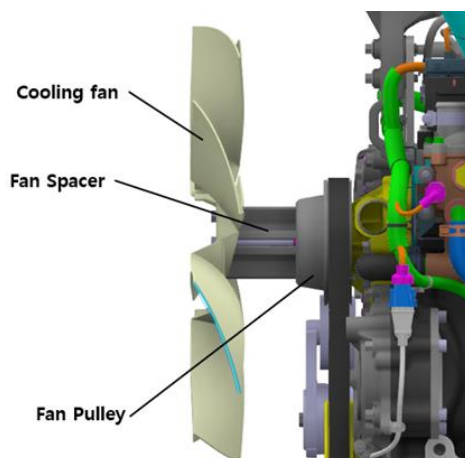
Water pump (rpm)	Coolant flow rate [l/min]				
	DM01	DM02	DM03	PM02	PM03
1200	40	55	50	40	40
1800	60	75	80	60	65
2160	70	90	95	75	80
2640	85	105	115	90	100
3120	100	120	135	110	120

The coolant flow rate is greatly affected by the total resistance of the cooling system and excessive differential pressure reduces the cooling performance. For this purpose, the external cooling system(from engine thermostat outlet to water pump inlet) should be not exceed 0.25 bar. Discuss with HDI before applying external cooling system beyond this.

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Note. To prevent cavitation, water pump inlet should be kept as positive pressure always.

8-2) Bearing load



The bearing load must be managed because fan assembly is installed on the water pump or fan bracket. Excessive load causes damage to bearing, follow the guide.

Caution: If it goes beyond the below table, HDI's approval is required.

DM01 /DM02	Length	Weight	Unbalance weight	Thrust force
Fan	-	$\leq 20\text{N}$	$\leq 30\text{g.cm}$	$\leq 90\text{N}$
Fan spacer	$\leq 80\text{ mm}$	$\leq 10\text{N}$	$\leq 10\text{g.cm}$	-
Fan clutch	Not allowed			

Note: Length is based on surface of fan pulley contacted fan spacer.

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Chapter 4. Exhaust System (After-treatment System)

Introduction

A main part of the exhaust system is composed of an exhaust gas aftertreatment system which reduces harmful emissions to the levels required to meet emissions legislations. Various connection pipes and components are also included in the exhaust system.

The exhaust gas aftertreatment system is mainly divided into two parts, i.e., catalytic converters and DEF (Diesel Exhaust Fluid) supply system.

- Catalytic converters include DOC, DPF.

Supply scope and responsibility

Given the importance of the exhaust system in controlling harmful emissions, only the parts or components that are supplied by HD Hyundai Infracore Co., Ltd. (hereafter referred to as 'HDI') should be applied. A customer shall be responsible for any damages caused by using non-HDI parts or components.

In case the manufacturers of vehicle or equipment supplies such a component as mounting bracket, pipe, flange, and bolt etc. that is connected to or applied with the HDI exhaust system, they should properly follow this installation guideline. Otherwise, the manufacturers of vehicle or equipment may take responsibility for damages or malfunctions and therefore the warranty of the products supplied by HDI will no longer be valid. Machine manufacturer is responsible for the verification and warranty of the parts or components that are supplied by machine manufacturer itself.

Mandatory requirements

① 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.
- The DOC/DPF end-cans must not be re-positioned from the supplied position.
- Additional change or manipulation such as piercing, welding, painting, insulation etc. onto the aftertreatment system and its components are strictly prohibited.

② Aftertreatment hardware requirements

- The exhaust system temperature drop and backpressure must meet the guideline which provided in the Chapter 4.1. 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.

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- 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 (eg., 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 minimise the joint load, prevent induced stress, avoid vibration and resonance.

③ 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 Chapter 4.2-3.
- 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.

④ Environmental requirements

- Customer (i.e., the machine manufacturer) should provide a proper environmental thermal management around the aftertreatment system to prevent thermal damage of accessories like Sensors, Dosing module, etc. Refer to each limit temperature of accessories which is given in (Chapter 2. and Chapter 4.3). This limit temperature must not be exceeded in the worst case that could occur in real field conditions. Customer (i.e., the machine manufacturer) should provide this worst-case information to HDI application engineer and is responsible for this worst-case information.
- The aftertreatment should be located where air circulation around the canister is allowed and be protected from debris or damage from outside the system.

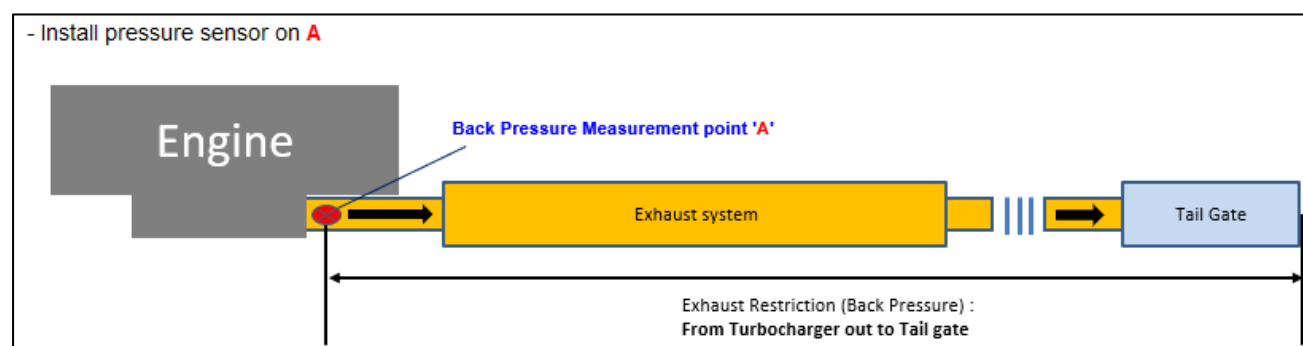
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1. System Specification

- 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 those in the table below, when the highest load possible is applied at the rated engine speed.

Exhaust Mass Flow [kg/hr]	Back Pressure [kPa]	
	StageV (DOC+DPF)	Tier4F (DOC)
108	6	3
144	8	5
180	11	7
216	14	9
252	18	12
288	22	15
324	26	19
360	31	22

Exhaust Mass Flow [kg/hr]	Back Pressure [kPa]
	StageV (SDPF)
108	6
144	8
180	11
216	15
252	19
288	24
324	29
360	35
396	42



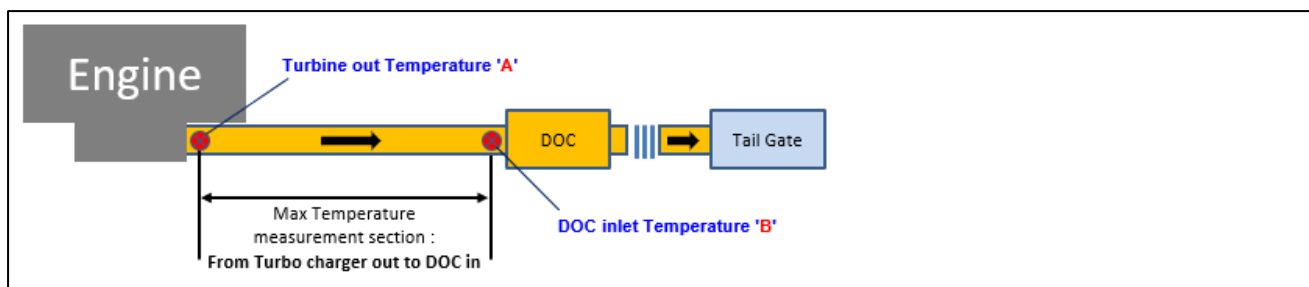
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- The maximum drop in exhaust pipe temperature is determined based on the application and the rated power. Make sure that the measured value is lower than those in the table below.
 - X axis: Exhaust Mass (kg/h)
 - Y axis: Turbine-out Temperature (°C)
 - Z axis: Temperature drop (°C)

DM01										
Y \ X	70	130	160	190	220	250	280	310	340	400
200	19	11	10	9	7	7	6	4	4	0
300	42	30	25	22	19	18	17	17	16	13
350	54	40	34	29	25	22	21	21	22	19
400	65	51	43	36	29	26	25	25	26	26
450	66	56	48	41	36	33	32	31	30	30
500	69	65	58	50	45	42	40	38	36	33
600	83	82	76	69	62	57	54	51	48	44
650	90	87	83	76	70	65	61	58	55	50

DM02										
Y \ X	70	130	160	190	220	250	280	310	340	400
200	23	14	13	11	9	8	7	5	5	0
300	51	36	31	26	23	22	21	21	19	16
350	66	49	41	35	30	27	25	25	26	23
400	79	62	52	43	35	32	31	31	32	32
450	80	68	58	50	43	41	39	38	37	36
500	84	78	70	61	54	50	49	46	44	40
600	101	99	93	84	76	69	66	62	59	53
650	109	105	101	93	85	78	74	70	67	60

DM02HP										
Y \ X	50	100	150	200	250	300	350	400	450	500
250	23	19	14	10	7	5	4	3	2	4
300	33	26	19	13	8	7	7	6	8	8
350	41	32	23	16	11	9	11	10	13	12
400	51	41	30	22	17	15	14	12	12	13
450	58	46	33	23	18	17	17	16	17	17
500	63	52	38	27	20	19	19	18	18	17
550	67	56	43	31	24	22	23	22	21	19
600	70	60	48	38	31	28	26	26	25	23



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2. After-treatment System

HDI after-treatment system has catalytic converters, such as DOC and DPF. Given their importance in controlling emission, only the parts that are supplied or applied by HDI must be used. Customers shall be responsible for any damage caused by usage of non-HDI parts.

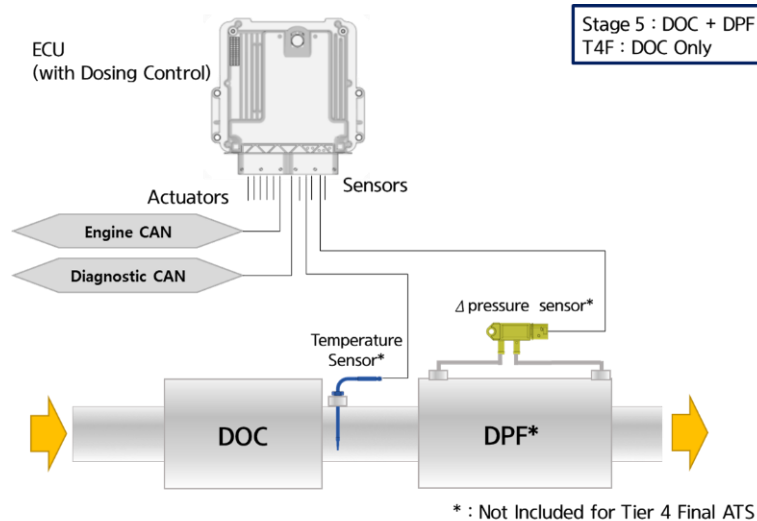


Figure 4-A. After-treatment system diagram

2-1) Safety

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

2-2) Mounting

- The converter must be located to minimize heat loss.
- The exhaust system must not contact any adjacent vehicle components. (minimum clearance with vehicle : 25.4mm)
- The after-treatment 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 after-treatment system because it induces a bending moment.
- For chassis-mounted after-treatment system, flexible connections are required between the turbocharger and the after-treatment system to prevent motion constraints between the engine and the machine frame.
- If HDI supplies after-treatment system with mounting brackets, the machine manufacturer must follow the assembly guidelines provided by HDI.
- If parts from the machine manufacturer are assembled in addition to after-treatment system 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 after-treatment 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

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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.
- One of the following three types of tail pipes must be selected and fitted. In the case of chassis mounting, the machine's tail pipe connected to the ATS outlet pipe must have the first fixation point applied to the chassis frame within 670mm from the reference point of the ATS outlet pipe, to prevent an excessive bending moment on it. Additionally, a flexible pipe (bellows) must be applied between the ATS outlet pipe and the first fixation point. HDI engineers can adjust the first fixation point based on the review for the exhaust layout.
- Machine (or Vehicle) side should satisfy the three concepts described in Figure 4-C. But, if Machine (or Vehicle) side is not able to follow one of the three concepts of Figure 4-C, they MUST discuss with a proper HDI engineer whether an alternative Machine (or Vehicle) tail pipe layout is possible or not. As a result of this discussion, additional validations such as machine durability test, RLDA vibration measurement, stress measurement, etc. could be requested to Machines (or Vehicles) side to verify the durability and reliability of HDI's ATS system.

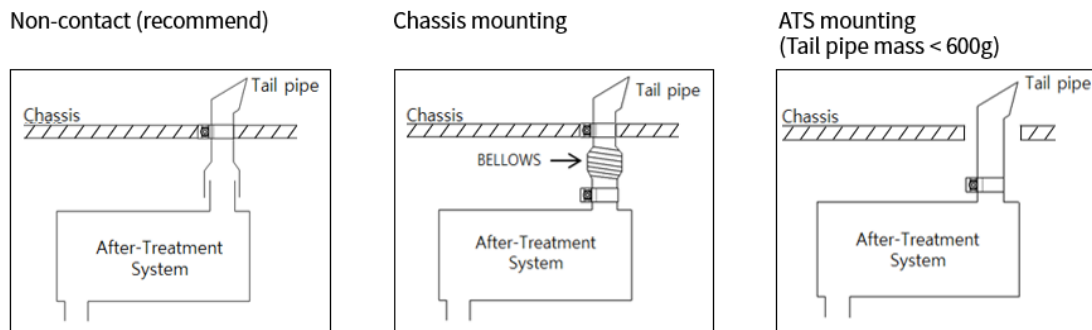


Figure 4-C. Types of tail pipe

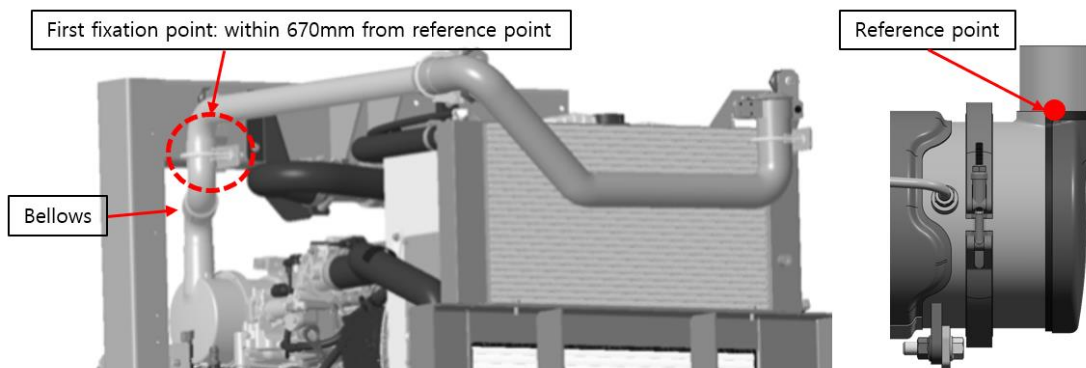


Figure 4-D. First fixation point of tail pipe chassis mounting



Caution : When mounting ATS, all bolting points must be tightened to the specified torque. Arbitrarily missing the bolting point or changing the assembly torque is not permitted.

2-3) Vibration

ATS vibration is validated by both PHV (Peak Hold Value) and PSD (Power Spectral Density). Machine side should conduct a machine vibration test to show that these ATS vibration guidelines are satisfied, and those test results should be reviewed with HDI. The ATS muffler system should be properly installed

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in the machine.

- Engine operating condition
 - The vibration loads must be measured in all relevant states of vehicle operation including worst-case vibration conditions.
 - Acceleration sensor should be installed on the center and top of the after-treatment.

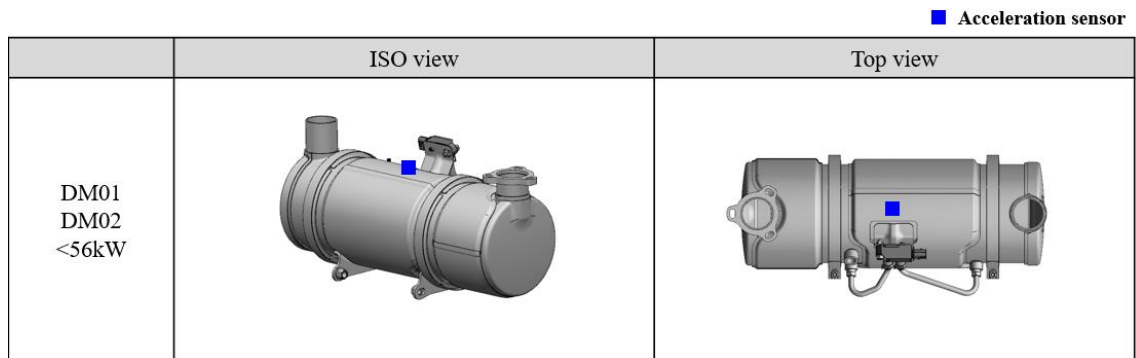


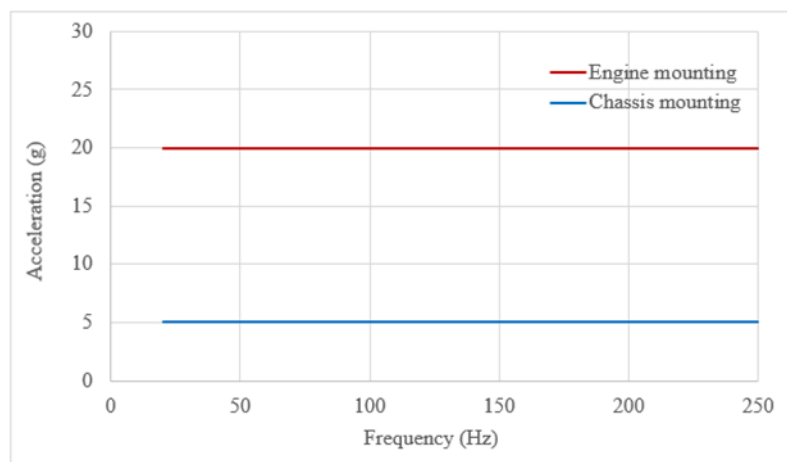
Figure 4-E. Location of acceleration sensor

- Permissible vibration loads

PHV (Peak Hold Value)

- The maximum vibration level of ATS muffler system is lower than 20G for engine mounting case or 5G for chassis mounting case.
- Measurement point: Muffler top (Measurement point should be checked by HDI.)

Mounting Position	Guideline
Engine Mounting	- Not to exceed 20g (peak value) within 10~250Hz. - The 1st resonance frequency should be over target frequency*. *Target frequency (Hz) : Rated engine speed /60 x Num. of cylinder x 0.5 x 1.4
Chassis Mounting	- Not to exceed 5g (peak value) within 10~250Hz. - The 1st resonance frequency should be over 50Hz.



	Test Spec
Averaging	PHV
Scaling	Peak
Resolution	1Hz
Sampling Frequency	> 500Hz
Bandwidth	> 250Hz

Figure 4-F. Vibration load of after-treatment system

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PSD (Power Spectral Density)

- PSD profile which is provided from HDI is satisfied (Refer to below example table and graph)
- Measurement point : Muffler mounting (Measurement point should be checked by HDI.)
- PSD profile will be provided according to ATS mounting position and machine application.

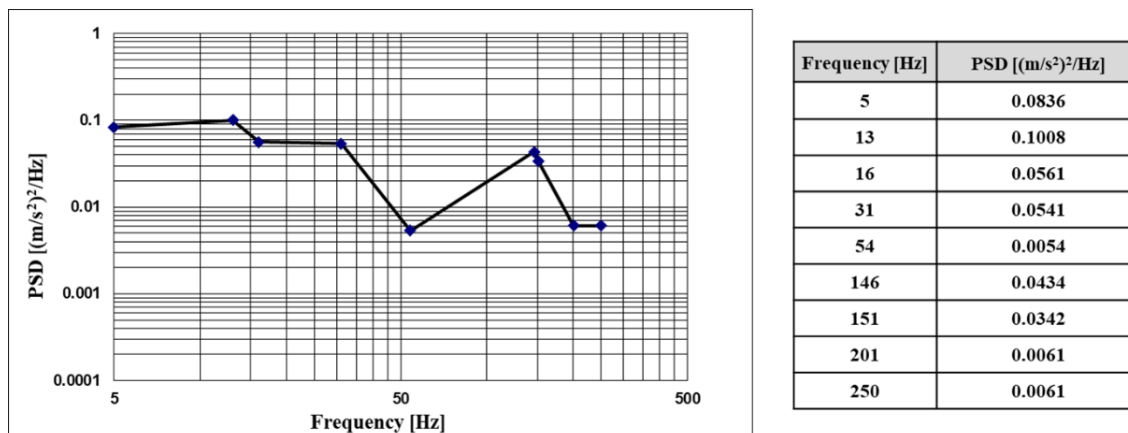


Figure 4-G. Example of PSD vibration load on after-treatment system



Caution : Both PHV and PSD should be satisfied as ATS mounted on application.

2-4) Remote DP sensor

- In case of remote DP sensor, customer should be mounted on the mounting plate or vehicle chassis by the below guidelines.
- Tightening torque of M6 screw: 8Nm \pm 2Nm
- To minimize the risk of intrusion of water, dust etc., and the risk for mechanical damage, the DP sensor should be located as well as possible in a protected area.
- The mounting plate or vehicle chassis on which the DP sensor is mounted must be corrected position as pin hole and guarantee durability for mounting the DP sensor.
- Pipes and hoses from the pipe port to the DP sensor must always be installed with an upward slope to prevent condensate from accumulating.
- For detailed guideline of the DP sensor, refer to “chapter.2 3.DPF Differential Pressure Sensor”.

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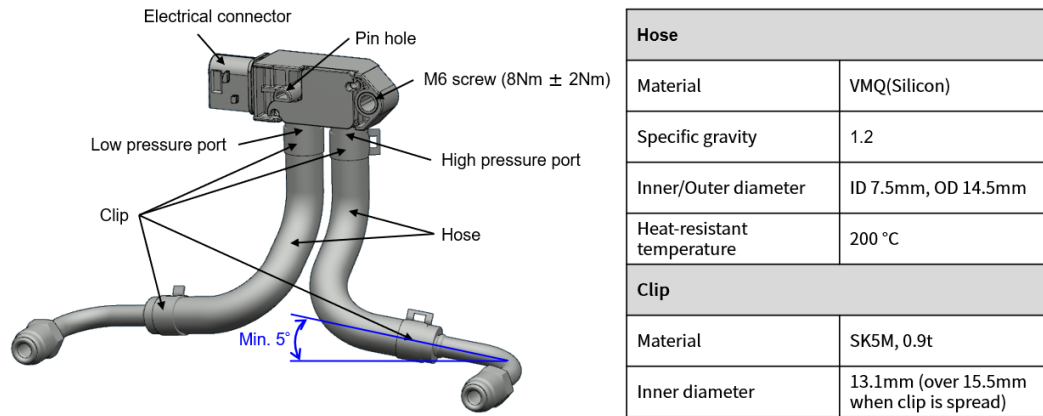


Figure 4-H. Layout and requirement of remote DP sensor

2-5) Fuel and Engine lubricant oil

- To prevent catalyst and filter from deactivating, the sulfur of fuel must be lower than ULSD regulation. (based on nationality)
- To prevent any catalyst and filter poisoning, a CJ-4/CK-4 grade lubricant oil must be used.
- To reduce ash generation from the engine, a low SAPs type lubricant oil is recommended. (Sulphated Ash ≤ 1.0 %wt)

2-6) Flow uniformity index (only for T4F canned DOC)

- Flow uniformity index at catalyst inlet : over 0.95 @ rated power (CFD analysis)

The uniformity of a scalar quantity is computed on a surface as:

$$Uniformity\ index\ of\ \phi = 1 - \frac{\sum_f |\phi_f - \bar{\phi}| A_f}{2|\bar{\phi}| \sum_f A_f}$$

where $\bar{\phi}$ is the surface average of ϕ , ϕ_f is the face value of the selected scalar and A_f is the area of a face. The uniformity index describes the distribution of a certain quantity on a surface. If the quantity is distributed equally, the resulting number is 1. This report is useful in applications where a uniform flow rate is desired across a whole area. Heat exchangers, catalysts, and filters are examples of such applications.

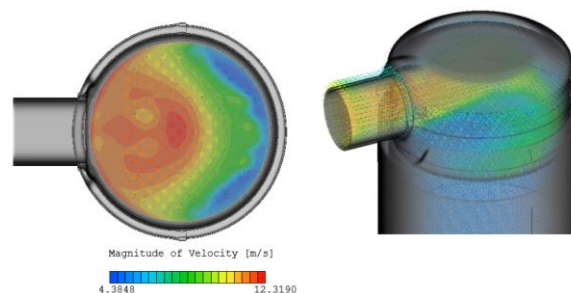


Figure 4-I. Example of uniformity index simulation

2-7) Welding guideline (only for T4F canned DOC)

Only the canned DOC (an orange-colored part in the figure below) is supplied by HDI. The inlet/outlets

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(black-colored parts in the figure below) should be manufactured by the machine manufacturer.

When welding canned TWC and converter, it must be welded all around so that exhaust gas flow completely through the catalyst and does not leak into the welding zone.

- Type 1 (End-in and end-out)

The converter must be welded into the inner side of the canned DOC to prevent erosion of supporter from direct flow of exhaust gas.

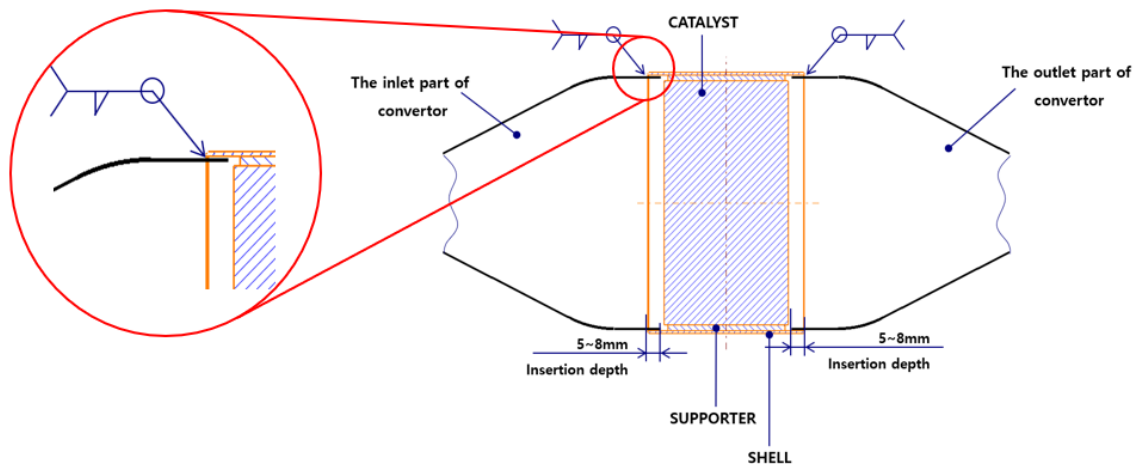


Figure 4-J. Type 1 welding guideline

- Type 2 (Side-in and side-out & Side-in and end-out)

The converter should be welded both inside or outside of the canned DOC. The canned DOC should be inserted into the converter.

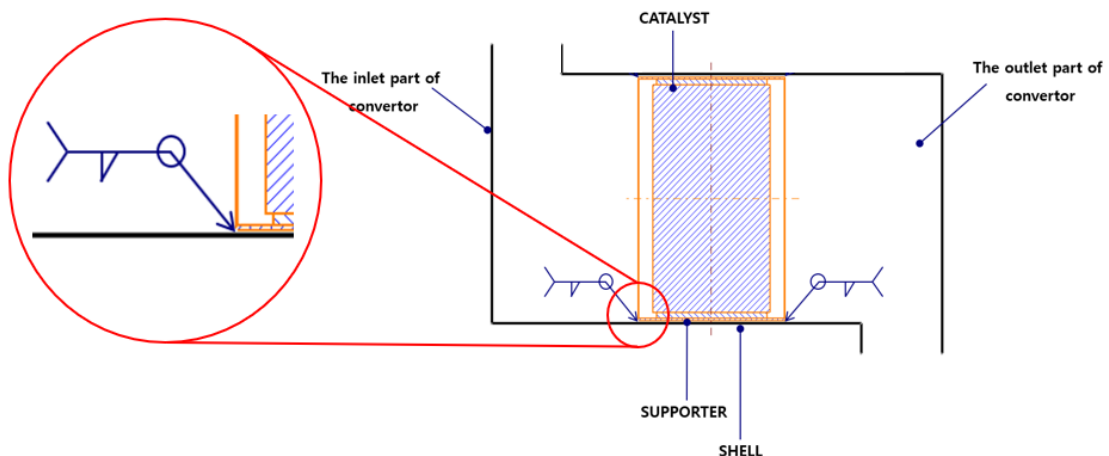


Figure 4-K. Type 2 welding guideline

3. NCD & PCD Inducement

To prevent failures that may be caused by emission-related parts (EGR valve / DPF System / SCR System), the ECU will gradually derate the engine speed and torque. Such data must be transmitted and drivers

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should be notified with a lamp. Equipment manufacturers should make sure that such inducement system is in place, and agreed with HDI prior to its installation. The system must comply with relevant regulations.

4. In-use Testing

The U.S. EPA certification regulations on NRCI engines require HDI to notify the equipment manufacturer that sampling of exhaust emissions must be done after engines are installed and placed in service. If this cannot be achieved by simply adding a 20-centimeter extension to the exhaust pipe, the equipment manufacturer must demonstrate to HDI how exhaust emissions can be sampled without diluting the exhaust sample with ambient air.

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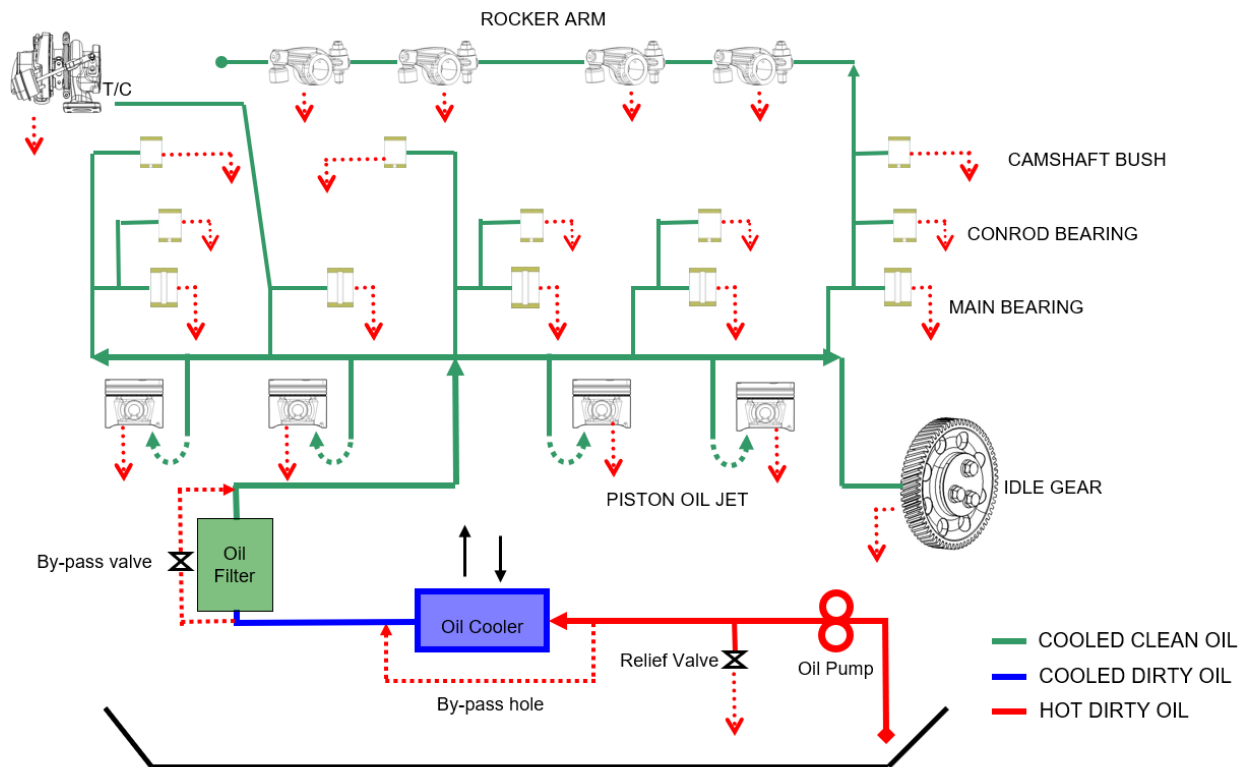
Chapter 5. Lubrication System

5. System Specification

- Minimum oil pressure at rated speed during operation: $4.0 \text{ kg/cm}^2 \sim 5.5 \text{ kg/cm}^2$ (at worst case)
- Minimum oil pressure at idle: 1.0 bar (at worst case)
- Maximum oil temperature (at oil main gallery): 135°C (at Operating condition)
- * Worst case: oil temperature is 135°C and Max. Clearance and tolerance of outlet

6. Additional design considerations

The engine must be equipped with a full flow lubricating oil filter and oil low pressure warning system, or engine shutdown device. An engine mounted filter is standard and is strongly recommended in order to ensure the optimum priming situation and reduce flow resistance and leaks.



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7. Engine Oil Specification

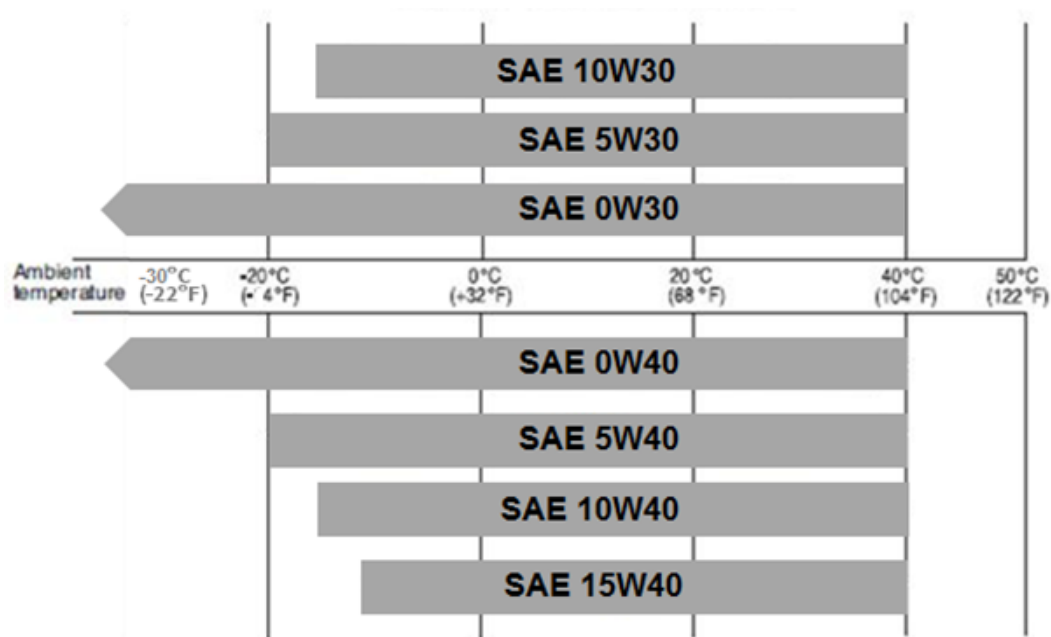
Please use the engine oil which satisfies the following recommended Specification.

Emission Regulation	SAE Classification	500 hours interval or 1 year	1,000 hours interval or 1 year
Tier3 / StageIII	10W40	API CI-4 (ACEA E5) or above	API CK-4 or above
Tier4 / StageIV	10W30/40 15W40	API CJ-4 (ACEA E6/9) or above	API CK-4 or above
Tier5 / StageV	10W30/40 15W40	API CJ-4 (ACEA E6/9) or above	API CK-4 or above

The specification above is for base engines (below 55kW). For higher power (excess 55kW) engines, contact HDI.

*The service interval varies depending on engine oil, diesel fuel quality and operation conditions and is determined by analyzing the engine oil properties under operating conditions and the result of the test. 1,000hr interval is applicable only when approved by HDI.

8. Engine Oil viscosity by temperature



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9. Inclined Performance

The engine uses a wet sump lubrication system oil pan. If the engine is operated at an inclination angle exceeding the maximum inclination angle, the air is taken in from the lubricating oil suction pipe and lubricating oil cannot circulate through the engine.

The maximum inclination angle of the engine with standard oil pan is 35°(Back, Forth, Left, Right Continuous)

NOTE: The engine is capable of operating in all directions with a maximum tilted angle of 55° for a short period of time when the oil level is at its highest. However, such usage is not recommended as it can lead to engine failure.

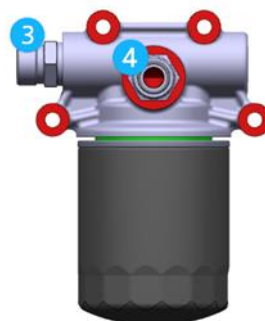
10. Remote Oil filter

HDI provides remote oil filters as an option to facilitate engine installation and maintenance. When using remote options, users should follow the instructions below.

- Length of the oil hose: shorter than 970 mm
- Inner diameter of the oil hose: 5/8 inch
- Oil flow: Cylinder block → ① → ③ → Oil filter → ④ → ②
- Fitting specification: ①, ③, ④ 1-14 UNF / ② 1-14 UNS-2A



< Remote oil filter adaptor on the engine side >



< Remote filter head on machine side >

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Chapter 6. Air Intake System

1. System Specification

1-1) Air Cleaner efficiency: 99.9% effective and removes 80% of ingested moisture.

1-2) Air Cleaner cleanliness: Follow ISO 5011, ISO 12103-1 (A2-fine test dust – 99.5% under 80 μ m)

1-3) Air Cleaner selection: Air cleaner has to be selected in consideration of the required air flow rate and pressure restriction.

Engine model	Airflow (m ³ /min)		Reference pressure restriction (kPa)
	Min	Max	
DM01	0.65	4.14	3.0 kPa
DM02	0.78	4.80	3.0 kPa

1-4) The temperature difference between inducing air (Compressor inlet) and ambient: Below 10 K

1-5) The maximum operating temperature of compressor out should not exceed 170°C, without addition al CCV oil filter.

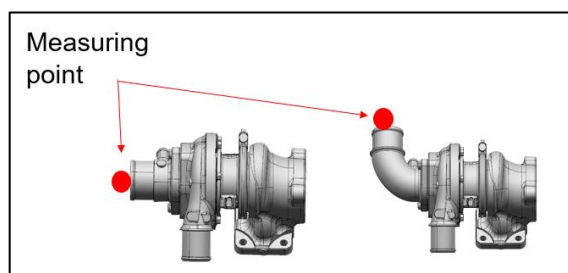
1-6) The turbocharger fouling should be validated through machine durability test if the compressor outlet temperature is over 170°C. However, such validation is needed only for CCV.

1-7) The average air flow rate between air filter and compressor inlet should not exceed 40m/s.

1-8) The minimum compressor inlet pressure should not exceed the limits below. The hose and the pipe should be connected during measurement and air filter contamination should be taken into consideration.

Item	Permissible compressor inlet negative pressure	Test condition	Check position	Remarks
TCI Engine	6.5 kPa	Max power condition of the machine	Turbocharger (compressor) inlet	With dirty element condition

- Compressor inlet Pressure Measurement
 - Pressure: Steady in Straight Area
 - Position: Within 30mm from the compressor inlet port, if possible

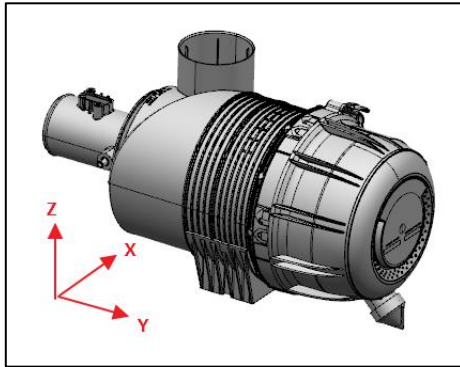


1-1) Air cleaner installation (Standard engine only)

. Air cleaner installation must follow below orientation and condition in order that g-force will not be exceed in case of using Cummins air cleaner. Don't need to measure g force in case of if use engine maker offered engine cleaner layout for Type 1. Air cleaner engine mount bracket only offered to type 1, and other types should be installed on machine side.

➔ All axis-5G

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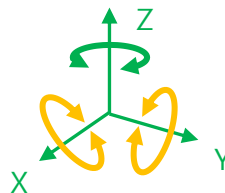
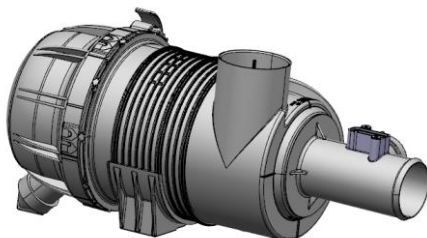
. Basically, all air filters(cleaner) must be followed the installation conditions with the MAF sensor, and not allowed air outlet pipe rotation even if it can be rotated. Due to change the MAF sensor's calibrated position, the flow rate deviation is enlarged, and it affects engine performance and emission.

. The angle of the air filter which is an integrated condition with the MAF sensor as the following above is allowed in terms of the MAF installation guide. (6-4 Mass Air Flow sensor Installation guide between the air cleaner and turbocharger.)

. Dust unloading valve should be installed toward to gravity direction

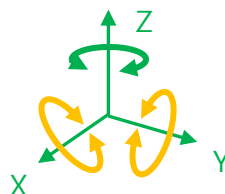
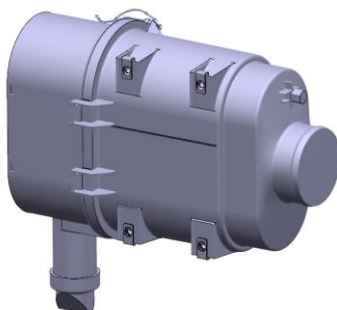
. For reference, user can buy type2~3 in general market and use it for machine package. In this case, engine maker offer hose for air cleaner and MAF sensor hosing.

Type 1. Cummins – (Part no. : 400414-00774)



— Allowed
— Follow MAF installation angle

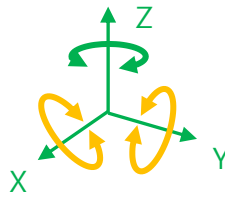
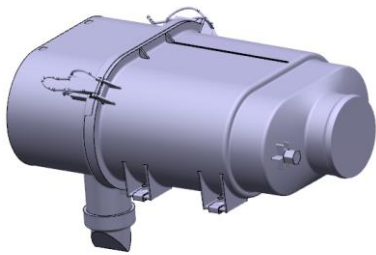
Type 2. Donaldson - (Part no. : 400414-00784, Supplier Part No. : D090101)





— Allowed
— Follow MAF installation angle

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Type 3. Donaldson - (Part no. : 400414-00785, Supplier Part No. : D090121)



-  Allowed
-  Follow MAF installation angle

2. Additional Design Considerations

- 2-1) The intake port should be positioned in such a way as to avoid the entry of water, dust or exhaust gas.
- 2-2) The system should be designed to avoid the entry of particles into intake line during maintenance/replacement of air filter cartridge.
- 2-3) The integrity of piping and connections must be guaranteed during the machine lifetime. The material of the air pipe hose that connects the turbocharger and the intercooler must resist high temperature and strength.
- 2-4) There must be no leakage between connections.
- 2-5) Weight should not be applied to the compressor inlet: a rubber connection must be used and pipes must be properly fitted.

3. Closed Crankcase Ventilation (CCV) System connected to the Air Intake System

- 3-1) The crankcase ventilation pipe for the air duct must be placed before the compressor inlet. The piping should be designed to allow the CCV system to thoroughly mix air and blow-by gas, while minimizing the formation of oil drop. The blow-by exit port should be located as far as possible from the compressor inlet.
- 3-2) The blow-by gas exit port should ideally be perpendicular to the air direction, against the airflow, not directed to the air duct surface, and if possible, it must be placed near the transition (turbulent/laminar) stream. If the port is within 0.5 m of the compressor inlet, it must be perpendicular.
- 3-3) To avoid inflow of oil, the gas exit port should not be positioned higher than the air filter..
- 3-4) The recommended internal diameter of pipe going into the air duct is 8mm.
- 3-5) Dips in the blow-by gas pipe must be avoided where possible.
- 3-6) If a port for an air compressor intake is present, the blow-by port should not be located before it.
- 3-7) The CCV system causes oil to flow into the after-cooler and air piping. The presence of oil residues between the turbo compressor and the intake system, including CAC system, therefore, is a normal condition.

4. Mass Airflow (MAF) Sensor Installation guide between the air cleaner and turbocharger

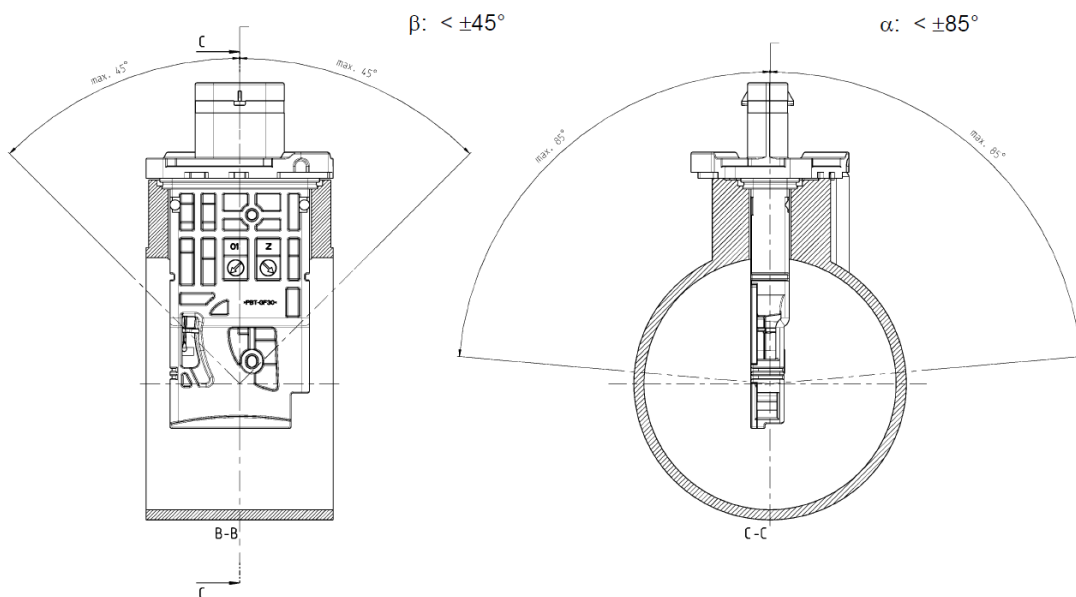
- 4-1) In order to meet emission regulations, the engine needs to have a mass air flow (MAF) to send information relating to the air flow rate to the ECU for calculation and to control the fuel injection rate in real time.
- 4-2) The entire air intake system should be validated and evaluated for accurate calibration of perform

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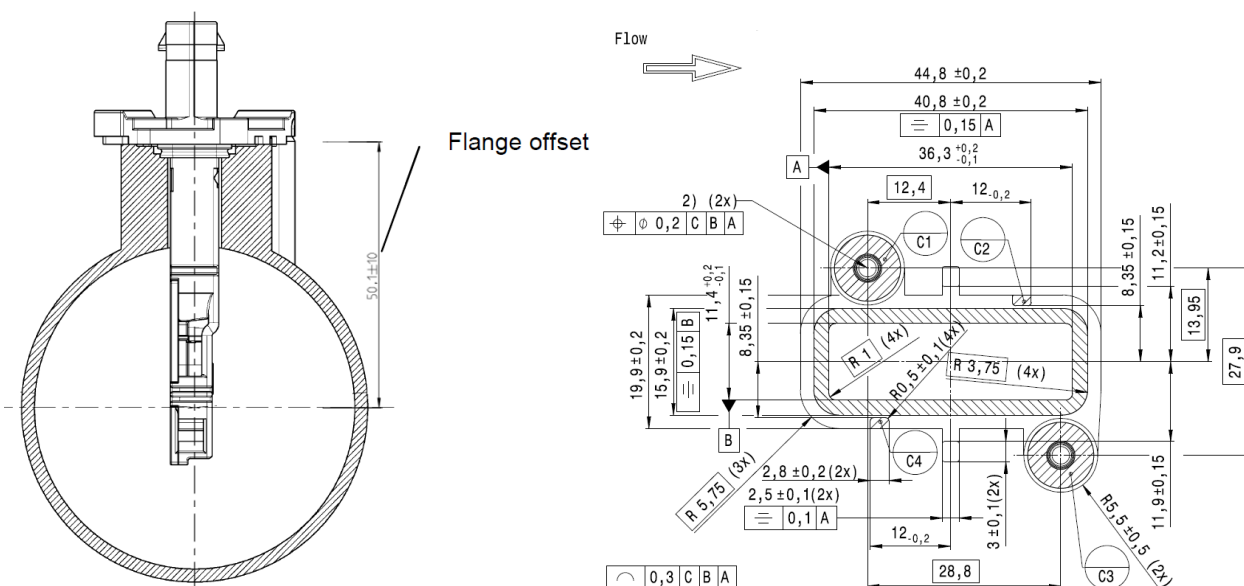
ance when developing the engine/machine with HDI. During calibration, HDI can request to modify the position of the MAF sensor to meet the air flow distribution tolerance ($\pm 2\%$).

Item	Range of Operation		Storage Temperature Range
	Temperature	Pressure (abs)	
MAF Sensor	-40 ~ 125°C	65 ~ 110kPa	-40 ~ 130°C

- 4-3) For customers who do not conduct MAF sensor calibration test with HDI, install the MAF Sensor and design the intake layout according to the guide of the Check Sheet.
- 4-4) The equipment manufacturer must meet the required MAF sensor orientation as shown below. For further details, refer to the MAF sensor orientation drawing or consult HDI.



* Warning: If the position of the MAF sensor is changed from when it was first installed, the values of the air flow table would change accordingly. Contact HDI if a change is made to the MAF sensor position.



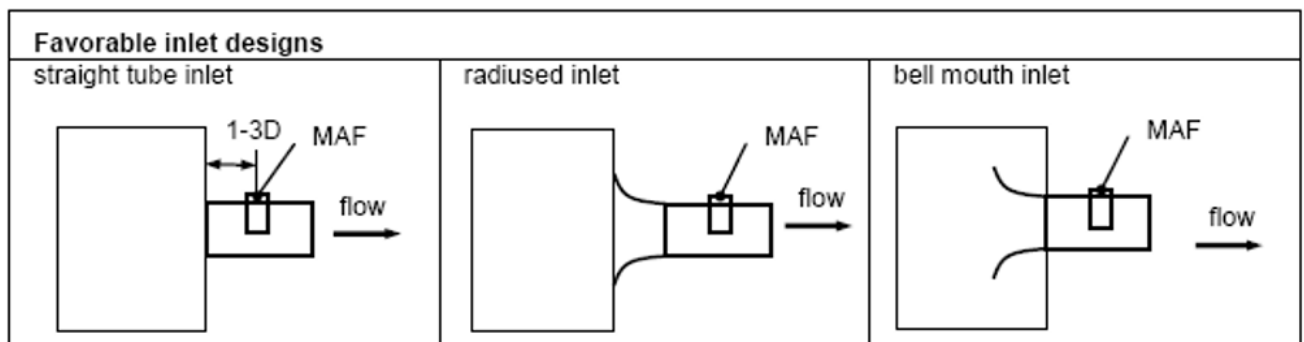
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4-5) The standard flange offset is 50.1 ± 10 mm. Insert depth should be reviewed with HDI, which will vary according to the air intake system.

	Qmin (kg/h)	Qmax (kg/h)
Range in 40mm ID tube	3.3	333
Range in 45mm ID tube	4.2	421
Range in 50mm ID tube	5.2	520
Range in 55mm ID tube	6.3	630
Range in 60mm ID tube	7.5	749
62mm MT Plug-in	8.0	800
Range in 65mm ID tube	8.8	879
Range in 70mm ID tube	10.2	1,020
Range in 80mm ID tube	13.3	1,332
Range in 90mm ID tube	16.9	1,686
Range in 100mm ID tube	20.8	2,081
Range in 110mm ID tube	25.2	2,518
Range in 120mm ID tube	30.0	2,997

4-6) The maximum flow of air mass is determined based on the inner diameter of the MAF sensor housing. The inner diameter of the MAF sensor housing must be designed with enough margin, in reference to the above table.

4-7) Air System Proposal Design



* **D**: Diameter of MAF housing.

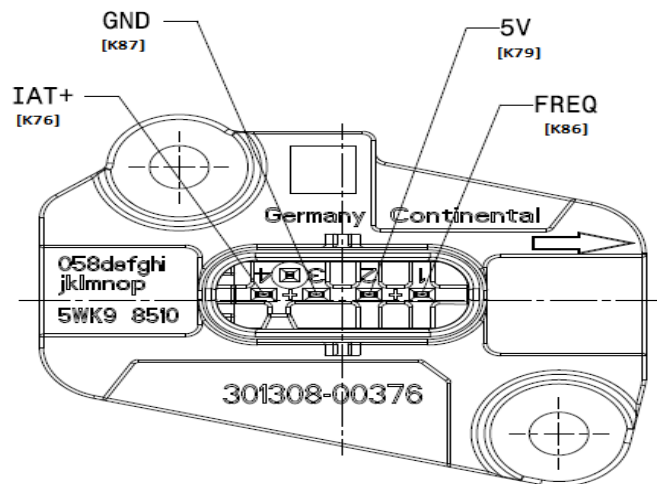
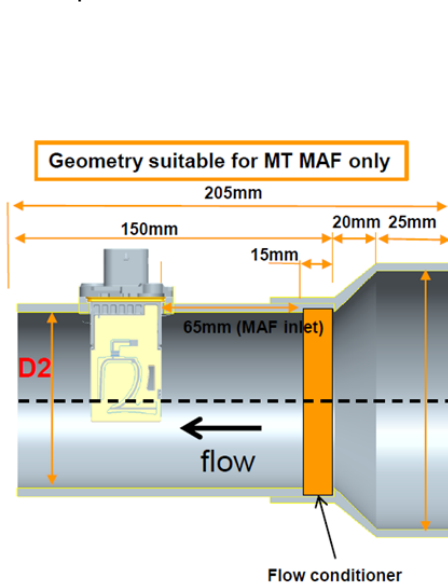
Installation of the MAF sensor can affect both combustion and emission. The initial air mass flow would be different from the ECU dataset if the MAF sensor is not installed in accordance with the installation guideline.

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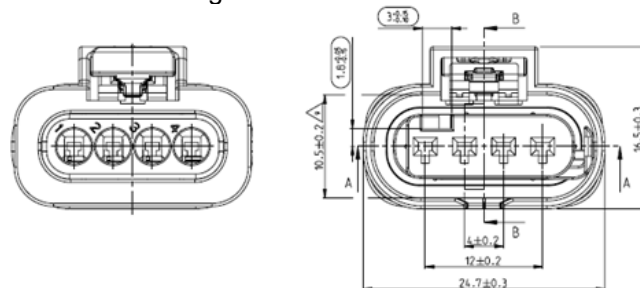
The MAF sensor is positioned so that the upper edge of the inlet is parallel to the MAF tube center. For further details, refer to the figure on the left.

Moreover, the connection between the air cleaner outlet and MAF sensor must be kept straight, as far as possible, in order to obtain accurate value of air flow rate.

• I/O Description



• MAF Sensor Mating Connector Information



- 1) Tyco 1-1670918-1
- 2) Hirschmann : 872-859-...KD
- 3) F.C.I : F881100

- Recommendations of MAF sensor housing :
Fixed as much as possible on the surrounding parts

5.Cleanliness for Air inlet between filter element and intake stake

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Component cleanliness of Intake system including air is critical to the turbocharger designed to function through all of its lifetime.

Turbocharger suppliers don't specify values for particle size or weight, but they ask following:

- Any particulates and drops flowing into the compressor inlet side are not permitted which will damage compressor wheel because the wheel assembly of turbocharger is rotated over 100,000rpm.
- Intake system shall be clean and free of debris, residual abrasive material and corrosion products.
- In addition, intake system components shall be maintained air tight seal to prevent foreign matter from entering.

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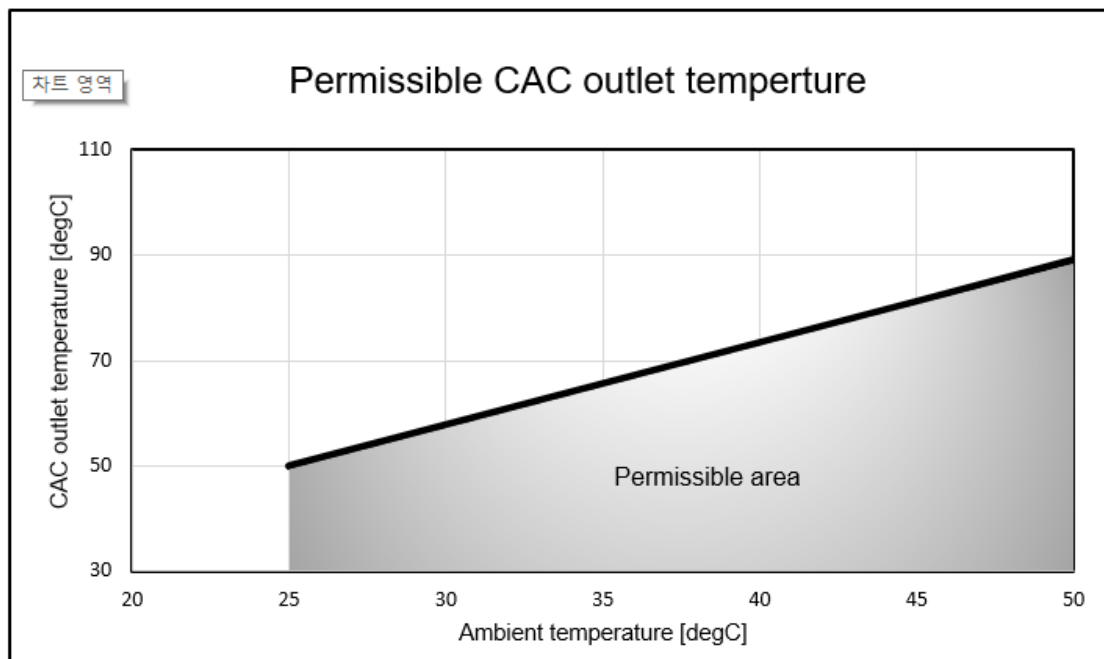
Chapter 7. Charge Air Cooling System

1. System specification

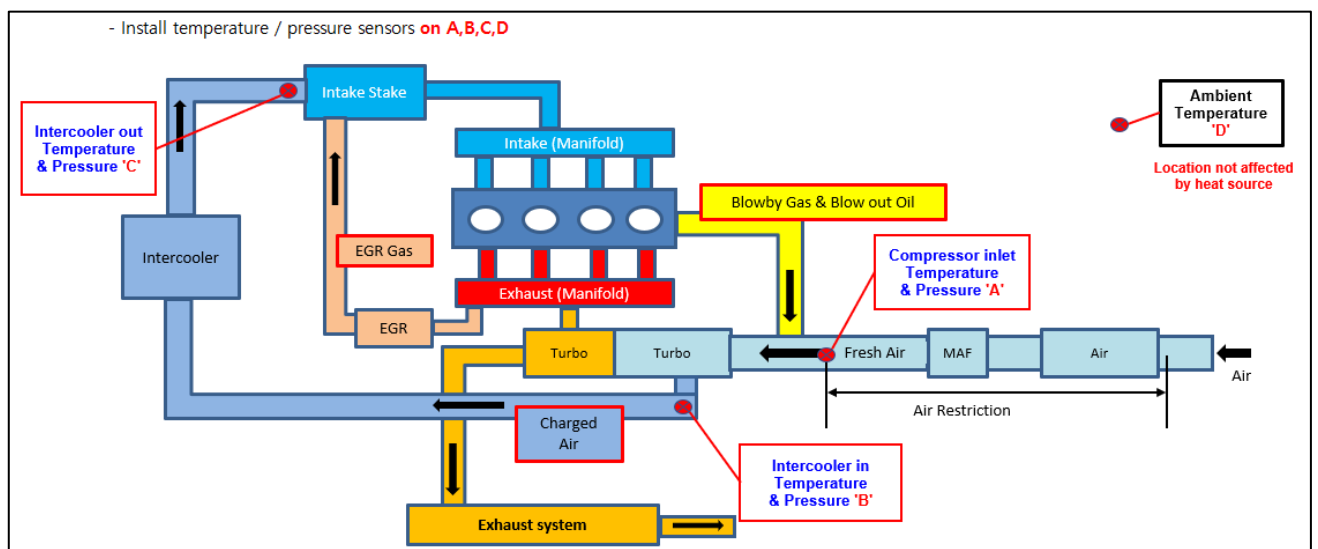
Intercooler System(Intercooler + air hose designed by machine side) design guide

- Permissible pressure drop: 0.1 bar (Measuring point : between closed to compressor out and closed to engine intake stake)
- Permissible CAC outlet temperature(degrees C) : $1.5625 \times (\text{Ambient temperature}^*) + 10.9375$

*Ambient temperature : It means the ambient temperature surrounding the equipment in operation, which is not affected by any heat source



- Allowable ambient temperature range for testing : 25degC ~ Machine development target temperature(degC)
- If the test conditions for measurement are not allowed, the test engineer should conduct a test after review through further communication with HDI engineers.



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DM01_Industrial

Engine Suffix	Engine Speed (rpm)	Power (kW)	Air mass (L/min)	Heat rejection of the intercooler(kW)
MFP00/LEP00	2600	45	3050	6
MFP01/LEP01	2500	41	2690	5
MFP02/LEP02	2200	41	2790	5
MFP03/LEP03	2500	37	2520	5
MFP04/LEP04	2200	31	2390	3
MFP05/LEP05	2400	25	2130	2

DM02_Industrial

Engine Suffix	Engine Speed (rpm)	Power (kW)	Air mass (L/min)	Heat rejection of the intercooler(kW)
MFP00/LEP00	2600	55	3810	8
MFP01/LEP01	2600	51	3730	7
MFP02/LEP02	2600	41	3580	6
MFP03/LEP03	2600	36	3470	6

DM01 / 02_Generator

Model	Suffix	Rpm / Hz	Gross Standby (kWm)	Air mass (L/min)	CAC (kW)
DM01	MFG00	1500 / 50	30.2	1740	3
		1800 / 60	42	2270	4
	LEG00	1500 / 50	30.2	1740	3
		1800 / 60	38.1	2230	4
DM02	MFG00	1500 / 50	48.1	2780	5
		1800 / 60	55	3140	6
	LEG00	1500 / 50	42.1	2570	5
		1800 / 60	50	3030	6

2. Additional design considerations

- Integrity of piping and connections must be guaranteed for vehicle life, under working conditions, without deformation.
- Use of elastic constant - pressure clamps are required for all the rubber connections.
- No weight is allowed on the compressor inlet: a rubber connection and a proper mounting of the pipes must be used.
- The weight upon both sides of the turbocharger should be minimized to ensure that the turbocharger is not additionally stressed.
- The pipe to the intercooler should have a diverging diffuser design close to the compressor outlet to maximize inlet system performance. An included diffusion angle of 7° is a good guideline. No diameter reduction is admitted on the pipe going between the compressor and the intercooler
- Flexible connections to the turbocharger are necessary to prevent constrained motion between engine and vehicle frame.

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- The Hose material of CAC system must be Oil resistance. FKM hose or Fluoro coating silicone hose at inner liner which has Oil resistant property are recommended. Silicone only hose must not be used to avoid oil permeation or swelling.
- The Hose must be designed to operate under the machine operating temperature and pressure conditions with min/max ambient temperature.
- Temperature testing should be performed under worst case ambient and with maximum engine rating that is used primarily customer and comply with the hose specification.

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Chapter 8. Cold starting requirement

1. Cold Start Requirement

- Minimum Cranking speed > Minimum 120rpm (at -20degC)
- ECU input voltage > 6V (at -20degC)

2. Cold start recommendations

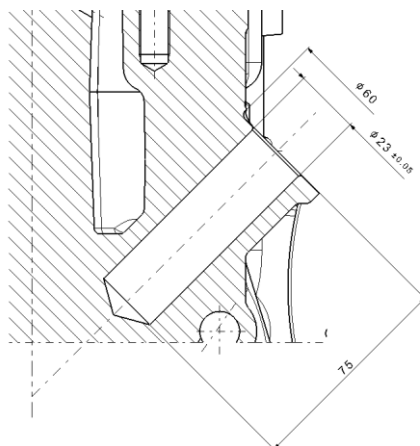
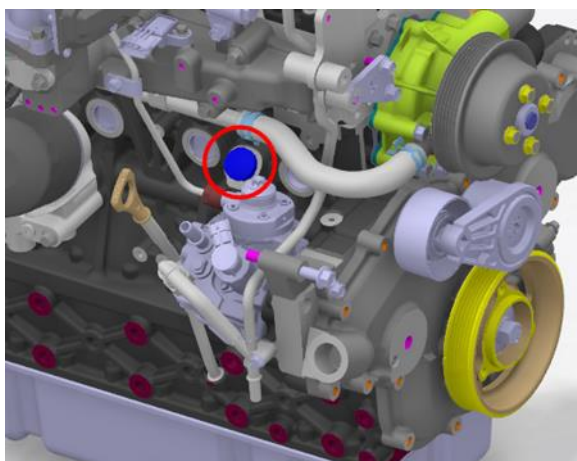
- The voltage drop between the battery & ECU input Voltage less than 0.6V (at -20degC)

The engine block heater heats the engine block that surrounds the combustion chambers. This heat improves the start-ability and reduces the warm-up time.

The port of block heater is shown as below.

3. Block Heater(400W @120V)

- Engine block heater heat the engine block that surrounds the combustion chambers. This heat provides the following functions.
 - Start-ability is improved
 - Warm up time is reduced
- Port of block heater is shown as below (DM01/02 same position)

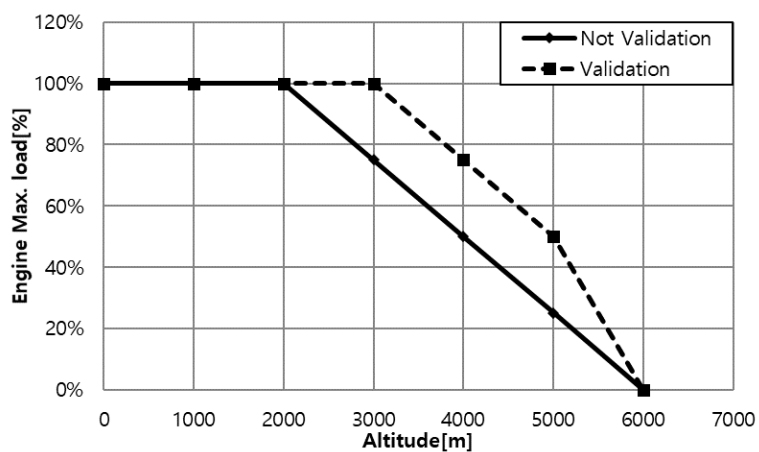


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Chapter 9. Altitude engine performance de-rating

The engine performance is guaranteed up to 2,000m altitude, generally.

HDI strongly recommends high altitude test. If not, the engine performance will be started reduction from 2000m altitude.



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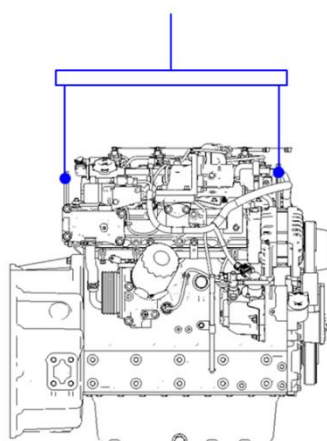
Chapter 10. Guide for machine assembly line

1. Engine Lifting

Only load the lifting hooks under tension. Remember that the capacity of a lifting hook is less as the angle between the supporting members and the object becomes less than 90 degrees.

All supporting members should be parallel to each other the chains and cables should be perpendicular to the top of the object that is being lifted.

Lifting hooks are designed and installed for specific engine. If alterations are made, ensure that correct lifting devices are provided. Consult your dealer or distributor for more information.



2. Engine to ECU serial number matching

The ECU has specific information about the engine. Therefore, the ECU and the engine serial number should be matched and installed.

3. Erasing all Faults of ECU

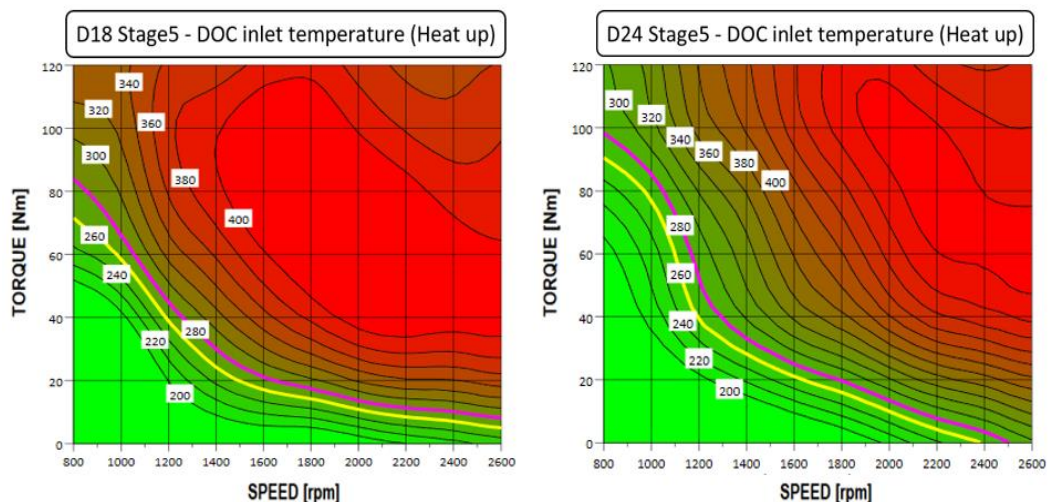
To prevent recording faults in the assembly line, Key-On should be performed after completing the machine. Before the Machine gets out of the factory, all faults of ECU should be erased using HDI Diagnostic Tool.

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Chapter 11. Minimum load requirement

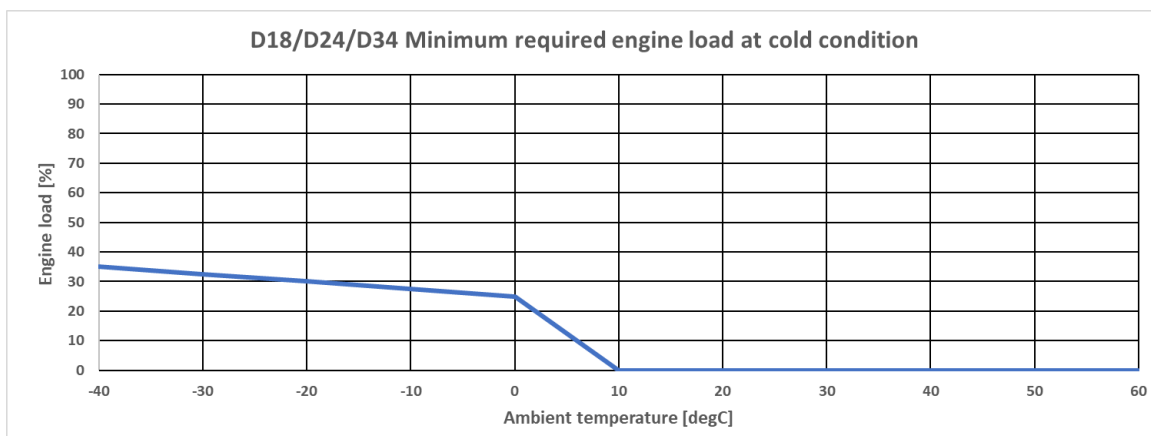
1. Minimum requirement load for DPF regeneration(DeSOx)

The minimum DOC inlet temperature for robust DPF regeneration(DeSOx) should be higher than 260degC. In terms of DPF regeneration(DeSOx) quality(efficiency) side, the soot could not be fully burned with lower exhaust gas flow in too low engine speed and load condition. It means that the high engine speed and load condition is better than robust DPF regeneration(DeSOx) This is also why set the engine speed as high as possible during manual regeneration(DeSOx)



2. Minimum load requirement at cold condition (especially Generator)

- The purpose is to provide low load and low temperature operating DeSOx, & regeneration guidance
- Prolonged operation in defined zone (typically several hundred hours) may result in degradation over time of the effectiveness of after-treatment system thermal management. Condensation of exhaust hydrocarbons can lead to a buildup of particulate matter on the face of the DOC. Operation for more than two hours at 30-40% load should reverse this buildup.



Chapter 12. Emission related installation instructions

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1. Emission related Installation Instructions

Failing to follow these instructions when installing a certified engine in a piece of nonroad equipment violates federal law(40CFR 1068.105(b)) subject to fines or other penalties as described in the Clean Air Act and EU Regulation. Tampering with the engine voids the US and EU type-approval of that particular engine.

These instructions are intended to give the installer of the engine all of the information that is necessary to properly install the engine and related components into the chassis. The United States Environmental Protection Agency (EPA) requires that the manufacturer of the engine provide installation instructions to the equipment manufacturers as defined in the Code of Federal Regulations (40CFR 1039.130).

The following instructions must be strictly adhered to when assembling a Hyundai HDI engine and the product requirements specified in the document followed.

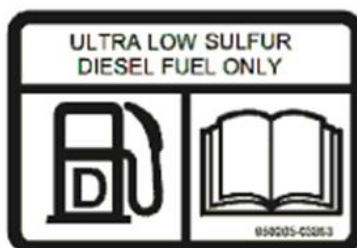
Install the intake and exhaust systems and any other components in accordance with the specifications provided in the document. Hyundai HDI may request the machine manufacturer to modify the original exhaust piping to satisfy the requirements described in 40 CFR 1039.205(u), if necessary.

Item	Chapter
Equipment labeling requirement	Chapter12-2
Electrical System	Chapter2, Chapter6 - 4
Exhaust System (After-treatment system)	Chapter4
Air Intake system	Chapter6
Air Cooler system	Chapter7
NCD & PCD Inducement	Chapter4 - 3
Guide for Machine assembly line	Chapter10
Emission Control Information Label	Chapter12-3

* NOTE: Do not install a constant-speed operation engine for variable-speed applications. (i.e. Do not use a product with a “constant speed only” EPA emission control label for variable-speed applications

2. “ULTRA LOW SULFUR DIESEL ONLY” Label.

- Attach “ULTRA LOW SULFUR DIESEL ONLY” label in accordance with EPA emission control regulation (40 CFR 1039.104(e)). A fuel inlet label must be attached to the machine near its fuel inlet. Create a separate label with the statement: “ULTRA LOW SULFUR DIESEL ONLY”. Permanently attach the label near the fuel inlet & engine name plate of machine



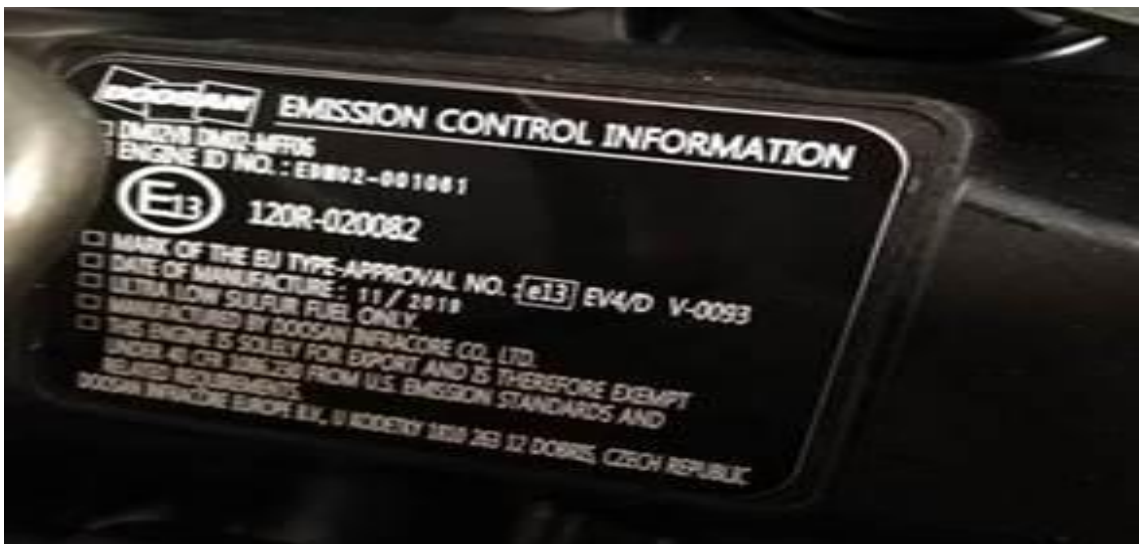
G2 Diesel Engine Installation Guide – DM01, DM02

3. Emission Control Information Label

- Where information relating to emission control is not visible during normal engine maintenance after installation, add a duplicate label on the equipment, as described in 40 CFR 1068.105.



[EPA & CARB Tier4 Final Label]



[EU Stage5 Label]

- To create a duplicate label, a written request, including the company's letterhead, must be sent to Hyundai HDI with the following information:
 - i. Machine type and engine and machine models that need label duplication
 - ii. Family (according to the original engine label).
 - iii. Reason for duplicating the label (per model)
 - iv. Number of duplicate labels needed

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- Upon receipt, attach the label to the equipment and make sure that it stays attached during normal operation and not normally requiring replacement. An average person should be able to easily read the descriptions on the label. Destroy any unused duplicate labels. Keep the following records for at least eight years after the end of the model year, shown on the engine label:
 - i. A copy of your written request.
 - ii. Drawings or descriptions for applying the duplicate labels to the equipment.
 - iii. A count of duplicate labels used and destroyed.
- For further details on the Electronic Code of Federal Regulation, refer to the website below:

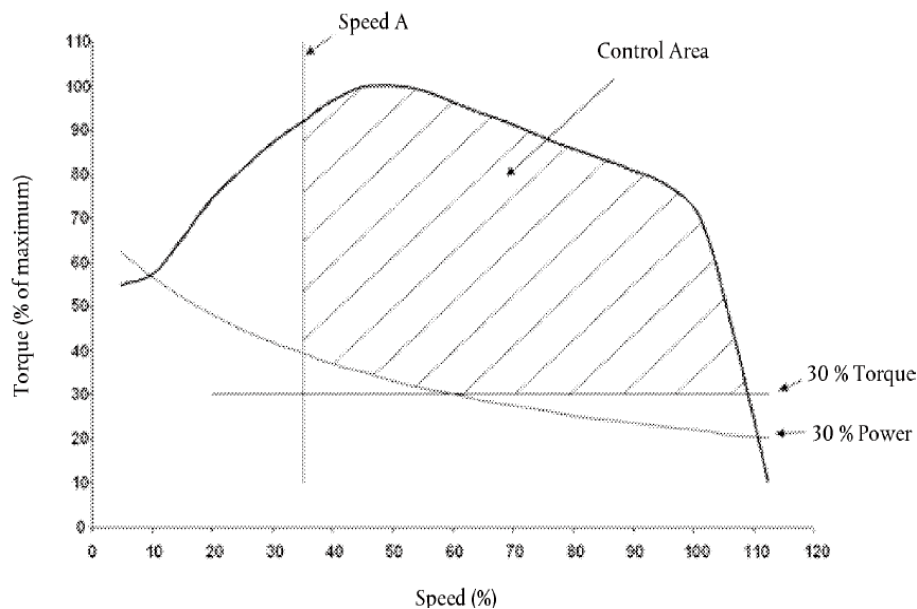
http://www.ecfr.gov/cgi-bin/text-idx?SID=9b8ddd011a04ff79dc10087b715d61cd&mc=true&tpl=/ecfrbrowse/Title40/40tab_02.tpl

4. Equipment-based Constraints (only for Stage-V engine)

The installation of the engine shall not permanently constrain the engine to exclusively operate within a power range corresponding to a (sub-)category with gaseous and particulate pollutant emission limits more stringent than the (sub-) category the engine belongs to.

Equipment manufacturers are prohibited from constraining the engine to operate permanently at speed and load points outside of the NTE (Not-to-Exceed) control area for the engine's broadest certified torque curve. Otherwise, the constraints are considered to be tampering according to the EU Regulation.

The definition of the NTE (Not-to-Exceed) control area is illustrated by the fundamental graph and explanations below.



The Not-to-Exceed control Area can be defined as follows:

Upper torque limit: full load torque curve;

Speed range: Speed A to n_{hi} ;

Where

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$$\text{Speed A} = n_{lo} + 0,15 \times (n_{hi} - n_{lo});$$

n_{hi} : high speed (the highest engine speed where 70 % of the maximum power occurs)

n_{lo} : low speed (the lowest engine speed where 50 % of the maximum power occurs)

The following engine operating conditions shall be excluded from testing:

points below 30% of the maximum torque

points below 30% of the maximum net power

If the measured engine speed A is within ± 3 % of the engine speed declared by the manufacturer, the declared engine speeds shall be used. If the tolerance is exceeded for any of the test speeds, the measured engine speeds shall be used.

Intermediate test points within the control area shall be determined as follows:

%torque = % of the maximum torque

$$\% \text{speed} = \frac{(n - n_{idle})}{(n_{100\%} - n_{idle})} \times 100$$

Where: $n_{100\%}$ is the 100% speed for the corresponding test cycle.

5. Delivering an engine separately from its exhaust after-treatment system

In the event where the engine is delivered separately from the exhaust after-treatment system, you shall confirm to Hyundai HDI that the engine has been brought into conformity with the approved engine type or engine family according to the instructions received and that all checks necessary to ensure the proper functioning of the assembled engine according to the approved engine type have been conducted.

Where you receive a regular supply of engines from Hyundai HDI, the confirmation set out in above must be provided to HDI at regular intervals agreed between the parties, but not exceeding one year.

6. Carbon Dioxide (CO₂) Emission (only for Stage-V engine)

The CO₂ measurement results from testing at a fixed test cycle under laboratory conditions does not constitute in any way that a(n) (parent) engine representative of the engine type (engine family) and shall not imply or express any guarantee of the performance of a particular engine. For further details on the test results, refer to HDI's Engine Manual.

7. Warning Indication

Machine manufacturers must install an alarm and inducement system (lamp, text display, beep, etc.) to notify the end users of warning.

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Chapter 13. Cleanliness for engine circuits

1. Lubrication system

The parts mentioned below must meet their required cleanliness to prevent engine failure potentially arising from the entry of foreign particles.

- I. Oil Hose
 - Mass : 4mg /1000 cm²
 - Size : max 400µm
- II. Oil filter adapter housing
 - Mass : 1.5mg
 - Size : max 400µm

2. Cooling System

No specified requirement for cooler and coolant plumbing Coolant must satisfy industrial standards

3. Air inlet, between filter element and engine

- Component cleanliness of Intake system including air is critical to the turbocharger designed to function through all of its lifetime.
- Turbocharger suppliers don't specify values for particle size or weight, but they ask following :
 - I. Any particulates and drops flowing into the compressor inlet side are not permitted which will damage compressor wheel because the wheel assy of turbocharger is rotated over 100,000rpm.
 - II. Intake system shall be clean and free of debris, residual abrasive material and corrosion products.
 - III. In addition, intake system components shall be maintained air tighten seal to prevent foreign matter from entering.

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4. After-treatment system

- Inlet line for Supply Module (Including DEF Tank and DEF plumbing)

Screen at Inlet Connector:

The screen at inlet connector is only a last chance for screening particles at the first run after installation.

AUS 32 screen at inlet connector	103 µm mesh width
----------------------------------	-------------------

Permitted particles at screen at inlet connector over lifetime:

Particle Classes	Particle Size [µm]			
	≥50 - <100	≥100 - <200	≥200 - <500	≥500
Number of Particles	n_1^*	n_2^*	n_3^*	0*
Permitted threshold of screen load = 11mm ² ** (= 17% of available free screen area)				
$A_{1,2,3} = d^2 \cdot 3.14 / 4 \cdot n_{1,2,3}$... screen load per particle class [mm ²] d ... upper diameter of particle class [mm] n ... number of present particles per class (Example for particle class "≥50 - <100µm": $A_1 [\text{mm}^2] = 0.1^2 \cdot 3.14 / 4 \cdot n_1$) Total sum of screen load for all particle classes $A_1 + A_2 + A_3 \leq 11 \text{mm}^2$ **				
*) A cleanliness check from customer for his components is necessary **) These limits are valid for particles except fibres and fluffs				

The customer must assure that the screen at the supply module inlet connector is not blocked due to fibres or fluffs.

- Inlet line for Dosing Module (Including DEF Tank and DEF plumbing)

Particle classes	Particle Size [µm]				Screen load over lifetime
	25 - 50	50 - 100	100 - 200	200 - 600	
Number of allowed particles over lifetime	500	180	30	3	≤ 3.5 mg

The sieve at the dosing module valve is implemented to block residual dirt. Exceeding the allowed particle limits can lead to malfunction or even cause a damage of the component.

The customer must assure that the sieve at the dosing module valve is not blocked due to fibres or fluffs.

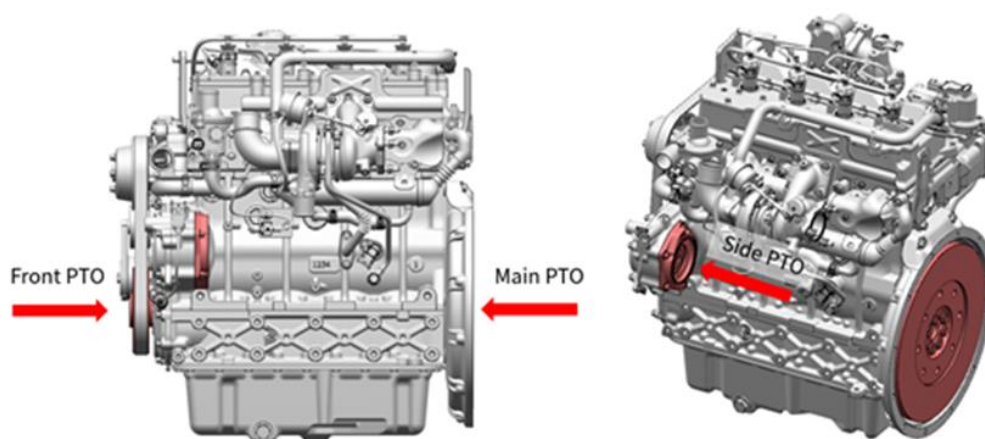
- Exhaust, between TC and Catalyst
 - Catalyst and canning supplier's requirement is 'Foreign material is not allowed to protect catalyst'
 - No specified value for particle size or weight.

G2 Diesel Engine Installation Guide – DM01, DM02

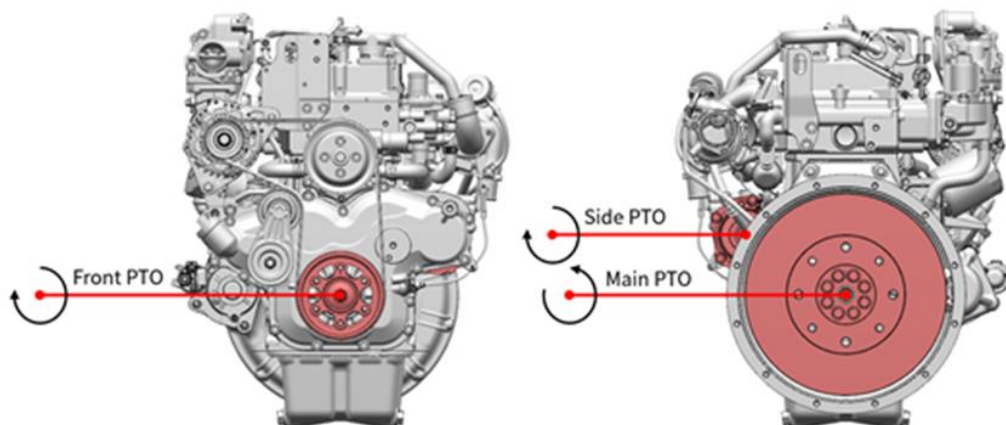
Chapter 14. Power take-off System

The Power take-off (PTO) system provides transmitting engine power to customer's machine by various method.

Power Take-Off	Mounting Position	Drive method
Main PTO	Flywheel	Direct mounting drive, Belt drive
Front PTO	Crankshaft Pulley	Direct mounting drive, Belt drive
Side PTO	PTO Adaptor	Spline



< picture 11-1: PTO Mounting position >



< picture 11-2: Rotating direction >

1. Main PTO and Front PTO

1-1) Direct mounting drive

This driving system is for the machine by directly mounted machine such as a hydraulic pump, transmission or etc by using a coupling to flywheel or crankshaft pulley. When using this system, the installation must meet the below requirements.

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1-2) Permissible external thrust load: 2,157.2 N

A directly mounted device at the engine makes external thrust load and that loading at the engine. If the external thrust load is too big, it will damage the engine. Therefore, to protect the engine, the external thrust load is restricted as follows table.

1-3) Permissible PTO torque

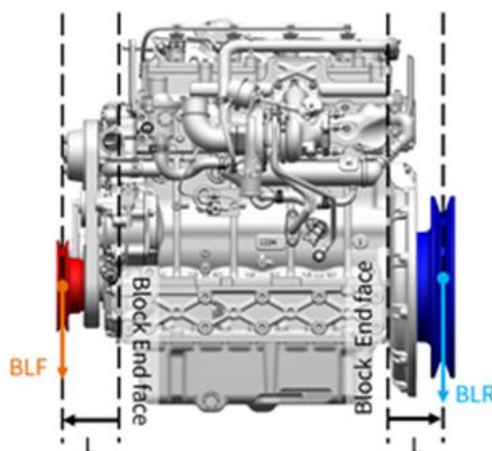
Under conditions that exceed the allowable conditions described below, engine damage or abnormal vibration may occur.

PTO	Permissible	Restrict condition
Main PTO (DM01)	100% torque is available.	Flywheel and directly mounted inertia - Min. 0.3 kgm ² - Max. 0.6 kgm ² - Available in all rpm range
Main PTO (DM02)	100% torque is available.	Flywheel and directly mounted inertia - Min. 0.3 kgm ² - Max. 0.7 kgm ² - Available in all rpm range
Front PTO (DM01 & DM02)	100% torque is available	CRS Pulley and directly mounted inertia - Max. 0.015 kgm ² Available up to 2,300 rpm - Only use front PTO at fixed rpm mode

1-4) Belt drive

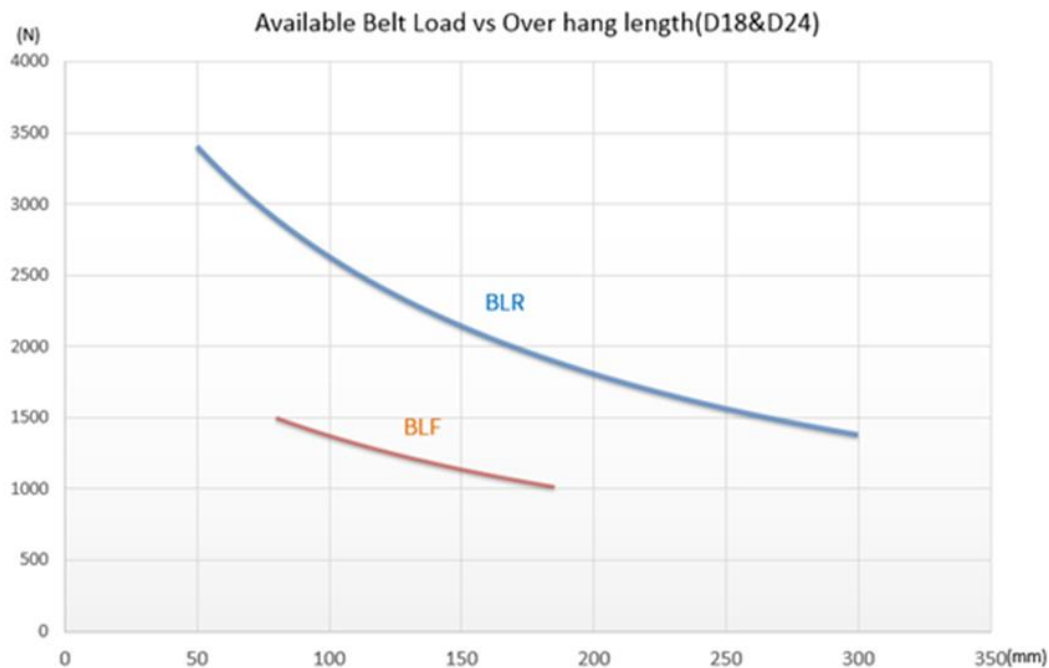
Belt Load (Tension) may damage the engine when power is drawn by using Belt, so it is available within the range of use that satisfies the following limitations.

- BLF: Belt Load at Front side (Pully mount)
- BLR: Belt Load at Rear side (Flywheel mount)
- L: Overhang length between the end face of the cylinder block and the center of pulley belt groove



< picture 11-3: Belt load at engine >

G2 Diesel Engine Installation Guide – DM01, DM02



< picture 11-4: Available belt load >

2. Side PTO (Hydraulic pump drive)

2-1) Specification

Flange type	SAE 82 A, 2-bolts flange (SAE J744)			
Spline standard	DIN 5482	ANSI B92.1	ANSI B92.1	ANSI B92.1
Teeth	9t	9t	10t	11t*
Dimension	17 × 14	16" / 32"	16" / 32"	16" / 32"
Pressure angle	30°	30°	30°	30°
PTO gear ratio	1.034 (CRS 30t / 2nd PTO 29t)	1.034 (CRS 30t / 2nd PTO 29t)	1.034 (CRS 30t / 2nd PTO 29t)	1.154 (CRS 30t / 2nd PTO 26t)
Continuous torque	110 Nm	85 Nm	110 Nm	100 Nm
Peak torque**	130 Nm	100 Nm	130 Nm	120 Nm
Max speed	2,690 rpm	2,690 rpm	2,690 rpm	3,000 rpm

* The ANSI 11t is only for the tractor application.

** Operating time at peak torque: Maximum 8 seconds, while not exceeding 5% of the total life cycle.

2-2) Calculate the load of the hydraulic pump

Calculated power **P**: $\Delta p \times Q / \eta \times 600$ (kW)

Calculate driving torque **T**: $P \times 9549 / n$ (Nm)

Total efficiency **η**: 0.8~0.85

Pressure **Δp** (bar), Flow **Q** (L/min), Pump speed **n** (rpm)

G2 Diesel Engine Installation Guide – DM01, DM02

Chapter 15. Engine Protection Strategy

It is designed to hold the engine speed after starting until the turbocharger oil pressure is over the threshold (180kPa)

- Holding engine speed of DM01: below 1,000rpm
- Holding engine speed of DM02: below 900rpm

G2 Diesel Engine Installation Guide – DM01, DM02

Chapter 16. Engine Mounting system

1. General

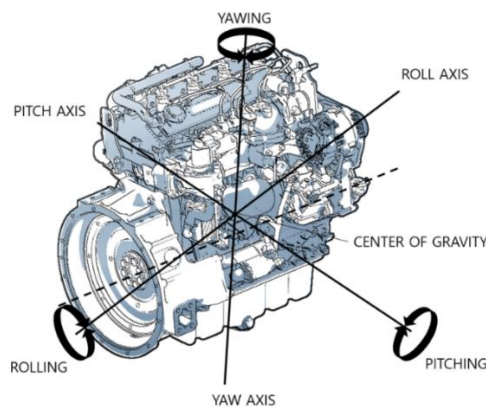
When the engine mount is designed, there are a few basic considerations.

- A properly designed flexible mounting system is preferred to other mounting system configurations.
- For optimal design of the flexible mounting, the natural frequency of the mounting system including the engine mass should be designed to be less than 40% of the engine's lowest exciting frequency.
- The vibrations between engine and equipment must be isolated to protect the systems.
- The engine movement from shock, inertia or force should be limited by the engine mounting system to prevent the contact between the engine and chassis components of the equipment.
- The first and second order vibrations must be adequately dampened by the engine mounting system, and the resonances within the normal operating speed range must not be induced.

2. The Nature of Engine Vibration

- The movement of the isolated engine has six degree-of-freedom as three translational motions and three rotational motions.
- Vibration forces is a type of vibration in which a force is repeatedly applied to a system. In case of the engine system, it is result from the reaction force by reaction between the engine and mounting system.
- In case of the in-line four-cylinder engine, vertical second order shaking force is excited in the vertical direction, and it will cause the vertical motion of the engine.

[Modes of vibratory motion]



G2 Diesel Engine Installation Guide – DM01, DM02

3. Maximum bending moment

- Ideally, engine mounting system should be arranged symmetrically about the combined gravity center of the engine and bolted-in equipment. This reduces the excitation of other modes of vibration when the system is vibrating in one specific direction.
- The bending moment can be calculated by the reaction force at engine supports and the support positions as below formulas.
- The following formula can be used to calculate the bending moment according to the reaction force of each engine support and the support position.

- Front reaction force:

$$R_1 = (W_e + W_t - R_2 - R_3)$$

- Rear reaction force:

$$R_2 = \frac{(W_e \times L_1 + W_t \times L_4 - R_3 \times L_5)}{L_3}$$

- Transmission(T/M) reaction force:

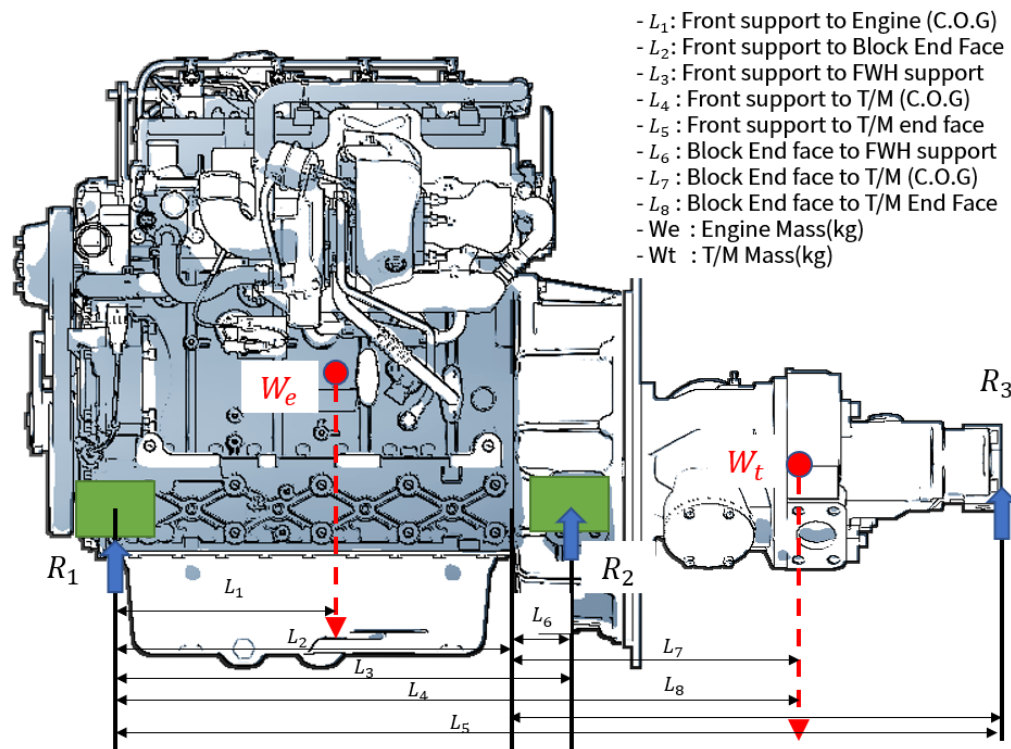
$$R_3 = \frac{W_e \times L_1 + W_t \times L_4 - \frac{W_t \times L_7 \times L_3}{L_6}}{L_5 - \frac{L_8 \times L_3}{L_6}}$$

- Static bending moment:

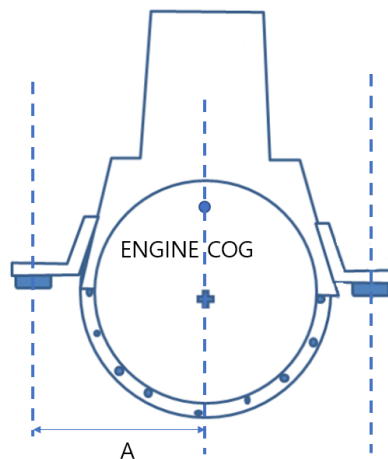
$$R_2 \times L_6 + R_3 \times L_8 - W_t \times L_7 = R_1 \times L_2 - W_e \times (L_2 - L_1)$$

G2 Diesel Engine Installation Guide – DM01, DM02

[Power train schematic to calculate the bending moment and reaction force]



- In order to reduce the torsional stiffness of the engine mounts, it is also desirable to locate the engine mounts laterally as closely as practicable to the center of the engine as below the figure. This will give the best isolation for a given set of mounts.

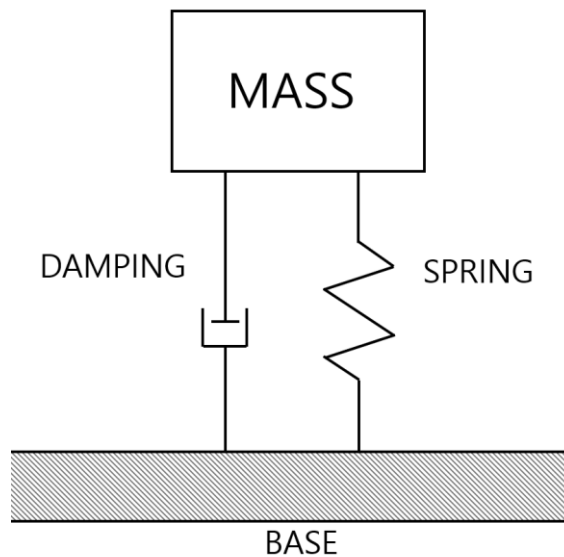


G2 Diesel Engine Installation Guide – DM01, DM02

4. Basic Theory of Flexible Mounting Systems

- When a vibration is excited to a mass-spring system, the system will also be caused to vibrate itself. The nature of this resultant vibration will be a function of:
- The point of application of the input force.
- The frequency and magnitude or amplitude of the input force.
- The natural frequency of the mass-spring system.
- The damping properties of the system.

[Vibration system]



- Transmissibility of vibration is defined as the vibration transmittance. The transmissibility (τ) is determined by the engine's kinematic frequency (f) and the mount's natural frequency (n).

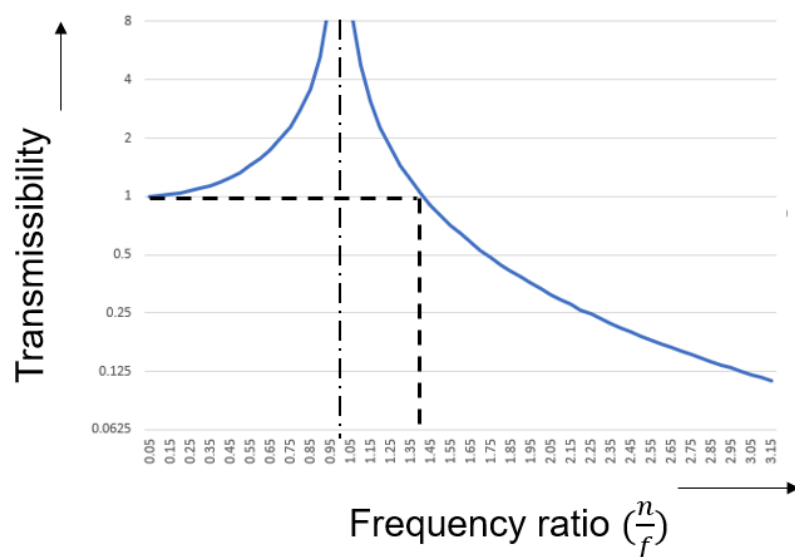
■ F_E : Forced excitation force of equipment

■ F : Forced transferred to the base

$$\tau = \frac{F_E}{F} = \left| \frac{1}{1 - \left(\frac{n}{f}\right)^2} \right|$$

G2 Diesel Engine Installation Guide – DM01, DM02

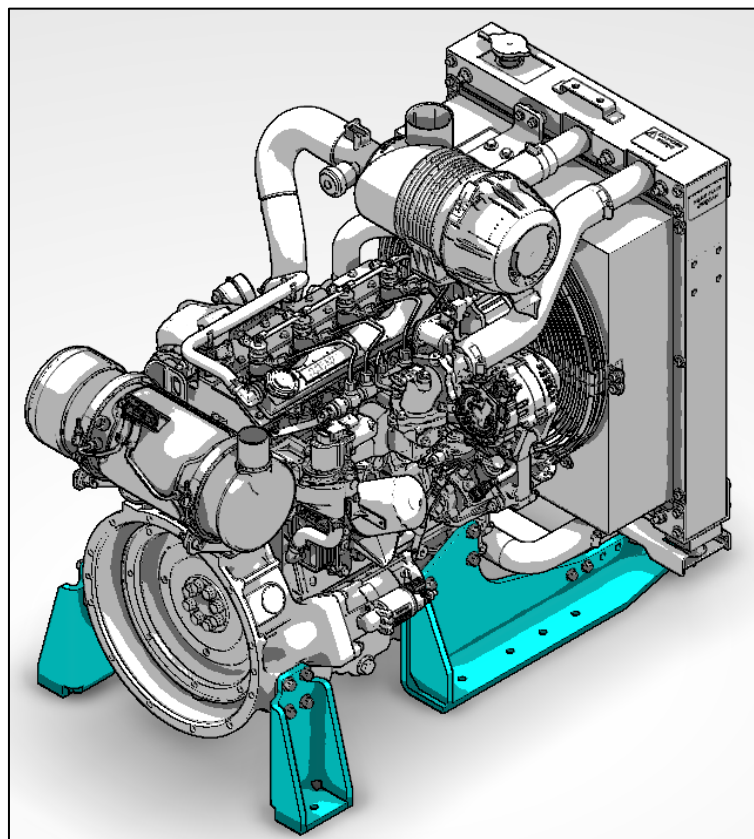
[Vibration transmissibility]



- The engine mount with high natural frequency and over 1.4 frequency ratio should be selected to effectively reduce the vibration.
- DI recommend that mounting types designed and provided by the customer. The well-known mounting manufacturers can advise you in this matter.

5. Engine Mount Bracket Option

DI supply engine mount bracket for option part like below, this mount bracket consists of engine mount bracket and radiator bracket for All in one.



<Example: Engine Mount Bracket supplied by DI>

G2 Diesel Engine Installation Guide – DM01, DM02

6. Engine Mount Position Recommendation

Mount Bracket which, supplied as option according to customer's choice by DI provides 4 mount position options.

Customer can use any position for engine mount, but DI preferably recommend using position 1 (Please refer to below picture)

