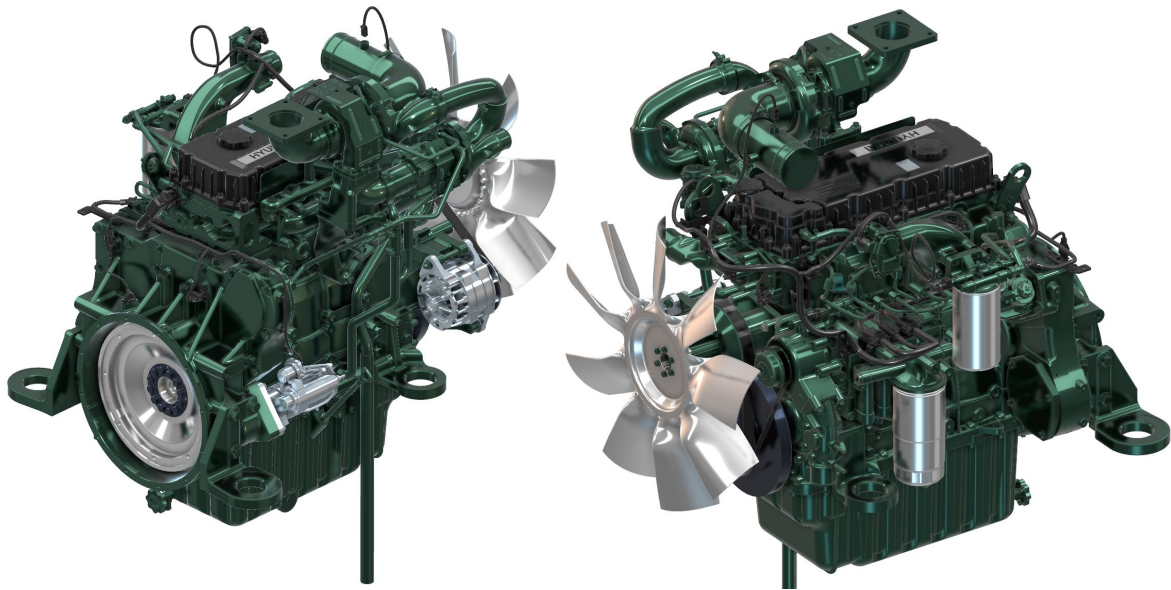
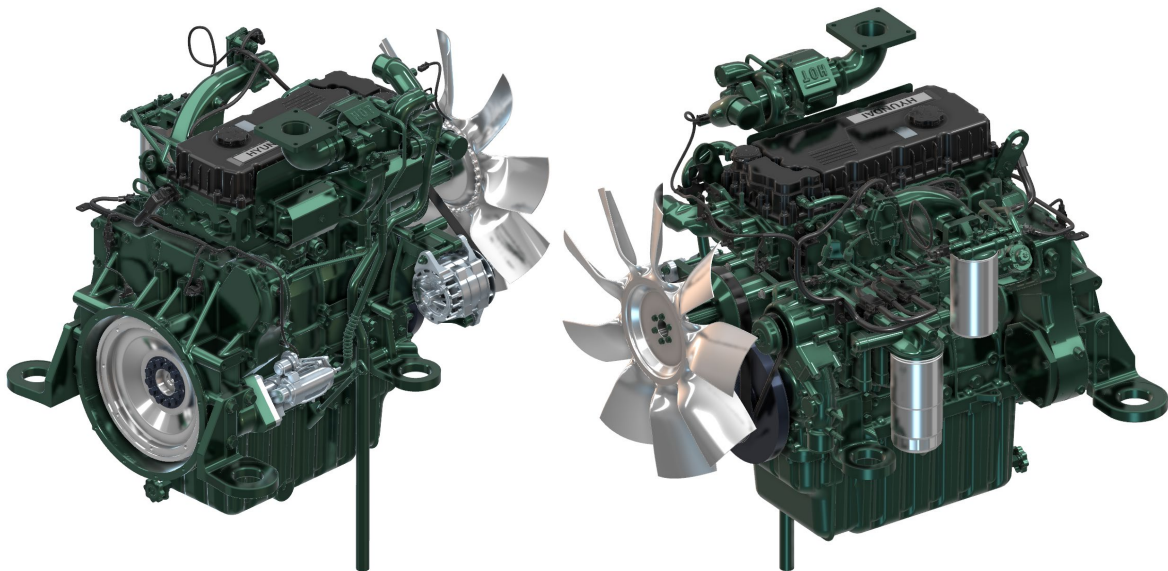
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[2 Stage Turbo Charger]




[Waste Gate Turbo Charger]

## DX05 Standard Engine

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**<Revision list>**

Date	Contents	Page	Who	Revision No.
24.03.14	Initial Release	-	DM Kang	V0.0
25.01.20	Updated All	-	SY Hwang	V1.0
25.02.14	Consistency Update	-	ALL	V1.1
25.05.12	Updated 9.1 for the DPF regen/inhibit switch, Accel. Pedal and ECU circuit diagram	87	H Choi	V1.2
25.06.17	oil change note for consecutive service regens	68	L.hyun	V1.3

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8. **Air Intake & Exhaust System**
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10. **Altitude Engine Performance De-rating**
11. **The Guide for Machine Assembly line**

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## 1. Specification

DX05 Standard	
MANUFACTURE	HD HYUNDAI INFRACORE Co.,Ltd.
ENGINE MODEL	DX05 Standard
USE	FOR Standard
TYPE	4CYCLE, TURBOCHARGED, INTERCOOLED DIESEL ENGINE


CYLINDER	
TYPE	LINERLESS
NUMBER	4
ARRANGEMENT	VERTICAL IN-LINE
COMBUSTION TYPE	DIRECT INJECTION (REENTRANT TYPE COMBUSTION CHAMBER)
BORE × STORE	110 × 132 mm
TOTAL PISTON DISPLACEMENT	5,018cc
COMPRESSION RATIO	18.4 : 1
FIRING ORDER	1 – 3 – 4 – 2
ROTATION	COUNTER CLOCKWISE VIEWED FROM FLYWHEEL

VALVE MECHANISM	OVER HEAD VALVE
VALVE LASH	HLA TYPE (AUTOMATIC ADJUSTMENT)
TIMING	OPENING CLOSING
Tier-3 INTAKE VALVE	4.0 DEG. BTDC 51.0 DEG. ABDC
Stage5/Non-Tier INTAKE VALVE	16.0 DEG. BTDC 39.0 DEG. ABDC
Tier-3 EXHAUST VALVE	43.0 DEG. BBDC 23.0 DEG. ATDC
Stage5/Non-Tier EXHAUST VALVE	43.0 DEG. BBDC 23.0 DEG. ATDC

PERFORMANCE	DX05 2-Stage T/C
ISO1585 (SAE J1349)	171(233)/2200, 955(97.4)/1400
MAX.OUTPUT , MAX.TORQUE [kW (PS) /rpm], [N-m(kg×m) /rpm]	DX05 WGT
	151(205)/2200, 830(84.6)/1400
NO LOAD MAX. ENGINE SPEED	2400 rpm
NO LOAD MIN. ENGINE SPEED	1000 rpm

WEIGHT (DRY)	
2Stage T/G	660kg (1455 lb) – w/ Fan
WGT	625kg (1378 lb) – w/ Fan
DIMENSION (L × W × H)	
Engine (2Stage T/C) - W/ Fan	1099 x 905 x 1175 mm
Engine (2Stage T/C) - W/O Fan	935 x 905 x 1175 mm
Engine (WGT) - W/ Fan	1099 x 825 x 1104 mm
Engine (WGT) - W/O Fan	935 x 825 x 1104 mm



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AIR INTAKE SYSTEM	TURBOCHARGED & INTERCOOLED
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FUEL SYSTEM	
INJECTION PUMP	BOSCH CP4 FUEL HIGH PRESSURE PUMP TYPE
FEED PUMP	GEAR TYPE
INJECTION TIMING CONTROL	ELECTRONICALLY CONTROL
INJECTION NOZZLE	MULTI-HOLE TYPE
OPENING PRESSURE	ELECTRONICALLY CONTROL (Max. working pressure 1,800bar)
FUEL FILTER	FUEL FLOW, CARTRIDGE TYPE
USED FUEL	DIESEL FUEL OIL (S<0.05%)

LUBRICATION SYSTEM	
LUB. METHOD	FULL FORCED PRESSURE FEED TYPE
OIL PUMP	GEROTOR TYPE DRIVEN BY CRANK SHAFT
OIL FILTER	FULL FLOW CARTRIDGE TYPE
OIL PAN CAPACITY	MAX 26L, MIN 15L
OIL COOLER	WATER COOLED, INTEGRAL TYPE
LUB. OIL (RECOMMENDED)	API CK-4 Grade, 10W40

COOLING SYSTEM	
COOLING METHOD	FRESH WATER FORCED CIRCULATION
COOLING WATER CAPACITY (ENGINE ONLY)	12.5 LITERS
WATER PUMP	CENTRIFUGAL TYPE DRIVEN BY BELT
CAPACITY	400 LITERS / min AT 2200 rpm (ENGINE)
THERMOSTAT	WAX – PELLET TYPE
OPENING TEMP	71 DEG.C
FULLY OPEN TEMP	85 DEG.C

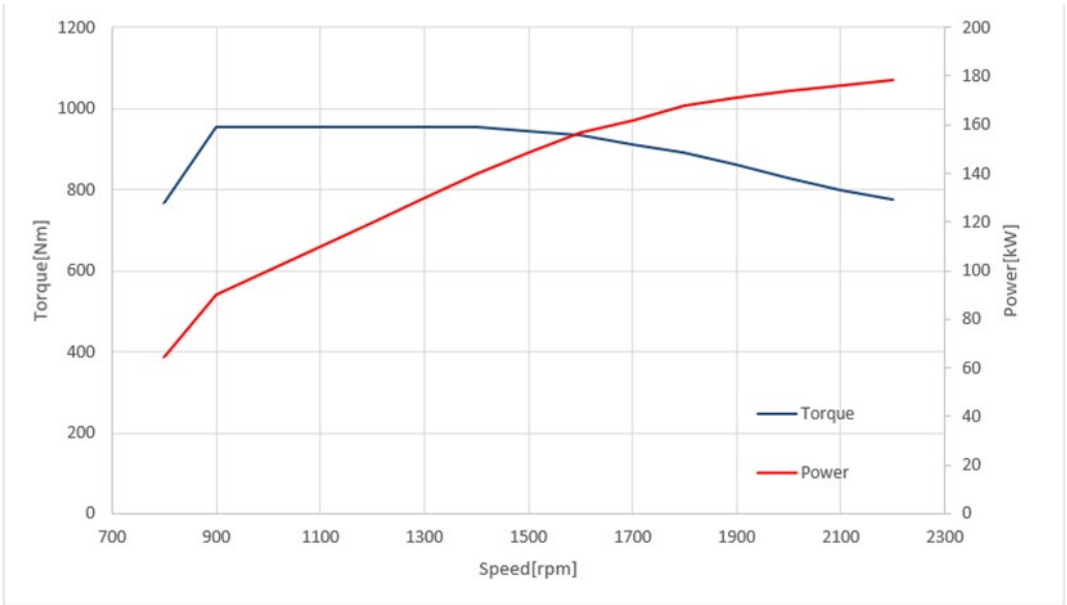
ELECTIRICAL SYSTEM	
ALTERNATOR	24V 80A
STARTING MOTOR	24V × 6.0 kW
STARTING AID	N/A
BATTERY VOLTAGE	24 V
CAPACITY(RECOMMENDED)	150 AH ´ 2 EA

POWER TAKE OFF	
PERMISSIBLE PEAK TORQUE	160 Nm (PTO #1), 140 Nm (PTO #2), 550Nm (Front PTO)
MAX PERMISSION THE ANGLE OF GRADIENT OF ENGINE	35°
LOC	BELOW 0.1 g/kWh

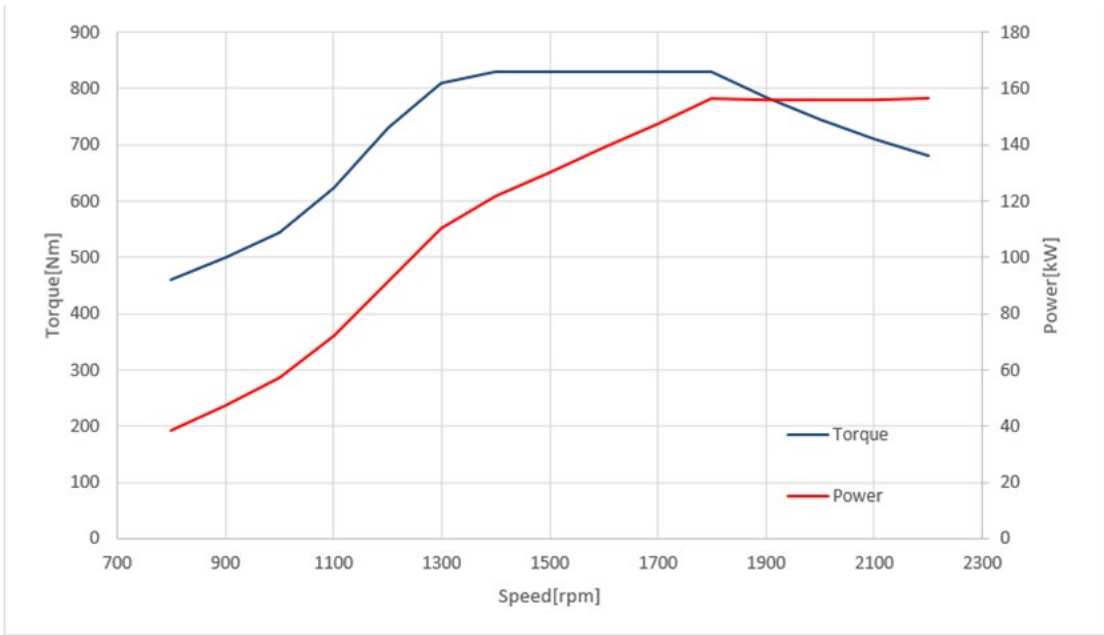
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1.1 Engine Performance

1.1.1 DX05 2-Stage T/C Parent



1.1.2 DX05 WGT Parent



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## 2. Head System

### 2.1 Headcover Temperature Limit

- Headcover Material: PP66 + GF35
- Maximum Allowable Temperature of Headcover
  - Constant Condition: Max.150°C
  - Temporary condition: Max.180°C for 5minutes after key off
- Minimum Allowable Temperature of Headcover: -40°C

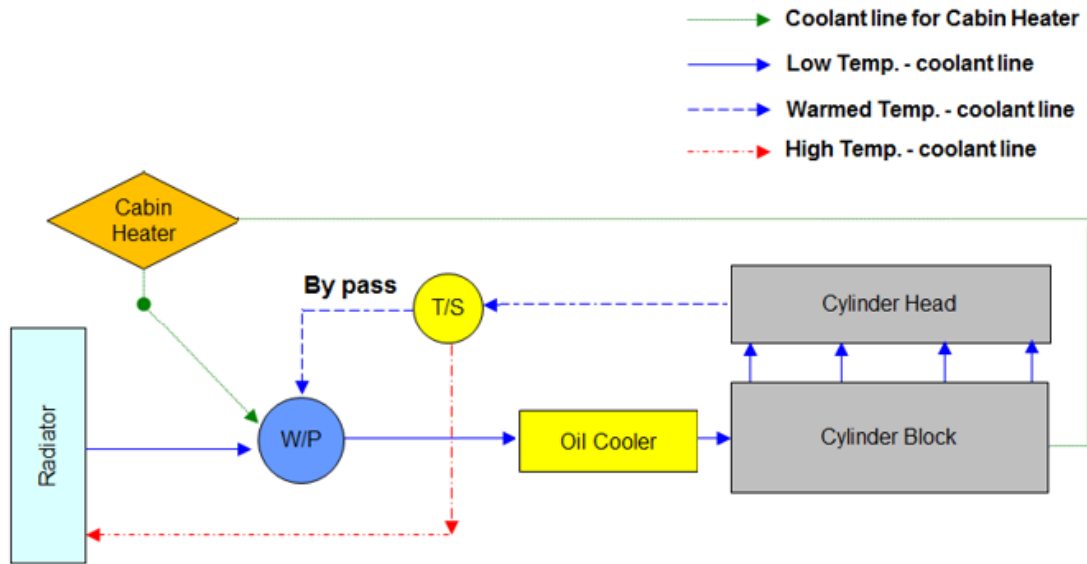
### 2.2 Exhaust Pipe installation Guide

- When the exhaust pipe passes close to the head cover, it is necessary to configure the layout so as not to exceed the maximum allowable temperature.
- If Maximum allowable is not met, Apply a heat shield so that it can be maintained below the maximum limit temperature.

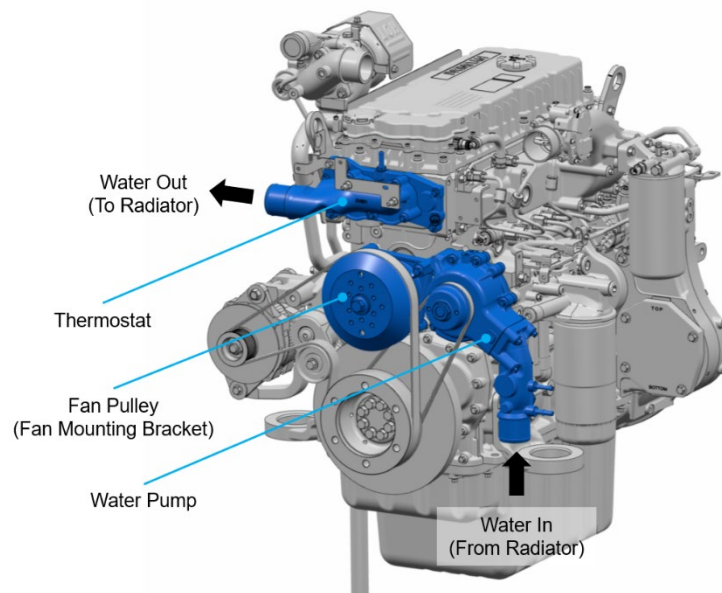
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### 3. Cooling System


#### 3.1 Cooling System Diagram



< Picture 3-1. Cooling system diagram >



< Picture 3-2. Cooling system description >

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### 3.2 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.

<b>Engine</b>	DX05	DX08
<b>Coolant volume</b>	12.5 liters	18.0 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	LLC (Long Life Coolant)
Tier4 / StageIV		General Coolant	LLC
Tier5 / StageV		General Coolant	LLC

Note: Genuine HDI LLC (part N.o for 200 L drum: 500201-00011, part N.o 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.

### 3.3 Radiator

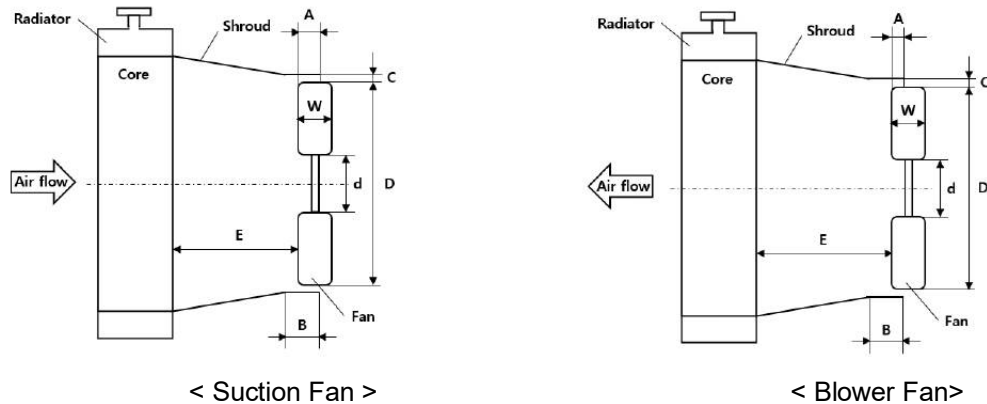
Radiator is important part that serve to release heat from the engine and need to select optimal location and capacity to maintain cooling performance and durability.

#### 3.3.1 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

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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.



< 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 ~ 25mm (0.4~1.0 inch)	
D	Fan Diameter		
E	Core-fan Clearance	d/2 to 25mm or more	
d	Fan boss diameter		
W	Projected fan width		

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

### 3.3.2 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)

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#### DX05 2-Stage T/C Parent

SUFFIX	Engine Speed (rpm)	Power (kW)	Heat rejection of the radiator(kW)	Heat rejection of the intercooler(kW)
MFP00	2200	171	73	44
MFP01	2200	162	71	41
LEP00	TBD	TBD	TBD	TBD
LEP01	TBD	TBD	TBD	TBD

#### DX05 WGT Parent

SUFFIX	Engine Speed (rpm)	Power (kW)	Heat rejection of the radiator(kW)	Heat rejection of the intercooler(kW)
MFP02	2200	151	61	27
MFP03	2200	129	53	22
LEP02	TBD	TBD	TBD	TBD
LEP03	TBD	TBD	TBD	TBD


#### DX08 2-Stage T/C Parent

SUFFIX	Engine Speed (rpm)	Power (kW)	Heat rejection of the radiator(kW)	Heat rejection of the intercooler(kW)
MFP00	2200	254	112	47
LEP00	TBD	TBD	TBD	TBD

#### DX08 WGT Parent

SUFFIX	Engine Speed (rpm)	Power (kW)	Heat rejection of the radiator(kW)	Heat rejection of the intercooler(kW)
MFP01	1800	227	91	34
MFP02	2200	207	88	35
LEP01	TBD	TBD	TBD	TBD
LEP02	TBD	TBD	TBD	TBD



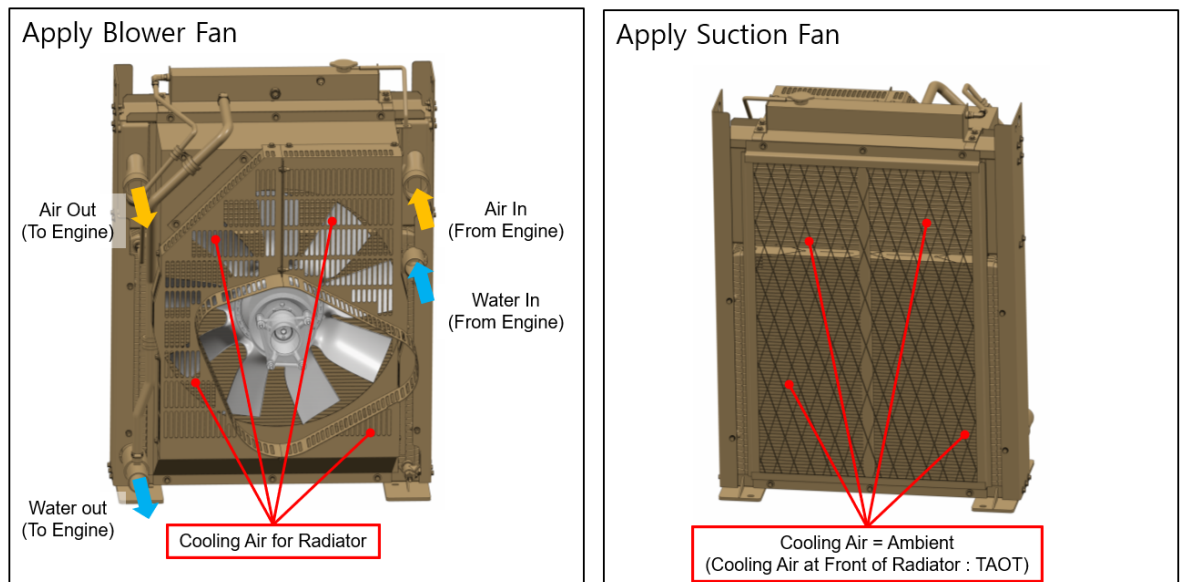
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### 3.3.3 Heat balance test


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  $T_{\text{Cooling Air}}$ , it is recommended to average after measuring four Points to reduce error.



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

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**Note:** Customer should select the fan size and speed, radiator capacity and air resistance in the engine room to satisfy Highest ambient temperature target for the machine. Temperature difference between  $T_{\text{Cooling air}}$  and  $T_{\text{ambient}}$  depends on the type of fan and engine room ventilation. (When Using Suction type,  $T_{\text{Cooling air}} = T_{\text{ambient}}$ )

Coolant temperature		Recommend Difference between radiator in. & outlet ( $T_{\text{wi}} - T_{\text{wo}}$ )	Maximum system pressure in pressurized cooling circuit	AOT (HDI supplied radiator) ( $110 - T_{\text{wi}} + T_{\text{Cooling Air}}$ )		
Optimum Temp. ( $T_{\text{wi}}$ )	Max. permissible Temp. ( $T_{\text{wi}}$ )			In moderate climates	In tropical climates	In tropical climates
80 ~ 90 °C	113 °C	8~10 K	0.9~1.5 bar	$\geq 42^{\circ}\text{C}$	$\geq 52^{\circ}\text{C}$	$\geq 62^{\circ}\text{C}$

**Note:** The AOT performance of the radiator provided by HDI can satisfy the table above, Customer should choose a radiator size considering the equipment usage conditions. (If customer use another company's Radiator, check the AOT capacity before installation)

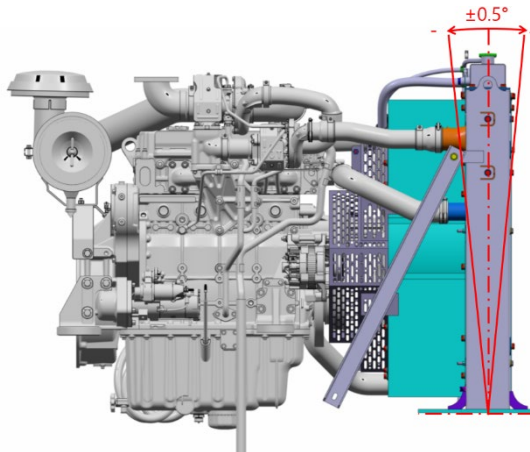
ATB represents the maximum available ambient temperature of the equipment. (the ambient temperature when the coolant is at the highest allowable temperature), therefore ATB will be decided by Temperature difference between  $T_{\text{Cooling air}}$  and  $T_{\text{ambient}}$ . If ATB is not satisfied, improving engine room ventilation by changing the fan size and speed or reducing air resistance in the engine room.


- HDI Recommendation:  $T_{\text{Cooling air}} < T_{\text{ambient}} + 10^{\circ}\text{C}$

### 3.3.4 Precautions for Installation

- 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  $0.5^{\circ}$  degree at the top of radiator)



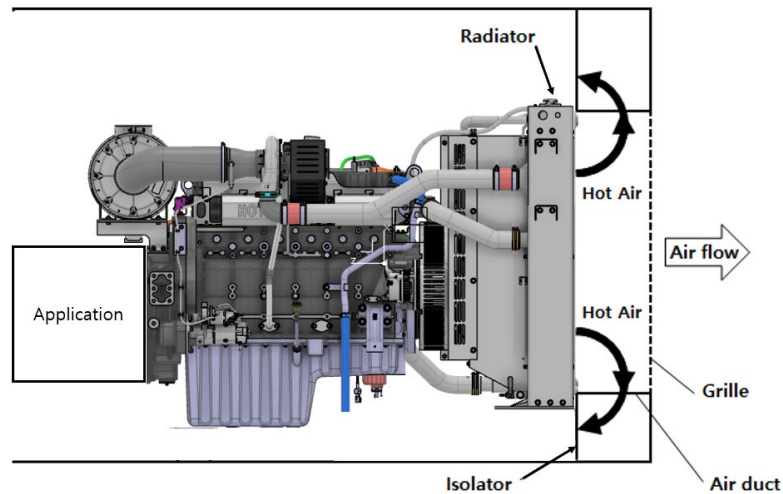
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- Clearance with counter components

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/ventilation 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.


If you want to know the details, refer to 8.3 Engine room ventilation system.

## 3.4 Cooling Hose

### 3.4.1 Specification of rubber hose

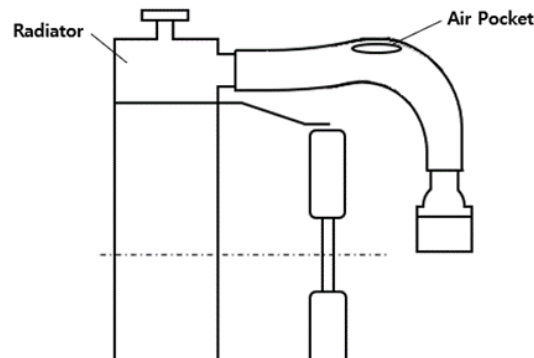
The rubber hose used in the cooling system should be durable to the heat and vacuum pressure and positive pressure of the system. If use the improper hose, it can be leak and deformed by vacuum pressure generated when coolant temperature change from high to low temperature. This interferes with the flow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

Item	Guide
Thickness	≥ 6mm
Pressure resistance	≥ 3 bar
Operating temperature	-40 ~ 120 °C
Material	EPDM with 1 or 2 Polynogic Rayon (Middle) *Reinforcement : HSW-1Ø1.6 Wire-30deg

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### 3.4.2 Precautions for cooling hose

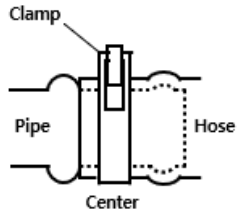
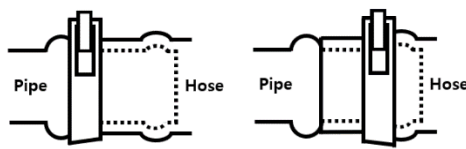
The cooling hose should be installed without contact with external component to avoid damage by contact.



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.

### 3.4.3 Hose clamp


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

### 3.5 Thermostat

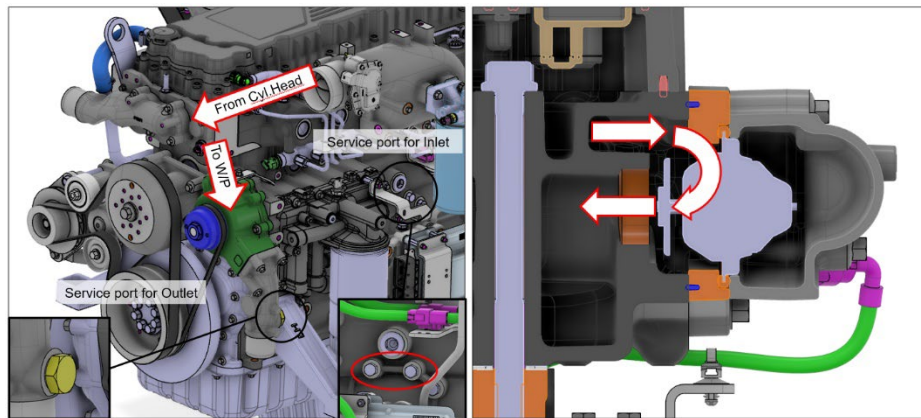
The thermostat is necessary for rapid preheating of the engine and is mainly installed cylinder head-top of the radiator line. The following table shows the thermostat specification of HDI.

Thermostat type	Opening temperature	Full open temperature	Maximum lift
Wax pellet	71°C	85°C	≥ 8mm

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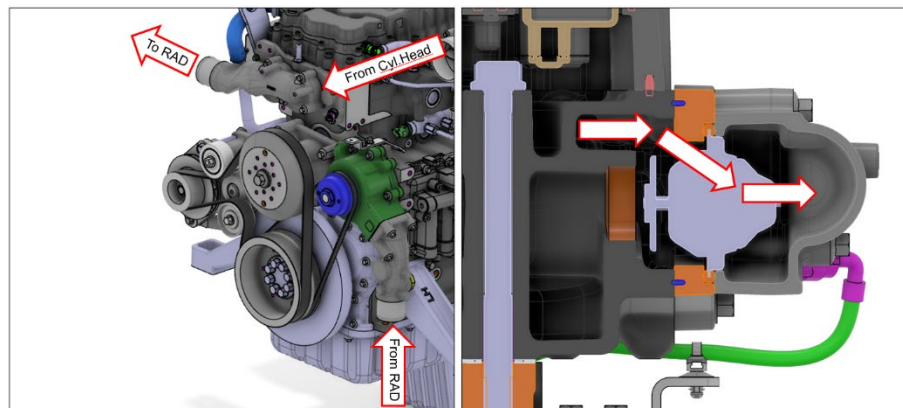
### 3.5.1 Operation of thermostat and flow of coolant

- Under Cold Condition



The thermostat valve 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.

### 3.5.2 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 water pump's service port. (Tightening Torque : 80 Nm)
- Outlet port location: Use the cyl.block's service port. (Tightening Torque : 50 Nm)

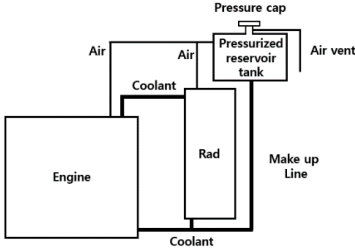
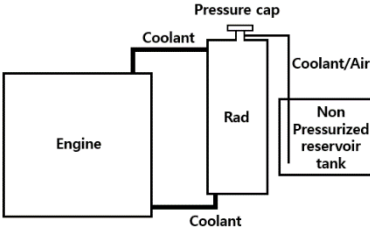
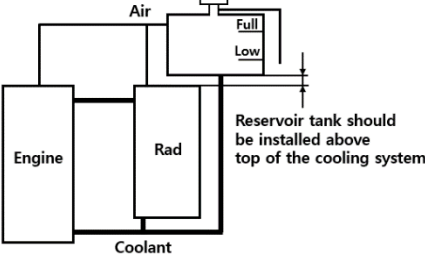
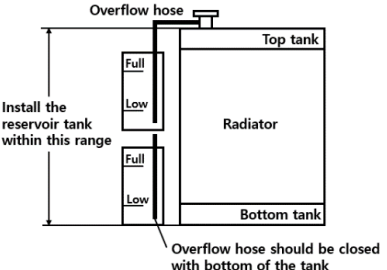
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## 3.6 Reservoir Tank


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.

### 3.6.1 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.

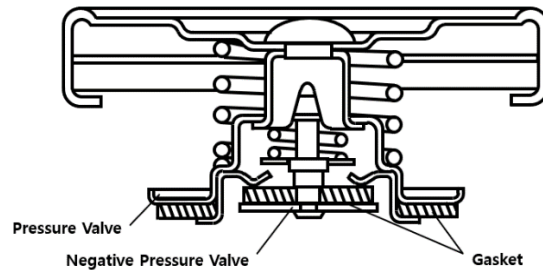
Condition	Pressurized Type	Non-Pressurized Type
Diagram		
Advantage	Easy to deaerate Available to replenish coolant immediately	Easy to design of package
Installation		
Description	Pressurized reservoir tank should be mounted at the highest for deaeration. Use the dummy radiator cap.	It should be installed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

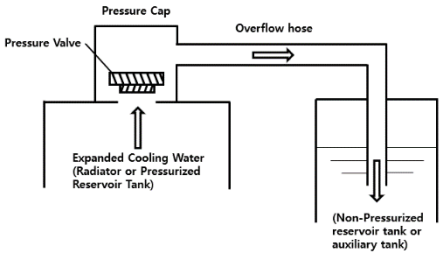
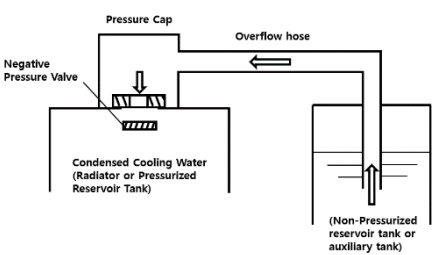
Note : Reservoir tank should be installed where the coolant level can be easily checked. If the cooling circuit is higher than pressurized tank or radiator cap in non-pressurized reservoir tank type, add an auxiliary reservoir tank for deaeration.

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### 3.6.2 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.




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.

### 3.6.3 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.



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### 3.6.4 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.

- (i) After filling the coolant at radiator and reservoir tank, operate the engine for short period to remove the air form the cooling circuit.
- (ii) If the coolant level is not just below of the filler, fill the coolant.
- (iii) Drive the engine sufficiently to open the thermostat and check that the radiator top is hot.
- (iv) Repeat this process until the coolant level is just below the filler.
- (v) Fill the reservoir tank with the coolant to the proper lint 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.

## 3.7 Cooling Fan

### 3.7.1 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.
- Lowing the fuel temperature
- Engine surface cooling
- Protecting electrical parts from heat and reducing wire harness voltage drop

### 3.7.2 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)

Engine	DX05	
Type	Blower	Suction
Part number	210101-00991	210101-00095
Fan rpm (1:1)	Air flow rate (m <sup>3</sup> /min)	
2200	330	340
1800	270	275
1500	228	230

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Engine	DX08	
Type	Blower	Suction
Part number	210101-00549	210101-01091
Fan rpm (1:1)	Air flow rate (m <sup>3</sup> /min)	
2200	410	420
1800	330	340
1500	270	275

### 3.7.3 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	<ul style="list-style-type: none"> <li>- Reduced engine room temperature</li> <li>- Reduced harness and electric parts temperature</li> </ul>	<ul style="list-style-type: none"> <li>- Increased radiator efficiency</li> <li>- Reduced fan noise</li> </ul>

### 3.7.4 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.

## 3.8 Water Pump

### 3.8.1 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.

Speed[Rev/min]		Coolant flow rate [l/min]	
Engine	Water Pump	DX05	DX08
2200	3740	400	400
1800	3060	325	325
1500	2550	272	272

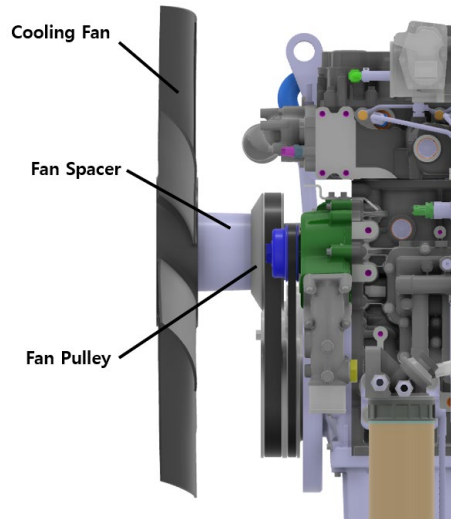
Note: Water pump Speed / Engine Speed Ratio is 1.7

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.

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

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### 3.9 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.

DX05/08	Length	Weight	Unbalance weight	Thrust force
Fan	-	≤ 35N	≤ 70g.cm	≤ 400N
Fan spacer	≤ 120mm	≤ 15N	≤ 20g.cm	-
Fan clutch	Not allowed			

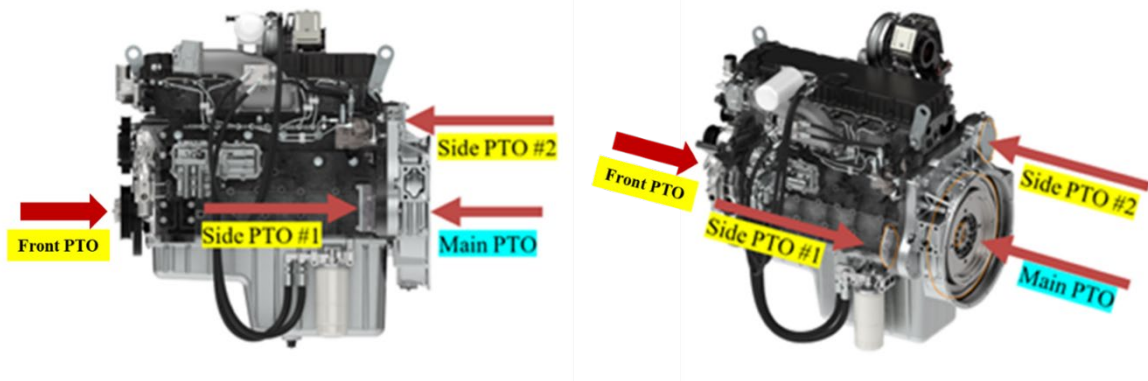
Note: Length is based on surface of fan pulley contacted fan spacer.

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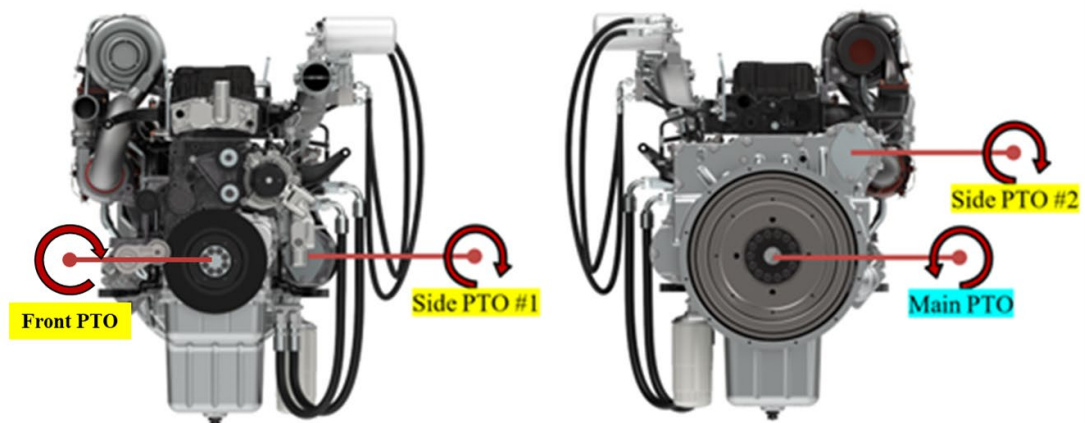
## 4. POWER TAKE-OFF SYSTEM

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
Side PTO #1	PTO Adaptor (Timing Gear Case)	Spline </td
Side PTO #2	Flywheel Housing	Spline
Front PTO	Crankshaft Pulley	Direct mounting drive



< PTO Mounting Position >



< PTO Rotating Direction >

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## 4.1 Main PTO

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. When using this system, the installation must meet the below requirements.

PTO	Permissible	Restrict condition
Main PTO (DX05)	Using only the Main PTO - 100% engine torque is available. Used with Side/Front PTO - [Engine torque – (Sum of Side/Front PTO Torque)]	Flywheel Direct Mounting - Flywheel inertia 0.87 kgm <sup>2</sup> - Available up to 2,500 rpm


- Permissible external thrust load : Max. 7,800 N (CRS axial direction, common requirement)

## 4.2 Side PTO (Hydraulic Pump Drive)

This driving system is only for the machine by directly mounted hydraulic pump with Spline Shaft. When using this system, the installation must meet the below requirements.

PTO Mounting Position	Side PTO #1 - TGC	Side PTO #2 - FWH	
Engine	DX05/DX08	DX08	DX05
Flange type	SAE 101 B (SAE J744)	SAE 101 B (SAE J744)	SAE 82 A (SAE J744)
Flange Bolting Spec.	M12x1.75, Tap Dp.24, Vertical Aligned 2-Bolt Pattern		
Spline Standard & Tolerance	ANSI B92.1, Class 5		
Spline Pitch	16" / 32"		
Pressure angle	30°		
Spline Teeth	13t	13t	10t or 9t
PTO Rotating Direction (Viewed from the PTO flange)	CW (Clockwise)	CW (Clockwise)	
PTO gear ratio	1.212 (CRS 40t / Side PTO #1 33t)	0.976 (CRS 40t / Side PTO #2 41t)	
Continuous torque	140 Nm	120 Nm	
Permissible Peak torque *	160 Nm	140 Nm	
Max speed	3,030 rpm	2,147 rpm	

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

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### 4.3 Front PTO

More power may be taken from a direct drive at the front of the crankshaft than any other accessory drive location. HD Hyundai Infracore engines can be fitted with FPTO clutch for driving accessories such as a winch, fire pump, hydraulic pumps or generator.

All directly driven equipment will have some effect on torsional vibration. Excessive torsional vibration in a system can result in excessive noise, gear failure, main bearing wear or, in the most severe cases, crankshaft failures. The maximum allowable torsional vibration angle is as follows in the table below.

The total power taken off at the front of the crankshaft cannot exceed the capacity of the FPTO clutch and the total required power from the engine may not exceed the values in the list below. This is the maximum amount of power that can be transmitted through the particular clutch.

Engine	Available Torque	Attached parts Inertia	Engine speed	Torsional vibration
	Nm	kg m <sup>2</sup>	RPM	° (degree)
<b>DX05</b>	550 (Max.) 330 (Open type)	w/ pulley : 0.085 w/o pulley : 0.04	2500	0.2
- For ranges of use outside the specified conditions, please contact HDI - Listed values represent allowable maximum limit.				

#### 4.3.1 Installation requirements

Brackets used to mount accessories must provide adequate strength to hold the static and dynamic load of the accessory and avoid resonant vibration within the normal operating range of the engine. Variance in accessory loads must be considered when selecting accessory drive location and capacity. Design service factors given in the installation recommendations should be used when determining accessory loads.

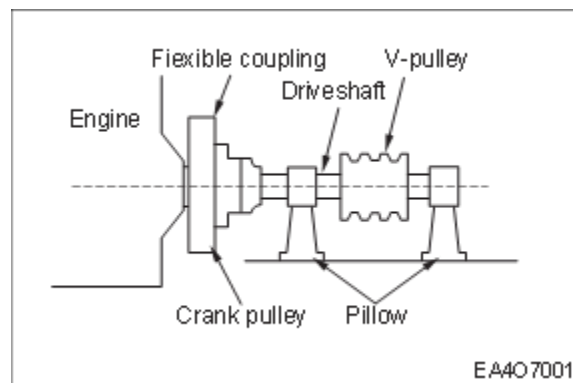
Belt-driven equipment must be held in alignment to a tolerance of 1 mm in 200 mm (1/16 inch in 12 inches).


The total power taken off at the front of the crankshaft cannot exceed the maximum capacity of the FPTO clutch and the total power absorbed from the engine may not exceed the specified value.

All exposed rotating components must have a protective guard.

#### 4.3.2 For maximum FPTO power

For front power take-off in engine with V-pulley, install a flexible coupling to the engine front crank shaft pulley and connect drive shaft and V-pulley by supporting them with two pillow blocks as shown in Fig. It is a standard procedure to support driveshaft and V-pulley with two pillow blocks by using flexible coupling for connection to engine. HD Hyundai Infracore recommends this type to use front power take-off. (FPTO) When the front PTO is installed, be sure to take deflection reading. Radial run-out should be no more than 0.02 mm.

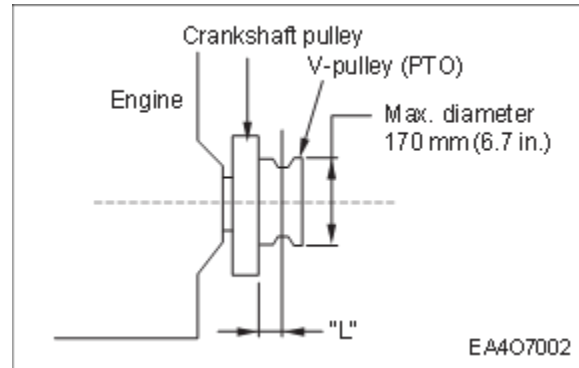


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#### 4.3.3 For small cross drive power

(No supporting bearing on front side of PTO pulley)

HD Hyundai Infracore does not recommend this type of arrangement, which is not standard procedure. However, If the FPTO as in figure have to apply the drive arrangement, the distance between the coupling end face of engine pulley and the centerline through pulley groove is not greater than 60 mm. The distance is indicated as "L" in the figure.

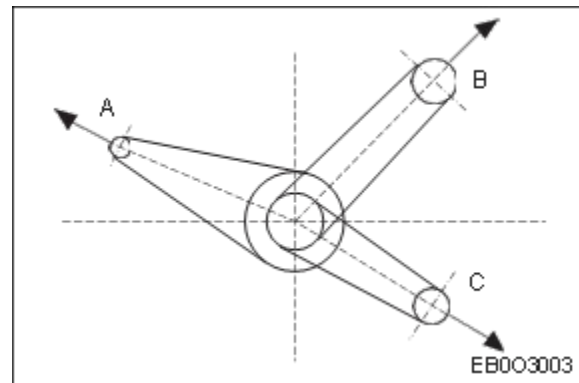


#### 4.3.4 Belt drives


Since engine-driven accessories will have experience fluctuations in the load during normal operation, the rated load of the accessories should be multiplied by a design service factor when determining the load imposed on the engine by the accessory. The direction as well as the load is important when considering belt driven accessories. The load capacity of crankshaft pulleys and other drive locations will vary at different angles due to the loading capability of the bearings.

If two or more accessories are being driven from a single multi-groove pulley, the accessories should be arranged to have opposing belt pulls so that the resulting force on the drive shaft is kept to a minimum.

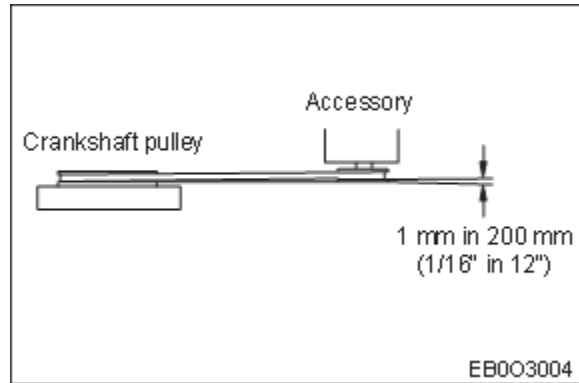
Any device rigidly attached to the front of the crank, other than an approved option, must be analyzed for the effects on crank bending, side-pull loading, mean and vibratory torques, and the capability of the crank bolted joint capacity.





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Belt driven equipment must be held in alignment to a tolerance of 1 mm in 200 mm (1/16 inch in 12 inches). Mis-alignment between the belt-driven equipment and the engine will result in bending forces on the shafts involved, wearing of the belt, belt jumping and can result in bearing or belt failure. This can usually be checked with a straight edge.



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## 5. Lubrication System

### 5.1 System specification

- Min oil pressure at rated speed during operation: 3.0 kg/cm<sup>2</sup> ~ 6.0 kg/cm<sup>2</sup> (at worst case)
- Min oil pressure at idle : 1.0 kg/cm<sup>2</sup> (at worst case)
- Max oil temperature (at Main gallery) : 120°C (at Operating condition)

### 5.2 Additional design considerations


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

### 5.3 Engine Oil Specification / 5.4 Engine Oil Change Interval

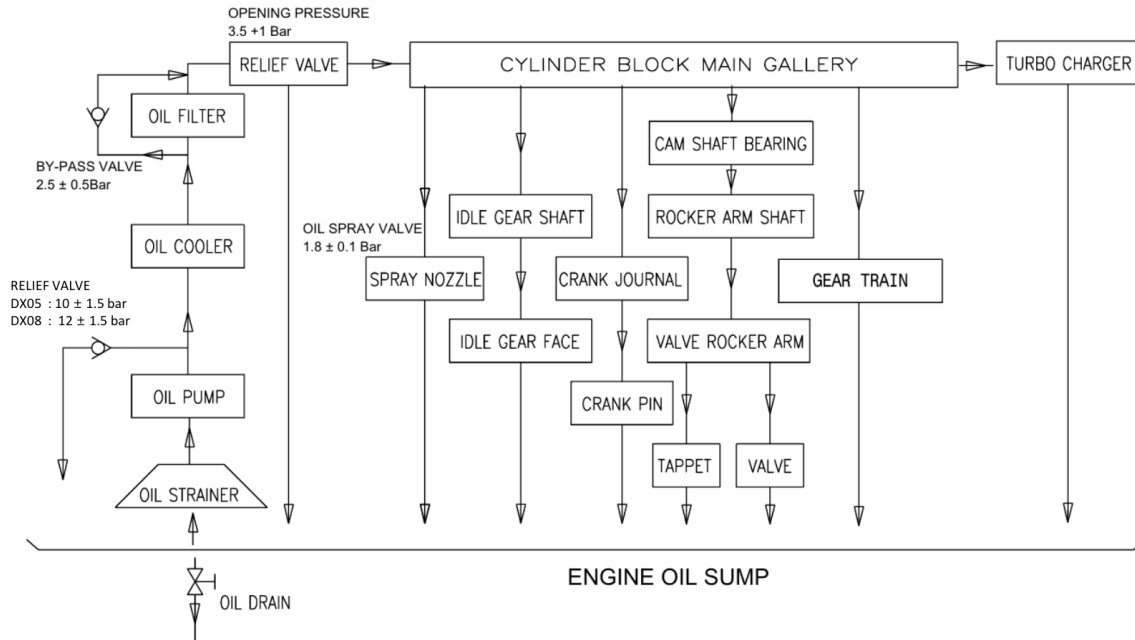
use the engine oil which satisfies the following recommended Specification

Emission regulation	SAE Classification	500hr interval or 1 year	* 1,000hr interval or 1 year
Tier4(Stage5)	10W30/ 40 or 15W40	ACEA E6/9(API CJ-4) or above	API CK-4 or above

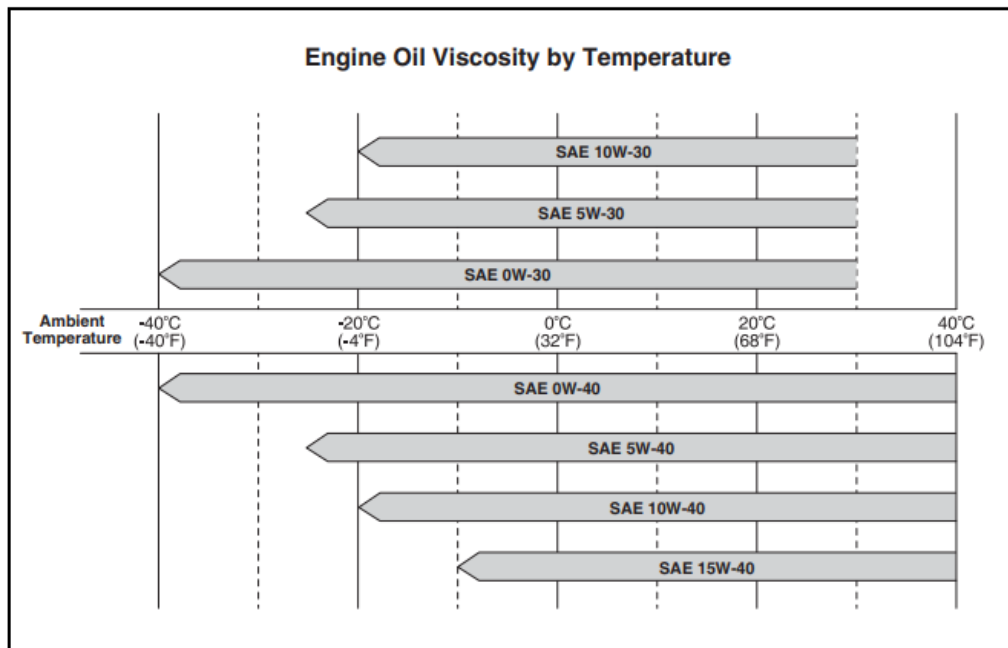
\* Service interval varies depending on Engine Oil, Diesel fuel quality and operation conditions. Determine service intervals by analyzing the engine oil properties under working conditions after analyzing the result of the test.  
1000hr interval is only for the customer who get the confirmation from HDI for the customer machine's highest usage profile data.  
Data can be measured and stored using the SCAN tool (service tool). For more information, contact a HDI engineer.

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## 5.5 Lubrication System Diagram



## 5.6 Engine Oil Viscosity Table

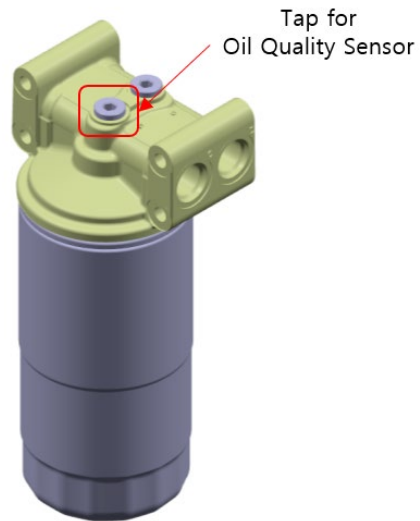



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## 5.7 Oil Quality Sensor Application

Cleanliness must be maintained when applying oil quality sensor to oil filter head in order to prevent foreign matters from entering into lubrication circuit.



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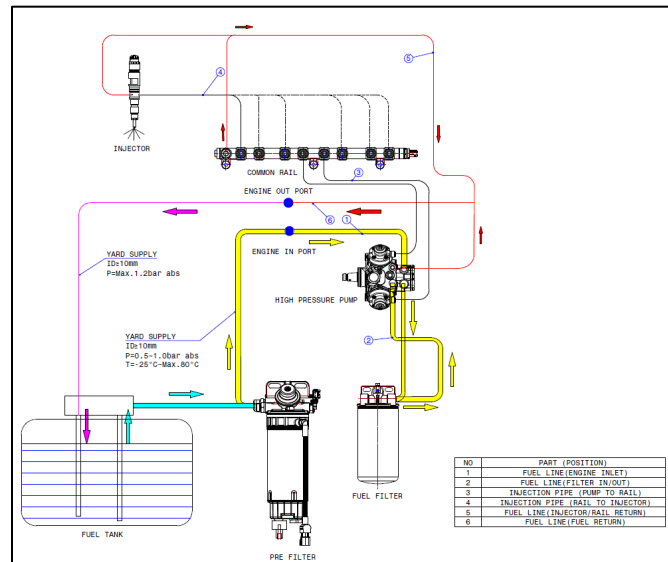
## 6. FIE System

### 6.1 Introduction


This guideline contains recommendations for the dimensioning of low pressure connections and for the tank system and gives an overview of the specifications of the 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 (ID) in the low pressure circuit are typical recommended values. Please note that the pressure specification at the interface to the components must be kept. Inner diameters of lines and connectors have to be chosen accordingly.

### 6.2 Connections in the Low Pressure Circuit

- Take care not to 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 and tin content must not be used
- Return flow pipe has to end below the min. fuel level of the tank
- Lines must withstand the occurring temperatures.
- Lines have to withstand the occurring pressures.
- Schematics of the system configuration



- Recommendations for Dimensions of Pipes and Connectors  
; The values listed in Table1 are valid for the feed and return lines configuration as shown in Fig.3. These lines constitute the hydraulic connection among the CR components and other LPC elements.(filters, tank, etc.)

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Vehicle Class	ID feed lines (1)	ID return lines (2)
Medium Duty, Off-Highway	$\geq 10 \text{ mm}^{(*)}$	$\geq 10 \text{ mm}^{(*)}$ $\geq 4 \text{ mm}^{(*)}(#)$
<sup>(*)</sup> with optimised low pressure connectors ( $\xi \leq 2$ ) <sup>1</sup> <sup>(#)</sup> applies only to the CRIN3-25 backflow lines		

**Table 1:** recommendations for the inner diameter (ID) of feed and return lines (total pipes length between tank and CP inlet/outlet  $\leq 4 \text{ m}$ )

<sup>1</sup>  $\xi$  is the resistance coefficient of connectors. The pressure drop caused by the connectors is defined as  $\Delta p = \xi \cdot \rho \cdot v^2 / 2$  ( $\rho$  = fluid density;  $v$  = fluid velocity in the connected pipe)

; The amount of fittings/connectors should be minimized. Use straight connectors and avoid a change of inner diameters which could result in an excessive pressure drop in the lines. It is recommended to use when possible flexible pipes instead of hard (e.g. steel) ones. This can reduce the pressure pulsations inside the circuit.

## 6.3 Recommendations for Tank System

- Generally speaking, the common-rail components must be protected against 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 tank breathing system with a 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 CP (and consequently into the CRS). This should be avoided by an adequate design of the tank or installations.


### 6.3.1 Ventilation for Fuel Tank

- Temperature increase leads to an expansion of the fuel in the tank. On the other side it might lead to appearance of vacuum into the tank, while fuel is taken out for the combustion and finally lead to contract the tank.

To avoid described scenarios a deaeration and aeration valve is necessary. A filter needs to be installed due to the fact, that dust and other particles might enter into the tank and contaminate the fuel for the CRS. The fuel tank setup might have the ability to guarantee the functionality of deaeration and aeration in non operation mode (parking in horizontal – and inclined position), during drive operation (acceleration, breaking, curve-, incline-, decline mode) as well as during fuelling.

Consequences :
Contamination on CRS
Suction pressure low
Unequal pressure built up
Rail pressure instability


RB recommendation:
Recommendation for low pressure circuit of CRSN2/3/4

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## 6.4 Requirements of Low Pressure Circuit

- Pre-Filter w/water separator
  - : Pre Filter Water Separation Efficiency always >93% per ISO 16332(2006)
  - fuel with IFT 11mN/m, DSEP <50, Droplet Size ≤150µm
  - : Mesh size (µm): Max. 100
  - : Max pressure drop (Initial) @ Max flow rate (bar): 0.1 (Max flow rate: 370l/h)
- Feed Pump Inlet Fuel Pressure @Max. Engine Speed (bar\_rel.): -0.5 ~ 0
- Feed Pump Inlet Fuel Temperature for Complete Life Time (deg.C): < 80
- Feed Pump Inlet Minimum Fuel Temperature (deg.C): - 25
- Required Fuel Line Inner Dia. (Fuel Tank ~ Feed Pump Inlet (mm)) : > Φ10
- Fuel Return Line Temperature (deg.C): < 120
- Fuel Return Line Pressure (bar\_rel.): 0~0.2
- Recommended Fuel Line Inner Dia. (Engine ~ Fuel Tank (mm)) : > Φ10
- Non dissolved water concentration in fuel (ppm): < 200
- Lubricity: Allowed HFRR of Fuel (µm): < 520. (First filling : <400)
- Fuel line components in direct contact with fuel must not contain copper (Cu), zinc (Zn), lead (Pb), sodium (Na) and calcium (Ca).
- The design layout is done for fuel fulfilling all requirements of at least one of the following standards:
  - : EN 590: 2013+A1:2017
  - : EN 16734:2016+A1:2018
  - : ASTM D975-19b Grades 1-D or 2-D, with the restrictions regarding paraffinic fuels as indicated below
  - : JIS K2204:2007 with a lubricity (HFRR test, per test method ISO12156-1) < 520 µm 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 K2390:2088.
  - : GB 19147:2016
  - : IS1460:2017
  - : GOST R32511-2013 (excluding arctic classes 3 & 4)
  - : EN 15940 (HVO, GTL)
- Additional allowable fuel after validation (Fleet test and FIE part inspection) on vehicle 1000hr is completed
  - : EN16709 (BD20/30)
  - : EN14214 (BD100)
  - : ASTM D6751-15c (BD100)
  - : ASTM D7467-19 (BD6 to 20)



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## 6.5 Initial Filling and Operation of CP4.1-OHW

- General considerations

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


- The filling time of the CP4.1-OHW and the Fuel Injection System (FIS) depends on the air content in the pump and the system and on the capacity of the used external lift pump. The completion of the pump / 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. In the procedure described below the given values are for reference only.

- Initial filling/deaeration procedure

General parameters settings		
$P_{\text{backflow}}$	$\leq 1,2 \text{ bar}_{\text{abs}}$	Average pressure
$I_{\text{FMU}}$	Project specific	FMU completely open (set current in order to avoid a throttling effect)
$Q_{\text{inlet}}$	$\geq 30 \dots 250 \text{ l/h}$	The test rig should be capable to provide a flow $Q_{\text{inlet}} = Q_{\text{CPmax}} + Q_{\text{backflow}}$ up to 250 l/h
$Q_{\text{backflow}}$	$\geq 30 \text{ l/h}$	Condition should be verified in all steps of the procedure
HP circuit	Empty (no fuel)	Condition applies only at the beginning of the procedure

Step 1: deaeration of the low pressure circuit		
$n_{\text{CP}}$	0 rpm	Pump stop
$P_{\text{inlet}} \text{ (SSF)}$	$2,0 \leq p \leq 6,5 \text{ bar}_{\text{rel}}$	RB recommendation is $p > 5,5 \text{ bar}$ . Attention to the main filter burst pressure!
$P_{\text{inlet}} \text{ (PSF)}$	$2,0 \leq p \leq 6,5 \text{ bar}_{\text{rel}}$	RB recommendation is $p > 4,5 \text{ bar}$ . <b>Important</b> → for $p > 3 \text{ bar}$ the usage of fuel with the cleanliness level specified in the TCD for the CRS (eg. level 3) is <b>mandatory</b>

Step 2: first start attempt		
$n_{\text{CP}}$	$200 \text{ rpm} \leq n \leq n_{\text{LowIdle}}$	...depending on the engine test rig capability
$t$	Project specific	
$P_{\text{rail}} (t = 0)$	0 $\text{bar}_{\text{rel}}$	For a correct start, ca. 10 ml of air should be purged through the HP circuit w/o rail pressure increase
$P_{\text{rail}} (t > 0)$	230 bar (Start: $> 120 \text{ bar}$ )	The usage of a deflating function (eg. "deflate2") is recommended in order to facilitate the purging of air from the HP circuit
$P_{\text{inlet}}$	According TCD	
$P_{\text{inlet}} \text{ (w/ EFP)}$	See Step 1	This is optional. If an EFP is used, $n_{\text{CP}}$ must be limited to $n_{\text{LowIdle}}$

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- Initial filling/deaeration procedure on vehicle (in plant)

If the CRS has already been deflated on the engine test rig and the CRS is full with fuel when the engine is mounted on the vehicle, then a normal start can be attempted without the usage of additional external feed pump (EFP). A deflate function (eg. „deflate 2“) is recommended in order to facilitate the purging of eventual residual air in the system.

If the CRS has not been deflated according to the procedure described in paragraph 5.2 or if the CRS is empty (no fuel, possible presence of air), the first start on vehicle should be attempted according to the guidelines valid for the initial operation on the test rig.

## 6.6 Re-start after Tank Empty Drive and After Fuel Filter or 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 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. RB recommends additionally the implementation of the function „deflate 2“ which ensures during the start attempt the rail pressure reduction to the ambient value through appropriate energizing of the injectors, making therefore the elimination of air from the system, and consequently a restart, possible.


- Fuel filter / CP change

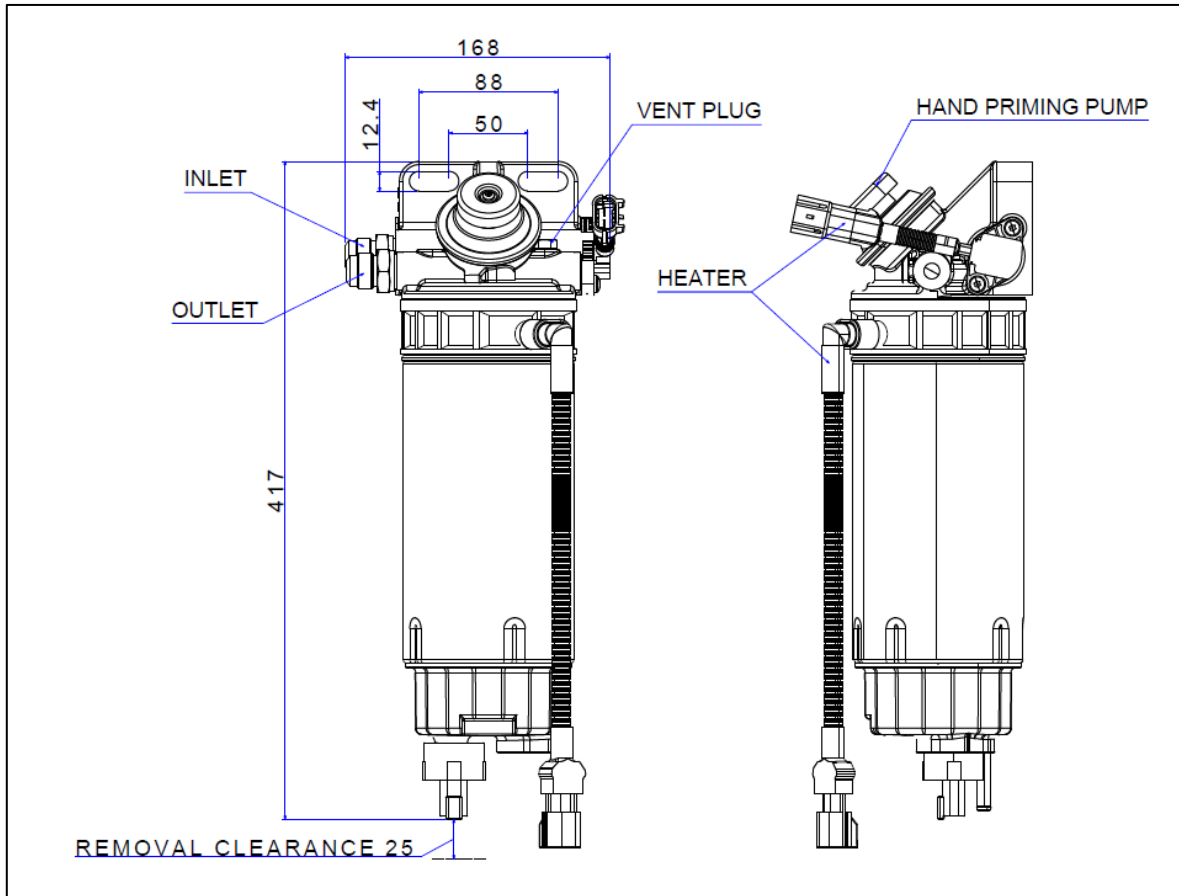
: After a fuel filter or CP change and before an engine restart, it is necessary to use the hand primer in order to fill the CRS low pressure circuit with fuel. The hand primer should be used until the fuel comes out from the CP backflow and the resistance encountered by activating the hand primer is big enough. In case of usage of non transparent pipes, we recommend to disconnect the CP backflow connector in order to check the fuel flow. The implementation of the „deflate 2“ function is recommended to ensure the restart, in case that some air is still present in the HP circuit.

## 6.7 Pre Fuel Filter

With regard to the lubrication and cooling of fuel injection system components, fuel must be supplied to the engine in a clean state without any air or moisture, and if fuel containing moisture enters the engine, it can drastically reduce the service life and cause high maintenance costs due to wear and corrosion of injection system components, so the following genuine pre-filter must be installed between the fuel tank and the engine.

A pre fuel filter is provided as separate accessories along with the engine.

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#### • Heater

In winter and in cold temperatures, the paraffin in diesel forms a gel and blocks the surface of the cartridge in the primary fuel filter, resulting in restricted fuel flow. In such cases, engine start-up may be delayed/ A impossible, the engine rpm may be unstable after engine start-up, or the engine may turn off. To prevent this phenomenon, turn the key switch on to run the heater mounted on the pre fuel filter (oil-water separator) before starting the engine to remove the paraffin from inside the pre fuel filter and the paraffin gel entering continuously from the fuel tank.

#### - Fuel heater specifications (for one heater)

Operating voltage: DC24V

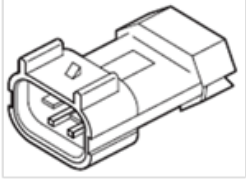
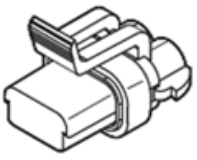
Operating power: 350 W

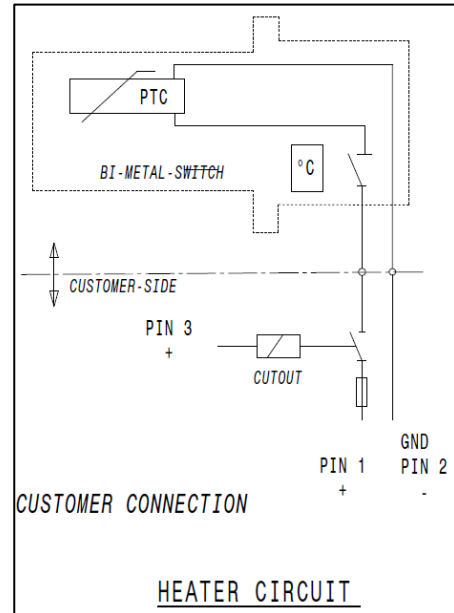
Bar Heater operating temperature: On under  $7 \pm 4^{\circ}\text{C}$ , Off over  $24 \pm 4^{\circ}\text{C}$

Sandwich Heater operating temperature: On under  $8 \pm 3^{\circ}\text{C}$ , Off over  $24 \pm 3^{\circ}\text{C}$

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- Heater Connector and Circuit

Pre Fuel Filter Side (Heater)	Harness Connecting Side
	
15300002(DELPHI)	15300027(DELPHI)



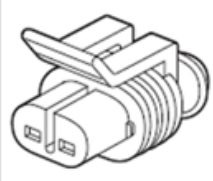
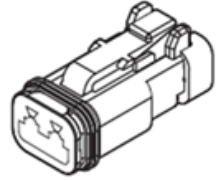
• Water-in-fuel sensor

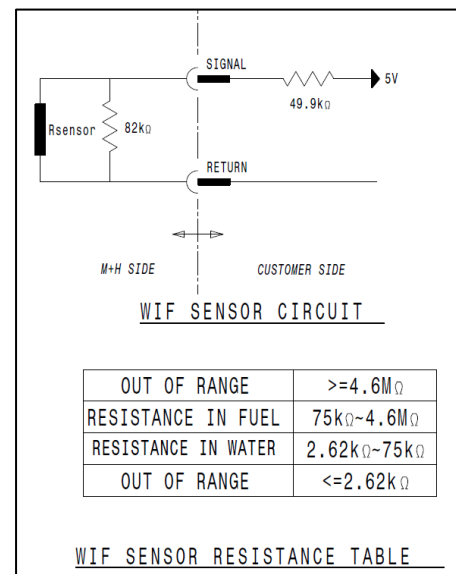
- Water in fuel sensor switch specifications


Operating voltage: 5V

Resistance: 82 k $\Omega$   $\pm$ 2% @ 25°C

- WIF Connector and Circuit

Pre Fuel Filter Side (WIF SENSOR)	Harness Connecting Side
	
15300002(DELPHI)	15300027(DELPHI)



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• Fuel Lines Connected to the Engine

Since the fuel lines connecting the engine and the fuel tank must be flexible enough to withstand vibrations while the engine is running, it is recommended to use hoses.

Install it to a necessary location according to the location of the primary fuel filter and the fuel tank.

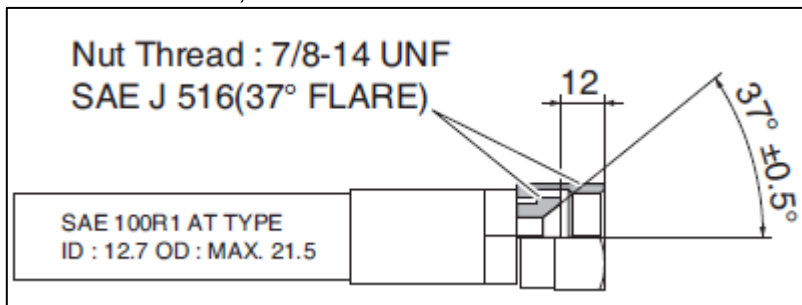
When additional fuel hoses of different lengths are required, use the fuel hose specifications provided to order hoses of the desired length from a hose supplier.


- Hose

SAE 100R1 AT Type I.D. Ø12.7, O.D. max. Ø21.5

- Hose Coupling

SAE J516 37° Flare, 7/8-14 UNF



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## 7. After-Treatment System

### 7.1 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 and SCR.
- DEF supply system includes a dosing module (DM), supply module (SM), hydraulic lines (selective supplement), engine control unit (ECU) and DEF tank (selective supplement).

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.

### 7.2 General information of HDI Aftertreatment system

HDI aftertreatment system consists of DEF dosing system and catalytic converters. These catalytic converters include DOC, DPF and SCR. The DEF dosing system has a dosing module (DM), supply module (SM), hydraulic lines (selective supplement), engine control unit (ECU) and DEF tank (selective supplement). 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.

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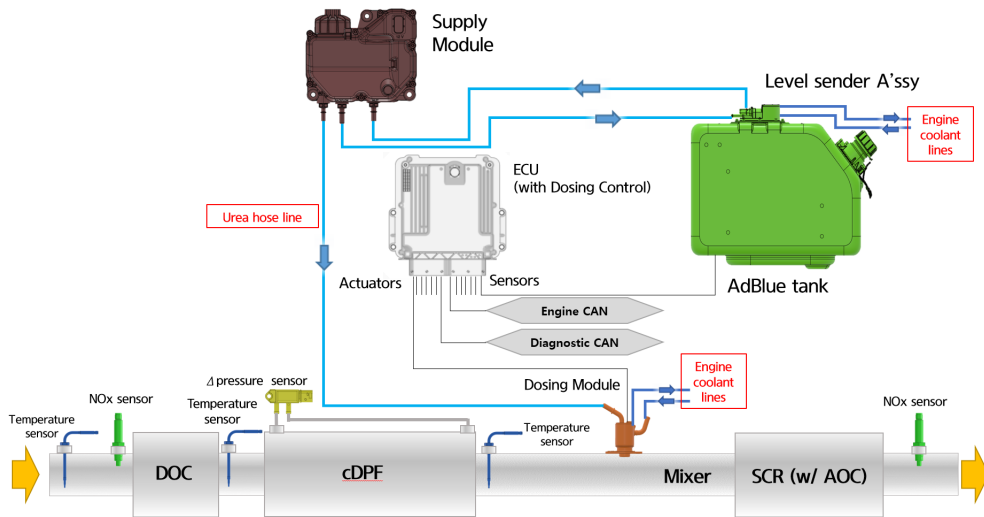


Figure 7-1. DX05/08 After-treatment system diagram

## 7.2.1 Supply Scope

HDI supplies the following components for customer installation of aftertreatment system.

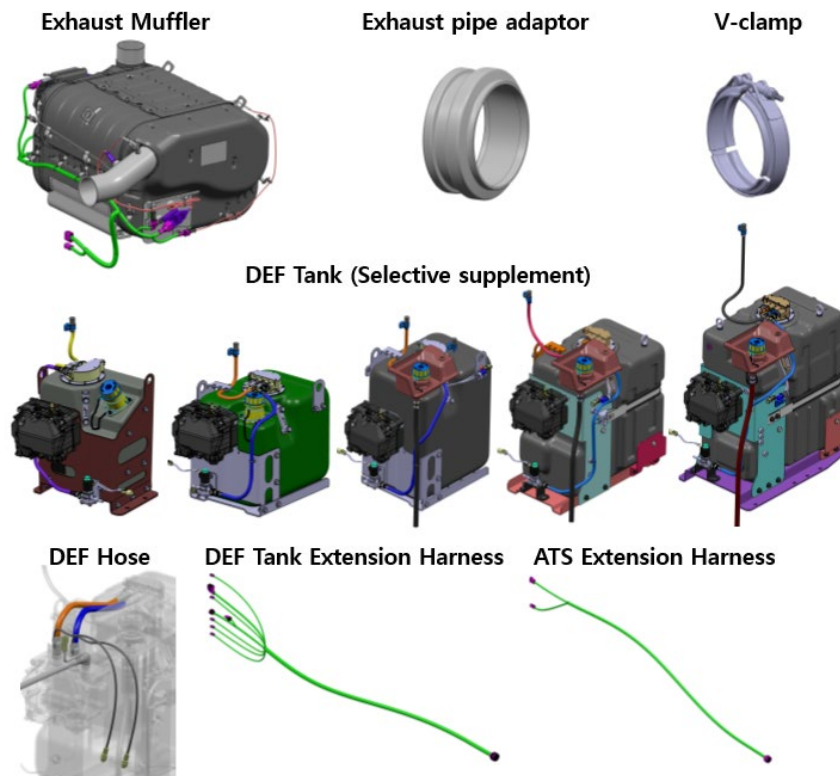



Figure 7-2. DX05/08 After-treatment system supply scope

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### 7.2.2 Muffler

HDI's Muffler is supplied in modular form with the following components for customer installation convenience.

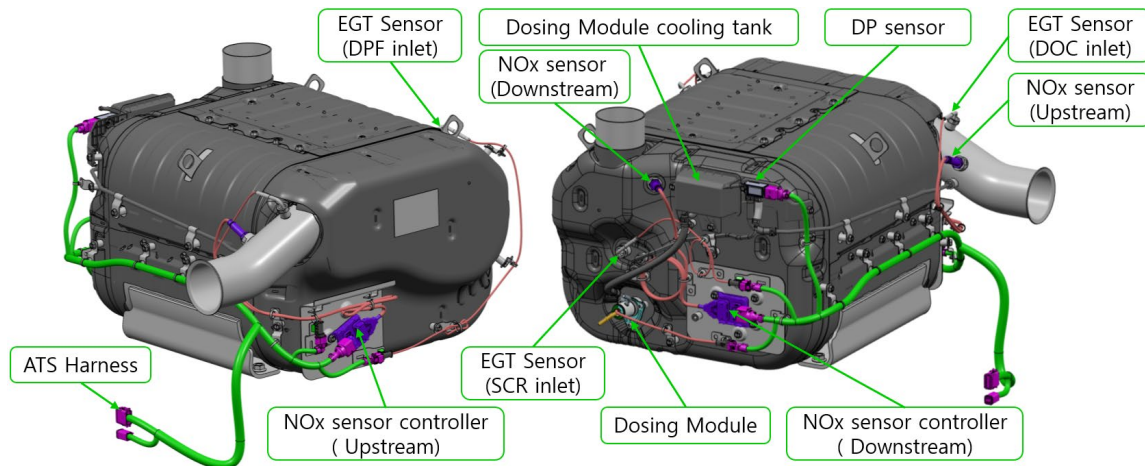


Figure 7-3. DX05/08 Modular muffler

### 7.2.3 DEF Tank

HDI's DEF Tank is supplied in modular form with the following components for customer installation convenience.

DEF Tank volume is a customer selectable option, and some parts may not be applicable depending on the tank type.

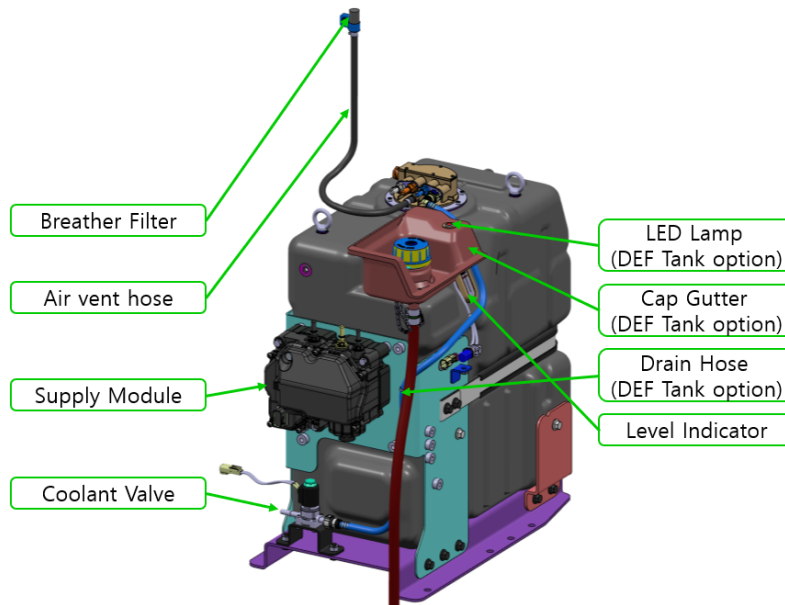



Figure 7-4. DX05/08 Modular DEF Tank



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### 7.3 General Requirements


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

### 7.4 Muffler Installation Guide

#### 7.4.1 Installation notes

##### General

- The aftertreatment must not be mounted on the application or the engine system without HDI approval.
- If parts from the machine manufacturer are assembled in addition to ATS supplied by HDI, the machine manufacturer must prepare and follow the appropriate overall assembly guidelines, including assembly guidelines for parts supplied by HDI.
- The exhaust layout must be designed to prevent water and dirt ingress into the aftertreatment.
- Aftertreatment location should be easy to access, without major component removal, for any service and maintenance requirements.
- The equipment must be designed to ensure that the exhaust temperature from the muffler does not cause property damage or physical injury to bystanders.
- 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 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.

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- 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.

### Mounting


- ATS muffler must be installed in the designed orientation.
- The aftertreatment must be mounted to a structure that should 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 7.4.2.
- 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 exhaust system must not contact any adjacent vehicle components. (minimum clearance with vehicle : 25.4mm)
- Muffler is designed to be fastened with 6-M14xP1.5 bolts. The recommended bolt strength and torque are 10.9T, 180Nm.



**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.

### Exhaust pipe

- 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.
- 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.
- The exhaust pipe should avoid touching or passing close to the air cleaner, fuel and lubricating oil filters, fuel tank or piping, injection or lift pumps, radiator and also, alternator, starter motor wiring or any electronic components.
- The inlet and outlet pipe must be adequately supported to minimize the joint load, prevent induced stress, avoid vibration and resonance.

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- For chassis-mounted after-treatment systems, flexible connections are required between the turbocharger and the after-treatment system to prevent motion constraints between the engine and the machine frame.
- 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.
- 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 7-5. But, if Machine (or Vehicle) side is not able to follow one of the three concepts of Figure 7-5, 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.

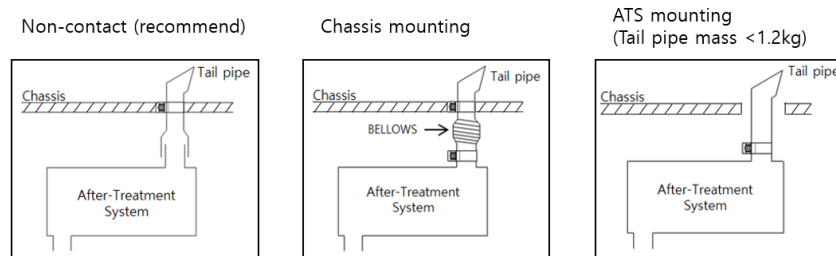


Figure 7-5. Types of tail pipe

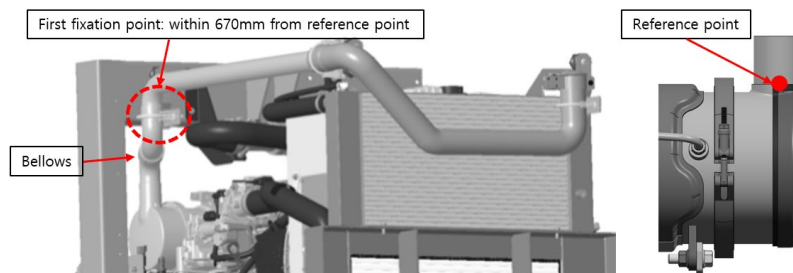



Figure 7-6. First fixation point of tail pipe chassis mounting

- For customers who have difficulty manufacturing the V-clamp joint shape of the exhaust pipe, an adaptor is additionally supplied, and the recommended tightening torque of the V-clamp is 11.5Nm.

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## Environment

- 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 7.6.3 and Chapter 9.2.2). 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.
- ATS system must be located to minimize heat loss.
- If the aftertreatment muffler is located in a canopy, then the design of the canopy should consider its thermal damages such as melting, surface separation, contamination, etc. Please refer to the 'Caution' below for the temperature of the aftertreatment system.
- If the aftertreatment muffler is located behind radiator, refer to 8.4 Engine room ventilation to ensure that the radiator performance is not affected by the muffler.
- The aftertreatment should be located where air circulation around the canister is allowed and be protected from debris or damage from outside the system.




Caution : Please consider the temperatures below for the design of canopy.  
Exhaust gas : Max. 650°C  
ATS in/out pipe (surface) : Max. 450°C  
ATS body (surface) : Max. 300°C

## 7.4.2 Test validation

### Temperature and back pressure of exhaust gas

- The exhaust system temperature drop and back pressure must meet the guideline. The maximum drop in exhaust pipe temperature and exhaust backpressure is determined based on the application, rated power and speed.
- Max. exhaust temp drop must be lower than target below table.
- 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, while engaging highest load at rated engine speed.
- Refer to service tool parameter for Exhaust mass flow and Turbine out temperature.

	Can Name	Can ID	PGN		Can Rate[ms]	Can bit position	Can size [ bits]	Unit	CAN Factor	CAN Offset	Operating Range	SPN number	SPN Name
			CANID HEX	CANID DEC									
Exhaust Mass	EEC3	0x18FEDF00	FEDF	65247	250	40	16	kg/h	0.2	0	(0, 12851)	3236	Aftertreatment 1 Exhaust Gas Mass Flow
DOC inlet temperature	A1DOC	0x18FD2000	FD20	64800	500	0	16	degC	0.0312	-273	(-273, 1734.96875 )	4765	Aftertreatment 1 Deisel Oxidation Catalyst Intake Gas Temperature

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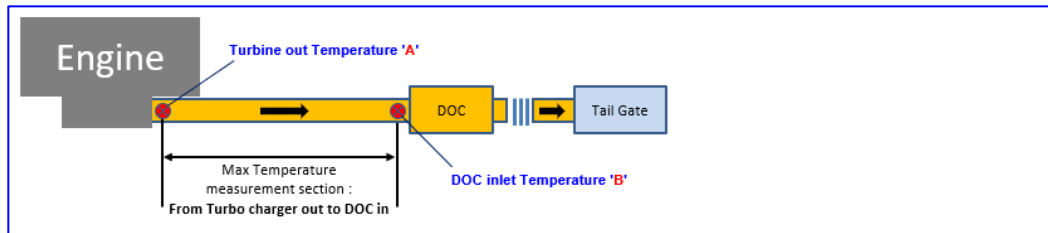
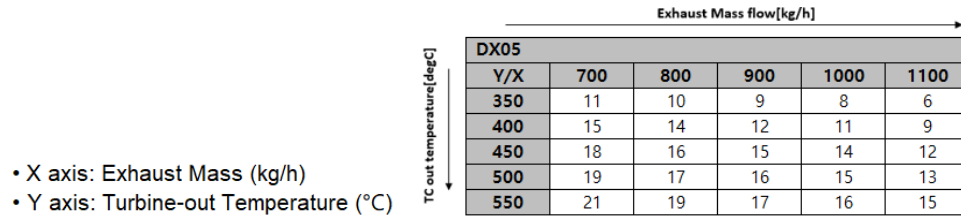


Figure 7-7. Allowable temp drop and test layout

- 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.

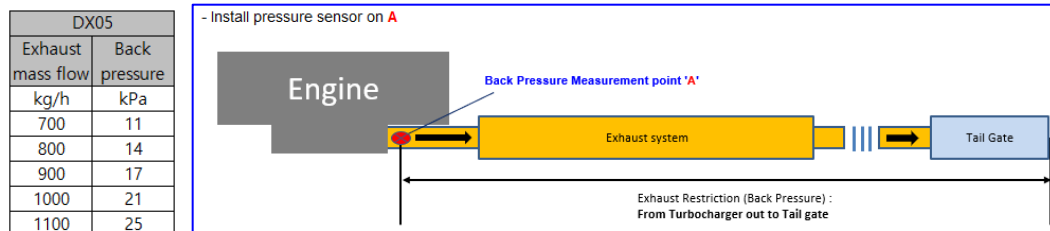



Figure 7-8. Allowable backpressure and test layout

## 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 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 measurement points of the muffler are shown in below figure.

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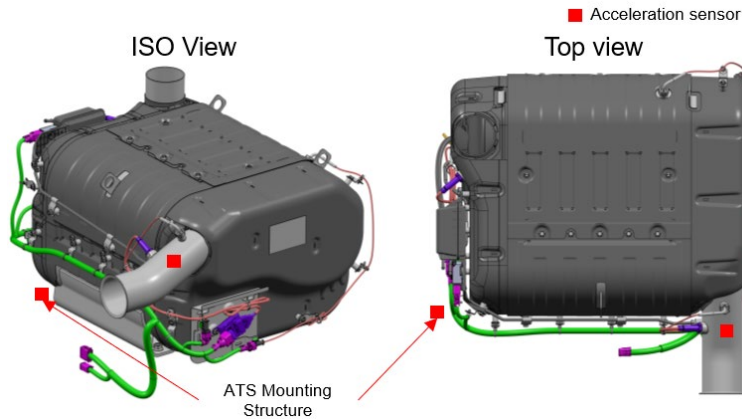


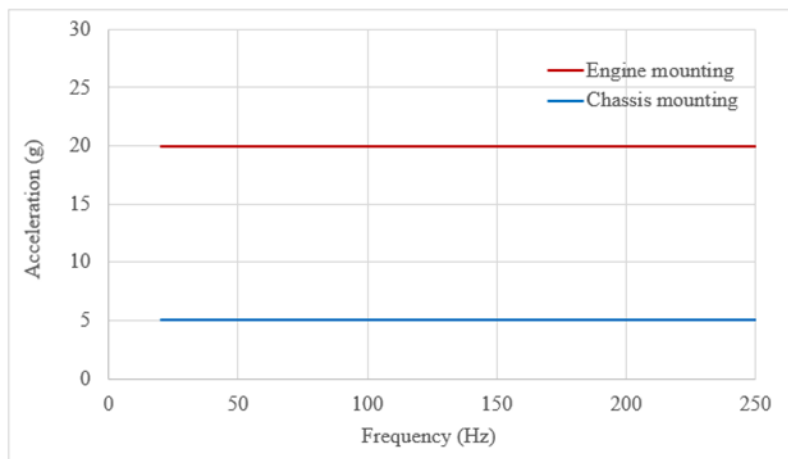
Figure 7-9. Location of acceleration sensor

- Permissible vibration loads

PHV (Peak Hold Value)


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

Mounting Position	Guideline
Engine Mounting	<ul style="list-style-type: none"> <li>- Not to exceed 20g (peak value) within 10~250Hz.</li> <li>- The 1st resonance frequency should be over target frequency*.</li> </ul> <p>*Target frequency (Hz) : Rated engine speed /60 x Num. of cylinder x 0.5 x 1.4</p>
Chassis Mounting	<ul style="list-style-type: none"> <li>- Not to exceed 5g (peak value) within 10~250Hz.</li> <li>- The 1st resonance frequency should be over 50Hz.</li> </ul>



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

Figure 7-10. 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 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.

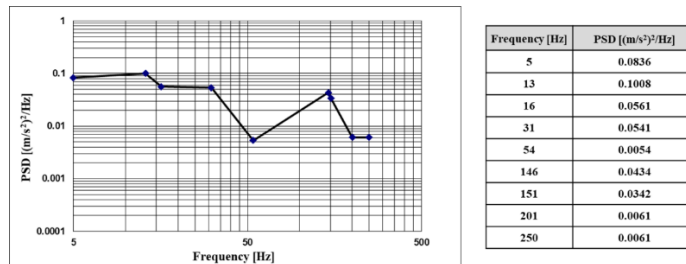


Figure 7-11. Example of PSD vibration load on after-treatment system


- The raw data of the vibration, speed and load data should be supplied to HDI application engineer with an appropriate file format such as LMS, SDF, SIF (LMS preferred).



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

### Limit temperature of ATS components (Dosing module, sensors and harness)

- Each component installed on the ATS has a temperature limit. This limit temperature must not be exceeded in the worst case that could occur in real field conditions. The worst case is summarized below. Refer each limit temperature value to Chapter 7.6.3, and Chapter 9.2.2. Customer must provide actual measurement data of each component to HDI to verify that it does not exceed the temperature limit under the worst-case operation.
- Worst-case engine operating condition
  - The temperature of ATS environment is 45 degree Celsius.
  - Run the engine at rated condition until the engine room temperature is saturated. (at least 1 hour and 30 minutes).
  - Proceed to DPF regeneration mode for 30 min.
  - Shut down the engine immediately after DPF regeneration mode is finished without any idling or low load cycle.
  - Measure the temperature until all measuring parts temperature begins to drop.
- If the customer has difficulty testing the engine conditions above, customer should contact HDI application engineer.

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### SCR Validation


- The following tests must be carried out to validate the SCR system. A test can be replaced or carried over with prior agreement with HDI. For further details, contact HDI application engineer.

Test	Details
SCR system check	<ul style="list-style-type: none"> <li>- Installation check</li> <li>- DEF dosing control check</li> <li>- DEF heating control check</li> </ul>
Hot test	<ul style="list-style-type: none"> <li>- Measure temperature for SCR components(DM, SM, etc)</li> <li>- in hot chamber or trip test</li> </ul>
Cold test	<ul style="list-style-type: none"> <li>- DEF defreezing test in cold chamber according to test mode of EPA or EU</li> <li>- SCR components temperature check (optional)</li> </ul>
High Altitude test	<ul style="list-style-type: none"> <li>- Implement test at high altitude if necessary</li> <li>- Check DEF dosing control function</li> <li>- Check temperature of SCR components</li> </ul>
Deposit check	<ul style="list-style-type: none"> <li>- DEF deposit check during machine durability test</li> <li>- Visual check or weight measure (every 200hours during the machine durability test)</li> </ul>
Vibration test	<ul style="list-style-type: none"> <li>- Measure vibration for SCR components</li> </ul>
DEF consumption	<ul style="list-style-type: none"> <li>- DEF consumption monitoring</li> </ul>

### NCD & PCD Inducement

- To prevent failures that may be caused by Emission-related parts (EGR valve / DPF System / SCR System), the ECU gradually derate the engine speed and torque. These are transmitted to specific lamps and equipment manufacturers must provide such lamp information to the driver as agreed with HDI Engineer. These inducements are needed for satisfying raw.
- The dosing control unit monitors the performance of the SCR catalyst by monitoring the level of oxides of nitrogen in the exhaust gases passing the SCR catalyst and DEF level in the tank. When the efficiency of the SCR catalyst fails or DEF level drops to a certain level to meet EPA requirements, fault codes will be stored and the indicator lamp will turn on. Also, these inducements limit the engine power and vehicle speed.
- So the indicator lamp must be operated as we have discussed to inform each inducement level to the driver. HDI engine with SCR system warn faulty DEF quality and low level in case bad quality is used or level is below warning threshold. Once operator notice warning message, they need to fill proper concentration DEF or refill DEF. Warning system follows CFR 1039.110.



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## 7.5 DEF Tank Installation Guide

### 7.5.1 Installation Notes

#### General

- Customer can choose to use various volumes of DEF tanks that is supplied by HDI. Check the list of supply and follow the instructions provided in this section, where applicable. In the cases of a standard & generator engine, you must use DEF Tank supplied by HDI according to its sales characteristics, and you can choose below table.

Tank Volume	Total volume (L)	Usable volume (L)	Weight - Empty(kg)	Weight - Full(kg)	DX05	DX08
15L DEF Tank	19.4	15.0	18	34	○	
30L DEF Tank	38.4	30.9	19	53	○	
45L DEF Tank	53.0	47.5	20	72	○	○
57L DEF Tank	66.0	57.2	29	91	○	○
72L DEF Tank	83.4	72.4	34	113	○	○

Figure 7-12. DEF Tank option table

- Please refer to the figure below for the definition of the usable volume of the DEF Tank.

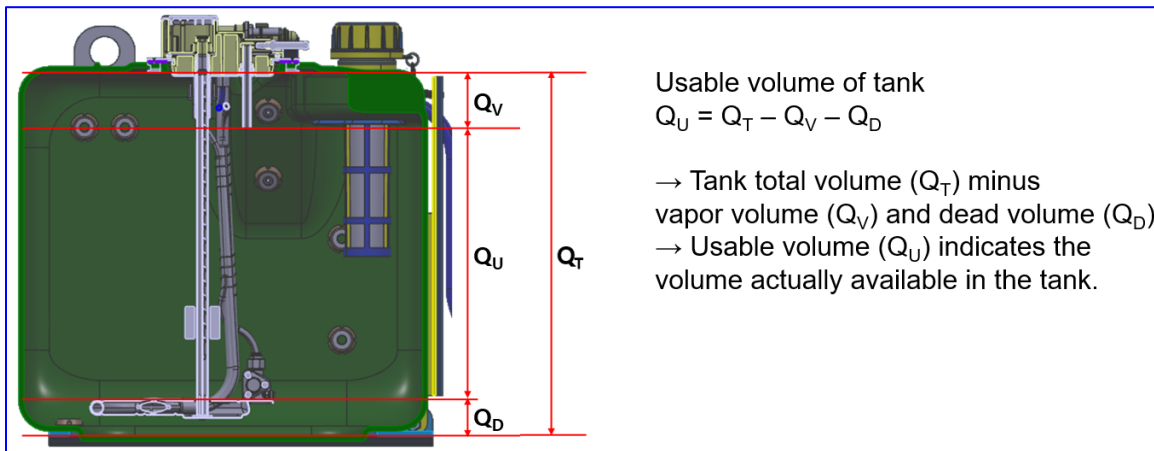



Figure 7-13. Definition of usable volume for DEF tank

- The DEF tank volume is determined based on the DEF refilling frequency and the fuel refilling frequency. According to the EPA, the DEF refilling frequency should be identical to or less than the fuel refilling frequency. In other words, fuel should be refilled more frequently than DEF.

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DEF refilling frequency =  $1 / (Q_{U\_DEF} / (Q_{U\_FUEL} * C_R * 0.01 * \sigma)) \leq 1.0$


- $Q_{U\_DEF}$  : Usable volume of DEF tank (L)
- $Q_{U\_FUEL}$  : Usable volume of fuel tank (L)
- $C_R$  : DEF consumption rate (%) → Variable according to the application
- $\sigma$  : 1.167 → 16.7% margin considering the DEF level inducement and relevant items  
→ Please check if DEF refilling frequency is same or less than 1.0 to meet 'Regulation'.

### Mounting

- Refer to Table 7-12, which lists the weights, and install the DEF by fixing it to a sturdy support so that it is not damaged by vibration.

### Temperature

- Avoid transfer of excessive heat from engine, gear box, muffler, exhaust pipe, and other components into the DEF tank.
- HDI's DEF defreezing logic is as follows: tank heating by tank heater valve control, electrical heating by the SM and the urea lines.
- The tank heater valve is triggered by the DEF temperature sensor which located inside the urea tank.
- The SM is heated electrically and the SM temperature sensor, which is located inside the SM, triggers its electrical heating.
- Increase in DEF temperature can cause decomposition, which, in turn, could lead to engine faults and emission performance failure. We recommend controlling the temperature to below 60°C during operation.
- The electrical heating by the DEF lines valve (not included in scope of delivery) must exceed 15 watts per meter for proper heating of the DEF lines.
- The DEF line heating is triggered by the environment temperature sensor (not included in scope of delivery) that measures the temperature around the DEF lines. The environment temperature sensor should be installed near the SM (typically within one inch around SM) by customer as all DEF lines start or end at the SM.

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## Wiring and hose connections

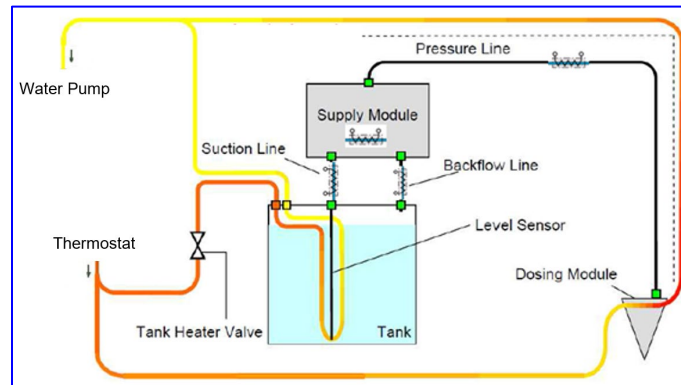


Figure 7-14. Layout of hydraulics

- The DEF and the coolant in/out ports should be connected correctly. Refer to the hose layout below.

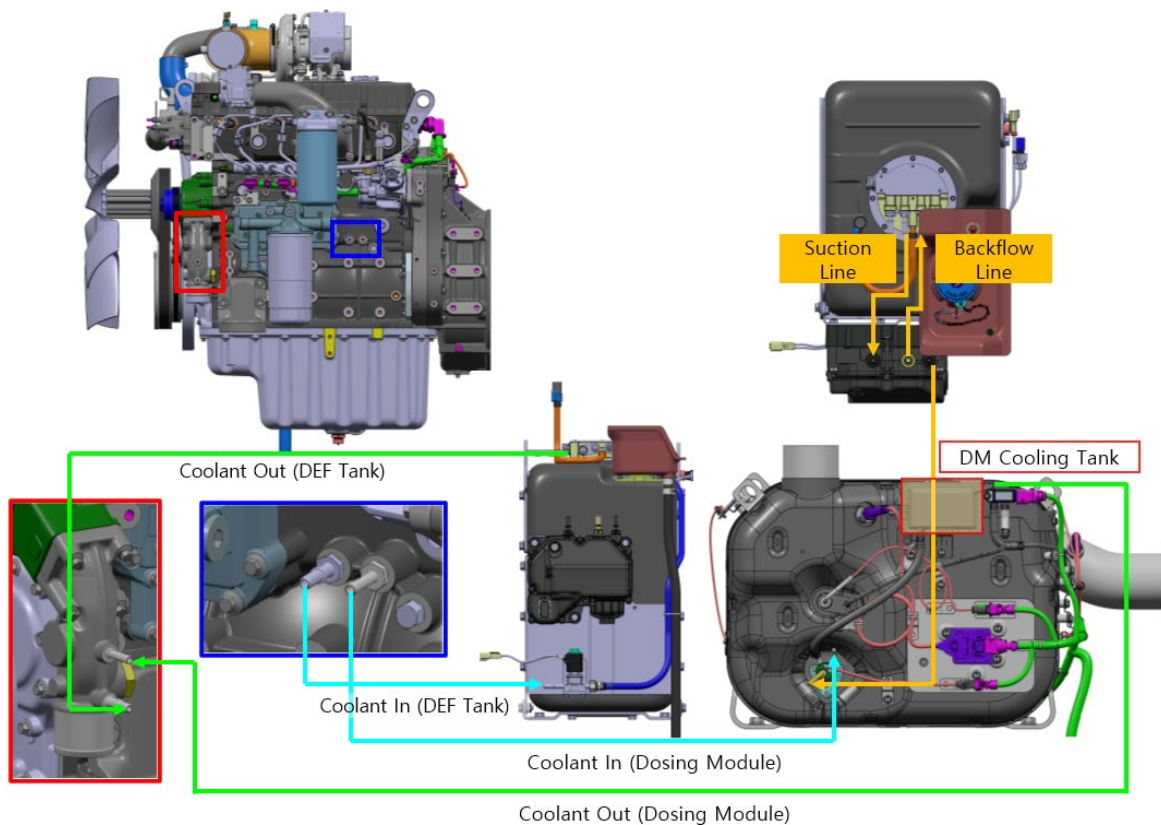

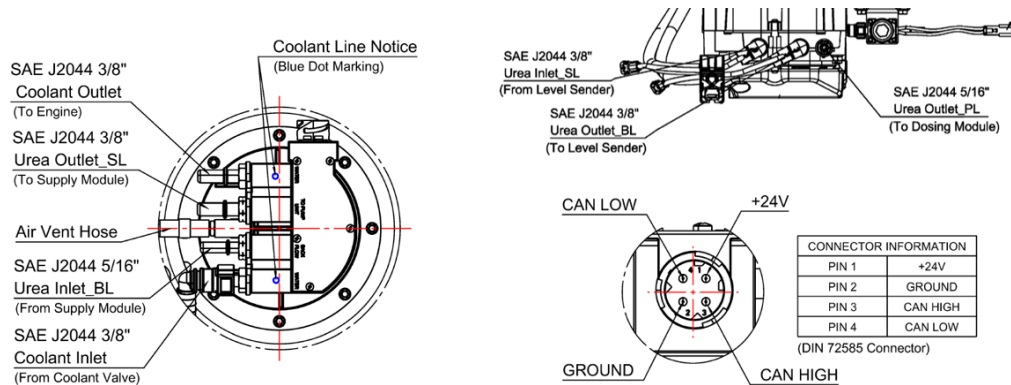


Figure 7-15. DX05 Standard engine Water/DEF hose layout

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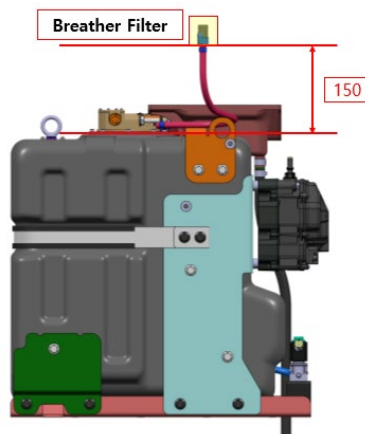
- Please refer to the figure below for specifications of the hose and wiring connector




- The battery (+) line (e.g. Ubatt, after ECU Main Relay) should be directly connected to the Pin 1(+24V). Do not connect the circuit controlled by key switch or any controller.

#### Breather Filter

- An air venting hose is mounted to breathe inside the tank. A breather filter is installed at the end of venting hose to prevent tank inside from debris.
- If there is drooping section in the air vent hose, depending on the equipment usage environment, the DEF in hose may remain and crystallization may occur in the filter. Therefore, the air vent hose is installed with an upward slope from the tank sender upper port to the filter. Also, there should no folding section.
- A breather filter should be installed 150 mm above the top of the tank.



Caution : Tank should not be filled over the Max. tank capacity.

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### 7.5.2 Test Validation


- Environmental agencies (EPA, EU and so on) regulate SCR systems to ensure that DEF does not freeze or refreeze during operation. For example, EPA stipulates the defreeze time and test mode, as shown in Figure 7-17.
- The DEF tank volume is determined based on the DEF refilling frequency and the fuel refilling frequency. According to the EPA, the DEF refilling frequency should be identical to or less than the fuel refilling frequency. In other words, fuel should be refilled more frequently than DEF.

- *Issue:* Whether SCR systems are designed to ensure that DEF does not freeze or refreeze during operation
- *EPA Thinking:*
  - Freeze protection systems will be evaluated as Auxiliary Emission Control Devices (AECDS)
  - Engine designs expected to incorporate DEF thawing and freeze prevention technology
  - For engines installed in equipment not intended to operate in cold temperatures, in lieu of a DEF thawing system, manufacturers may demonstrate engine is designed not to operate in freezing conditions
- *Examples:*
  - The following test procedure has been offered as an example of a test procedure that could be used for ensuring that the AECDS is used appropriately
 

- Prior to Procedure:
      - Temperature: DEF at 20° F (maximum)
    - Soak Conditions:
      - Temperature: 0° F (maximum)
      - Time: 72 hours or solid DEF (whichever occurs first)
    - Test Duty Cycle:
      - Temperature: 0° F (maximum)
      - Time: 70 minutes (maximum)
        - » Start engine and idle with no engine load for 20 minutes
        - » Operate engine at no more than 40% load at rated speed for up to 50 minutes
  - SCR systems that are capable of fully functional dosing at the conclusion of the test procedure may be considered acceptable

Figure 7-17. EPA regulation on DEF defreezing

- The DEF tank is heated by engine coolant. The coolant hose to the DEF tank have to be designed by customer. The mass flow rate to the DEF tank must exceed 4 l/min at high idle.

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## 7.6 DeNOx System Installation Guide (with Bosch)

### 7.6.1 Installation Notes

- DEF system (Supply module, Dosing module, DEF tank etc..) must be protected against collection of rocks, mud and heat source. (bypassing exhaust pipe, muffler, turbocharger, engine, etc.).
- Electrical wire and Hydraulin lines of DM and SM require proper fixing to prevent damage due to vibration or load. Therefore, the first fixing point of each component is guided as follows. For detailed information, please refer to the contents of each chapter.

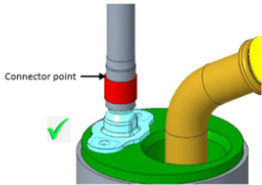
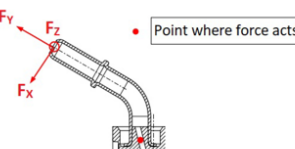
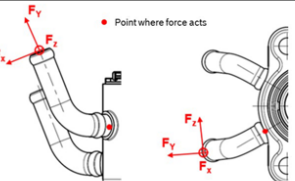
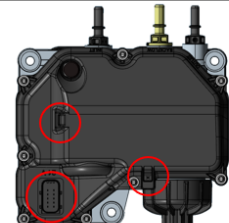
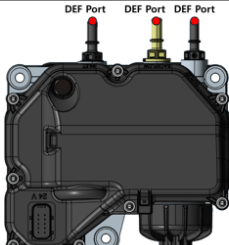

Component	Wire category	Reference Point	Measure	note
DM	Electrical wire		160mm	<p>The electrical cable must be supported with suitable support devices to withstand the same vibration level occurring at the DM (fastening point).</p> <p>The electric cable can be fixed to the DEF and coolant lines with clips or cable ties.</p>
	Hydraulic line (DEF)		250mm	<p>The maximum force that can be applied at the end of the DEF connector is 50 N under all operating conditions.</p> <p>A suitable support device is needed for the hydraulic hose (DEF).</p>
	Hydraulic line (Coolant)		250mm	<p>The maximum allowed force at the end of the coolant connectors is 50 N in all operating conditions.</p>
SM	Electrical wire		100mm	<p>The routing needs to be kept straight for the harness section leading to the first fixation point (directly from the connector or from the clamping point on the cover).</p>
	Hydraulic line (DEF)		200mm	<p>The clamping points for electrical cables must not be used for attaching hydraulic lines.</p>

Figure 7-18. Summary of electrical wire and hydraulic line first fix point

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### DEF Dosing system connectors for SM and DM

- There are two hydraulic connectors, SAE J2044 3/8" and 5/16"

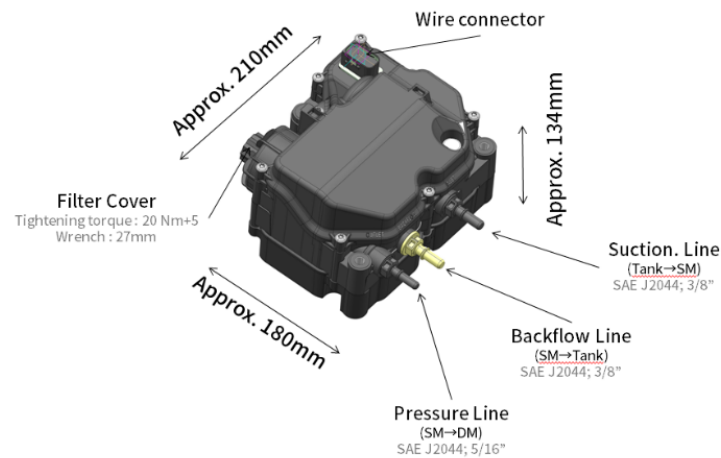


Figure 7-19. Supply module connector

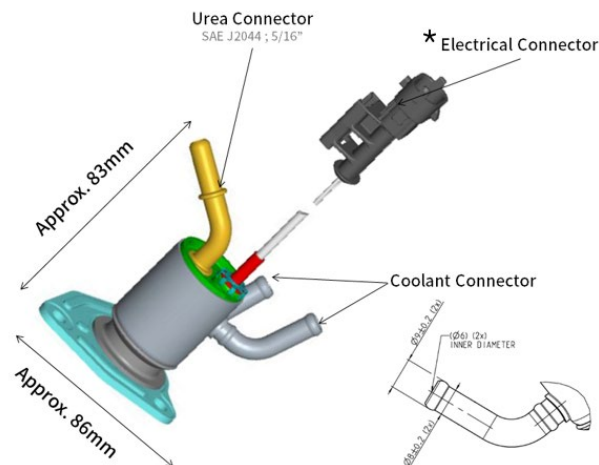


Figure 7-20. Dosing module connector




Caution : The same counter connector is used for DPF temperature sensor and dosing module. A sufficient distance should be secured between the two to prevent any mis-assembly.



Caution : Do not confused where to install between coolant line and DEF line



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### Installation of supply module

- Install the SM at an angle between  $-45^\circ$  and  $+45^\circ$  from the reference point (RP) in both directions. These angles should be measured from the horizontal.

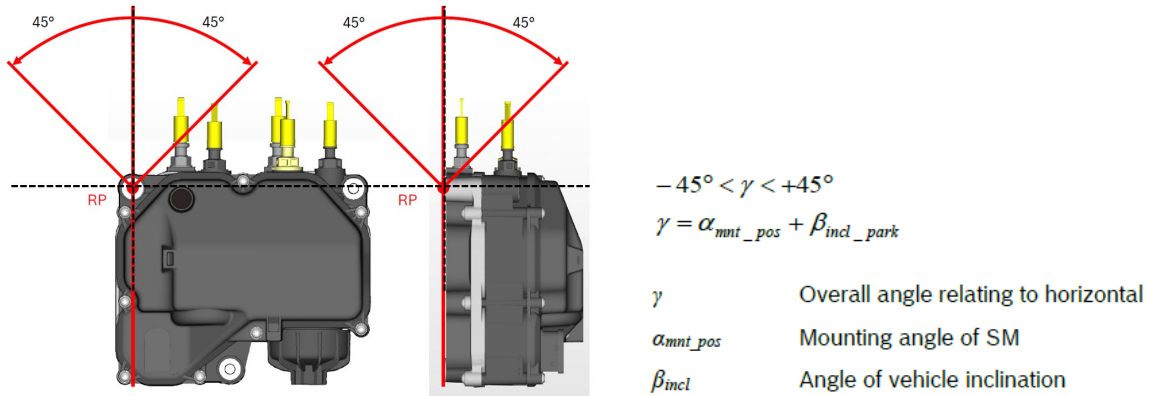


Figure 7-21. Supply module orientation

- HDI DEF Tank is supplied with the SM mounted at 0 degrees, so the DEF Tank must be installed horizontally.

### Distance for supply module replacement

- The SM filter has to be replaced periodically. For further details, refer to “Operation & Maintenance Manual”
- The distance between the tool and the SM should be at least 155mm when the filter is completely uninstalled.

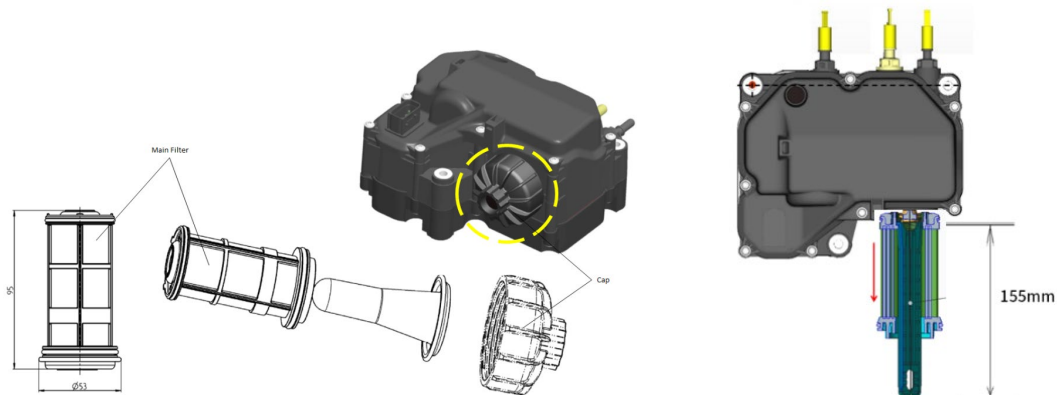



Figure 7-22. Supply module filter replacement



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### Electric connector interface for SM

- Avoid placing freely vibrating T-connections before the first fixation point (limit free vibrating mass).
- The vibration load specification must be followed for the intended machine application.
- We recommend using one of the default cable clamping points for the SM cover. Refer to Figure 7-23.
- The SM housing and the first fixation point of the wiring harness should be positioned to avoid any relative motion, caused by vibration, between the wiring harness and SM. The distance between the first fixation point and the clamping point on the cover must not exceed 100 mm. If there is no clamping point, the distance between the first fixation point and the connector must not exceed 100 mm. In any case, the routing needs to be kept straight for the harness section leading to the first fixation point (directly from the connector or from the clamping point on the cover).

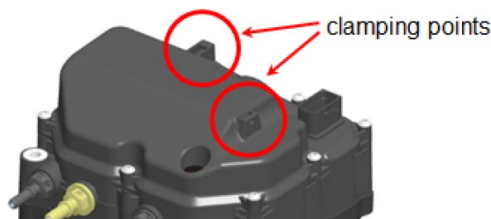



Figure 7-23 Clamping points for electrical cables

### Electric connector interface for DM

- The electrical wiring has a capillary barrier (dosing module side) with a length of at least 40 mm. This capillary barrier prevents DEF ingress in the direction of ECU.
- Make sure that the electric connector does not come into contact with DEF or water during assembly or disassembly.
- For further information, refer to the technical document on electrical plug: 1 928 A02 11T-000.
- The electrical cable must be supported with suitable support devices to withstand the same vibration level occurring at the DM (fastening point). The distance between the DM and the support device should not exceed 100mm along the wire.
- Maximum tensile load at the cable (application of force parallel to DM-axis): 80 N.
- Bending radius of electrical cable:
- Single bending: 5 x cable diameter,
- Multiple bending: 15 x cable diameter.

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#### Hydraulic (DEF) line fixation for SM

- The SM fixation and the first fixation point of each hydraulic line must ensure that relative motion between the SM and hydraulic line is avoided.
- The line should be routed and fixed to ensure that preload on mechanical connector (transverse forces and/or torsion) is reduced to a minimum.
- The maximum distance between the SM hydraulic connector and the first fixation point of the hydraulic line is 200 mm. The clamping points for electrical cables (Refer to Figure 7-F) must not be used for attaching hydraulic lines.

#### Hydraulic (DEF) connector interface of DM


- The maximum force that can be applied at the end of the DEF connector is 50 N under all operating conditions. There should be no pre-load applied to the connector during installation (see Figure 7-24).
- A suitable support device is needed for the hydraulic hose(DEF). The maximum distance between the support device and the connector point is 200 mm at the vibration level of DM.



Figure 7-24 Force at DEF- hydraulic connector

#### Requirements for dosing module coolant layout

- The DM should operate within the required operating temperature range(refer to chapter 7-6-3). The design must assure appropriate cooling performance due to potential overheating of DM after engine shut-off.
- The DM coolant connector has to be installed as to avoid drainage. The coolant hose should be capable of holding a coolant volume that is greater than 250cc, when facing upwards, as shown in Figure 7-25.
- For DM Cooling and thermal damage prevention, HDI ATS modular has 500cc DM Cooling tank installed.

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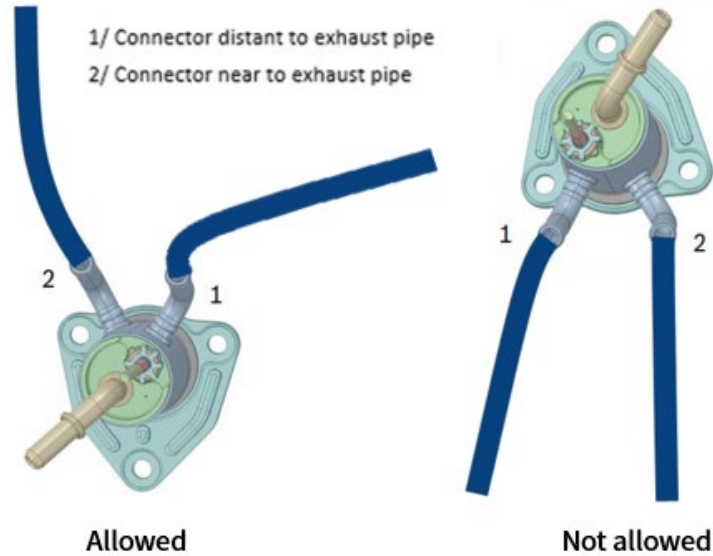


Figure 7-25. Dosing module coolant hose

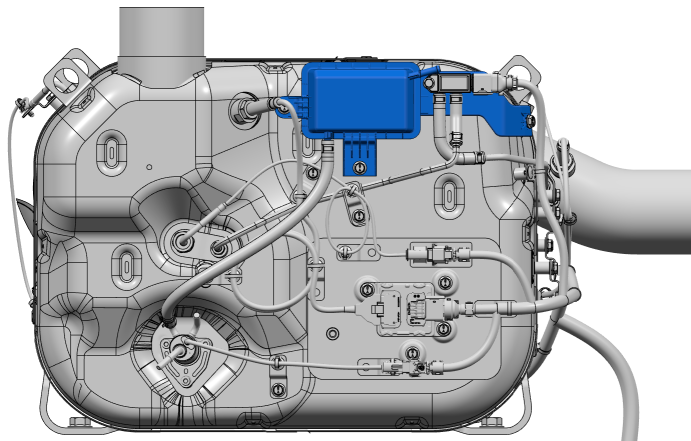



Figure 7-26. Dosing module cooling tank (supplied with ATS modular)

- The DM cooling tank should be installed in the coolest area inside the machine. The coolant line from the DM to the DM cooling tank inclined upward to prevent air from being trapped inside the coolant line.
- Measures, other than those recommended by HDI, can be applied to prevent overheating of DM.
- The cooling tank, whether supplied by HDI or purchased by customer, must be connected directly by customer. When installing the coolant hose, refer to the coolant direction and tank installation direction as shown in Figure 7-15.

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## 7.6.2 DEF system layout

- The layout of DM, SM, and DEF tank is critical to assuring the performance of DEF dosing, filling, and emptying. This chapter presents our recommendation for the layout of DEF system.

### Layout of DEF system: from tank to supply module

- HDI DEF Tank is supplied with an SM assembled and a matching DEF Hose. Therefore, the location of the supply module does not need to be considered unless the customer moves it separately.
- Figure 7-27 and 7-28 are the recommended layouts for installing the suction line and the backflow line. A siphon must be integrated in the system. It has to be appropriately sized to trap any residual AUS from the lines. The section A should be as short as possible.

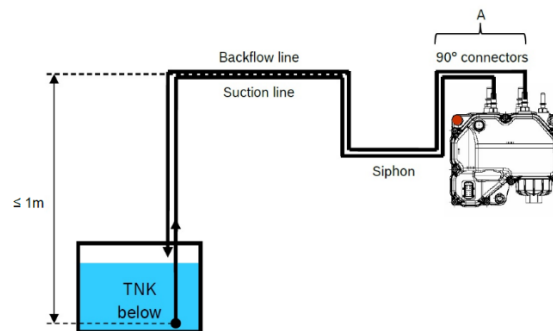


Figure 7-27. Layout: Tank below supply module

- As shown in Figure 7-28, the difference between the height of the reference point and the height of the highest point in the suction line has to be considered for emptying of SM after operation. Additionally, the highest point of the suction line has to be above the maximum DEF tank fill level to avoid any backflow into the SM after emptying it.

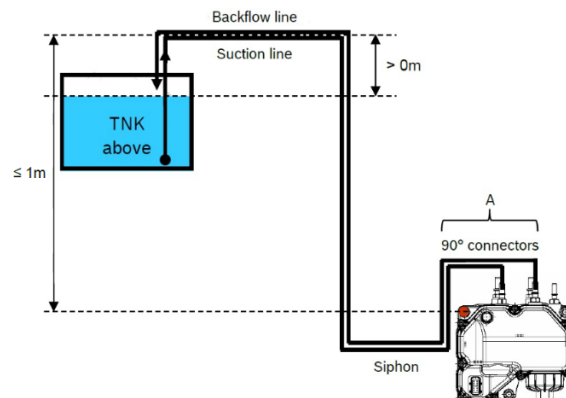



Figure 7-28. Layout: Tank above supply module

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### Layout of DEF system: From supply module to dosing module

- In Figure 7-29, the DM is installed below the suction module. An appropriately sized siphon must be integrated close to the DM, coupled by an angled line connector pointing downwards towards the hydraulic connector of the DM. This can be achieved by using a rectangular connector. The section A and B should be as short as possible. The pressure line must be routed downwards from the SM connector (angled line connector recommended). If that is not possible, an additional siphon is needed at the SM.

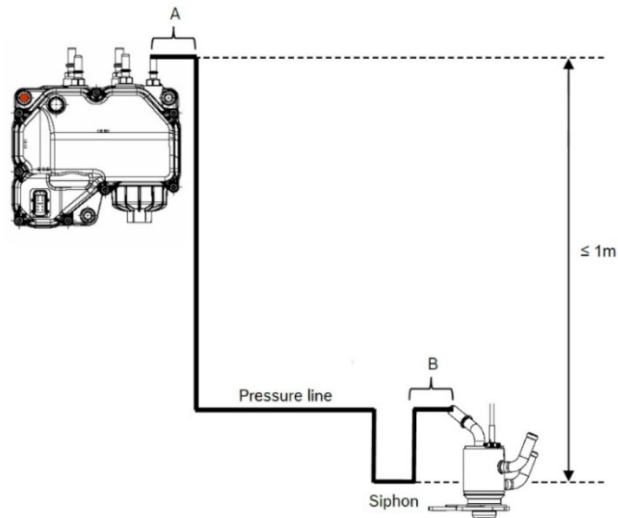


Figure 7-29. Layout: Dosing module below supply module

- In Figure 7-30, the DM is installed above the SM. An appropriately sized siphon must be integrated close to the SM. The section A and B should be as short as possible. The pressure line must be routed downwards from the DM, coupled by an angled line connector. If that is not possible, an additional siphon is needed at the DM.

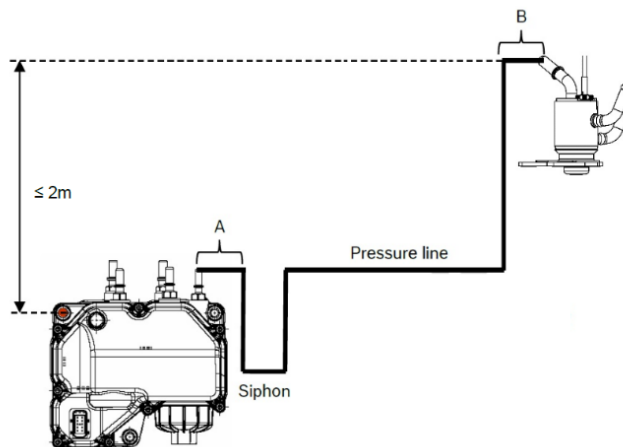



Figure 7-30. Layout: Dosing module above supply module

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### Hydraulic circuit pressure paths

Hydraulic Lines	Details	Conditions
Suction Line (SM Inlet)	Pressure loss between tank and SM inlet (across tank prefilter and SL) inclusive height differences at <b>maximum dosing and backflow mass flow</b>	Normal operation
	Recommendation for inner diameter: 6mm Line length shall comply with maximum differential pressure requirement defined in the 7-31, especially during pressure build-up and maximum dosing	
Backflow Line (SM Backflow)	Pressure difference between SM backflow outlet and tank inclusive height differences and overpressure of tank	Normal operation
	Recommendation for inner diameter: 3mm (orifice) Line length shall comply with maximum differential pressure requirement defined in the 7-31. In case of partial emptying the backflow line volume restrictions shall be considered.	
Pressure Line (SM Outlet)	Pressure difference between SM outlet and DM inlet at <b>maximum dosing rate</b> inclusive height difference	Normal operation
	Pressure loss between DM inlet and SM outlet <b>during emptying</b> with open dosing valve inclusive height difference	Afterrun
	Recommendation for inner diameter: 3mm (orifice) Line length shall comply with maximum differential pressure requirement defined in the 7-31.	



Note : Any deviation from recommended diameter would have to be assessed and evaluated.

Hydraulic Lines	Operating condition	Max. differential Pressure / hPa
Suction Line (SM Inlet)	From pressure build-up to max. dosing rate	-200 <sup>2)</sup>
	Purging, after operation	+150
Backflow Line (SM Backflow)	From pressure build-up to max. dosing rate	+150
	Purging, after operation	-150
Pressure Line (SM Outlet)	From pressure build-up to max. dosing rate	+200 <sup>3)</sup>
	Purging, after operation	-200

Figure 7-31. Differential pressure / pressure loss<sup>1)</sup>


<sup>1)</sup> Reference for pressure loss: Temperature: 25 °C Altitude: 0m to 450m above sea level

<sup>2)</sup> We recommend an inner diameter of 6 mm for the suction line, connected to the SM inlet. Avoid using long and thin lines as it may lead to high pressure loss. Filter pressure loss (prefilter loaded with AUS, breather line filter, etc.) and the difference in system components' heights would have to be considered as well.

<sup>3)</sup> Depending on the amount of pressure loss, the pressure at the DM inlet connector may deviate from the nominal AUS pressure, provided by the SM. The level of pressure (and their possible impact on flow rate and spray quality) needs to be checked for every vehicle-specific parameter combination.



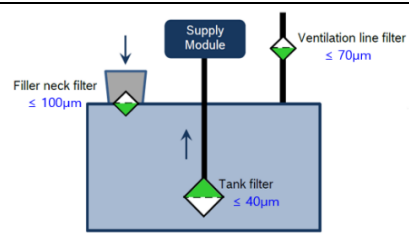
Note : Depending on the flow direction, a positive or a negative differential pressure occurs at each connector

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## Protection of System Components

- The components need to be protected against mechanical and heat impacts as described below.

System Component	Protection against	Description
Supply Module	Rocks, mud and debris	The shield must be structured as to avoid collection of rocks, mud, etc.
	Overheating during operation	The module needs to be protected against heat sources (bypassing exhaust pipe, muffler, turbocharger, engine, etc.).
Dosing Module	Rocks, mud and debris	The shield must be structured as to avoid collection of rocks, mud, etc.
	Overheating during operation	The module needs to be protected against heat sources (bypassing exhaust pipe, muffler, turbocharger, engine, etc.).

DEF Tank	Requirement	Description
Backflow Line	The backflow line needs to be positioned at the end of line.	The line should be placed in air, above fluid.
Residual Air	The residual air needs to be above fluid, at the maximum level of DEF tank.	The requirement should be followed.
Tank Ventilation	The tank needs to be equalized with ambient pressure. ( $\pm 5\text{hPa}$ )	Contact with DEF fluid should be avoided.
Temperature Sensor	The temperature sensor needs to be located close to the suction line to minimize any impact that the tank heater may have on its measurement. It should also be placed at the minimum tank level.	
Pre-filter in Tank	Use of pre-filter recommended - Tank Neck Filter : $\leq 100\mu\text{m}$ - Tank Vent line Filter : $\leq 70\mu\text{m}$ - Tank Suction Filter : $\leq 40\mu\text{m}$ (3D filter)	

- The suction line should be connected at the top of the tank filter

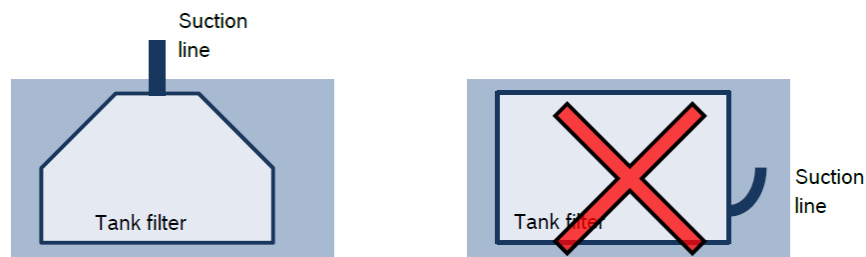



Figure 7-32. Suction line

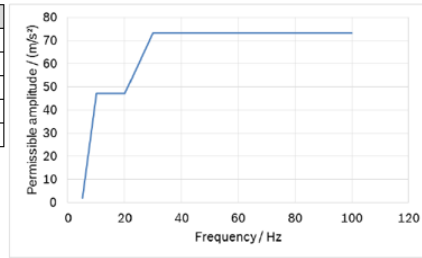
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### 7.6.3 Test Validation

#### Vibration

- The permissible vibration loads in the frequency & time domain are shown below.  
PHV : The measured value should be plot on the linear scale

Frequency [Hz]	Acceleration / (m/s <sup>2</sup> peak)
5	2
10	47
20	47
30	73
100	73



PSD : The measured value should be plot on the Log scale

Frequency [Hz]	PSD / ((m/s <sup>2</sup> ) <sup>2</sup> /Hz)
100	3.10
215	3.10
320	0.44
2000	0.44

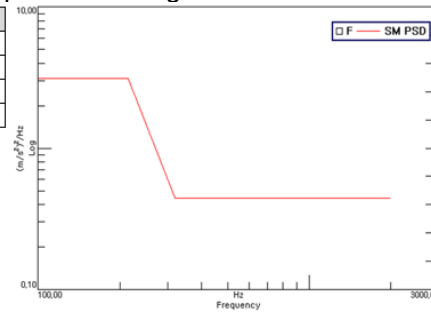
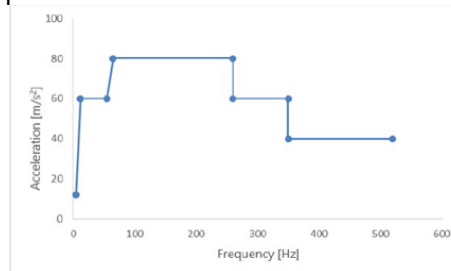


Figure 7-33. Vibration limit of supply module

PHV : The measured value should be plot on the linear scale

Frequency [Hz]	Acceleration[m/s <sup>2</sup> ]
5	12
12	60
55	60
65	80
260	80
260	60
350	60
350	40
520	40



PSD : The measured value should be plot on the Log scale

Frequency [Hz]	PSD [(m/s <sup>2</sup> ) <sup>2</sup> /Hz]
520	4.5000
600	8.9000
2000	8.9000

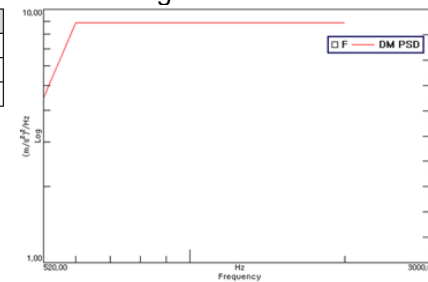



Figure 7-34. Vibration limit of dosing module



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## Temperature

- The functionality of DM/SM in the context of the complete system must be assured by the customer through vehicle trials under realistic vehicle conditions.
- If temperature measurements are performed, the measurement points (figure 7-35) of the instrumented dosing module are shown in the offer drawing and must be used.  
TCoilhousing, TFlange and TCableholder are not relevant for release.

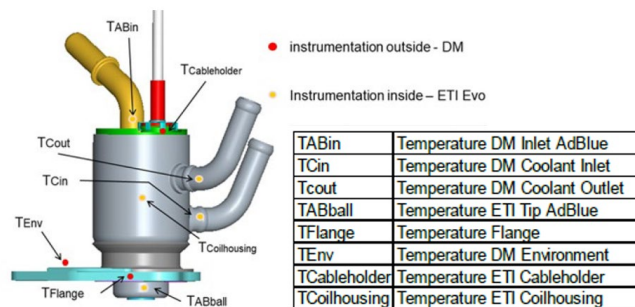




Figure 7-35. Measurement points for instrumented dosing module

Temperature: engine on				
	T min	T max	Tmax short term	Remark
	[°C]	[°C]	[°C]	
DEF temperature inside valve <b>T_ABball</b>	-5	120	-	temperatures >120 °C lead to flash boiling
Ambient temperatures <b>TEnv</b>	-40	160*	180**	Coolant must not freeze. Strong flow of cold air against the DM could freeze the area at the DEF-connector during longer periods of non-dosing.
DEF inlet temperature <b>T_ABin</b>	-5	120	-	If T_Env reaches the range of >180°C insulation/cooling of DEF-inlet is necessary. Below mentioned restriction applies
Coolant inlet and outlet <b>T_Cin</b> <b>T_Cout</b>	-5	110	***	For coolant temperatures are < -5°C freezing of DEF may occur during operation. For "cold start" this should be taken into account for the specified time in standby mode. Following restriction applies
Temperature difference between coolant ( <b>T_Cin</b> ) and DEF inlet ( <b>T_ABin</b> )			70 (operation mode) 100 (coil heating)	Due to the thermomechanical stability of the welded valve a maximum difference of temperature change between DEF and coolant or coolant and coil temperature has to be met. A distribution of temperature changes between occurring events e.g. start & stop and operation mode is shown in pic. 34. Remark: This distribution of temperature changes can be overlapped with max. 500 coil heating operations (coil temperature 160°C, effective at component, coolant temp. 20°C: dT 100°C) over lifetime.
* Tmax = limit temperature (no continuous operation) ** short-term: < 15 min., ∑ 100h over lifetime, for stable temperatures, by cooling down at air e.g. during after run conditions, (no water shock). *** Max. temperature for valve parts and DEF temperature specification has to be complied with.				

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Temperature: engine off					
	T min	T max	Remark		
	[°C]	[°C]			
DEF inlet temperature <b>T_ABin</b>	-40	180	maximum of 80 h over operating time		
functional temperature inside valve <b>T_ABball</b>	-40	140	temperature s [°C]	Time slice [h]	
			80	5179	
			90	4072	
			100	3601	
			110	3194	
			120	2905	
			130	2810	
			140	4343	
			150	46	
			160	45	
			170	45	
			180	80	
			<p>The table shows the temperature distribution of component (based on representative field data) after engine stop for <b>T_ABball</b> over usage time. Basis for the given temperature profile is 1 shut-down (with cooling down lower than 80°C of the DM) per day. Short breaks are included. Resultant is projection over lifetime.</p> <p>&gt;100°C the risk of DEF crystallization is increasing. Additionally</p> <p>&gt;132°C the risk of non-solvable DEF secondary products is increasing. The risks mentioned before can result in a potential reduction of the dosing module's functionality (sticking needle/ orifice plate blockage). This must be avoided in the customer application.</p> <p>Equipped with MDG1 control device RB offers at system level a heating needle function with the purpose of loosening a sticking needle. The functionality of this feature cannot be ensured under all conditions, i.e. in particular for temperatures above 132°C this functionality is limited.</p>		
Material limit temperature		180	The specified temperature represent material temperature limit only.		
Ambient temperatures <b>TEnv</b>	-40	160*	180°C short-term: < 15 min., ∑ 100h over lifetime, for stable temperatures, by cooling down at air e.g. during after run conditions, (no water shock)		
*Tmax = limit temperature (no continuous operation).					

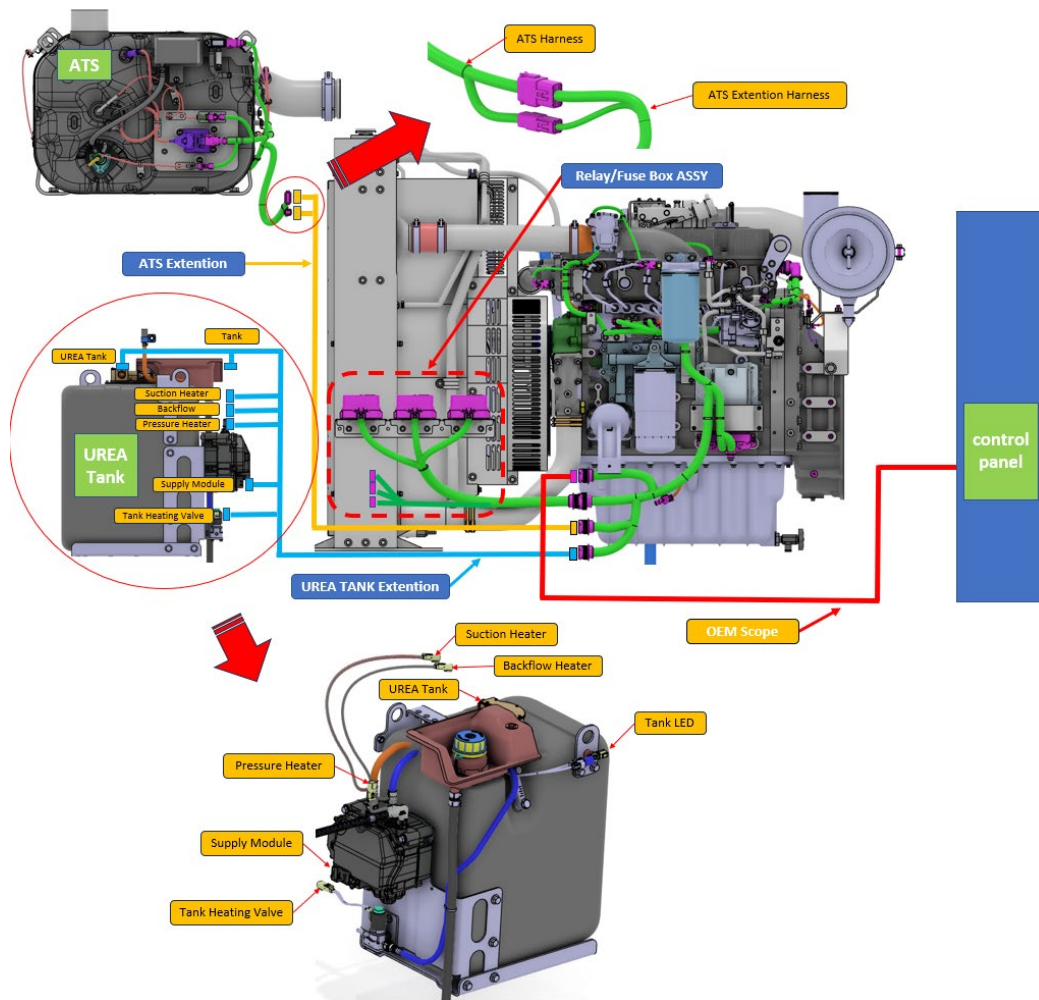
Feature	Remark / conditions	Unit	Min. value	Max. value
AUS temperature	at SM inlet; above +60 °C for a maximum of 1400 h (accumulated over useful life)	°C	-5	70
	at SM inlet, mean value over useful life for On-HW applications	°C		50
	at SM inlet, mean value over useful life for Non-Road Mobile Machinery applications	°C		60
Ambient temperature	during operation, above +70 °C for a maximum of 1400 h (accumulated over useful life)	°C	-40	85
	during non-operation	°C	-40	60
	after hot shutdown	°C		85
	new and empty SM with plugged hydraulic and electrical connectors; exposure limited to one event with max. 2 h	°C		100

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## 7.7 ATS Electrical system installation guide


### 7.7.1 ATS Electrical system layout

HDI supplies wiring harness for controlling aftertreatment system from the ECU as loose parts. Please refer to the layout below for the connection of each connector of the electrical system.



### 7.7.2 Installation notes

- Apply a matching connector to the engine interconnector and use wires and terminals that meet the connector specifications.
- Fix the interconnector appropriately in a place free from vibration, humidity and heat sources. If it is not properly fixed in the connected state, connector damage due to external factor and poor contact due to vibration may occur.

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- When wiring the wire harness, avoid sharp bends and contact with sharp edges. Also, fix it at 200mm intervals to prevent the wiring from moving.
- Do not wire the wire harness overlapping with the generator power line or the engine jacket heater power line. Noise generated from the power line and power line can affect the operation of the engine.
- To minimize the effect of noise, wire it so that it is at least 100mm away between the power lines.

## 7.8 Follow-up Management

- To prevent any deactivation of catalysts or filters, the sulfur content in fuel must be lower than ULSD regulation. (based on nationality)
- To prevent any poisoning of catalysts and filters, CJ-4/CK-4 grade lubricant oil must be used.
- If service regeneration is performed three or more consecutive times, the vehicle user must replace the engine oil in accordance with maintenance procedures. This is because engine oil viscosity may fall below the specified threshold, potentially compromising engine durability.
- To reduce ash generation from the engine, we recommend using low SAPs type lubricant oil. (Sulphated Ash  $\leq$  1.0 %wt)

### Battery disconnection

- The battery should not be switched off for 2 minutes after turning the key off for SCR system protection. (After operation -> Emptying -> Pressure Compensation, etc.)

### DEF dosing system shutdown

- Shutdown of DM

Follow the normal shutdown (entire emptying of DM completed) procedure. The DM can remain deactivated under the following circumstances:

Water present in residual DEF inside the DM must not evaporate.


Do not disconnect any electrical or hydraulic connectors.

6 months: Ambient temperature of -40°C to 40°C

9 months: Ambient temperature of -40°C to 25°C

Recommissioning must be performed when restarting after the required shutdown period, as described below:

1. Refill the tank with new DEF.
2. Start the dosing system.
3. If a failure is detected, shut down the dosing system.
4. Wait until the main relay of the ECU is deactivated (depending on application) and re-start the dosing system.
5. If failure persists, contact a qualified service engineer.

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- Shutdown of SM

After following the standard machine shutdown procedure, including DEF purging, the SM can be deactivated if water present in residual DEF inside the SM remains unevaporated (we recommend refilling with DEF until the maximum tank level is reached) and all hydraulic and electrical connectors stay plugged in. Follow the period and temperature limits are provided table.

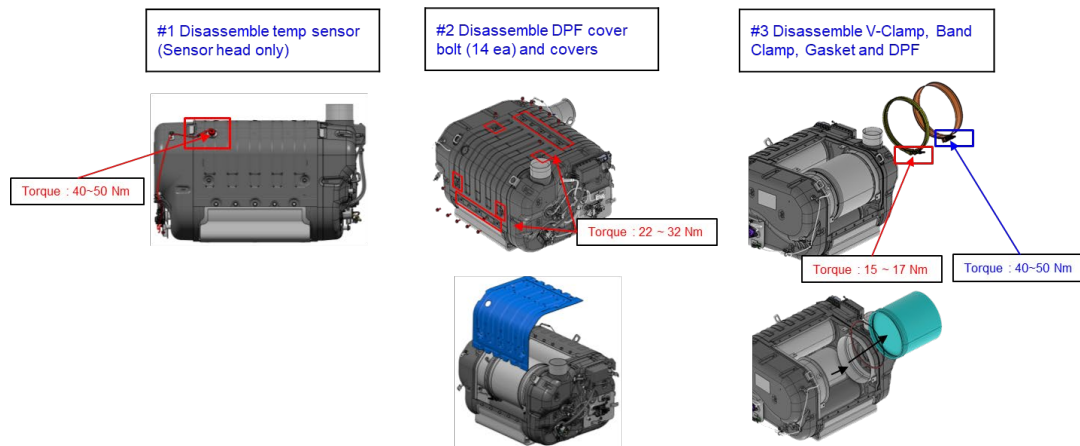
Maximum period/ months	Minimum ambient temperature / °C	Maximum ambient temperature / °C
2	-40	40
4	-40	25

Recommissioning process:

1. Refill the DEF tank with new DEF.
2. Replace the main filter of the SM.
3. Start the denoxtronic system.

## DPF replacement

- The following is information on how to remove and attach the DPF so that it can proceed according to the process.




\*Assembly procedure is performed in the reverse order of Disassemble.

\*\*Beware not to reuse clamps and gasket.

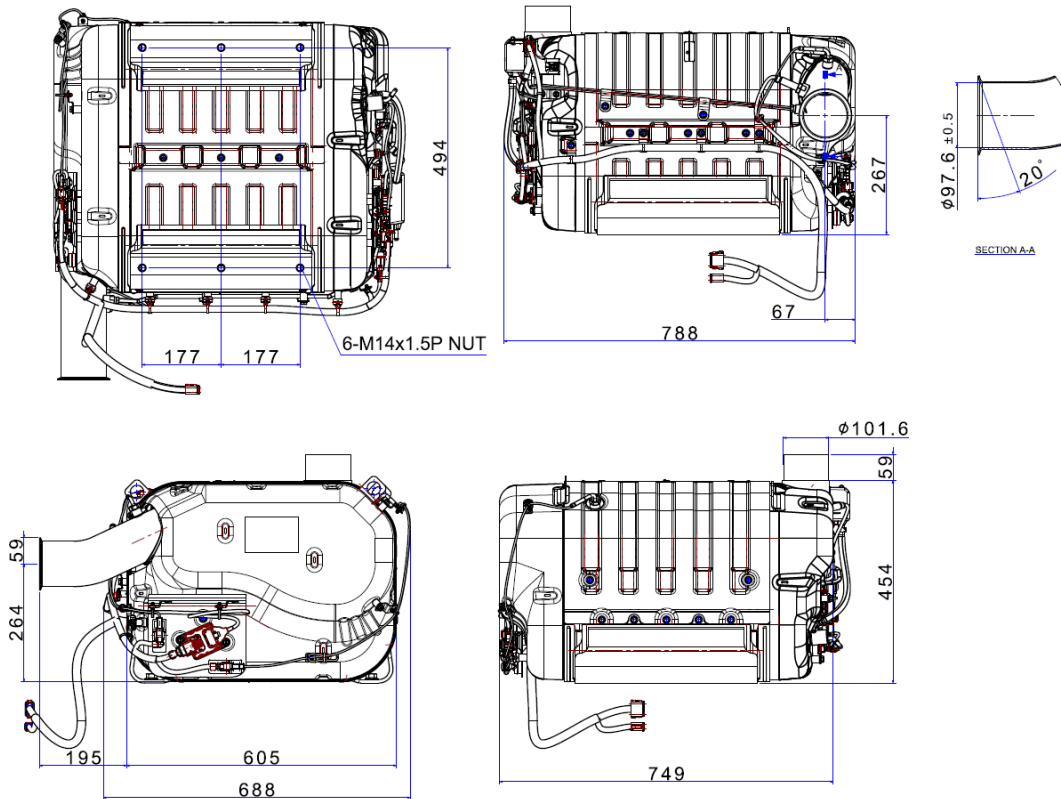
## In-use testing

- The U.S. EPA certification regulations for NRCI engines require the engine manufacturer HDI to notify the equipment manufacturer that sampling of exhaust emissions must be possible after engines are installed in equipment and placed in service. If this cannot be done by simply adding a 20-centimeter extension to the exhaust pipe, you, as the equipment manufacturer, must demonstrate to HDI how to sample exhaust emissions in a way that prevents diluting the exhaust sample with ambient air.

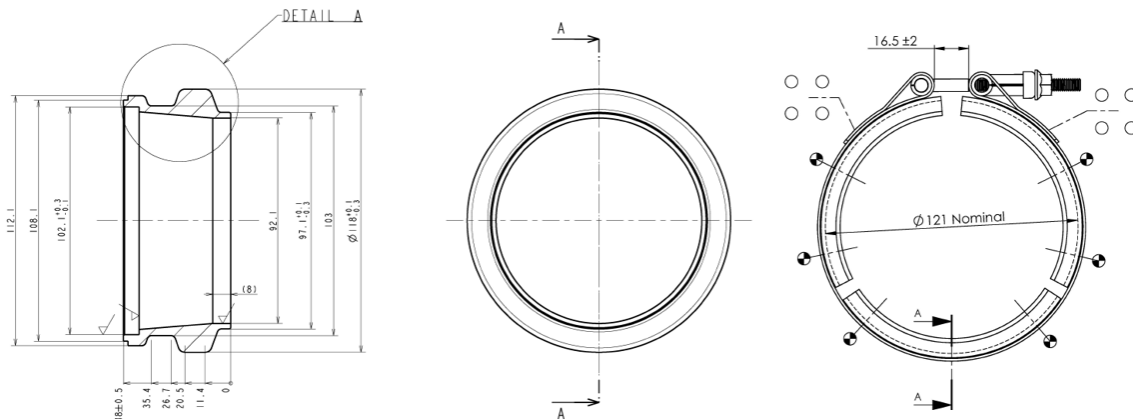
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## 7.9 APPENDIX

### 7.9.1 Drawing for aftertreatment system



### 7.9.2 Drawing for exhaust pipe adaptor and V-clamp



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## 8. Air Intake & Exhaust System

### 8.1 Exhaust System

#### 8.1.1 System Specification

- Max exhaust back pressure:
  - Non-tier, Tier3: < 10 kPa @ Normal operations
  - Tier4, Stage5: < 25 kPa @ Normal operations
- Max exhaust gas temperature-Exhaust Manifold (TE1) < 730℃
- Max exhaust gas temperature-Turbo Charger Outlet (TE2) < 650℃
- On chassis mounted after treatment system, flexible connections from turbocharger to after treatment system are required to prevent constrained motion between engine and vehicle frame

Permissible Exhaust Back Pressure	Test Condition	Check Position	Remarks
<10 kPa (Non-tier, Tier3) < 25 kPa (Tier4, Stage5)	at the full load	Downstream of the Turbocharger turbine	- Power decreased - Increased fuel consumption - higher exhaust temp. and emission worsen, smoke

#### Recommendation of Exhaust Back pressure


Position installed exhaust brake	Downstream 1,500mm from turbine outlet on exhaust pipe
Specification of exhaust brake	Symmetrically ø5~7mm relief hole on throttle valve
Permissible pressure in exhaust pipe	Below 5.0kg/cm <sup>2</sup>
Remarks	Trouble in engine durability

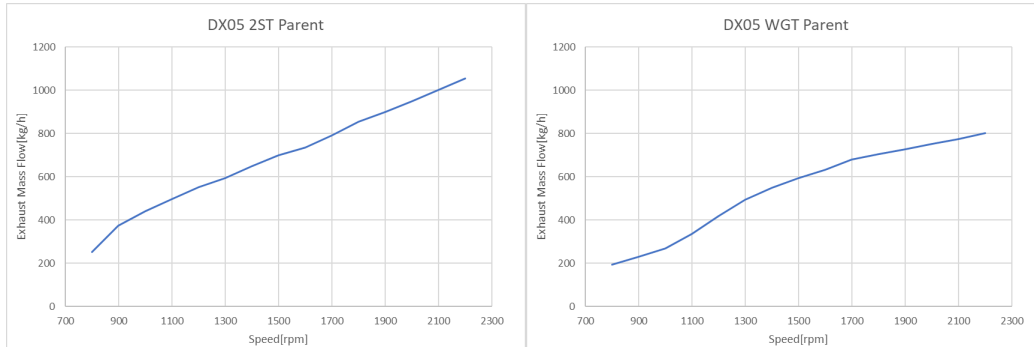
#### Recommendation of Exhaust Brake

- If too short to distance installed exhaust brake, happen to wear of rocker arm and broken exhaust valve & retainer and turbocharger

< Exhaust Mass Flow>



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### 8.1.2 Exhaust Bellows

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

The bellows adjust for small radial movements but are weak against torsional or axial movements, so they must be installed vertically and without any bending.

To account for the thermal expansion of the exhaust pipe, the exhaust bellows must be lengthened by 0.5 mm per 1 m of exhaust pipe length and per 100°C of exhaust temperature. The system creates a certain resistance to the flow of exhaust gas.

This resistance or back pressure must be maintained within a specified limit. Excessive back pressure causes a loss of power, worse fuel consumption, and high exhaust temperatures. These conditions cause overheating and excessive smoke in the machinery while also shortening the engine life.


- $X \text{ (mm)} = 0.5 \times \text{exhaust temperature (}^{\circ}\text{C)} / 100^{\circ}\text{C} \times \text{length of exhaust pipe (m)}$

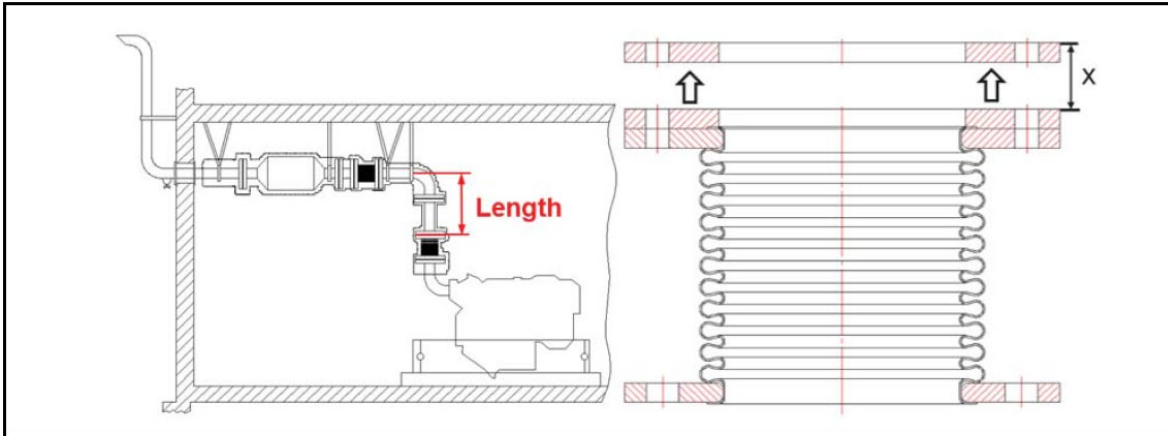
For example, in the case of a 4 m exhaust pipe with an exhaust temperature of 500°C, the bellows must be installed with a space of 10 mm.

- $0.5 \times 500 / 100 \times 4 = 10.0 \text{ mm}$

Incorrectly aligned bellows may lead to damage.



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### 8.1.3 Condensate Drain


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

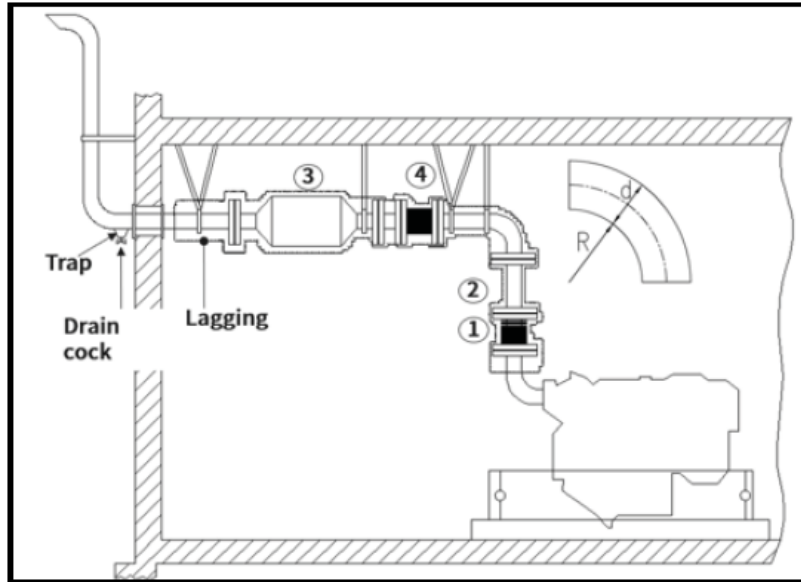
### 8.1.4 Silencer

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

### 8.1.5 Exhaust Pipe Lagging Guide

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

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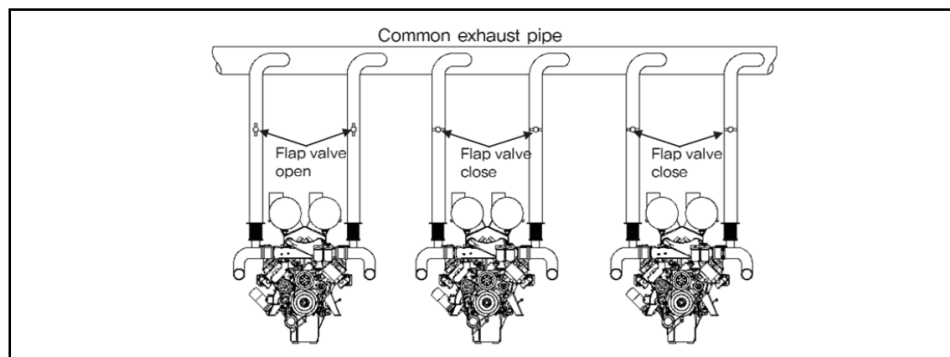
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### 8.1.5 Multiple Exhaust Systems

When more than one engine is installed as a complex assembly, all of the exhaust pipes from the engines must not be connected to a single pipe (if one of the engine stops, the concentrated carbon enters the cylinder and may severely corrode the latter).


If a flap valve with guaranteed performance is installed on each line, it is possible to connect the exhaust pipes from several engines to a single pipe.

The formula for determining the diameter of the exhaust pipe is as follows.



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- $D \text{ (Total)} = D \times K$   
D: diameter of each engine exhaust manifold  
K: constant (see table)

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

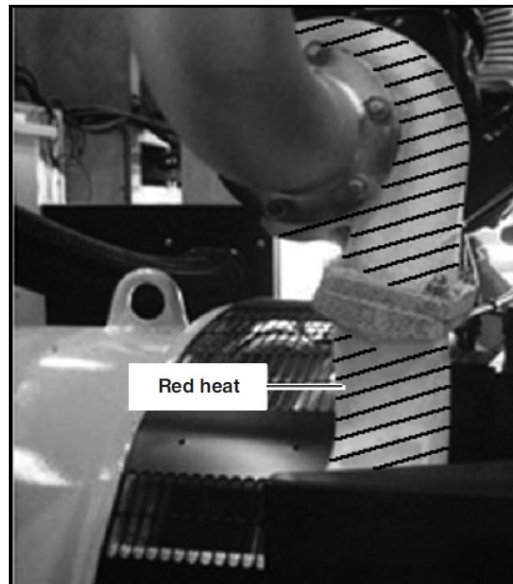
• Factor K=  $\sqrt[5]{(\text{number of engines})^2}$

### 8.1.6 Red Heat Phenomenon of Exhaust


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

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

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



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## 8.2 Air Intake System

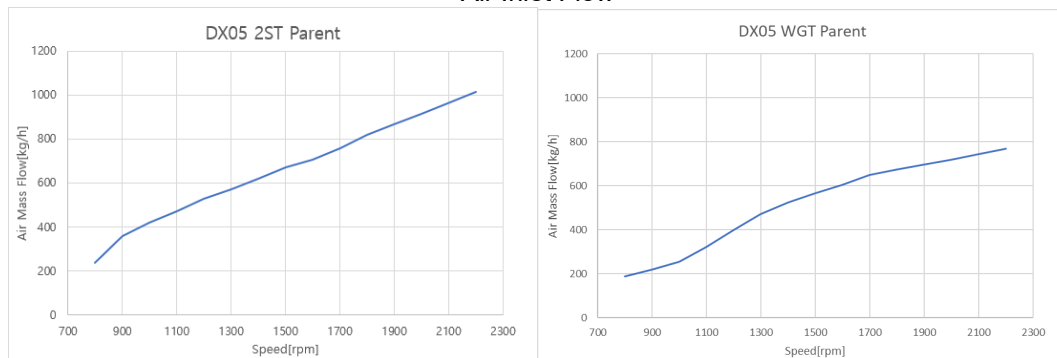
### 8.2.1 System Specification

- Temperature difference between inducing air (Compressor inlet) and ambient : Below 10 K
- Inducting flow speed : max. 4m/sec
- Recommended air filtration specification: Over 99.9% effective at 1.0g/m3 (Acc. To JIS D1612, Test Dust : ISO Fine)
- Recommended to take pre-air cleaner according to dirty ambient condition.

Permissible intake negative Pressure		Test condition	Check position	Remarks
when used the new filter	when contaminated air filter element			
300 mmH2O	630 mmH2O	at the full load	between turbocharger and air cleaner	Smoke Power BSFC


<Recommendation of Intake Pressure>

< Air Inlet Flow >



### 8.2.2 Additional Design Considerations

- Proper location of the intake port must avoid water, dust or exhaust gas entrance.
- Proper design must ensure that no solid parts can drop in the intake line after the filter cartridge during maintenance / cartridge change intervention.
- Integrity of piping and connections must be guaranteed for vehicle life.

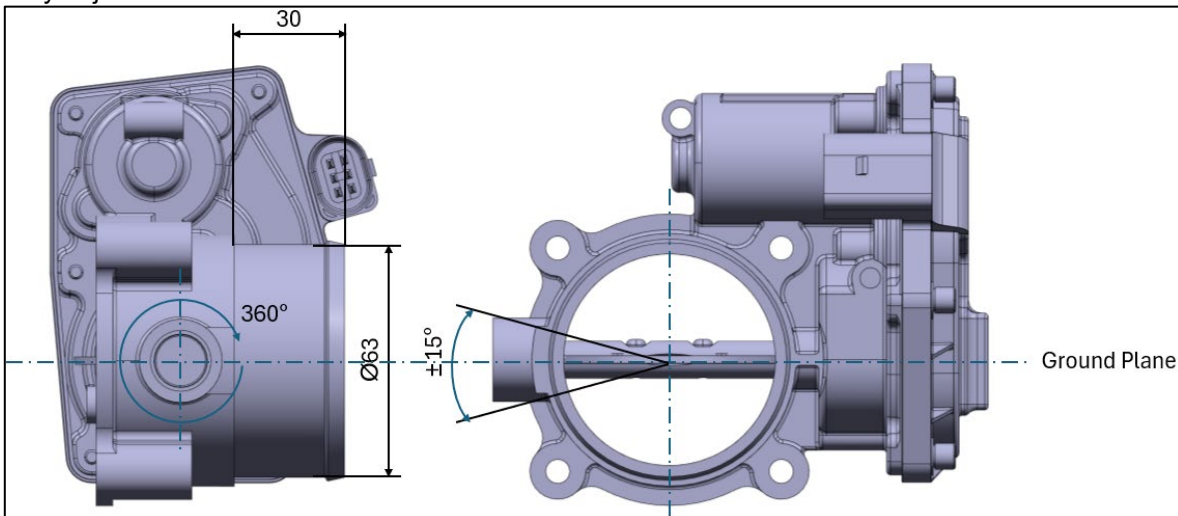
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(Connection hose of air pipe from turbocharger to intercooler must take high temperature and strength materials.)

- 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 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.

### 8.2.3 Intake Throttle Valve

- Intake throttle valve is used for controlling the exhaust gas temperature for the after-treatment by adjust intake air flow



- Do not change the valve position. The valve has been installed considering installation guide
- The valve should be protected from water and heat source
- Operating temperature: -40°C~+130°C


## 8.3 Charge Air Cooling System

### 8.3.1 System Specification

- Intercooler design guide
  - . Permissible pressure drop : 0.1 bar
  - . Permissible temperature difference ( $\Delta T$ ) : max. 25°C  
(CAC outlet Temp-Ambient temp.)

### 8.3.2 Additional Design Considerations

- Integrity of piping and connections must be guaranteed for vehicle life, under working conditions,

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without deformation.

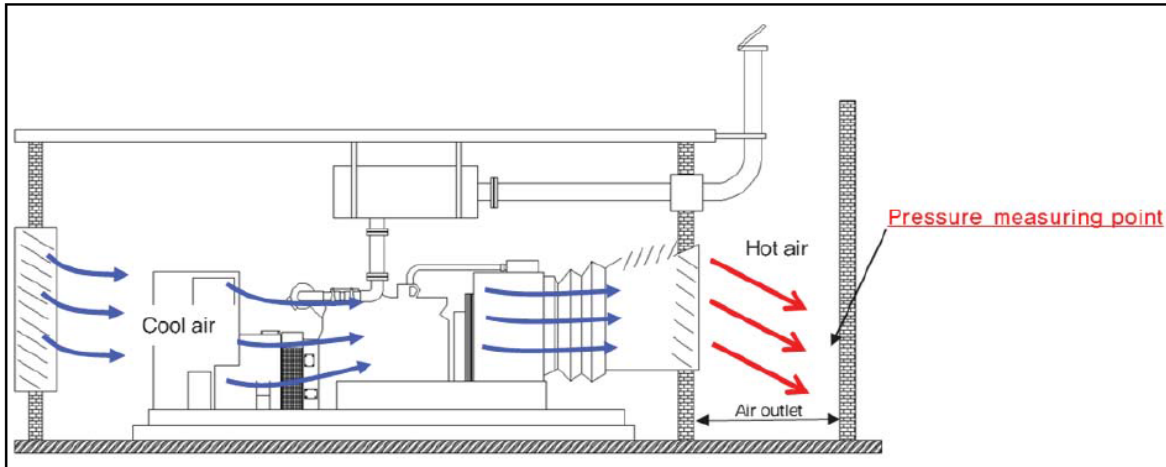
- Use of elastic constant - pressure clamps are required for all the rubber connections.
- No weight is allowed on the compressor inlet: a rubber connection and a proper mounting of the pipes must be used.
- The weight upon both sides of the turbocharger should be minimized to ensure that the turbocharger 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. 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
- 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 has been performed under worst case ambient and duty cycle conditions with maximum engine rating to be used and comply with the hose specification.

## 8.4 Engine Room Ventilation System

### 8.4.1 Induction System

- 1) The length of the air outlet must be greater than the height of the radiator core.
- 2) The direction of the inlet/outlet dampers must be such that airflow is directed downwards in order for air to pass by the engine.
- 3) The maximum allowable pressure at the air outlet is 12.7 mmH<sub>2</sub>O, which should be measured at the end of the wind wall as shown in the figure. If the allowable pressure standard is not satisfied, cooling performance may be degraded.
- 4) The temperature in the engine room must be designed to satisfy the following requirement  
 1. air cleaner intake air temperature  $\leq$  ambient temperature + 10°C.  
 requirement 2. radiator cooling air temperature  $\leq$  ambient temperature + 10°C.
- 5) If aftertreatment placed behind the radiator, in order to meet the above temperature difference requirement between inlet and outlet of radiator, it is recommended that OEM adds an insulation material around the exhaust pipe from T/C to ATS. Also, an additional cooling could be required to meet the above temperature difference.

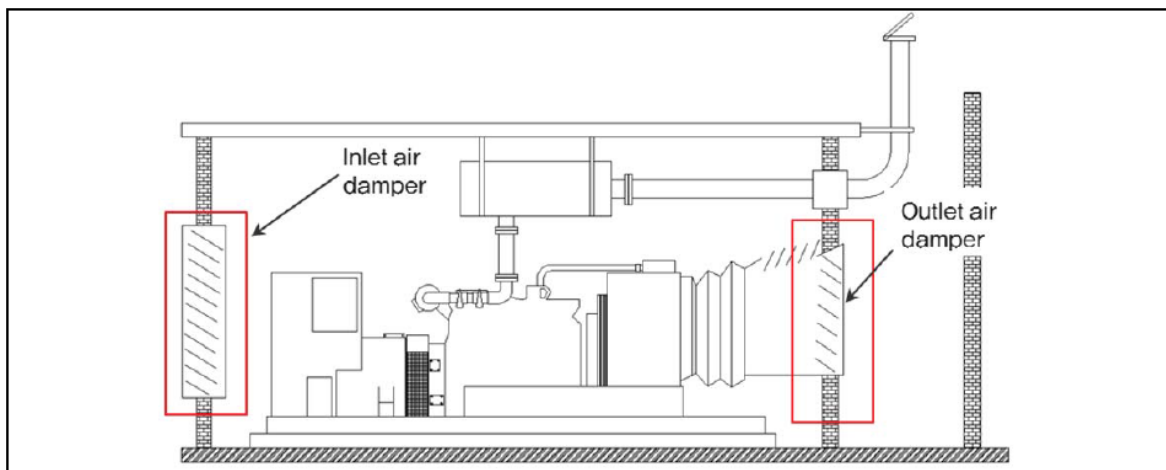
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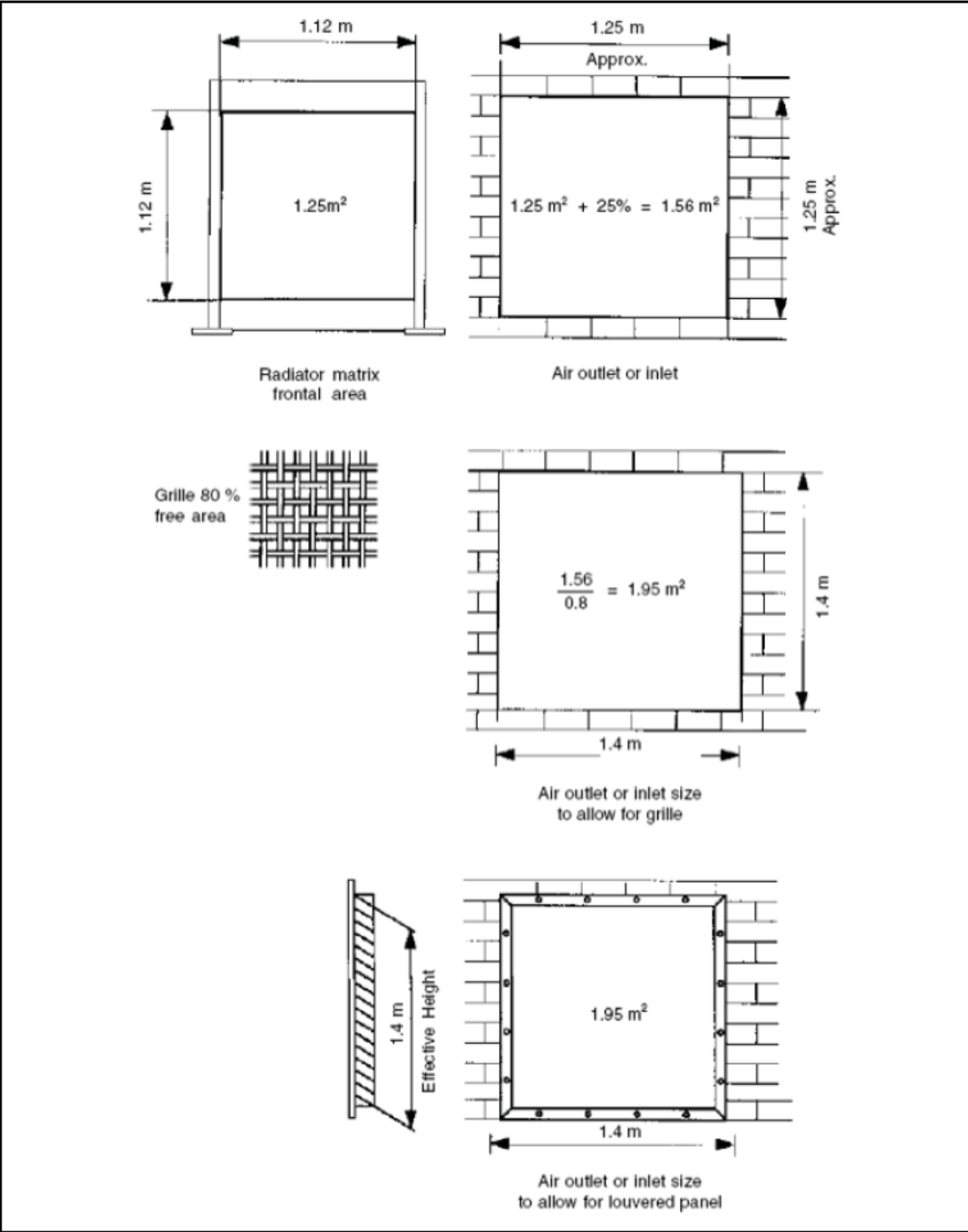
#### 8.4.2 Ventilation

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




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## 9. Electrical System

### 9.1 ECU

#### 9.1.1 Scope of TCD (Technical Customer Document)

##### 9.1.1.1 Voltage Ranges

The ECU is designed for power supply in the vehicle with 24V supply, the effective supply is 28V. Measured at control unit pins and applicable for:

- Full functional range 9 V – 32 V
- Normal operation with increased tolerance\*1 6 V – 9 V and 32 V to 36 V
- Jump Start\*2 36 V

For operating voltages <6V 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 increased tolerance is mainly applicable to the common rail injection and the power stages. For voltage in the range of 32-36V, a maximum operating temperature of (T<sub>amax</sub> - 10°C) is permissible.

\*2 For 60 s at T<sub>a</sub> < +40°C permissible.

##### 9.1.1.2 Environmental specification

- Operating ambient temperature      -40 ~ 85°C
- Humidity                                      below 100%
- Waterproofing                                IPx6K and IPx9K

##### 9.1.1.3 Installation Location and Position


The installation location of the ECU is to be selected in such a way that the ambient conditions and limit values specified in this TCD are adhered to. Hints for installation location, fastening points, tightening torques and correct installation are specified in the offer drawing.

Installation location and installation procedure shall be determined for the respective project and validated and released in production configuration (e.g., installation and support for the control unit as well as cable harness fittings corresponding to production release) by the customer. The measurements have to be carried out regarding temperatures and vibrations occurring at the mounting location. Different vehicle and power variants are to be considered. The test execution can be ordered from Bosch and is to be agreed upon between the customer and Bosch specifically for the project, within the framework of system release.

Provide air circulation over the control unit to keep its temperature within the specified design limits. Air circulation is necessary for cooling.

Place the electronic control unit away from radiating heat sources. Radiating heat sources are components which have a higher temperature than the ambient air temperature. When a radiator is mounted near the cover of the control unit, the absorbed radiated heat may increase the control unit temperature. If the electronic control unit temperature exceeds the specified design limits malfunction or degradation of lifetime is the consequence.

For natural convection installations (e.g., installation in a closed box where no extra air movement is present), placement of reflective surfaces (objects with a low emissivity coefficient) near to the black cover will reduce the control unit's thermal performance. If the electronic control unit temperature exceeds the specified design limits malfunction or degradation of lifetime is the consequence.

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#### 9.1.1.4 Acceptable Vibration Level

Broadband noise	
Valid for A-B-C direction	
Frequency [Hz]	PSD [ $[(m/s^2)^2/Hz]$ ]
10	8
20	16
30	16
180	0,44
2000	0,44

Table 19: Random Vibration Profile (Permissible load, CV-Chassis mount)

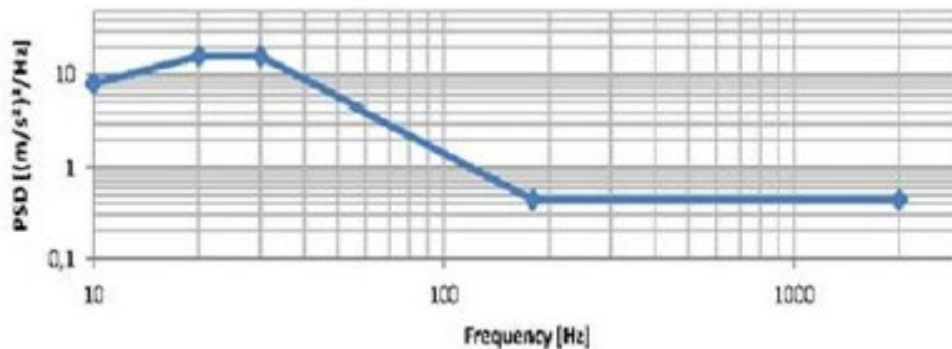


Figure 19 Random Vibration Profile (Permissible loads – all directions)

#### - Engine/Chassis mount.

The environmental conditions of the ECU are specified in the documents Environmental Specification for Electronic Control Unit.

Emissions from mobile transceivers in the close-up range can exceed the limits for the immunity to interference specified in the customer requirements.

Functional failures of the vehicle component cannot be excluded in case of distances less than or equal to 200 mm between the installed vehicle component and all possible positions of the mobile transceivers


- The latter is restricted to the passenger compartment and trunk in passenger cars and commercial vehicles. If the customer intends to fall below the minimum safety distance of 200 mm, it is the customer's responsibility to check whether additional measures are necessary for this application, and implement these measures.

Please contact Robert Bosch GmbH in case of any modification regarding ECU mounting position and condition.

#### - Coating of the Electronic Control Unit (ECU)

The coating process has to be discussed with Robert Bosch GmbH.

If the Electronic Control Module is coated, it must be ensured, that the Pressure Compensation Element (PCE), the connector and the label are free of coating.

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#### 9.1.1.5 Environmental Loads

##### - Thermal load


The mounting position of the ECU has to be in a distance which is large enough from a heat source to avoid any influence of heat transfer to the ECU. For additional protection of heat transfer, heat shields should be mounted (Figure 5). In case of doubt the minimal distance between ECU and heat source should be measured. The permissible ambient temperature for the ECU is contained in the project-specific TCI. The appropriate measuring points for the temperature revision are described in the TCI or the offer drawing. For the heat dissipation of the ECU cooling fins at the housing are intended. These must be streamed by air. The specified value of the air flow rate is described in the project-specific TCI. In case of using an additional cover for the ECU Figure 6, a temperature measurement must be executed before the release of the ECU. By mounting the ECU in an electronic box (e-box), a heat build-up inside the e-box must be avoided. This could be achieved by ventilation inside the e-box. For confirmation of the ventilation, the thermal situation must be measured in critical cases and the values must be within the permissible limit set in the TCI.



Abbildung 5: Hitzeschutzblech  
Figure 5: heat shield



Abbildung 6: zusätzliche Abdeckung am MSG  
Figure 6: additional cover of the ECU

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#### -Humidity and Corrosion Load

The mounting place of the ECU should be chosen to gain low humidity and corrosion loads. Permanent water spraying based on splash water must be avoided by appropriate protections. An example for a critical mounting position or respectively effects measures is given in Figure 7.

Possible load cases are water at parking and moving vehicles, spraying at cleaning events and dripping water from neighbouring parts.

To avoid incoming water through the connectors in the ECU (capillary attraction), the open wire ends (e.g. ground connectors) must insulated.



**Abbildung 7: kritischer Einbauort bezüglich Korrosion und Wasserlast**

**Figure 7: critical mounting area for corrosion and water load**

#### - Chemical Load (Media)

The impact of chemicals (e.g. oils, diesel, and gasoline, detergents for cleaning, brake fluid, battery acid, and so on) should be low.

Thereby the misuse of the chemicals could be critical and should be considered.


#### - Recommendation for installation places

Regarding the environmental load, the following order of the general installation places for electronic control units can be given. The list is sorted according to ascending load:

- : Passenger compartment
- : Boot, e.g., spare wheel recess
- : Plenum chambers
- : Engine Compartment
- : Under body
- : Fenders

This list serves as a reference; permutations can appear in the order. The respective loads must be checked project-specifically.

For mounting the ECU in the engine compartment, the best placements are on the firewall or at the left or right fender.

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### 9.1.2 Wiring harness laying

The first fixation point of the wiring harness must be in a distance  $<150$  mm from the cable outlet and on the same vibration level as the ECU (figure 3).

Relative motion between the wiring harness and the ECU has to be minimized. Tension- and pressure force on the connector caused by the wiring harness is not permissible. For detailed values please contact the connector manufacturer.

The wiring harness is not allowed to rub on neighbouring parts.

It has to be assured that no water can infiltrate through the wiring harness into the connector or the ECU respectively. This can be achieved by using a Siphon or a breathing hole according Figure 4.



Figure 3: Example of wiring harness layer (distance  $\leq 150$  mm, same vibration level)

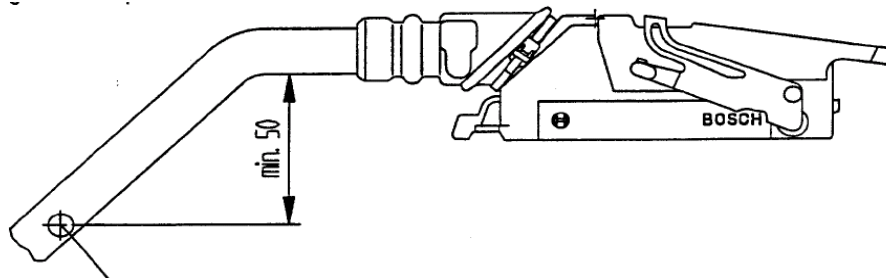



Figure 4: ventilation opening on the wiring harness

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### 9.1.3 Battery Connection to ECU

#### Battery (+) Connection

Power dissipation is highly dependent on application and operating point of ECU.

There is a maximum temperature limit of the ECU which must never be exceeded during the active lifetime of the ECU. This maximum temperature is 95°C at a location at the bottom plate of the ECU housing. The exact location is defined in offer drawing [3].

#### Battery (-) Connection

The ECU case has an electric connection to VBAT-, composed out of a resistor parallel to a capacitor. When the ECU is mounted on the engine this configuration will prevent excessive currents from flowing through the ECU to VBAT+. See also wiring harness guideline [4]

#### Correct Power Supply Wiring

- ECU Positive wires connected direct to battery, not via starter motor
- Power supply wires go to all 3 positive pins and all 3 negative pins on the ECU connector
- ECU Negative is wired to the battery rather than return through chassis.
- The engine is grounded to the machine chassis.

#### Incorrect wiring

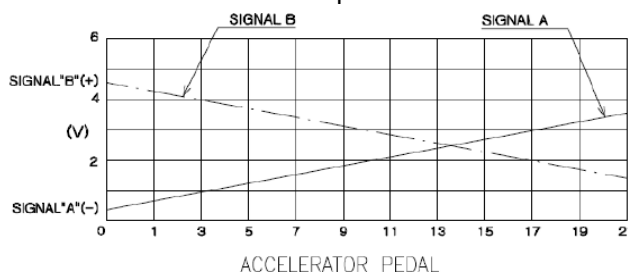
- Positive wired via starter motor. High volt drop to ECU on starting
- Single pin on ECU used for each of positive and negative supply. Possibly exceeding pin ratings and possible risk of arcing or overheating.
- ECU return through chassis – risk of conducted noise and also additional voltage drop.
- Engine not grounded – risk of engine component damage.

### 9.1.4 Circuit Diagram


- Switches (Droop, Engine stop, AUX input) type is lock type.
- Switches (DPF regen/inhibit) type is self-return and need to press and hold the switch for more than 3 seconds to activate the signal.
- LEDs(Cold start, SCR Tank LED, Wait to disconnect) current consumption should be around 20mA and parallel resistance(1.2kohm) need to be connected to prevent mild glowing.
- Accel. Pedal can be used with the following two spec. (Hardwire interface only)

#### 1) Dual Signal - cross type

- : Sensor Supply Voltage: 5V(Nom.)
- : Sensor supply capacitance should be lower than 1uF.
- : Sensor current consumption should be lower than 150mA.



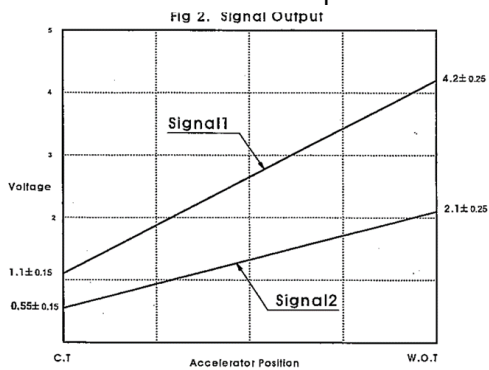


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App Angle	Vout (Min)	Vout(Nominal)	Vout(Max)
0	0.35	0.40	0.50
0.5	0.45	0.50	0.60
1	0.54	0.60	0.70
1.5	0.64	0.70	0.80
2	0.74	0.80	0.91
2.5	0.84	0.90	1.01
3	0.93	1.00	1.11
3.5	1.03	1.10	1.21
4	1.13	1.20	1.31
4.5	1.23	1.30	1.41
5	1.32	1.40	1.51
5.5	1.42	1.50	1.62
6	1.52	1.60	1.72
6.5	1.61	1.70	1.82
7	1.71	1.80	1.92
7.5	1.81	1.90	2.02
8	1.91	2.00	2.12
8.5	2.00	2.10	2.22
9	2.10	2.20	2.33
9.5	2.20	2.30	2.43
10	2.29	2.40	2.53
10.5	2.39	2.50	2.63
11	2.49	2.60	2.73
11.5	2.59	2.70	2.83
12	2.68	2.80	2.93
12.5	2.78	2.90	3.03
13	2.88	3.00	3.14
13.5	2.98	3.10	3.24
14	3.07	3.20	3.34
14.5	3.17	3.30	3.44
15	3.27	3.40	3.54
15.5	3.36	3.50	3.64
16	3.46	3.60	3.74
16.5	3.56	3.70	3.85
17	3.66	3.80	3.95
17.5	3.75	3.90	4.05
18	3.85	4.00	4.15

## 2) Dual Signal – 1:2 Ratio Type


- : Sensor Supply Voltage: 5V(Nom.)
- : Sensor supply capacitance should be lower than 1uF.
- : Sensor current consumption should be lower than 150mA.



	APP position	Min	Typical	Max
APP1	closed throttle	0.95	1.1	1.25
	wide open throttle	3.95	4.2	4.45
APP2	closed throttle	0.4	0.55	0.7
	wide open throttle	1.85	2.1	2.35



Circuit Diagram

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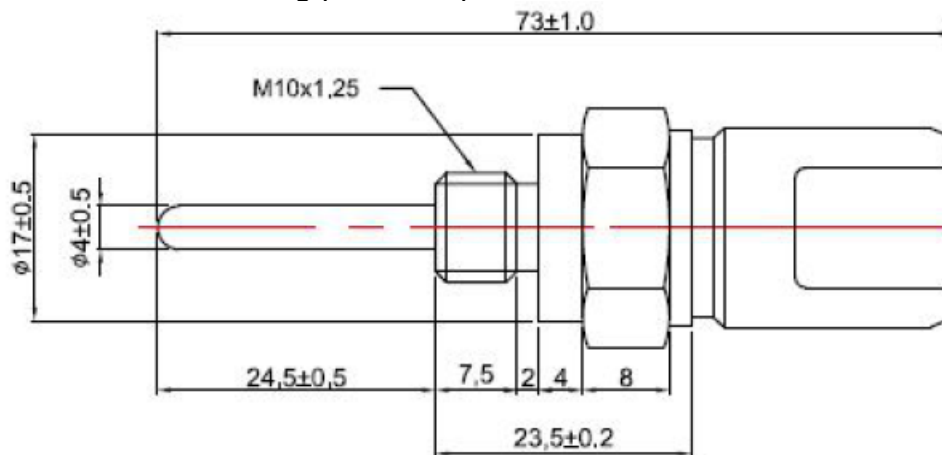
### 9.1.5 Wiring Harness Guide



## 9.2 Sensors

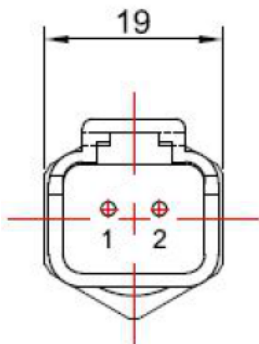
### 9.2.1 Ambient Temperature Sensor

#### 9.2.1.1 Sensor 2D drawing (dimension)



#### 9.2.1.2 I/O description


- Counter connector : DEUTSCH CONNECTOR DT06-2S



#### 9.2.1.3 Operating temperature: -40°C ~ 125°C

#### 9.2.1.4 Tightening Torque: 10±1 Nm



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## 9.2.2 After-treatment System Components (Sensors & Harness)

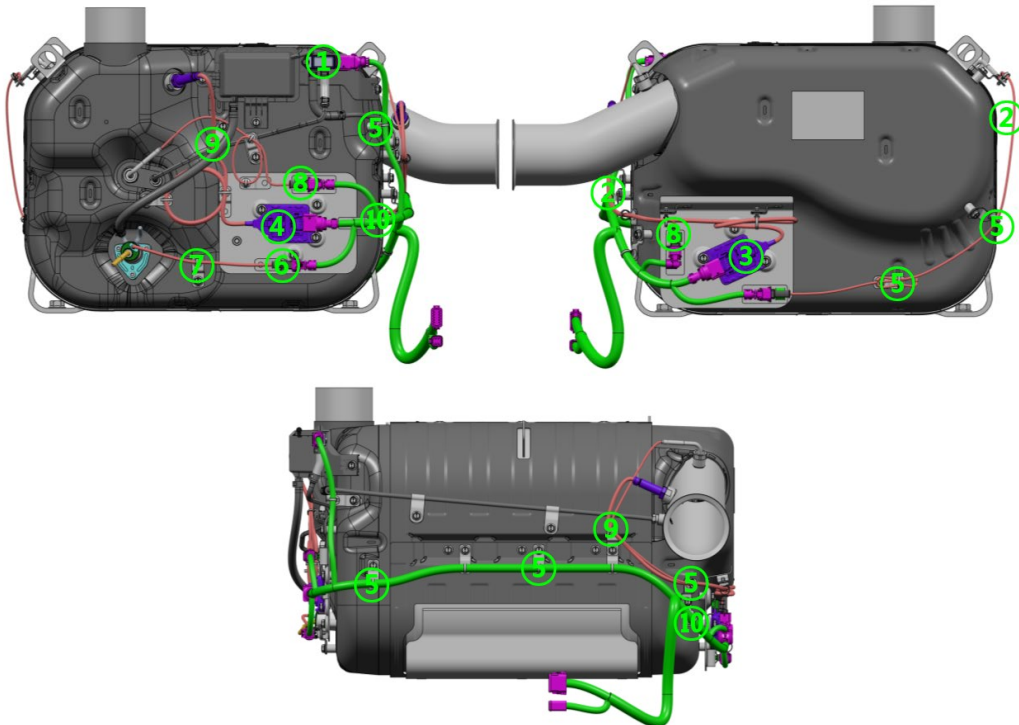
### 9.2.2.1 ATS Electrical Part List


NO	Part	Limit(°C)	Remark
1	DPF DP Sensor	130	Measuring of surface temperature
2	Temp sensor cable	240	Measuring of cable surface temperature nearest to aftertreatment canning
3	NOx sensor controller (Up-stream)	125	Measuring of controller surface temperature nearest to aftertreatment canning
4	NOx sensor controller (Down-stream)	125	
5	Band cable (wire harness)	150	Measuring of surface temperature
6	Dosing module connector	140	
7	Dosing module cable	180	
8	Temp sensor connector	140	
9	NOx sensor cable (Up&Down stream)	200	
10	Wire harness	150	

### 9.2.2.2 Measurement

- In case of electrical parts applied to After-treatment system, user need to consider the location in order to avoid thermal damage.

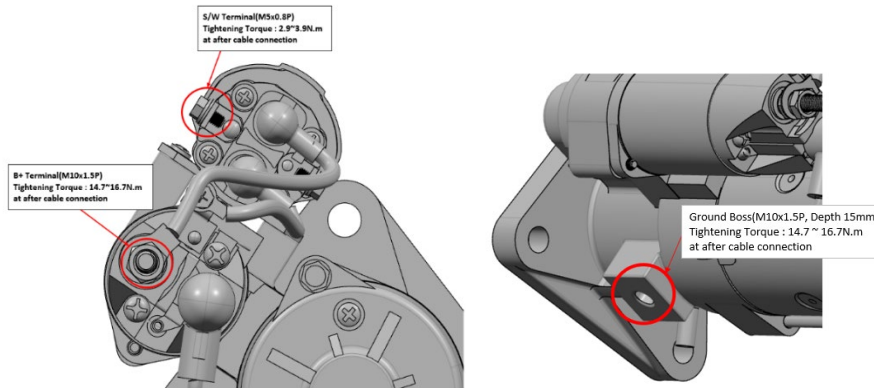
#### 9.2.2.2 Location of surface temperature measurement for ATS electrical parts



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## 9.3 STARTER

### 9.3.1 Starter Terminal Connection



### 9.3.2 IP(International Protection) grade for Starter

- IP (International Protection) grade
  - : Engineering discussion is required if there is an IP grade requested by the Customer
  - : In general, electrical parts should be protected from direct high-pressure washing and rainfall ingress.

### 9.3.3. Operation Voltage for Starter Solenoid


- The minimum voltage required to operate the starter solenoid is at least 16V(24V System)

### 9.3.4. 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.

### 9.3.5. Mandatory Caution of Starter Control

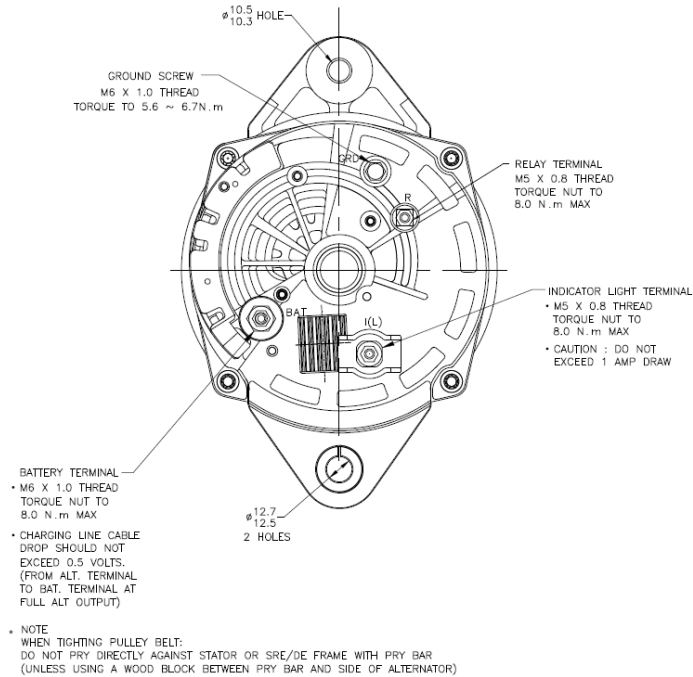
- Guide the engine not to hold the key over 30 seconds when starting the engine.
  - : Recommend trying to start after checking the parts related to starting (Battery, Relay, Cable, Etc.) when starting occurred twice continuous fails.

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## 9.4 Alternator

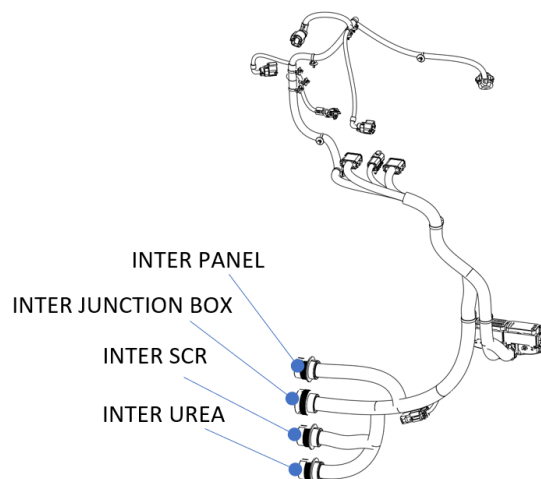
### 9.4.1 Alternator Counter Connector


- Resistance installation may be required to meet the reference values of the alternator's L terminal voltage and current.



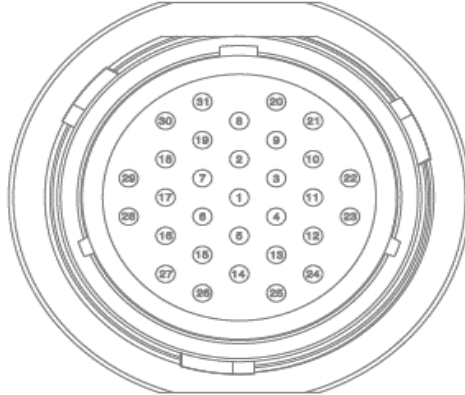
## 9.5 Wire Harness

### 9.5.1 Wire Harness Counter Connector



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- To Panel Connection Counter Connector : DEUTSCH - HDP26-24-31SE  
[Engine]



[Counter]

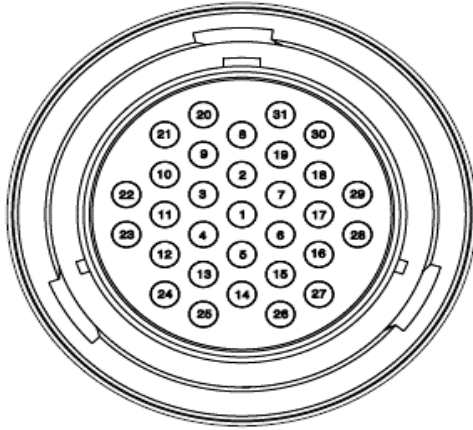
1	2	3	4	5	6	7	8	9	10
27A	26A	25A	23B	23A	22A	21A	20A	K02A	G01A
11	12	13	14	15	16	17	18	19	20
-	19A	-	17A	K77A	K78A	K76A	K75A	A73A	A72
21	22	23	24	25	26	27	28	29	30
K45	K61	K63	K44	K83	K84	-	K68	K14	K64
31									
K82									



Circuit	Size(mm)	Color	Insulation	Circuit description	From	No.	To	No.
27A	2	R	FLR91X-A	ECU PWR	INTER PANEL(INT PANEL)	1	INTER JUNCTION BOX(INT JBOX)	27
26A	2	P	FLR91X-A	HOSE HEATER SUPPLY	INTER PANEL(INT PANEL)	2	INTER JUNCTION BOX(INT JBOX)	26
25A	1.5	Y	FLR91X-A	UREA TANK SUPPLY	INTER PANEL(INT PANEL)	3	INTER JUNCTION BOX(INT JBOX)	25
23B	2	R	FLR95X-A	FUEL HEATER SUPPLY	INTER PANEL(INT PANEL)	4	INTER JUNCTION BOX(INT JBOX)	24
23A	2	R	FLR95X-A	FUEL HEATER SUPPLY	INTER PANEL(INT PANEL)	5	INTER JUNCTION BOX(INT JBOX)	23
22A	2	B	FLR95X-A	HOSE HEATER GND	INTER PANEL(INT PANEL)	6	INTER JUNCTION BOX(INT JBOX)	22
21A	2	B	FLR92X-A	FUEL HEATER #2 GND	INTER PANEL(INT PANEL)	7	INTER JUNCTION BOX(INT JBOX)	21
20A	2	B	FLR91X-A	FUEL HEATER #1 GND	INTER PANEL(INT PANEL)	8	INTER JUNCTION BOX(INT JBOX)	20
K02A	1.5	B	FLR91X-A	ECU GND	INTER PANEL(INT PANEL)	9	SP_01	
G01A	0.75	B	FLR91X-A	UREA TANK GROUND	INTER PANEL(INT PANEL)	10	SP_10	
19A	1.5	W	FLR91X-A	T15_1GNITION	INTER PANEL(INT PANEL)	12	INTER JUNCTION BOX(INT JBOX)	19
17A	2	B	FLR91X-A	T50 (START)	INTER PANEL(INT PANEL)	14	INTER JUNCTION BOX(INT JBOX)	17
K77A	0.75	Y	FLR91X-A_T06	CANO LOW	INTER PANEL(INT PANEL)	15	SP_04	
K78A	0.75	W	FLR91X-A_T06	CANO HIGH	INTER PANEL(INT PANEL)	16	SP_05	
K76A	0.75	O	FLR91X-A_T09	CAN1 LOW	INTER PANEL(INT PANEL)	17	SP_06	
K75A	0.75	R	FLR91X-A_T09	CAN1 HIGH	INTER PANEL(INT PANEL)	18	SP_07	
K73A	0.75	R	FLR91X-A	BATTERY PLUS OUTPUT	INTER PANEL(INT PANEL)	19	SP_12	
K72	0.75	Y	FLR91X-A	WAIT TO DISSCONNECT LED LOW	INTER PANEL(INT PANEL)	20	INTER 4(1NT 4)	9
K45	0.75	R	FLR91X-A	PEDAL POSITION 1 PWR(5V)	INTER PANEL(INT PANEL)	21	ECU K(ECU K)	45
K61	0.75	Y	FLR91X-A	PEDAL POSITION 1 SIG	INTER PANEL(INT PANEL)	22	ECU K(ECU K)	61
K63	0.75	B	FLR91X-A	PEDAL POSITION 1 GND	INTER PANEL(INT PANEL)	23	ECU K(ECU K)	63
K44	0.75	R	FLR91X-A	PEDAL POSITION 2 PWR(5V)	INTER PANEL(INT PANEL)	24	ECU K(ECU K)	44
K83	0.75	G	FLR91X-A	PEDAL POSITION 2 SIG	INTER PANEL(INT PANEL)	25	ECU K(ECU K)	83
K84	0.75	B	FLR91X-A	PEDAL POSITION 2 GND	INTER PANEL(INT PANEL)	26	ECU K(ECU K)	84
K68	0.75	R	FLR91X-A	SWITCHED BATTERY UB25	INTER PANEL(INT PANEL)	28	ECU K(ECU K)	68
K14	0.75	O	FLR91X-A	DPF REGNERATION SWITCH	INTER PANEL(INT PANEL)	29	ECU K(ECU K)	14
K64	0.75	Y	FLR91X-A	DPF REGNERATION INHIBIT SWITCH	INTER PANEL(INT PANEL)	30	ECU K(ECU K)	64
K82	0.75	G	FLR91X-A	ENGINE STOP SWITCH	INTER PANEL(INT PANEL)	31	ECU K(ECU K)	82

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- To Junction Box Counter Connector : DEUSCH - HDP24-24-31PE  
[Engine]




[Counter]

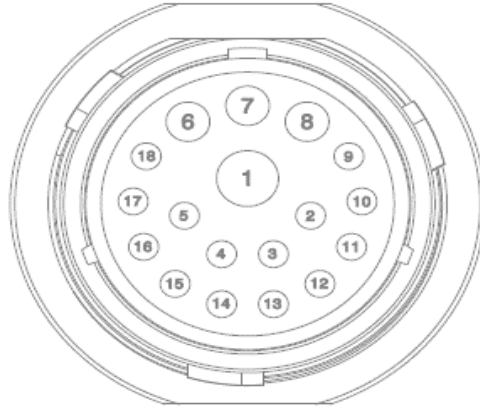


<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>
S01	K36	K90	K29	K73	K21	K50	K26	K25	10A
<b>11</b>	<b>12</b>	<b>13</b>	<b>14</b>	<b>15</b>	<b>16</b>	<b>17</b>	<b>18</b>	<b>19</b>	<b>20</b>
11A	12A	P01A	14A	K20A	K74	17A	K88A	19A	20A
<b>21</b>	<b>22</b>	<b>23</b>	<b>24</b>	<b>25</b>	<b>26</b>	<b>27</b>	<b>28</b>	<b>29</b>	<b>30</b>
21A	22A	23A	23B	25A	26A	27A	K01A	K86	K70
<b>31</b>									
-									

Circuit	Size(mm²)	Color	Insulation	Circuit description	From	No.	To	No.
S01	2	W	FLR91X-A	STARTER SIG	INTER 4(INT 4)	6	INTER JUNCTION BOX(INT JBOX)	1
K36	0.75	Y	FLR91X-A	START RELAY HIGH	ECU K(ECU K)	36	INTER JUNCTION BOX(INT JBOX)	2
K90	0.75	Brn	FLR91X-A	START RELAY LOW	ECU K(ECU K)	90	INTER JUNCTION BOX(INT JBOX)	3
K29	0.75	Y	FLR91X-A	HOSE HEATER RLY SIG	ECU K(ECU K)	29	INTER JUNCTION BOX(INT JBOX)	4
K73	0.75	G	FLR91X-A	HEATER RLY PWR	ECU K(ECU K)	73	INTER JUNCTION BOX(INT JBOX)	5
K21	0.75	L	FLR91X-A	PRESSURE HEATER RLY SIG	ECU K(ECU K)	21	INTER JUNCTION BOX(INT JBOX)	6
K50	0.75	O	FLR91X-A	SUCTION HEATER RLY SIG	ECU K(ECU K)	7	INTER JUNCTION BOX(INT JBOX)	7
K26	0.75	Y	FLR91X-A	BACK FLOW HEATER RLY SIG	ECU K(ECU K)	26	INTER JUNCTION BOX(INT JBOX)	8
K25	0.75	W	FLR91X-A	SUPPLY MODULE HEATER RLY SIG	ECU K(ECU K)	25	INTER JUNCTION BOX(INT JBOX)	9
10A	1.5	R	FLR91X-A	PRESSURE HEATER	INTER UREA(INT UREA)	19	INTER JUNCTION BOX(INT JBOX)	10
11A	1.5	Brn	FLR91X-A	SUCTION HEATER	INTER UREA(INT UREA)	18	INTER JUNCTION BOX(INT JBOX)	11
12A	1.5	L	FLR91X-A	BACK FLOW HEATER	INTER UREA(INT UREA)	18	INTER JUNCTION BOX(INT JBOX)	12
P01A	0.75	R	FLR91X-A	UREA TANK SUPPLY	SP_11		INTER JUNCTION BOX(INT JBOX)	13
14A	1.5	Y	FLR91X-A	SCR SUPPLY MODULE HEATER GND	INTER UREA(INT UREA)	5	INTER JUNCTION BOX(INT JBOX)	14
K20A	2	R	FLR94X-A	HOSE HEATER BAT+	SP_13		INTER JUNCTION BOX(INT JBOX)	15
K74	0.75	B	FLR91X-A	KEY SWITCH START(TS0)	ECU K(ECU K)	74	INTER JUNCTION BOX(INT JBOX)	16
17A	2	B	FLR91X-A	T50 (START)	INTER PANEL(INT PANEL)	14	INTER JUNCTION BOX(INT JBOX)	17
K88A	0.75	Brn	FLR91X-A	KEY-ON(T15)	SP_03		INTER JUNCTION BOX(INT JBOX)	18
19A	1.5	W	FLR91X-A	T15_1GNITION	INTER PANEL(INT PANEL)	12	INTER JUNCTION BOX(INT JBOX)	19
20A	2	B	FLR91X-A	FUEL HEATER #1 GND	INTER PANEL(INT PANEL)	8	INTER JUNCTION BOX(INT JBOX)	20
21A	2	B	FLR92X-A	FUEL HEATER #2 GND	INTER PANEL(INT PANEL)	7	INTER JUNCTION BOX(INT JBOX)	21
22A	2	B	FLR95X-A	HOSE HEATER GND	INTER PANEL(INT PANEL)	6	INTER JUNCTION BOX(INT JBOX)	22
23A	2	R	FLR95X-A	FUEL HEATER SUPPLY	INTER PANEL(INT PANEL)	5	INTER JUNCTION BOX(INT JBOX)	23
23B	2	R	FLR95X-A	FUEL HEATER SUPPLY	INTER PANEL(INT PANEL)	4	INTER JUNCTION BOX(INT JBOX)	24
25A	1.5	Y	FLR91X-A	UREA TANK SUPPLY	INTER PANEL(INT PANEL)	3	INTER JUNCTION BOX(INT JBOX)	25
26A	2	P	FLR91X-A	HOSE HEATER SUPPLY	INTER PANEL(INT PANEL)	2	INTER JUNCTION BOX(INT JBOX)	26
27A	2	R	FLR91X-A	ECU PWR	INTER PANEL(INT PANEL)	1	INTER JUNCTION BOX(INT JBOX)	27
K01A	1.5	R	FLR91X-A	ECU PWR	SP_02		INTER JUNCTION BOX(INT JBOX)	28
K86	0.75	L	FLR91X-A	WIF SENSOR	ECU K(ECU K)	86	INTER JUNCTION BOX(INT JBOX)	29
K70	0.75	Y	FLR91X-A	WIF SENSOR	ECU K(ECU K)	70	INTER JUNCTION BOX(INT JBOX)	30

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-. To SCR(Muffler Assembly) Counter Connector : DEUSCH - HDP26-24-18SE




[Counter]

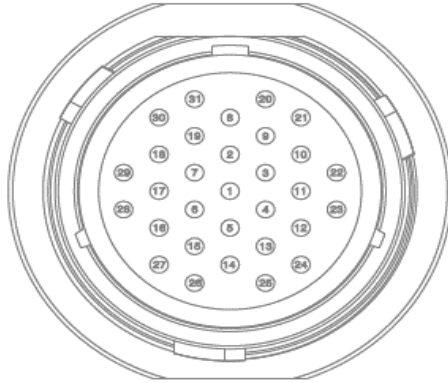


1	2	3	4	5	6	7	8	9	10
-	K10	K11	A85	A04	-	-	-	A38	A55
11	12	13	14	15	16	17	18		
P01	G01	A12A	A13A	A96	A25	A26	-		

Circuit	Size(mm)	Color	Insulation	Circuit description	From	No.	To	No.
K10	0.75	L	FLR91X-A_T04	DOSING VALVE HIGH SIDE	ECU K(ECU K)	10	INTER SCR(INT SCR)	2
K11	0.75	B	FLR91X-A_T04	DOSING VALVE LOW SIDE	ECU K(ECU K)	11	INTER SCR(INT SCR)	3
A85	0.75	Y	FLR91X-A	DOC UPSTREAM SIGNAL	INTER 3(1NT 3)	1	INTER SCR(INT SCR)	4
A04	0.75	B	FLR91X-A	DOC UPSTREAM GND	INTER 3(1NT 3)	2	INTER SCR(INT SCR)	5
A38	0.75	W	FLR91X-A	DPF UPSTREAM SIGNAL	INTER 3(1NT 3)	3	INTER SCR(INT SCR)	9
A55	0.75	O	FLR91X-A	SCR UPSTREAM SIGNAL	INTER 3(1NT 3)	4	INTER SCR(INT SCR)	10
P01	0.75	R	FLR91X-A	NOX SENSOR PWR	SP_11		INTER SCR(INT SCR)	11
G01	0.75	B	FLR91X-A	NOX SENSOR GND	SP_10		INTER SCR(INT SCR)	12
A12A	0.75	Brn	FLR91X-A_T02	CAN2 LOW	SP_08		INTER SCR(INT SCR)	13
A13A	0.75	O	FLR91X-A_T02	CAN2 HIGH	SP_09		INTER SCR(INT SCR)	14
A96	0.75	R	FLR91X-A	DPF DP SENSOR SV SENSOR SUPPLY 1B	INTER 4(1NT 4)	5	INTER SCR(INT SCR)	15
A25	0.75	B	FLR91X-A	DPF DP SENSOR GND	INTER 4(1NT 4)	4	INTER SCR(INT SCR)	16
A26	0.75	Brn	FLR91X-A	DPF DP SENSOR FLEX 1/O 1B	INTER 4(1NT 4)	3	INTER SCR(INT SCR)	17

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- To UREA Tank Assembly Counter Connector : DEUTSCH - HDP26-24-31SE




[Counter]

1	2	3	4	5	6	7	8	9	10
K24	K54	K53	K20B	14A	K07	K71	K09	K51	K27
11	12	13	14	15	16	17	18	19	20
K91	K28	P01B	G01B	A13B	A12B	12A	11A	10A	A71
21	22	23	24	25	26	27	28	29	30
A73B	-	-	-	-	-	-	-	-	-
31									
-									



Circuit	Size(mm)	Color	Insulation	Circuit description	From	No.	To	No.
K24	0.75	R	FLR91X-A	SCR PRESSURE SENSOR (5V)	ECU K(ECU K)	24	INTER UREA(INT UREA)	1
K54	0.75	W	FLR91X-A	SCR PRESSURE SENSOR (I)	ECU K(ECU K)	54	INTER UREA(INT UREA)	2
K53	0.75	B	FLR91X-A	SCR PRESSURE SENSOR (G)	ECU K(ECU K)	53	INTER UREA(INT UREA)	3
K20B	2	R	FLR95X-A	HOSE HEATER BAT+	SP_13		INTER UREA(INT UREA)	4
14A	1.5	Y	FLR91X-A	SCR SUPPLY MODULE HEATER GND	INTER JUNCTION BOX(INT JBOX)	14	INTER UREA(INT UREA)	5
K07	0.75	B	FLR91X-A	SCR AGENT PUMP MOTOR CONTROL (GROUND)	ECU K(ECU K)	7	INTER UREA(INT UREA)	6
K71	0.75	R	FLR91X-A	SCR AGENT PUMP MOTOR CONTROL (24V)	ECU K(ECU K)	71	INTER UREA(INT UREA)	7
K09	0.75	O	FLR91X-A	SCR AGENT PUMP MOTOR CONTROL (B,P)	ECU K(ECU K)	9	INTER UREA(INT UREA)	8
K51	0.75	R	FLR91X-A	SCR REVERTING VALVE (24)	ECU K(ECU K)	51	INTER UREA(INT UREA)	9
K27	0.75	L	FLR91X-A	SCR REVERTING VALVE (P)	ECU K(ECU K)	27	INTER UREA(INT UREA)	10
K91	1.5	R	FLR91X-A	SCR TANK HEATING VALVE (24V)	ECU K(ECU K)	91	INTER UREA(INT UREA)	11
K28	0.75	Y	FLR91X-A	SCR TANK HEATING VALVE (S)	ECU K(ECU K)	28	INTER UREA(INT UREA)	12
P01B	0.75	R	FLR91X-A	UREA TANK SUPPLY	SP_11		INTER UREA(INT UREA)	13
G01B	0.75	B	FLR91X-A	UREA TANK GROUND	SP_10		INTER UREA(INT UREA)	14
A13B	0.75	O	FLR91X-A_T03	CAN2 HIGH	SP_09		INTER UREA(INT UREA)	15
A12B	0.75	Bnn	FLR91X-A_T03	CAN2 LOW	SP_08		INTER UREA(INT UREA)	16
12A	1.5	L	FLR91X-A	BACK FLOW HEATER	INTER JUNCTION BOX(INT JBOX)	12	INTER UREA(INT UREA)	17
11A	1.5	Bnn	FLR91X-A	SUCTION HEATER	INTER JUNCTION BOX(INT JBOX)	11	INTER UREA(INT UREA)	18
10A	1.5	R	FLR91X-A	PRESSURE HEATER	INTER JUNCTION BOX(INT JBOX)	10	INTER UREA(INT UREA)	19
A71	0.75	W	FLR91X-A	SCR TANK LED LOW	INTER 4(1NT 4)	8	INTER UREA(INT UREA)	20
A73B	0.75	R	FLR91X-A	BATTERY PLUS OUTPUT	SP_12		INTER UREA(INT UREA)	21

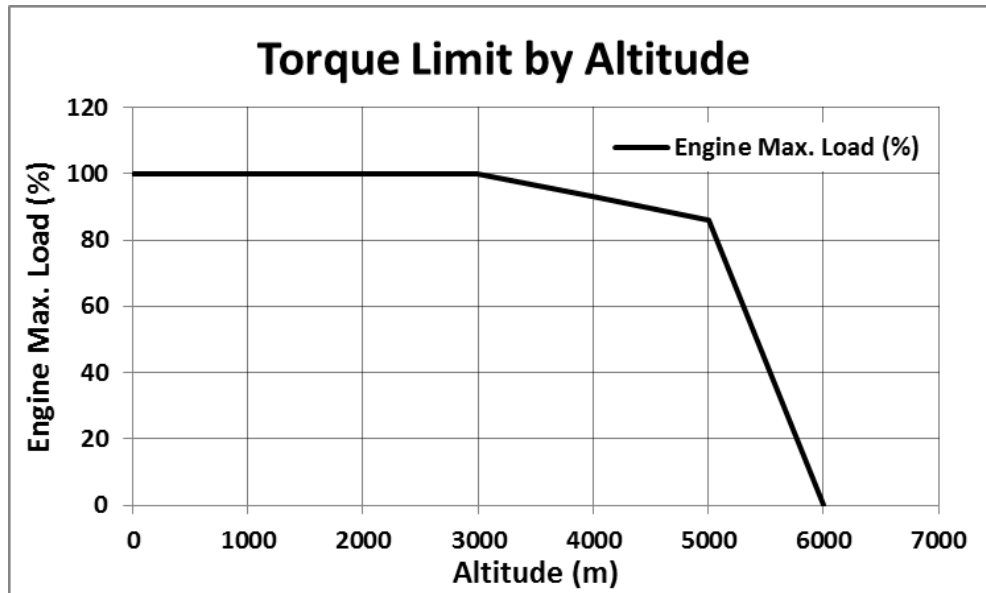


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## 10. Altitude Engine Performance De-rating

### 10.1 Altitude Engine Performance De-rating

- The engine performance is guaranteed up to **3,000m** altitude, generally.
- **HDI** strongly recommends high altitude test. If not, the engine performance will be started reduction from 3000m altitude **by 7%/1,000m**.



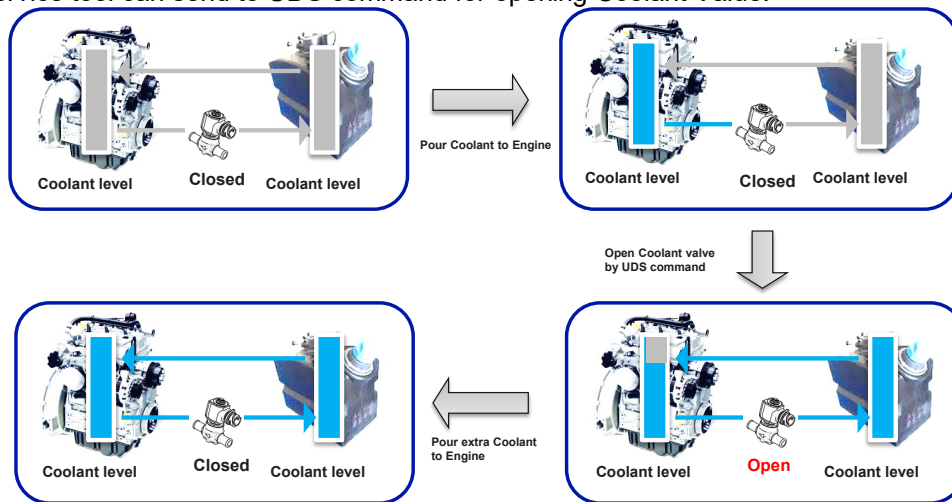


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## 11. The Guide for Machine Assembly line

### 11.1 Open Coolant valve between DEF Tank and Engine

- After Engine is installed to Machine in Machine assembly line, Coolant valve should be opened temporarily to pour extra coolant for bleeding air.
- HDI Service tool can send to UDS command for opening Coolant Value.



### 11.2 Erasing all Faults of ECU

- To prevent recording Faults in assembly line, Key-On should be performed after Engine and SCR modules are perfectly installed to Machine.
- Before Machine get out of factory, all faults of ECU should be erased by HDI Service Tool.