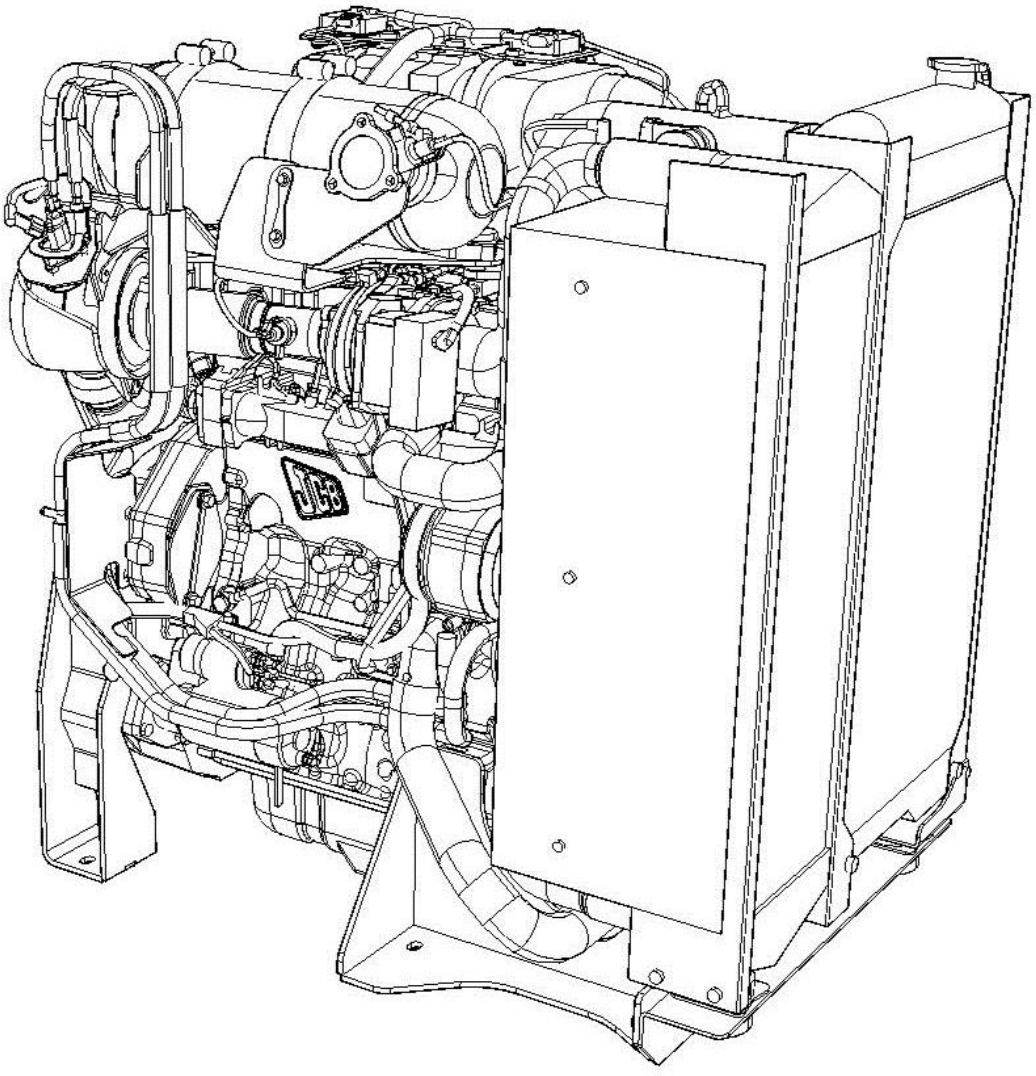
JCB Tier 4/Stage IV Industrial Power Unit

Installation Manual



This manual contains original instructions, verified by the manufacturer (or their authorised representative).
The original language is British English.

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Contents

1. Safety

1.1 Safety Notices

There are safety notices in this manual. Each notice starts with a signal word. The meanings of the signal words are given below.

The safety alert system also helps to identify important safety messages in this manual and on the engine. When you see the danger, warning and caution symbols you must be alert as your safety is involved.

Symbol	Description
W	***DANGER!*** ***The signal word 'DANGER' shows a hazardous situation which, if not avoided, will result in death or serious injury***.
W	***WARNING!*** ***The signal word 'WARNING' shows a hazardous situation which, if not avoided, could result in death or serious injury.***
W	***CAUTION!*** ***The signal word 'CAUTION' shows a hazardous situation which, if not avoided, could result in minor or moderate injury.***
C	***NOTICE!*** ***The signal word 'NOTICE' shows a hazardous situation which, if not avoided, could result in machine damage.***
N	*NOTE:* *Notes give additional information, hints and tips that help you to use your product.*

1.2 General Safety

Clothing

You can be injured if you do not wear the correct clothing. Loose clothing can get caught in the machinery.

Keep cuffs fastened. Do not wear a necktie or scarf. Keep long hair restrained. Remove rings, watches and personal jewelry.

Alcohol and Drugs

It is extremely dangerous to install or operate the engine when under the influence of alcohol or drugs. Do not consume alcoholic drinks or take drugs before or while operating the engine. Be aware of medicines which can cause drowsiness.

Feeling Unwell

Do not install or operate the engine if you are feeling unwell. By doing so you could be a danger to yourself and those you work with.

Mobile Phones

Switch off your mobile phone before entering an area with a potentially explosive atmosphere. Sparks in such an area could cause an explosion or fire resulting in death or serious injury.

Lifting Equipment

You can be injured if you use incorrect or faulty lifting equipment. You must identify the weight of the item to be lifted then choose lifting equipment that is strong enough and suitable for the job. Make sure that lifting equipment is in good condition and complies with all local regulations.

Raised Equipment

Never walk under or work under raised equipment unless it is supported by a mechanical device. Equipment which is supported only by a hydraulic device can drop and injure you if the hydraulic system fails or if the control is operated (even with the engine stopped).

Make sure that no-one goes near the engine while you install or remove the mechanical device.

Raised Engine

Never position yourself or any part of your body under a raised engine which is not correctly supported. If the engine moves unexpectedly you could become trapped and suffer serious injury or be killed.

Engine Modifications

This engine is manufactured in compliance with legislative and other requirements. It must not be altered in any way which could affect or invalidate any of these requirements. For advice consult your JCB dealer.

Clothing and Personal Protective Equipment (PPE)

Do not wear loose clothing or jewellery that can get caught on controls or moving parts. Wear protective clothing and personal safety equipment issued or called for by the job conditions, local regulations or as specified by your employer.

1.3 Lifting Safety

WARNING

Severe injury can occur if faulty or incorrect lifting equipment is used. Lifting equipment used must be in good condition and suitably rated for the lift. Make sure that the lifting tackle complies with the local regulations.

WARNING

Spreader bar must be parallel to the top of the engine during lift.

WARNING

Lifting chains must be perpendicular to the spreader bar to ensure a straight lift is achieved.

WARNING

Do not lift engine if chains are divergent or convergent.

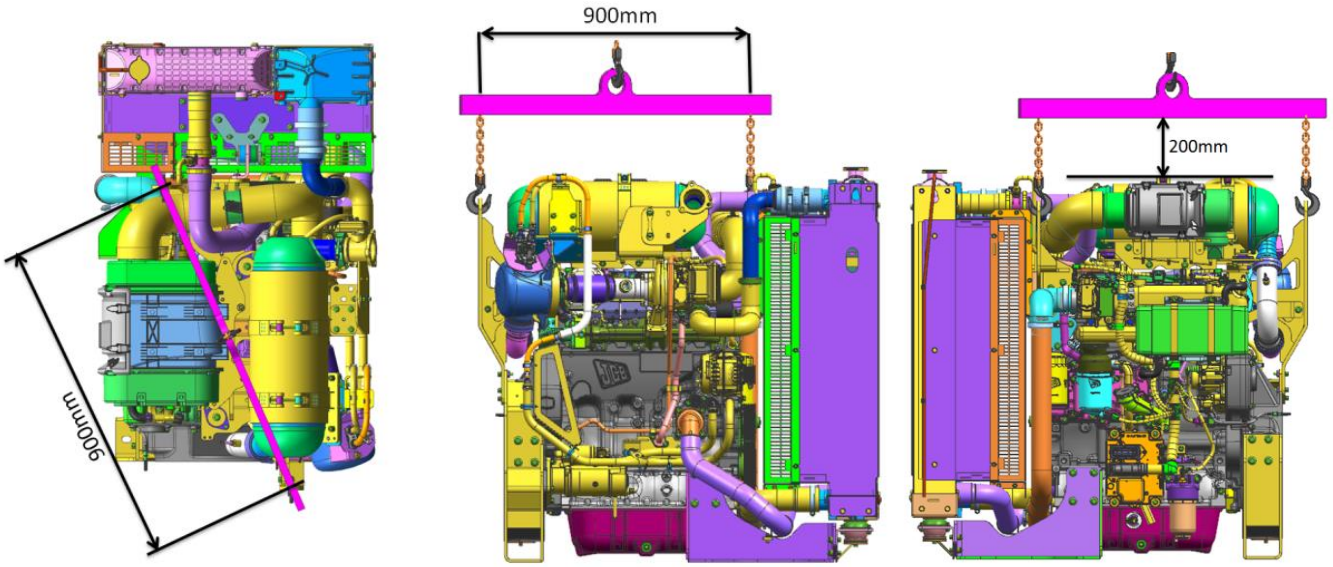
WARNING

No parts of the lifting equipment during a lift procedure should touch the engine assembly except for the specified lifting eyes. Failure to comply may result in damage to the sensitive aftertreatment systems.

Spreader Bar Size – The dimension of the spreader bar given below for each of the engine variants, is the distance at which the lifting chains should be mounted to achieve a straight lift.

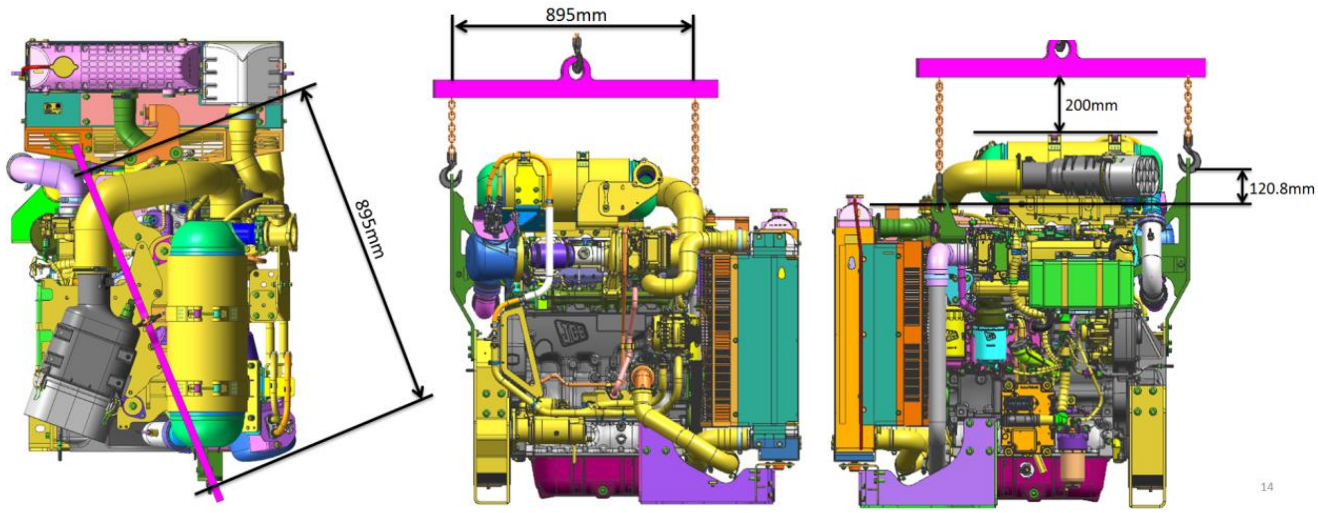
Lift Chain Length – The critical distance which must be adhered to is the difference in height between the lifting eyes perpendicular to the engine. This distance specified refers to the extra chain length that will ensure a straight lift is achieved.
A minimum distance of 200mm must be maintained between the bottom of the spreader bar and the top most feature of the engine.

Large Cooling Pack IPU
Spreader Bar Required (Distance between chains): 900mm
Lifting Eye Horizontal Height Variation – 0mm



Small Cooling Pack IPU

Spreader Bar Required (Distance between chains): 895mm
Lifting Eye Horizontal Height Variation: 120.8mm



2. Installation

2.1 Engine Model

This Installation Manual gives information for the JCB Tier 4/Stage IV EcoMAX Industrial Power Units and associated Selective Catalytic Reduction aftertreatment ancillaries.

The JCB EcoMAX engines installed in the Industrial Power Unit meet EEC/EPA emissions regulations at Stage IV / Tier 4 depending on emissions label, and are intended for these markets.

If the engine is installed in a way that makes the engine's emission control information label hard to read during normal engine maintenance, you must place a duplicate label on the equipment, as described in 40 CFR 1068.105. JCB will supply a duplicate label as required.

2.2 Application

The JCB IPU has been designed and validated for installation into OEM machines where static applications are the primary operational mode at either a constant or variable speed; care should be taken when fitting the IPU into mobile or semi mobile applications where external shock loadings and vibrational loads could take the IPU components outside of their validated boundary. Further advice can be obtained from the JCB dealer or JCB Applications department but it is the responsibility of the OEM to ensure adequate testing has been carried out to ensure the IPU product is fit for purpose in any mobile or semi mobile application.

2.3 Using this Installation Manual

This manual is arranged to give a good understanding of the JCB EcoMAX Industrial Power Unit and guidance on its safe integration into equipment. The main purpose of the manual is to help engineers and designers specialising in installing JCB EcoMAX engines into equipment. It gives advice on good practice together with requirements to ensure expected operation and engine longevity. Adherence to the advice contained in this manual will help ensure acceptance of the installation by JCB Power Systems.

Fully read this manual before you install the engine into equipment. You must give particular attention to all the safety aspects of the installation. It is the engine installer’s responsibility to ensure that users of equipment are provided with adequate instruction for safe operation of the equipment – including an Operator’s Manual, warnings, and labelling as required.

References to the ‘left’ side and the ‘right’ side of the engine are when viewed from the flywheel end of the engine.

All equipment, whether mobile or static, can be hazardous. When the engine is correctly installed, operated and maintained it can be safe to work with, but when it is not it can become a danger. The engine installer must design the installation to avoid hazards to the operator and other persons. These hazards may include component edges, surfaces and angles, as well as hot surfaces and gases or excessive vibration and sound.

Throughout this manual there are safety messages. Please read and understand these safety messages before you install the engine into equipment.

N *NOTE: For more advice and guidance consult JCB Power Systems Applications department.*

2.4 Emissions Related Installation Instructions

Failing to follow these instructions when installing a certified engine in a piece of non-road equipment violates federal law (40 CFR 1068.105(b)), subject to fines or other penalties as described in the Clean Air Act

If you install the engine in a way that makes the engine's emission control information label hard to read during normal engine maintenance, you must place a duplicate label on the equipment, as described in 40 CFR 1068.105(c)

3. Cooling System

WARNING

The cooling system is pressurised when the coolant is hot. Hot coolant can spray out on removal of the cap when the coolant is hot with the risk of causing burns injuries; ensure that the engine is cool before working on the cooling system.

WARNING

Antifreeze can be harmful. Obey the manufacturer's instructions when handling full strength or diluted antifreeze.

WARNING

Do not work on the cooling pack while the engine is running. There are rotating parts in the vicinity of the cooling pack that can cause injury. Ensure that the engine cannot be started when the fan and FEAD guarding are removed for the purpose of working on the cooling system.

CAUTION

Fans are a significant source of Off-Highway equipment noise.

3.1 Introduction

With an IPU the JCB EcoMAX engine is cooled using the supplied liquid cooling system to maintain the correct operating temperature. The engine installer must ensure the cooling performance of the unit is maintained when installed in the finished equipment. There are maximum limits for coolant and lubricating oil temperature which must not be exceeded. See the Technical Data Sheet for specific values.

The cooling pack is a combination cooler and incorporates both the radiator and charge air cooler. The coolant expansion volume is incorporated within the moulded plastic header tank which also has a filler neck fitted with a pressure control cap of 1 bar. The relief flow from the pressure cap is routed down the side of the cooling pack. The engine installer should ensure this is a safe position on the equipment or is routed to a separate reservoir and that good access can be gained to fill the cooling system.

A port is available in the header tank for the fitment of an optional coolant level switch – it is recommended that this is fitted. Particularly in static machine applications where the operator may not always be available to shut the machine down should the unit loose coolant the OEM should utilise this switch to automatically shut the engine down. .

IPUs are shipped from the factory without coolant and the engine installer must ensure that the system is filled with coolant of a minimum concentration of 30% antifreeze/corrosion inhibitor. Antifreeze and corrosion inhibitor must be ethylene glycol based to specification ASTM D6210. Failure to use the correct specification and concentration of coolant could invalidate warranty.

3.2 System Performance

The Cooling system is designed to provide a Limiting Ambient Temperature of 46 ^{0}C providing sufficient air flow is provided in the installed arrangement. The cooling system must be tested during machine development and appraisal trials to ensure the required LAT is achieved for the most onerous machine duty and operating environment. To ensure cooling performance is achieved canopy/enclosure design and machine components should be such that the air flow through the cooling pack isn't restricted and canopy depressions don't exceed the figures stated on the technical data sheet. Canopy design should also be such that recirculating air can't occur.

3.3 Fan Design

A pusher type cooling fan is normally fitted on the engine; Puller fans are available for some of the IPU products however fitting a puller fan will increase the temperature around the engine bay and aftertreatment components and could risk causing temperature limits for such components to be exceeded. For further advice and guidance consult your JCB EcoMAX dealer, or JCB Power Systems Applications department.

Alternator air inlet temperature at the rear of the unit must not exceed 118 ^{0}C in maximum ambient temperatures.

It is important that the engine installer takes care to adequately guard the flywheel and other moving equipment. These guards should be earthed to prevent the build-up of static electricity. The installer should ensure that it is not possible for any part of an operator's body to come into contact with moving parts.

4. Intake System

WARNING

The Stage IV/Tier 4 engines Induction System is uniquely linked to the engine calibration therefore the design arrangement of the induction system must be retained in the installations; if this is not feasible a request should be submitted to JCB Power Systems to obtain a quotation to develop a suitable calibration for an alternative induction system arrangement.

An air intake system is provided and fitted to the Industrial Power Units. The engine installer must ensure that the air intake system has an adequate supply of fresh cool air. There are limits to the inlet temperature of the air entering the Turbo which are detailed in the technical data sheet. These limits must be adhered to and should be measured during a cooling trial. The pressure drop performance of the IPU induction system has be validated by JCB Power Systems and therefore does not need to be tested again.

Important: Air intake systems are a significant source of noise. This must be considered when ensuring compliance with regulations.

5. Crank Case Ventilation (CCV)

WARNING

Breathing the engine crank case gases can harm and possibly kill.

Stage IV / Tier4 EcoMAX Engines

JCB EcoMAX Stage IV / Tier4 engines are fitted with an open crankcase ventilation (CCV) system. Engines are supplied with a CCV filter unit connected to the rocker cover by a hose.

The CCV gasses exit at the bottom of the engine behind the ECU as shown in Figure 1.

The service interval for the CCV filter is 1500 hours.

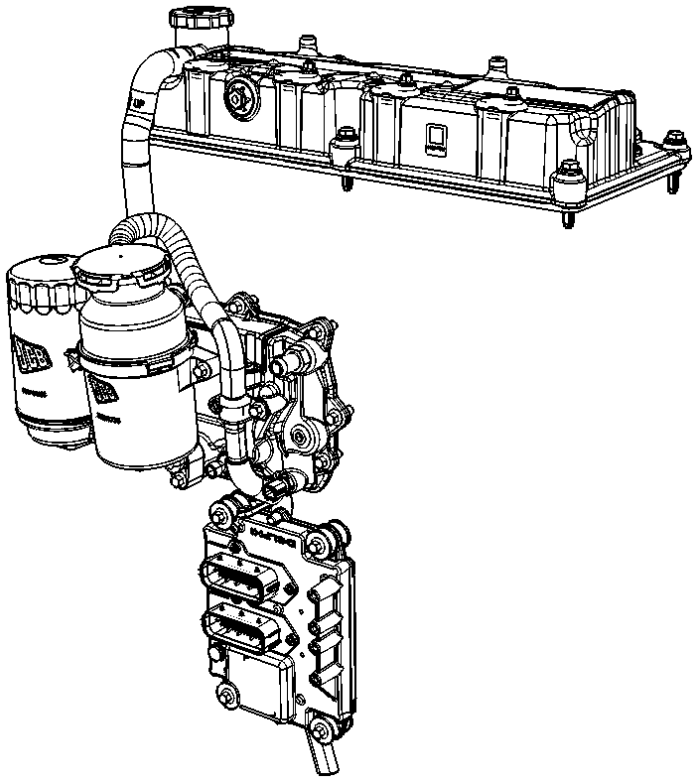


Figure 1: Stage IV/T4 CCV system

6. Exhaust System

6.1 Overview

WARNING!

Be aware of the hot exhaust system even with the engine stopped.

WARNING!

Breathing the engine exhaust gases can harm and possibly kill you. Do not operate the engine in closed spaces without making sure there is good ventilation. If possible, fit an exhaust extension. If you begin to feel drowsy, stop the engine at once and get into fresh air.

NOTE: Tier 4 / Stage IV engines must also refer to JCB EcoMAX Emissions Related Installation Instructions. For more advice, contact JCB Power Systems Applications department.

The engine installer must fit an exhaust system. The purpose of the exhaust system is to pipe hot, noxious gases to a safe outlet position and to quieten the noise carried by the exhaust gas. The engine installer must take care with the selection of the materials used and the mounting of the exhaust system to make sure it is durable and effective.

The design of the exhaust system can have a negative effect on engine performance if it is too restrictive or the outlet position allows exhaust gas to be drawn into the air intake.

Design considerations also need to include corrosion resistance, pipe sizes and bends, flexible elements and thermal expansion.

Packaging of the exhaust pipework and silencer also needs careful consideration due to their high temperature and high levels of vibration.

Off-highway equipment employs several different exhaust mounting strategies including engine mounted silencers, equipment mounted silencers and cab mounted silencers. Each approach requires special consideration in relation to accommodation of relative movement between sections of the exhaust system, methods of mounting and noise emission.

The OEM must make sure that vibrations transmitted personnel are minimised as vibration is uncomfortable and can be damaging to health.

Where there is risk of access to the hot components on the engine, the OEM must make sure that appropriate warnings are made on the equipment and in the equipment operating manual.

The position of the outlet also needs consideration to make sure that the exhaust gases are directed away from personnel.

NOTICE! Water ingress at the exhaust pipe may cause engine damage.

The exhaust system must be designed to prevent water ingress. Heat from exhausts and turbo chargers can be a source of ignition or can damage adjacent components.

Consider the position of the exhaust system in relation to fuel system components, cables, plastics, hoses, wiring, soundproofing and to oil and fuel fillers.

You must make allowances for combustible airborne material such as chaff, sawdust, paper.

You must use insulating jackets or heat shields to protect against fires or heat damage.

6.2 Performance

The OEM must test the exhaust system to make sure it meets performance requirements for backpressure, vibration levels, turbocharger mounting loads (see Technical Data Sheet).

6.2.1 Backpressure

The exhaust backpressure, measured on a straight section of pipe close to the turbocharger outlet, must be within the minimum and maximum range specified limits shown in the Technical Data Sheet for the specific engine rating.

All exhaust backpressure figures are stated at Full Load Rated Speed and must be tested at such condition (or as close to this point as machine controls allow). Note any additional restriction required to meet the minimum exhaust backpressure must be fitted in the OEM exhaust pipework downstream of the SCR components.

6.2.2 Noise Emissions

N *NOTE: Exhaust systems are a significant source of off-highway equipment noise. You must take this into account and make sure you comply with regulations.*

The exhaust is a significant source of noise and can be a major contributor to the noise emissions assessed under Directive 2005/88/EC for Equipment Used Out of Doors. You must position the exhaust outlet and the direction in which it points carefully. You must not install the exhaust close to the measuring positions or point it towards one of these positions.

The aftertreatment system may aid in the reduction of noise by up to 10 dBA, as a result some machines may not need a muffler.

6.3 Exhaust Installation

C ***NOTICE! Never use exhaust paste upstream of the catalyst, when exhaust paste hardens it can break off causing a hotspot on the face of the catalyst brick and destroy it.***

The Industrial Power Unit comes complete with all aftertreatment components mounted on an isolated structure. This structure and mounting arrangement should not be disturbed or altered. A supported Stub pipe (Figure 2) has been provided which will help prevent loads being transferred into the SCR canister; however the guidelines in this section must be followed to ensure a successful exhaust installation is achieved. The mating flange and gasket as supplied as part of the IPU kit of parts.

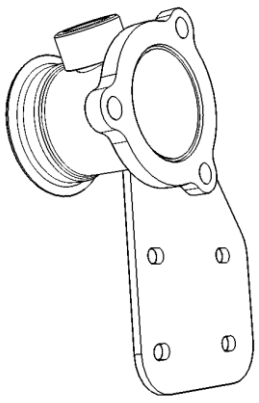


Figure 2: Exhaust mounting stub pipe

The NOx sensor must not be removed from the stub pipe. Welding this stub pipe is also not approved. The JCB flange, which is supplied loose, may be welded and then bolted, with the supplied gasket, to the stub pipe.

6.3.1 Exhaust Mounting

The exhaust must be supported so that the stresses generated in the exhaust due to thermal expansion, engine vibration, (cab vibration if the muffler is mounted to the cab) and vibration induced through operation of the machine doesn't exceed the capability of the materials used.

Vibration from the exhaust can be a source of noise in the cab. This is a particular issue with A-pillar mounted systems so you must be very careful with these types of mounting systems. Use appropriate anti-vibration mounts where you have to attach the exhaust to bodywork or chassis.

Consideration to the exhaust loading on the aftertreatment outlet stub pipe should be undertaken during the design phase so that the weight of a stub pipe does not exceed 5Kg and 300mm in length. If a longer exhaust system is required it must be supported within 500mm of the mounting flange and be fitted with a flexible element before the support.

6.3.2 Flexible Elements

A flexible elements must be fitted downstream of the SCR can interface in a position so that that they will compress longitudinally to accommodate thermal expansion. Equally, the OEM must install a flexible element to allow for relative movement between the engine/aftertreatment arrangement and the fixed machine. Production tolerance should also be considered and the installer must ensure the flexible element isn't pre-loaded during assembly.

The expansion coefficient for steel is approximately 1 mm per metre of pipe per 100ºC temperature rise. So, for example, a 2 metre pipe might be expected to expand by over 5 mm. You must allow for this by using a mounting system that allows for such expansion, or include flexible bellows that allows for the compression without transmitting excessive forces back into the manifold or support brackets.

6.3.3 Materials

Exhaust gas contains corrosive chemicals, as well as water vapour, so the materials selected for the exhaust have a significant effect on the life of the system. Mild steel may be used for commodity products downstream of the after-treatment catalyst, however austenitic steel is recommended.

N *NOTE: Engine meeting Stage 3b and newer legislation produce significantly less soot than previous engines and therefore exhaust systems used on previous emissions Stage engines may corrode more quickly. This is because soot acts as a corrosion barrier.*

6.3.4 Pipe Sizes and Bends

The exhaust pipe must be at least a nominal 60 mm internal diameter, including pipework inside the silencer.

Avoid sharp bends as they increase restriction. Make all bends around as large a radius as possible and avoid mitred joint type bends if possible.

Restriction is inversely proportional to the 5th power of pipe diameter so, if you need a complex routing with many bends for package reasons, a small increase in pipe diameter can help to compensate for the restriction caused by the bends.

6.3.5 Water Protection

The aftertreatment system must be protected from water ingress up the exhaust pipe as this may freeze and damage the catalyst. Protection of the NOx sensors from water and other contamination is also mandatory to avoid premature damage to the components.

6.3.6 Exhaust Tailpipe

The exhaust gas tailpipe (installed directly after the SCR canister) must stop water ingress. Lengths over 300 mm must use a separate mounting for support. Ref 6.3.1 and 6.3.2.

The exhaust gas tailpipe must allow for installing exhaust emissions sampling equipment for in-service conformity testing. To allow for this, the exhaust outlet must be of a continuous uniform section and have sufficient clearance from other components to allow for a 200mm extension to be fitted for this purpose.

N *NOTE: Scavenge systems are to be removed from the exhaust system prior to emissions sampling takes place.*

7. Fuel System

7.1 Fuel System Overview

WARNING!

Fuel is flammable; keep naked flames away from the fuel system. Stop the engine immediately if a fuel leak is suspected. Do not smoke while refuelling or working on the fuel system. Do not refuel with the engine running. Completely wipe off any spilt fuel which could cause a fire. There could be a fire and injury if you do not follow these precautions.

NOTICE! Do not allow the engine to run out of fuel. If you do not follow these instructions it could seriously damage the fuel injection equipment and may be expensive to repair.

NOTICE! Do not allow dirt to enter the fuel system. Before you disconnect any part of the fuel system, thoroughly clean around the connection. When a component has been disconnected, for example a fuel pipe, always fit protective caps and plugs to prevent dirt ingress. If you do not follow these instructions it will lead to dirt entering the fuel system. Dirt in the fuel system will seriously damage the fuel injection equipment and may be expensive to repair.

The fuel system included on the JCB EcoMAX engine meets the required legislated emission standards.

The engine needs a supply of clean fuel and a return line back to the fuel tank. The system is designed to allow high bypass fuel flow and can deliver full flow return to tank.

Materials used for all components and pipe fittings in the fuel system must be resistant to Diesel fuel. Copper, bronze, brass, tin, lead and zinc coatings can cause deposit formations which will damage components in the fuel system and therefore must not be used.

Parts of the fuel system which the engine installer needs to provide are normally the following:

Fuel tank

Fuel feed hoses and pipework

Pre fuel filtration and water agglomerator

Fuel return to fuel tank

The OEM must make sure that these parts are adequately earthed to prevent the build-up of static electricity.

The OEM must test the fuel system to make sure that it meets the performance requirements for depression at lift pump inlet, fuel return backpressure and fuel temperature (see the Technical Data Sheet).

7.2 Installation of the Fuel System

7.2.1 Fuel Tank

The OEM must install the fuel tank in a position between 0.7 m above the engine and 0.7 m below the engine (defined as the fuel outlet position in the tank to the fuel inlet position on the engine). The fuel tank must also incorporate a drain plug to allow draining and flushing of the tank to remove sediment and water that typically build up in the fuel tanks of off-highway equipment.

Install the fuel feed to the engine pipe centrally inside the fuel tank, at a height above the bottom of the tank so that 5% of the tank's volume lies below the bottom of the suction pipe with the machine on a flat and level surface. This makes sure that the fuel feed pipe does not become blocked and water ingress is reduced to the fuel filter and sedimenter.

Fuel tanks must ideally be of 1:1 aspect ratio. If possible, avoid shallow tanks. If a shallow tank is unavoidable, the risk of fuel starvation when the machine is inclined can be reduced by fitting baffles in the tank.

Install the return pipe to avoid the return fuel being directly drawn back into the fuel feed pipe by separating the two by approximately 300 mm and by baffling.

Vent the tank to prevent the formation of a vacuum as fuel is used up. The vent must not allow ingress of dirt or water to the fuel tank. A vented fuel tank caps can be used.

Install the fuel tank so that any relative movement of the mounting locations is not transmitted into the tank structure and that stresses in the tank are within the material's capabilities when the full tank is subjected to operating loads.

Install a label permanently stating: "ULTRA LOW SULFUR FUEL ONLY" in a clearly visible location near to the fuel filler cap by the machine manufacturer on all series built equipment that is to enter the US Commerce. (40 CFR 1039.135(e))

7.2.2 Fuel Feed Pipe (Suction Pipe)

Fuel feed pipe material must be resistant to fuel oil and from materials that can operate safely up to 100ºC and tolerate the inlet depression for the engine.

Connection to the engine is made using quick release connectors as described in SAE standard J2044.

Use an internal hose diameter of 8 mm to allow for a fuel flow rate of up to 100 L/hour.

The hose and pipework must give a smooth flow to the engine without any sharp bends or rising loops. You need to clip the hose and pipework at intervals to prevent chafing and to avoid fatigue failures due to resonant vibration.

7.2.3 Injector Leak Off Return to Fuel Tank

Connection from the engine is made using a quick release connector, as described in SAE Standard J2044.

This pipe must conform to the requirements of the fuel feed pipe. With exception that the fuel return hose must have an internal diameter of at least 6.0 mm and must follow the most direct route back to tank, avoiding sharp bends and restrictive adaptors. Avoid close proximity of fuel pipes and hoses to hot surfaces such as exhaust pipes.

The return line must feed back into the tank a minimum of 300 mm away (Ref 7.2.1) from the fuel supply outlet and under the level of the fuel. See the Technical Data Sheet for the maximum pressure that can be seen in the fuel return line.

7.2.4 Fuel Filters and Water Separators

A machine-mounted electric lift pump, fuel pre-filter and water agglomerator is supplied loose with the engine. The OEM must install this onto the equipment chassis, close to the engine and in a warm position. However not adjacent to the exhaust system. The efficiency of the water separation must be a minimum of 95% (measured to SAE J1839).

This electric lift pump filter unit includes a water presence detector which must be connected to the engine control unit. The positive feed to the water in fuel sensor must come from the ignition relay. The electric lift pump must also be connected to the appropriate relay controlled by the engine control unit.

Install the agglomerator above the maximum fill level of the tank to avoid fuel syphoning when servicing.

Fit a strainer or gauze to the filler neck of the fuel tank to stop large items blocking the fuel feed pipes.

Water separation requirements vary depending on fuel quality. If the fuel does not comply with EN590 you may need to install an additional water separator. JCB Power Systems Applications Department can give advice on expected regional fuel conditions.

N *NOTE: If the fuel temperature drops below the cloud point then fuel filters may become blocked.*

See Figure 3 for recommended fuel filtration schematic.

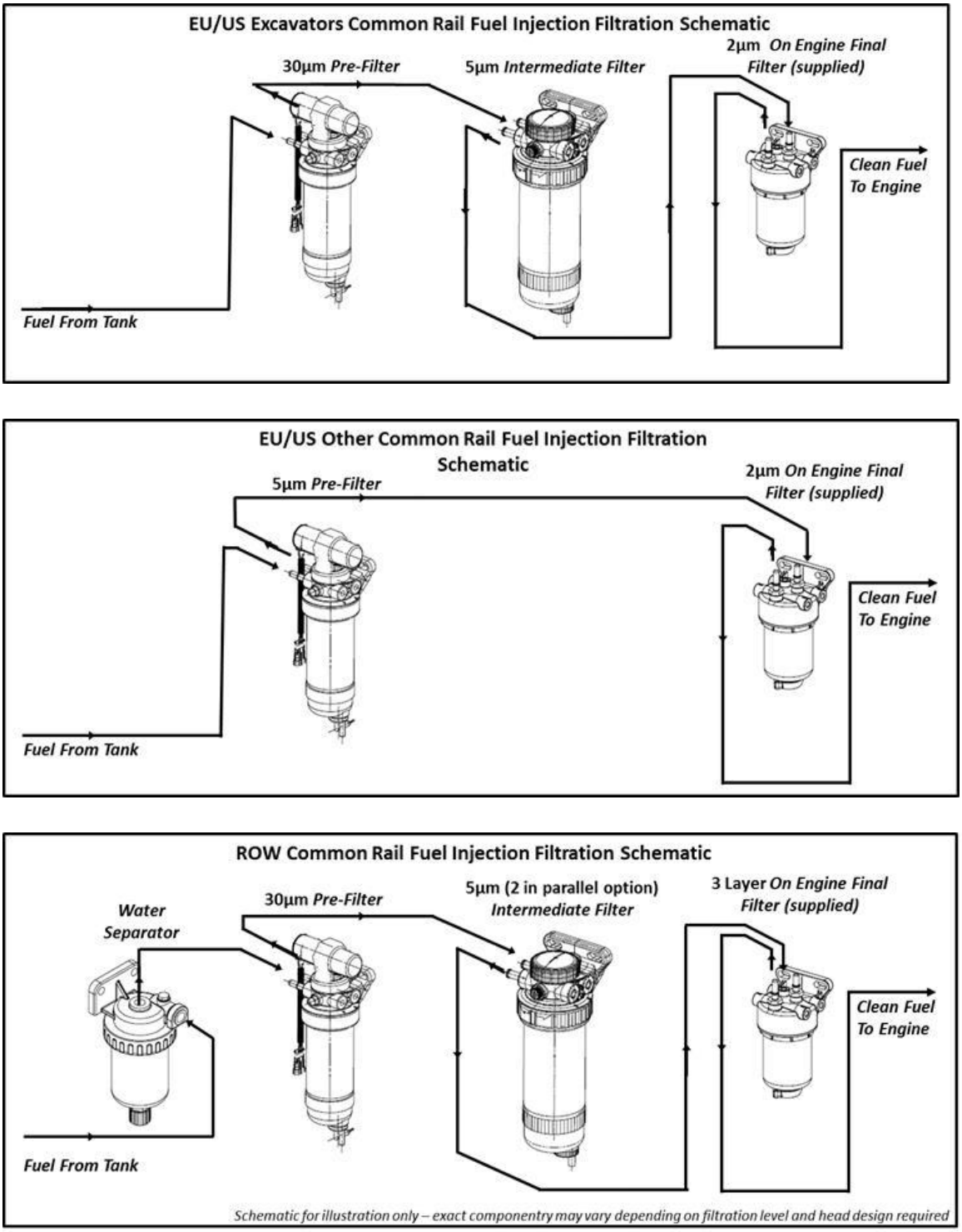


Figure 3: Example fuel filtration schematics for common rail fuel injection systems

7.2.5 Fuel Temperature

Do not install the fuel pipes and hoses close to hot surfaces such as exhaust pipes.

When the engine senses that the fuel temperature is too high, the control system reduces the torque of the engine and therefore the heat rejected to the returned fuel. This is to protect the fuel injection equipment from damage. Therefore a fuel cooler maybe required to stop the engine from 'de-rating'. Refer to the Technical Data Sheet for the fuel temperature at which the engine de-rates and the heat rejected to returned fuel.

Fuel coolers are not normally needed on these engines due to the high by-pass fuel flow characteristics. During the cooling trail of the engine in its final installation the fuel temperature should be recorded to ensure it doesn't reach the 'de-rate' limit.

Diesel fuels have a cloud point at which wax crystals begin to form. Below this temperature, problems may result from these crystals partially or completely blocking the system. It is possible to install an electric heater adjacent to the engine mounted fuel filter for extreme temperature situations.

N *NOTE! Refer to JCB Power Systems Applications department for more advice.*

7.2.6 Fuel Lubricity Additive Dosing Filters

A lubricity additive dosing filter unit is available for use with low lubricity fuels. Diesel fuel specification EN590 states a lubricity limit of 460 µm (wear scar diameter), for fuels with wear scar values higher than 500 µm, fitment of a lubricity dosing filter is recommended.

N *NOTE: Please contact JCB Power Systems Applications Department for more information and advice on installation and expected regional fuel conditions.*

8. IPU Mounting and Noise Reduction

WARNING!

Poor engine mount design may lead to excessive operator environment noise and vibration levels resulting in personal injury.

NOTICE! Poor engine or powertrain mount design may cause engine damage.

The purpose of the engine mount system is to locate the engine whilst reducing the vibration transmitted into the equipment structure. The engine installer should take care to ensure that vibrations transmitted to the equipment operator and other people are minimised; vibration is uncomfortable and can be damaging to health. It is important to ensure that rigid body modes of vibration of the powertrain do not coincide with sources of vibration input, such as engine firing frequency or modes of the whole equipment.

The largest single factor affecting vibration isolation, are the bump stops. The engine installer should take care to ensure adequate clearance of the bump stops and that there are no fouls between the engine or its associated pipes and hoses, and the chassis / body. It is very important that the engine mounts provide physical restraints that prevent engine movement becoming large enough to allow clashes between engine components and the body work or chassis. Care should also be taken with clearance between the fan tip and radiator shroud.

The industrial Power Unit comes fitted complete with legs to allow the unit to be mounted into the equipment using Anti Vibrational Mounts. In specifying the mounts consideration should also be given not only to the static stiffness but also to the damping provided by the mounts. Excessive damping can result in poor isolation and problems with mount durability.

If the Aftertreatment system is not sufficiently isolated from machine borne and engine borne vibration, premature failure of components may occur. As outlined above, care must be taken when specifying Anti Vibration Mounts.

Any additional brackets which attach to the engine also need careful consideration. They should be free of resonances up to 150 Hz.

The engine mount system requires testing to ensure that performance requirements (see Section 1), for stationary bending moment applied to the flywheel housing, resonant bending frequencies of the powertrain, control of engine movement, control of rigid body modes of vibration and isolation of engine vibration are met.

Off-Highway equipment must generally meet noise legislation appropriate to the territory of operation. In order to achieve legislated limits on noise emissions it may be necessary to apply noise shields around the engine. The engine installer should take care to ensure that adequate airflow is maintained. Note: Cooling fans are one of the most significant sources of noise on Off-Highway equipment.
Consideration should be given for the design of bump stop clearances, mistake-proofing of mounts, mount positions relative to the engine centre of gravity, mount positions relative to the equipment, protection of the mounts and noise shields.

9. Power Take-Offs

9.1 Positions of Power Take Offs

WARNING!

Operating the engine PTOs beyond their design limits may result in engine damage or personal injury.

The four Power Take-Off (PTO) points are provided on the JCB EcoMAX engine, as shown in Figure 4. These PTO points and maximum loadings are as follows:

PTO No. 1 – Flywheel. Full load engine torque at rated speed

PTO No. 2 – Crank Pulley. 60 kW / 260 Nm at rated engine speed (Not available in IPU configuration)

PTO No. 3 – RHS gear case. 60 kW / 205 Nm max. at 1.268x engine speed

PTO No. 4 – LHS gear case. 15 kW / 40 Nm max. at 1.625x engine speed

PTO No. 3 & PTO No. 4 are mounted to the gear casing by two-bolt flanges to the SAE standard J744 pattern. PTO No. 3 conforms to the SAE B standard, while PTO No. 4 conforms to the SAE A standard. A four bolt-boss has been provided on the cylinder block adjacent to PTO No. 3 to allow for supplementary support brackets if required, as shown in Figure 5. Devices attached to both PTO No. 3 and PTO No. 4 must carry their own gears. For gear details please contact JCB Power Systems Applications department.

PTOs operate in the anti-clockwise direction when viewed from the rear of the engine.

A flange to SAE standard J1946 (size code 1410, Type S) is provided on the crank nose for provision of PTO No. 2.

The alternator is direct mounted to the RHS of the engine and driven by the FEAD system.

Provision has been made for the direct mounting of an air-conditioning compressor to the lower LHS of the engine. The FEAD is capable of driving this type of compressor.

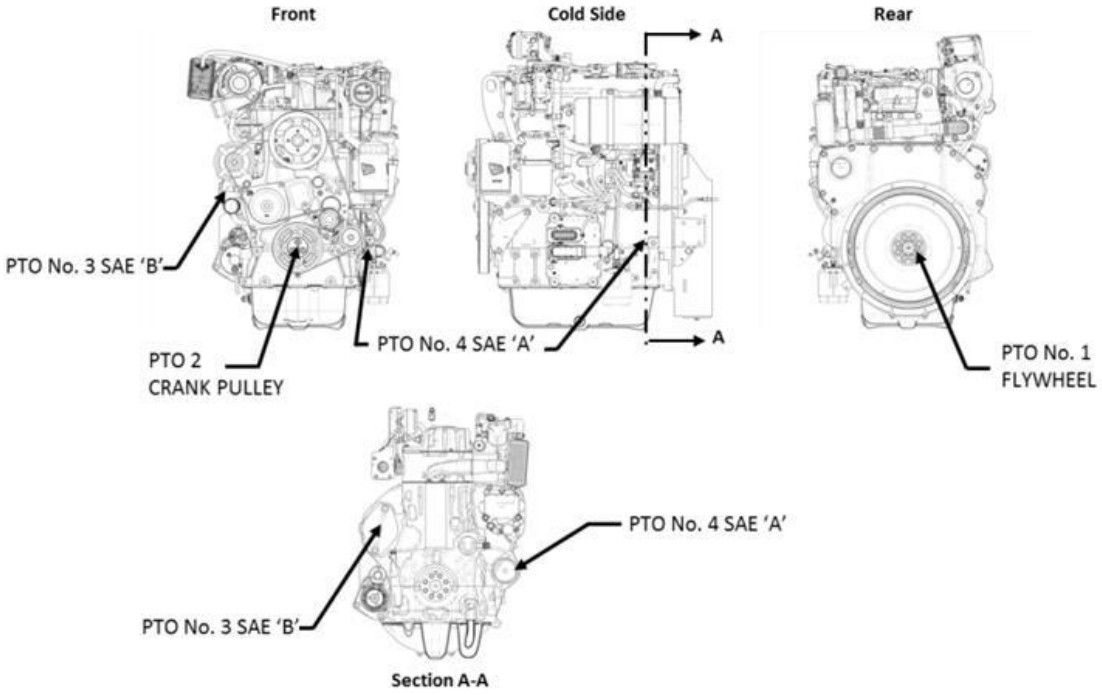


Figure 4: Positions of Power Take-Offs

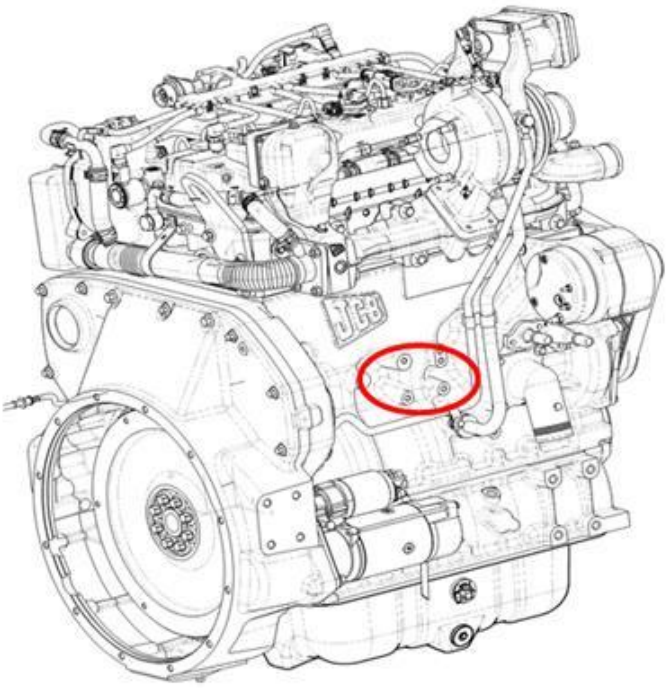


Figure 5: Supplementary support bosses

9.2 Performance of Power Take Offs

You must make the following considerations about the PTOs:

PTO No. 1 loading with belt or chain drive

PTO No. 2 maximum unsupported weight and bending moment

PTO No. 3 & PTO No. 4 Pump efficiency (mechanical and hydraulic) , duty cycle of PTO pump, relief valve setting and location must be reviewed to ensure gears are not overloaded. As well as the mass and supporting of the pump.

You must make sure that, in common with all other structures attached to the engine, the PTO-driven device has a primary resonant frequency greater than 150 Hz. Bosses have been provided at various positions on the engine (see Figure 5) to which you can attach additional support brackets, if necessary.

PTO No. 3 has been evaluated successfully with cast iron hydraulic pumps with no additional support and a calculated bending moment of up to 33 Nm.

Please consult JCB Power Systems Applications department for specific information and advice.

9.3 Front End Accessory Drive (FEAD)

WARNING!

The engine has rotating parts. You must make sure that you give a clear warning to stop anyone starting the engine when someone is working on the FEAD due to risk of personal injury.

The FEAD gives drive for the cooling fan, water pump, alternator, and an air conditioning compressor. The alternator is direct mounted to the RHS of the engine and driven by the FEAD system. You must allow for the direct mounting of an air conditioning compressor to the lower left-hand side of the engine.

9.3.1 Torsional Vibration

The JCB EcoMAX engine gives generally refined torsional vibration characteristics. The crank is exceptionally stiff giving very low levels of wind-up between the crank pulley and the flywheel.

Torsional vibrations must not present a problem for transmissions (manual and torque converter) and hydrostatic pumps typically used in construction equipment and attached to PTO No. 1.

There may be instances, particularly in respect of devices attached to PTO No. 2 and devices that require particular limits on torsional vibration, where care needs to be taken to ensure the engine characteristics are appropriate. In such cases cyclic velocity curves are available from JCB Power Systems on request.

10. Fluids and Ambient Temperature: Fuel, Lubricant and Coolant

10.1 Overview

C ***NOTICE! If you do not use recommended fluids it may result in engine damage.***

The quality of fluids used in an engine can have a significant effect on the engine performance and durability. You must select fluids appropriate for the engine and the climatic conditions in which the equipment is to be used. The JCB EcoMAX engine has been developed to operate using particular quality fuels, lubricants and coolant. If you use other fluids then you must consult JCB Power Systems Applications department confirm that they are acceptable.

10.2 Fuel

See the Engine Operator's Manual for a statement on preferred fuels.

10.3 Lubricant

See the Engine Operator's Manual for a statement on preferred lubricants.

You must select the lubricant viscosity based on the lowest ambient temperature at which the equipment is started and the maximum ambient temperature at which it operates. Table 1 gives guidance on suitable oils for ambient temperature ranges.

You must change the oil and the oil filter at the specified service intervals. For oil change intervals refer to the Service Manual. The oil filters installed with the flange facing downwards.

Do not allow oil to come into contact with the FEAD belt.

Table 1: Ambient temperature ranges for typical oil viscosity grades

Oil Viscosity	Min Temp (ºC)	Max Temp (ºC)
SAE 0W30	-40	+30
SAE 0W20	-40	+10
SAE 5W20	-30	+10
SAE 5W40	-30	+40
SAE 10W30	-20	+40
SAE 15W40	-15	+50

JCB suggest the following oil specifications in Table 2:

Table 2: JCB oil suggestions

Oil Viscosity	Condition
SAE 5W30	Operation in conditions below -20ºC
SAE 10W30	Oil fill as delivered (fill at factory)

10.4 Dipsticks

The dipstick is located on the left-hand side of the JCB EcoMAX engine, as shown in Figure 6. You must make sure that the dipstick is accessible to the equipment operator.

There are various dipstick options available. Please contact JCB Power Systems Applications department for more information.

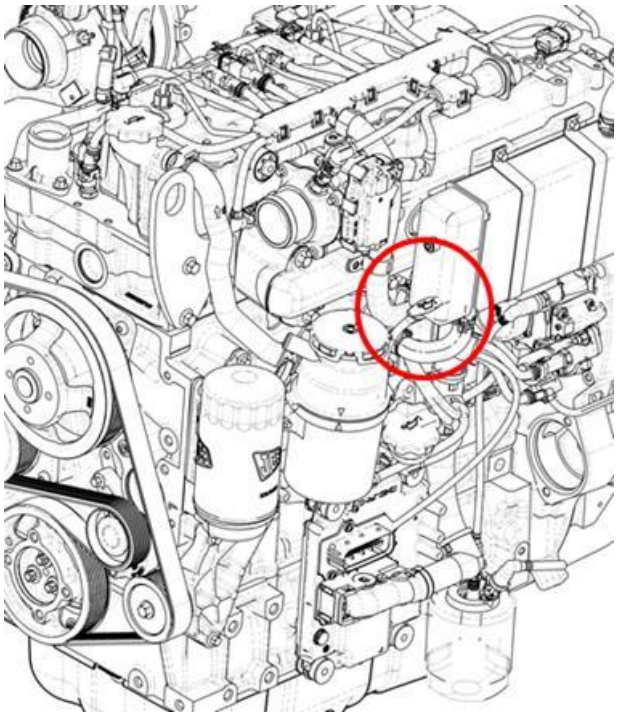


Figure 6: Location of a standard dipstick on an EcoMAX engine

10.5 Coolant

Use a minimum concentration of 30% antifreeze and corrosion inhibitor. You must choose the concentration to give protection to the lowest expected ambient temperature. JCB Power Systems Applications department for further information.

Table 3 shows the concentration you need to use depending on the ambient temperature. The JCB EcoMAX engine coolant must be ethylene based to ASTM D6210. Please contact JCB Power Systems Applications department for further information.

Table 3: Antifreeze concentration to protect at different ambient temperatures

Protection to	Antifreeze Concentration
-15ºC	30%
-23ºC	40%
-37ºC	50%
-51ºC	60%

11. Hostile Environment Precautions

The JCB EcoMAX engine has been designed for use in a wide range of conditions. Normal environments are described as temperate and tropical, and are defined in terms of the following:

Temperate - Ambient temperatures between -20ºC and +40ºC

Tropical - Ambient temperatures between -20ºC and +46ºC

Normal environment covers operation above sea level, up to and including 3000 metres elevation.

Special provisions for operation in hostile environments have been made. You can consult JCB Power Systems Applications department about any application that falls outside what is considered to be normal environments.

Temperature and altitude affect the engine's performance so you must consider this when you pick an engine's type and rating.

11.1 General Provisions

11.1.1 Cold Climates

Provision has been made for the installation of an engine block heater (mains powered, screwed into the oil cooler housing on the LHS of the block) for operation in cold climates. Provision has also been made in the inlet manifold for the installation of a grid heater for improved cold start.

The engine block heater is rated at 1000 watts.

The grid heater is rated at 1200 watts.

11.1.2 Wading

The engine is capable of wading for intermittent, short durations up to the centre line of the crankshaft without modification, although you must make sure that the fan can still operate properly under these conditions. For greater depths or duration consult JCB Power Systems Applications department.

11.1.3 Operation in Explosive Atmospheres

For operation in explosive atmospheres, such as in mining applications, you may need to fit spark arrestors, an air-flow limiting valve or both of these devices.

12. Electrical System

12.1 Overview

WARNING!

Battery electrolyte is toxic and corrosive. Do not breathe the gases given off by the battery. Keep the electrolyte away from your clothes, skin, mouth and eyes. Wear safety glasses.

WARNING!

Batteries give off explosive gases. Keep flames and sparks away from the battery. Do not smoke close to the battery. Make sure there is good ventilation in closed areas where batteries are being used or charged. Do not check the battery charge by shorting the terminals with metal, use a hydrometer or voltmeter.

WARNING!

Understand the electrical circuit before connecting or disconnecting an electrical component. A wrong connection can cause injury and damage.

WARNING!

Injury may occur when lifting batteries. Do not lift heavy objects on your own. Use lifting equipment or the help of an assistant.

The basic electrical system consists of the following:

Battery or batteries (24 V systems)

Starter motor

Alternator

Key-switch

Various sensor and relay devices.

Always use proprietary parts that are properly matched to the requirements of the engine and which have been proven to be durable in the application being considered. Make sure that the earth paths are short as this gives reliable operation and avoids EMC problems.

Additional devices for operation in low temperatures, such as below -12°C ambient may be required. A 1000 W block heater is available in both 110 V and 240 V variants. Block heaters will be most efficient in terms of engine core temperature when left on overnight. However, they show a significant benefit after four hours of operation. The offered block heater is not thermostatically controlled and does not suit continuous operation.

12.2 Performance

The OEM must test/check the electrical system to make sure it conforms with the performance requirements for voltage overload, EMC emissions (where applicable), cranking speeds, alternator loads, earthing, cold start strategy and warning device functionality.

12.3 Voltage Capability

All system components must be capable of withstanding a 50% voltage overload. This means that for a 12 V system, all components must be capable of safe operation at voltages up to 18 V. For a 24 V system the limit is 36 V. (See JCB standard 00140, section 12). A minimum of 6.5 V must be seen at the ECU to avoid ECU brown out.

12.4 Electromagnetic Compatibility

Electromagnetic emissions for the electrical system of the machine must be tested when it is applicable to the application.

N *NOTE: It is the manufacturers' responsibility to make sure that the machine conforms to the overall EMC limit.*

12.5 Cold Start Strategy

The grid heater (when supplied) is located in an aperture in the inlet manifold. Its use depends upon ambient temperature and available cranking speed in the machine. The control of the heater is done by the engine ECU which automatically activates it when required.

Sometimes it may be beneficial for the grid heater to stay energised whilst cranking. Some post heat (after start) will occur automatically under severe cold conditions.

Table 4: Cold start strategies

Temperature (°C)	Start Aid	Mean crank speed required (rpm)
-30	Block heater plus grid heater	90 – 100
-20	Grid heater	90 – 100
-12	No aid	100 – 110

12.6 Battery

W **WARNING!**

You must always remove the negative battery lead before you do any work on the equipment or engine. You must also make sure that all appropriate warnings, and or, labels advise accordingly.

Use only one battery for 12 V systems. You need two batteries for 24 V systems. Each battery must have a minimum rating of 900 CCA (SAE) / 145 Ahr.

12.6.1 Installation

You must support the battery or batteries on a carrier that holds the battery flat and level under normal load conditions. The battery carrier must have sufficient strength to hold the battery in place under all conceivable conditions, including equipment roll over. Make the bracket sufficiently stiff that it does not suffer from significant resonant vibration under normal operating conditions.

It is important that the battery compartment is open to the atmosphere to avoid a build-up of dangerous gases. You can improve the battery performance and life by protecting it from large variations in temperature (either excessive heat or excessive cold). The battery temperature must stay below 50°C at all times. Take account of maintenance of the batteries when you design and locate the battery carrier.

12.6.2 Earthing

The negative terminal of the battery must be earthed to the main chassis (through a battery isolator, where required). Earth leads must be kept as short as possible and have a minimum cross-sectional area of 95 mm^2 for a 12 volts system and 70 mm^2 for a 24 volts system.

12.6.3 Battery Isolators

The use of a battery isolator allows you to completely isolate the electrical system from the equipment battery, or batteries. You must make sure that the battery isolator hardware is sized in accordance with the expected current demand and that it has good environmental protection. You must make sure that the contacts in the isolator are of a good, robust design and offer minimal resistance. You must install the isolator as close as possible to the battery and make sure that the operator can access the isolator easily.

N *NOTE: The battery isolator must not be used to shut down the machine.*

12.7 Starter Motor

The geared motor on the JCB EcoMAX engine is rated at 4.2 kW for the 12 V and 24 V systems.

The starter motor's cranking speed varies depending on a range of different conditions such as ambient temperature, parasitic loads and available battery charge. To ensure a reliable start in cold climate conditions tests have shown that particular cranking speeds must be attained (see Table 2). For successful operation below -30ºC, you need full winterisation.

12.7.1 Starter Motor Earthing Requirements

Route the battery negative cable directly from the switched terminal of the isolator (or directly from battery negative if no isolator fitted) to the earth stud on the rear casing of the starter motor. This keeps the voltage drop at the starter motor to a minimum and makes sure that a high integrity earth connection is maintained throughout the equipment's life.

A separate earth cable is also needed to earth the equipment chassis. You must connect the earth cable from the starter motor earth stud or the switched side of the isolator (if fitted) to the chassis. Use an appropriate fastener where all paint has been removed at the point of connection. The minimum recommended cable cross-section is 95 mm^2.

12.8 Alternator

The alternator is direct mounted to the engine and is driven by the FEAD system. You do not need to adjust the alternator belt as a sprung tensioner is included in the FEAD system.

The alternator rating must be at least 25% greater than the maximum continuous electrical machine load. Check the relevant specific product technical data sheet for the exact alternator fitted and refer to JCB Applications department for alternative options available. The alternator charging lamp must be of a 3 watt rating to give the correct level of excitation to the alternator upon initial start-up.

It is recommended that the engine speed signal is taken from the CAN bus however a W terminal is provided on the alternator for engine speed indication. The frequency is 6 pulses per alternator revolution. The alternator speed is dependent on the effective alternator pulley diameter. Table 5 shows the speed ratios. This signal incorporates a filter network to enable a stable tachometer response, which limits voltage output from the terminal to 1.5 Volts.

Table 5: Alternator speed ratios

Effective Diameter (mm)	Alternator: Engine speed ratio
50	3.113:1
56.2	2.787:1

12.9 Electrical Load

When calculating total machine load consideration should be given to the engine electrical consumption including the aftertreatment components. For a 12 volt system for design purposes it should be assumed that the ECU and Fuel Pump can draw up to 15 Amps continuous current draw and the aftertreatment system can consume 10 Amps with an additional 10 Amps for the heated lines consumption.

For further advice on the power requirements for various sub-systems please contact the JCB applications engineering department.

12.10 Wiring

All wiring in the engine bay must have insulation that can withstand temperatures up to 150°C (Class D wiring to ISO Standard 6722, JCB Standard 7000/3400). The wiring must also be resistant to Diesel, moisture and lubricating oil.

Battery cables must be as short as possible. The minimum recommended cross-section is 95 mm^2.

The starter motor must be earthed to the equipment chassis and also directly back to battery negative with a cable of adequate cross-section. The minimum recommended cross-section is 95 mm^2.

The alternator wiring must have a cross sectional area of at least 16 mm^2 for 24 V systems and 25 mm^2 for 12 V systems dependent upon the alternator specification. See JCB Standards 00127 & 00137.

12.11 Earthing

Voltage drop on a 12 V system between any earth, or component negative terminal and the negative terminal of the battery must not be greater than 0.5 V, measured whilst cranking. Similarly, the voltage drop between any component positive terminal and the battery's positive terminal must not be greater than 0.5 V under similar conditions. In each case, for 24 V systems a limit of 1.0 V is used instead of 0.5 V. You need to account for the voltage drop across battery isolators, where fitted.

12.12 Switches and Sensors

All engine related switches and sensors must be of the insulated earth type.

13. Electrical Control & System Integration

13.1 Introduction

A Delphi DCM Common Rail Engine Control Unit (ECU) has been installed onto the JCB EcoMAX engine to manage the combustion process in line with the requirements of Stage 4 / Tier 4 emissions regulations.

The ECU has two connectors:

Engine Connector

Machine Connector

The engine is supplied with all appropriate engine sensors installed and connected to the Engine Connector through an engine wiring harness. The Machine Connector provides the interface to the equipment electrical system.

N *NOTE: For engine maintenance and diagnostic purposes, the OEM must ensure that an SAE J1939-13 diagnostic connector is installed in the equipment's wiring harness. This diagnostic connector must be located in a suitably protected location, such as inside the cab, and have a removable, sealed protective cover. The diagnostic connector interfaces with the ECU through the CAN Bus wiring through the Machine Connector. Please contact JCB Power Systems Applications department for more information and advice.*

13.2 IPU Harness / Electrical Integration

As part of the Industrial Power Unit design and scope of supply electrical harnesses have been designed and included. The IPU has a machine side harness which integrates all the engine machine side connections and aftertreatment sensor connections fitted to the engine. A customer connection (29 way Deutsch Connector) is included.

The Tank module has a separate harness which integrates the DCU, Coolant valve, head unit and Supply module and connects to the on engine harness through a length of cable which allows for installation flexibility.

The customer side harness must include connection to the 29 way machine connector, Fuel pump power, Water in Fuel Sensor, Power Hold Relay Box connection, Diagnostic Socket connection, 250 Kbps bus termination resistor and customer control panel connection. Please see the Schematic requirement. Harness breakout lengths should be designed to suit individual installation component positions.

The schematic for the customer harness is detailed in the schematic part number 320/A9656

With the exception of the control panel connection which is customer/control panel specific all the mating connectors for the machine side harness are included within the connector kit which can be included as part of the unit scope of supply – please check the exact product specification for details of optional connector kit

Should a grid Heater be required the installer must provide supplementary wiring and relays to power this – further advice is available from the JCB Applications Department

13.3 General Information

Detailed manual 320/A9167 is available to assist with the System's Integration of the DCM 3.3 and Manual 320/A9059 to detail the integration with Bosch aftertreatment DCU.

13.4 Control Unit Power Strategy

The ECU requires a 6 V to 16 V supply. It must not be connected to a 24 V equipment supply. A 24 V to 12 V converter is available from JCB Power Systems Ltd for use on equipment with a 24 V electrical system.

Never supply power to the electrical loads without the ECU being properly grounded.

13.5 Electrical Integration

13.5.1 Environmental Requirements

The ECU is sensitive to temperature so you must not expose it to temperatures that cause the case to exceed 112°C or the internal circuits to exceed 125°C.

N *NOTE: These internal temperatures cannot be measured and are for information only.*

To avoid potential EMC issues, you need to arrange the harness routing as follows:

- **Avoid close proximity to high current loads such as starter motor, alternator, and so on.**
- **Lie as close to the machine chassis as possible to make use of the natural screening effect – discontinuities in the chassis metalwork to be avoided.**
- **The wire from Machine Connector pin 2 to the Power Hold relay does not exceed 2 metres.**
- **Do not use un-terminated communication wires.**
- **Make sure the power wires are closely coupled so that the communication wires are as far as possible from the power wires.**
- **Avoid continuous lengths of wires in one plane greater than 1 metre.**
- **Avoid the proximity of different signal characteristics – that is to say, switched, power and data signals.**

13.5.2 Ancillary Earth Requirements

Connect any ancillary components, which have an electrical ground requirement, through the equipment chassis. Make sure that these earth wires are kept as short as possible to avoid EMC issues.

13.5.3 Emergency Stop Switch

If your application needs an emergency stop please contact JCB Power Systems Applications department for more information and advice.

The IPU and tank module require battery power up to 40 seconds after the ignition is turned off to purge the system of DEF. This process must not be affected by the isolation or emergency stop systems.

13.5.4 Wiring Requirements

DC resistance between the battery and the ECU must be minimised to avoid voltage drop at a peak current of approximately 15 A for the supply wire and 15A for the return. Use a maximum resistance of 40 mΩ (total supply and return). Make the ‘splice’ (4 wires to 1

(pin numbers 58, 59, 61, 62)) as close to the ECU as possible. Make the splice using ultrasonic weld and cover it in adhesive lined heat shrink. Make the ECU ground as close as possible to the battery negative, while retaining the battery isolator if fitted.

Twisted core shielded cable to SAE J 1939-11 specification must be used for all CAN Bus wires. A minimum of 33 twists per metre must be used, with the twist starting and finishing as close to the connector shells as possible.

The installer must make sure that:

The ECU is earthed back to the battery negative terminal, through the isolator where fitted.

All loads must be powered through the ECU in accordance with the Electrical Wiring Diagrams chapter.

The ECU will take a maximum of 40 seconds to remove power from the control system through the Power Hold Relay, following removal of the switched ignition supply. Therefore, the Power Hold Relay coil must take a supply from the battery positive and not the switched ignition supply. During this time, the power must not be removed through the battery isolator.

All CAN Bus wiring must be terminated with two 120 Ω resistors (60 Ω total resistance) at each end of the CAN Bus. CAN Bus termination is not provided in the ECU. If the ECU is located at the end of the CAN Bus, you need to make a 'splice' into the harness as close to the ECU as possible to accommodate the CAN termination resistor. CAN terminating resistors are available from JCB Power Systems in either 2 way; JCB part no. 7212/0059 or 3 way; JCB part no.727/00002 or 727/00003.

13.6 Required Operator Warnings

13.6.1 Operator Interface & Warnings

For more information please refer to JCB Systems Integration Document 320/A9167 or contact JCB Applications Department.

The following warnings must be displayed to the operator in a clean clear position:

Oil low pressure

Coolant over temperature (Configured to Specific Coolant Temperature)

Check engine

Malfunction indicator

Water in fuel

Alternator charging indication

J1939 Suspect Parameter Numbers (SPN) and Failure Mode Indicator (FMI) codes

In addition there are specific aftertreatment warnings which must be displayed to meet legislative requirements. Please refer to the Systems Integration Document 320/A9167 for these requirements. This document also defines the inducement strategy which is outlined in both Figure 7 and Figure 8.

DEF Availability

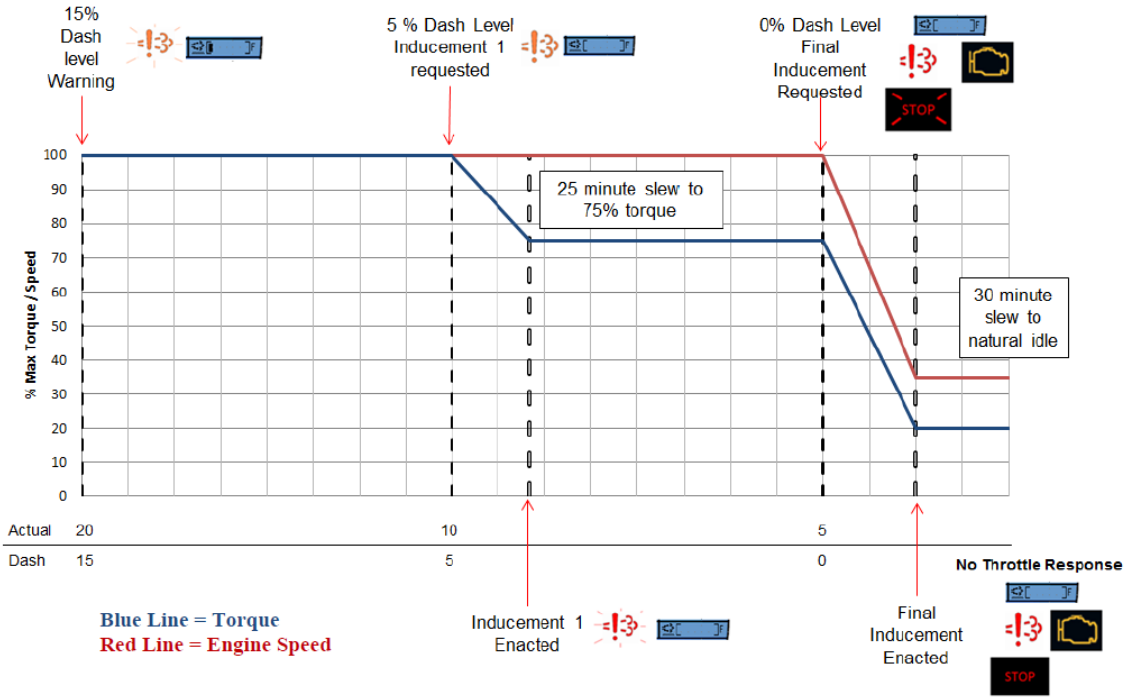


Figure 7: Tier 4 Final Inducement DEF Availability

Reagent Quality / Reagent Dosing Activity (Interruption) / System Tampering / Emissions fault (EGR)

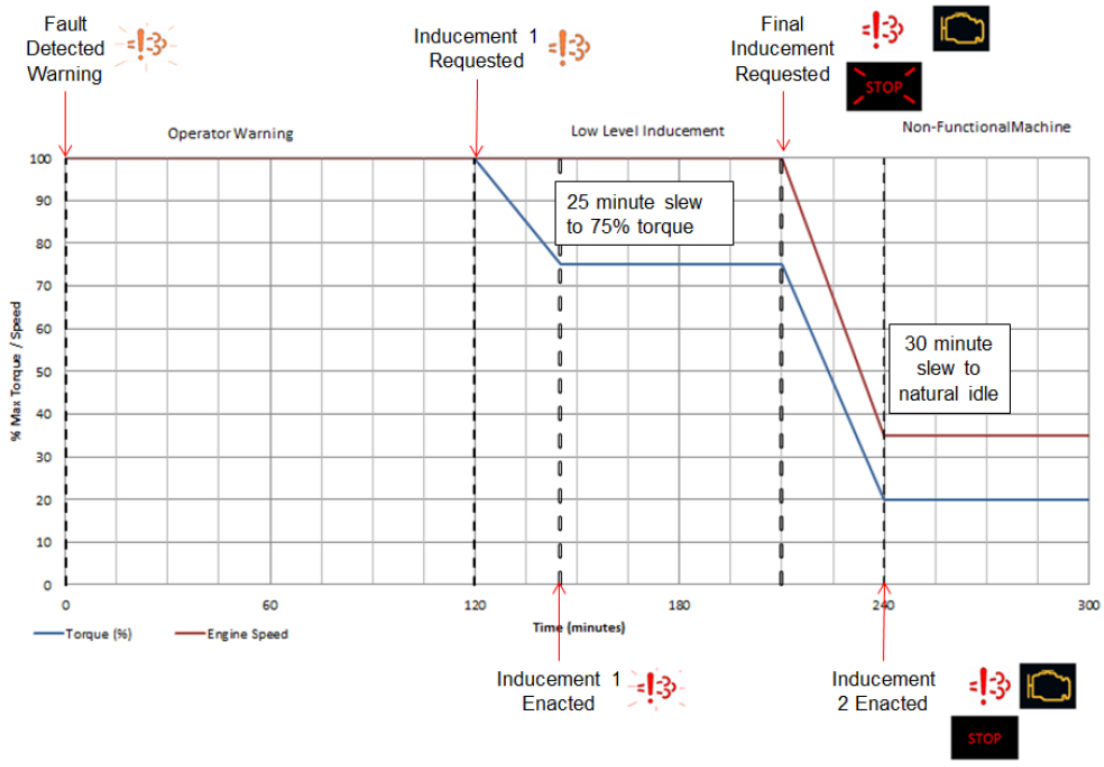


Figure 8: Tier 4 Final Inducement Strategy Other

13.7 Engine Control Devices

13.7.1 Engine Throttles

The engine can be controlled by any of the following devices:

Single foot throttle

Single hand throttle

Combination of foot and hand throttles

Two hand throttles

Engine fixed speed control

TSC1 CAN speed control

The foot pedal and hand lever can be either:

Twin track ratiometric voltage output

Single ratiometric voltage output, with CAN taking the place of the other track.

The characteristics required from the twin track ratiometric device are shown in Figure 9. A typical circuit diagram for the electronic device is shown in Figure 10.

The engine speed can also be controlled by the TSC1 CAN message. This can be done by either a CAN enabled dash controller or by a TSC1 pedal which sends the speed request. Further details can be seen in the electronic integration manual 320/A9059.

Please contact your JCB EcoMAX Dealer, or JCB Power Systems Applications department, for more information and advice.

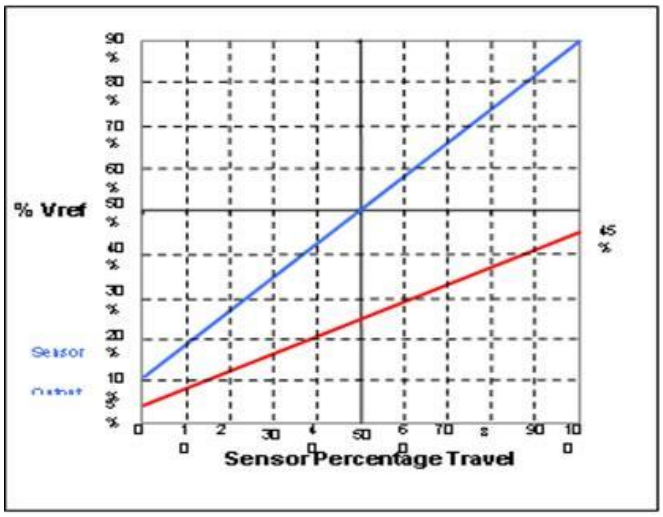


Figure 9: Characteristics of a twin track electronic throttle

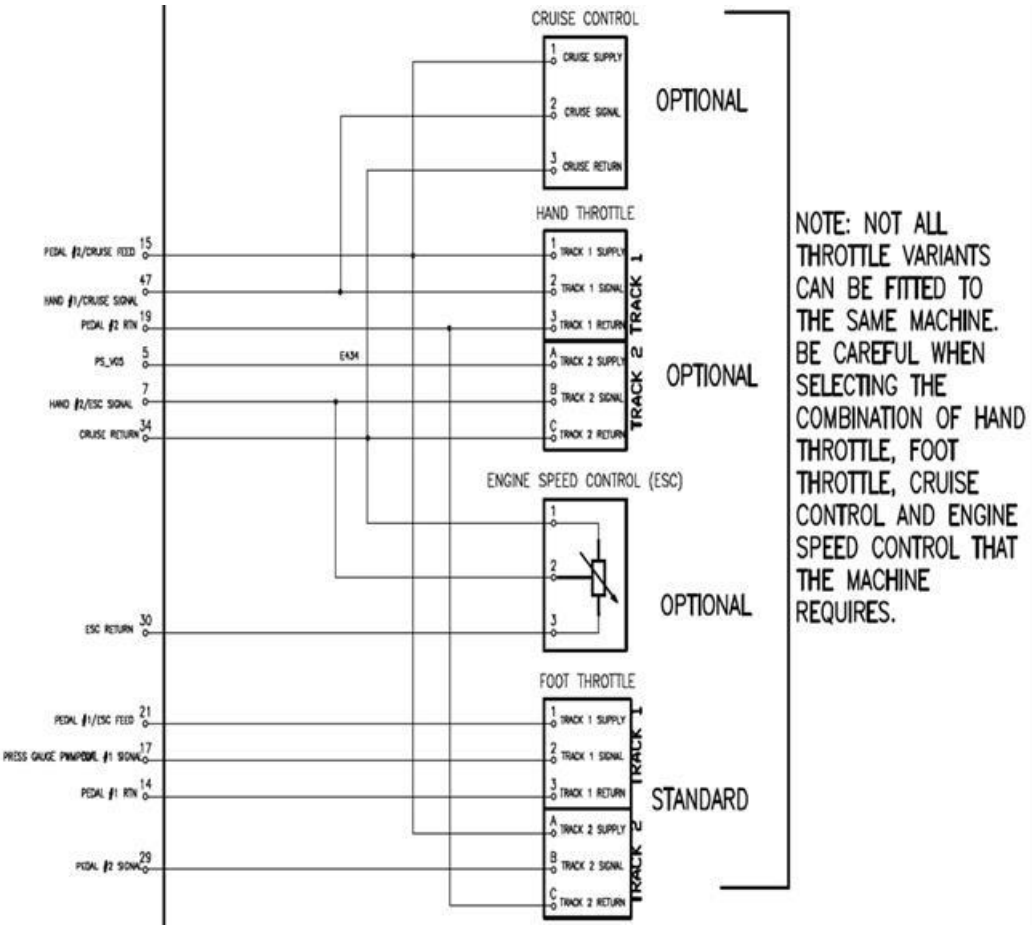


Figure 10: Electronic throttle pin-outs

The following electronic throttle specification must be complied with:

Temperature Range

Operating:	-40°C to +85°C
Storage:	-50°C to +105°C

Functional Life

Full cycles (full rotation):	30 000 000
Dither (2 degrees rotation):	100 000 000

Electrical Specifications for Ratiometric Voltage Output

Supply (Reference)	
Voltage Operating:	5 V ±0.5 V
Supply Over voltage	
Cont. max.:	+16 V, -15 V for min. 1 min @ +25°C ±14.4 V for min 10 min.
Supply Current Draw:	max. 10 mA per Output
Sensor Hysteresis:	max. ±1% of supply voltage
Sensor Linearity:	See Figure 29
Minimum Load Resistance:	>30 kΩ
Maximum Load Capacitance:	<1000 nF
Output short circuit:	unlimited time
Output time response:	max. 10 ms
Power-up time:	max. 50 ms
Environmental Specification	
EMC:	150 V/m
ESD:	±15 kV
Seal Compliance:	IP67
Chemical Resistance as per.	SAE J1455

13.7.2 Engine Fixed Speed Control (EFSC)

This feature is enabled in the ECU software for all IPU applications. The EFSC system can be set On or Off, with a range of set speeds and choice of increment and decrement step sizes.

This system needs electrical switches to be connected to three pins on the engine ECU. This feature cannot be used in conjunction with two twin track control devices. Please contact your JCB Power Systems Applications department for more information and advice.

13.7.3 Low Fuel Level Switch

The engine ECU needs a low fuel level input. The input can be hard wired or through a CAN Bus message. When a hard wired input is selected and Pin #46 is switched to ground, a low fuel level condition is determined. Please contact JCB Power Systems Applications department for more information.

13.7.4 Electric Lift Pump

The JCB EcoMAX Common Rail engine uses an electric lift pump and fuel pre filter supplied loose with the engine. This unit **must not be installed on the engine** but to the machine chassis as close as possible to the engine and away from significant sources of vibration. The electric lift pump is a 12 V device and is controlled by the engine ECU through a suitable (10 A_{DC}, SPNO) relay. The ECU will disable the electric lift pump if the engine is not run within 15 seconds of the ignition being switched on. The electric lift pump and fuel pre filter also incorporates a water in fuel sensor which must be connected to the engine ECU. The positive feed to the water in the fuel sensor must come from the ignition relay.

13.7.5 Displays

CAN enabled displays driven by the CAN Bus must be capable of supporting messages which conform to the SAE J1939 communication protocol. Please contact JCB Power Systems Applications department for more information and advice.

13.7.6 Power Relay Box

Included within the scope of supply is a Power Relay and Distribution box which includes various fuses and relays for the operation. This component should be mounted in a position where it is not subjected to excessive vibration, temperature and where service access is possible to change fuses if required.

Power relays included within the box carry out the following fuctions:

Power Hold Relay

Grid Heater Relay

Fuel Lift Pump Relay

13.7.7 Fault Manager

Faults on the ECU system are managed and displayed through a CAN enabled display.

Fault diagnosis is also available through the JCB ServiceMaster™ tool. Please contact JCB Power Systems for more information.

14. Accessibility

WARNING!

You can be injured if you use faulty lifting equipment. Make sure that lifting equipment is in good condition. Make sure that lifting tackle complies with all local regulations and is suitable for the job. Make sure that lifting equipment is rated for the job.

Figure 11 shows the positions of the main engine components you need to access regularly. You must make sure that you can easily and safely do all maintenance activities, such as checking and filling the fluids. You must give appropriate advice and warning to operators and other persons.

The IPU has lifting eyes (seen in Figure 12) to lift the weight of the IPU only. You must use an approved type of lifting equipment which can lift the IPU safely.

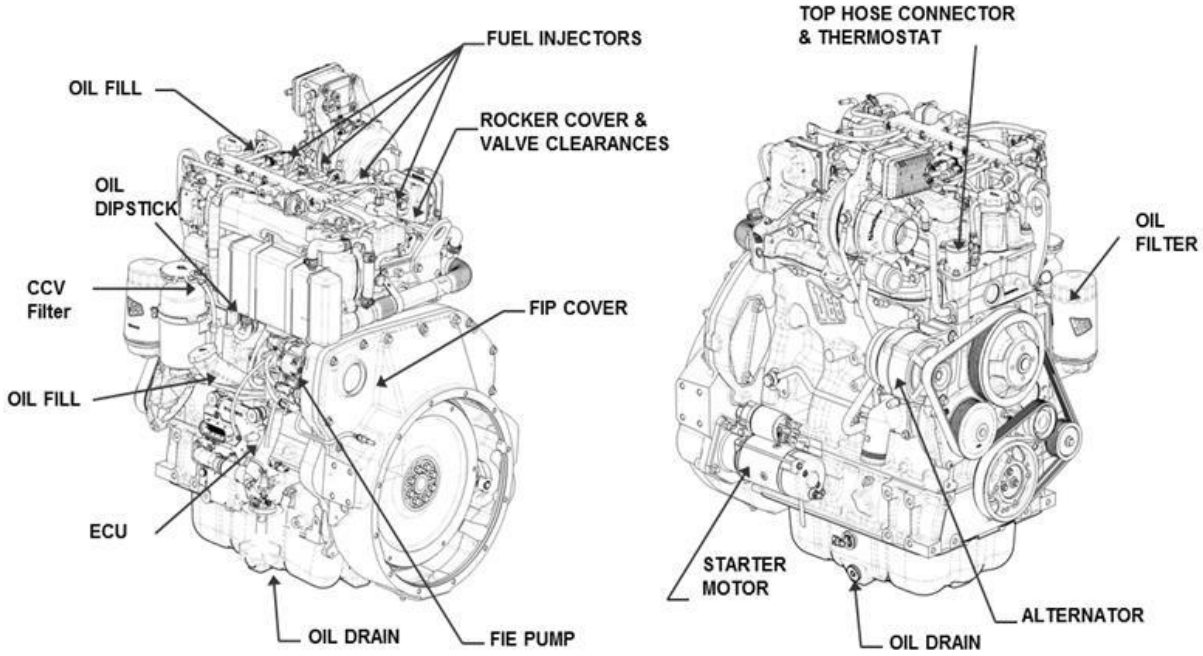


Figure 11: Position of regularly accessed items on the engine

Figure 12 shows the positions of the main IPU components you need to access regularly. You must make sure that you can easily and safely do all maintenance activities, such as checking and filling the fluids. You must give appropriate advice and warning to operators and other persons.

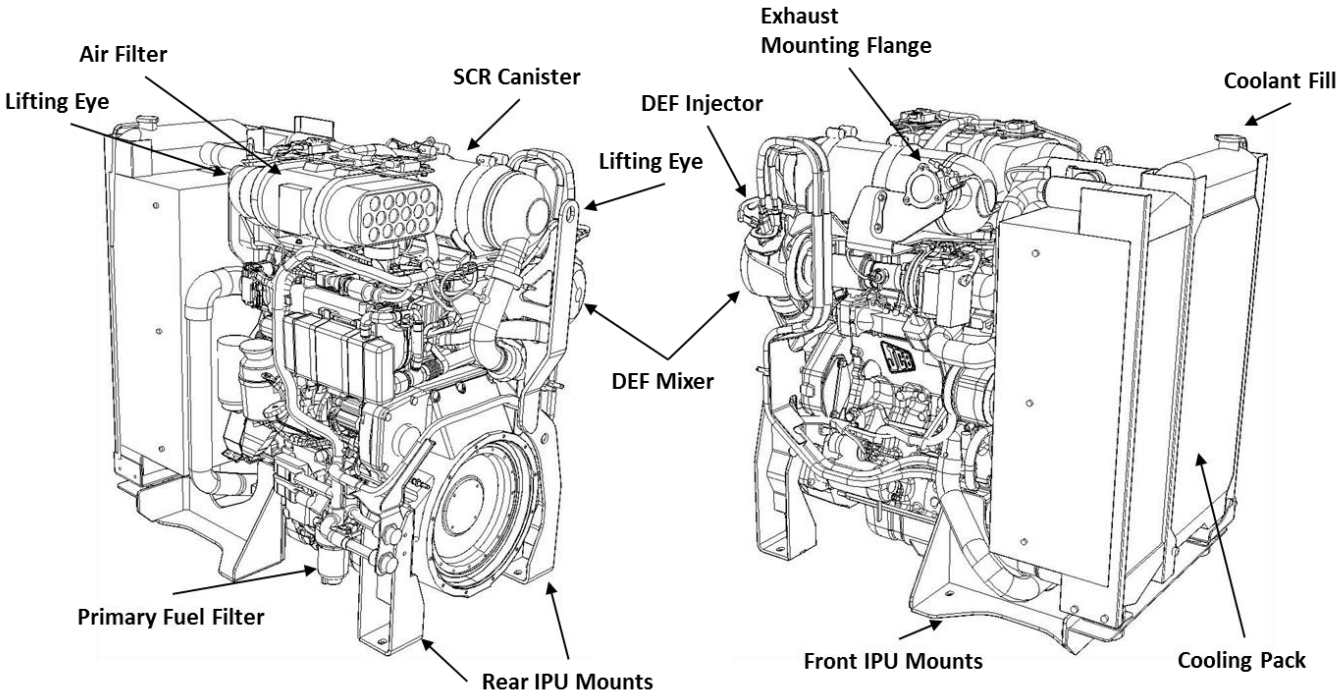


Figure 12: Position of regularly accessed items on the IPU

Figure 13 shows the aftertreatment components mounted to the tank module that need to have suitable access for servicing. Particular attention must be given to the removal of the filter from the supply module, DEF tank drain and the tank breather filter on the end of the breather pipe.

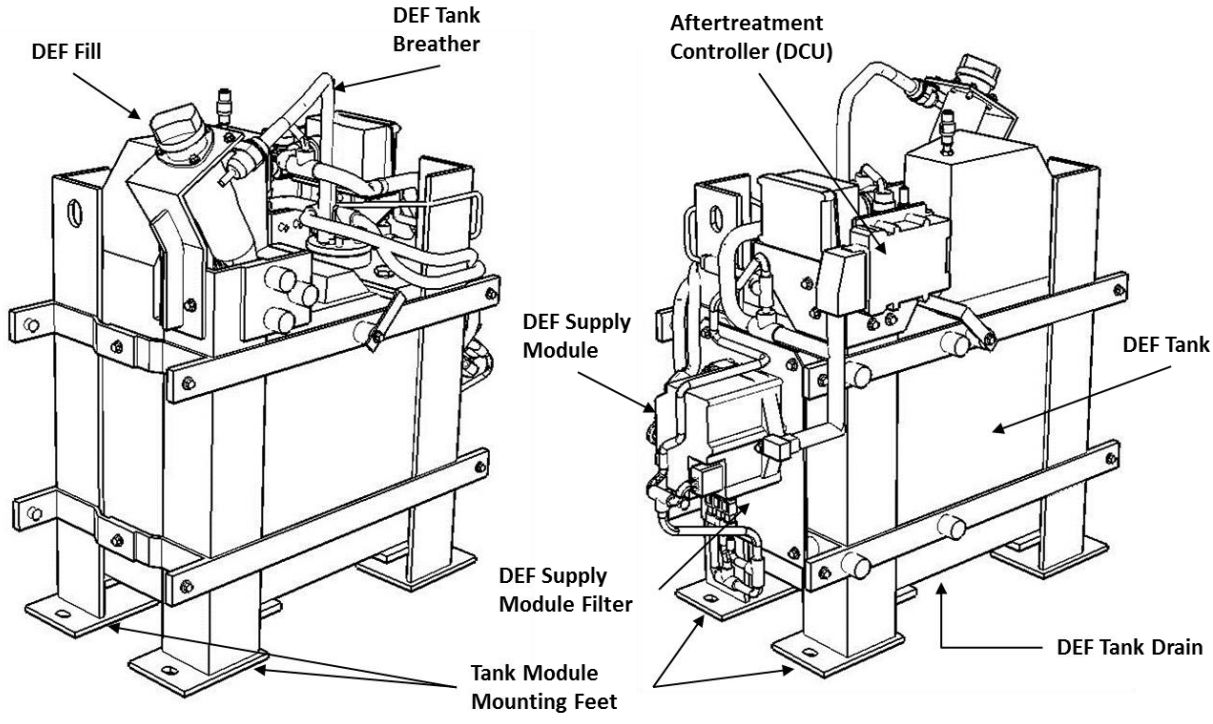


Figure 13: Position of regularly accessed items on the DEF Tank Module

15. Installation Approval Limits

In addition to the guidelines covered in this manual, you must do satisfactory testing to make sure that the limits for the following fluid temperatures and pressures are not exceeded during all operation duties of the equipment.

15.1 Engine Installation and Operation Limits

Maximum coolant temperature

Maximum oil temperature

SCR System Limit

Inlet temperature

Charge air cooler out temperature

Charge air cooler restriction

Exhaust back pressure

Fuel intake restriction

Fuel intake temperature

Fuel return backpressure

Battery voltage when cranking

ECU temperature

Alternator temperature

The limits listed are shown in the appropriate JCB EcoMAX Technical Data Sheet.

15.2 Exhaust After treatment Installation and Operation Limits

Stub pipe length and weight

Diesel exhaust fluid (DEF) bulk temperature

Vibration (as yet undefined)

The limits listed are shown in the appropriate JCB EcoMAX Technical Data Sheet.

16. Delegated Assembly Approval

For engines that are to enter the US or EU the delegated assembly must be adhered to. Deviation from the design is not permitted. The EcoMAX T4 IPU is supplied with all the delegated assembly components mounted either to the engine or the tank module. If the engine and tank module are not installed into a machine, both the engine and the tank module must be shipped on a single pallet to ensure that the delegated assembly is retained. The components supplied on a single pallet **must** be fitted to the same machine, components cannot be 'mixed and matched'. An agreement must be signed by the OEM to state that components will not be changed.

17. Aftertreatment Components Installation

17.1 Introduction

To reduce the installation design and validation activity required by the OEM, JCB have packaged two options of Tank Module which are an integrated solution for the remainder of the system components built into a single unit.

This chapter details the installation requirements and instructions for mounting the Tank Module within the equipment.

If the OEM does not follow these instructions when installing a certified engine in a piece of non-road equipment it violates federal law (40 CFR 1068.105(b)), subject to fines or other penalties as described in the Clean Air Act.

17.2 Using these instructions

This section is arranged to give a good understanding of the JCB aftertreatment system and guidance on its safe integration into equipment. Its primary purpose is to assist engineers and designers specialising in installing JCB EcoMAX engines into equipment. It gives advice on good practice together with requirements to give the expected operation and aftertreatment system life. Adherence to the advice contained in this manual will help ensure acceptance of the installation by JCB Power Systems.

Fully read this section before installing the aftertreatment system into equipment. The OEM must follow all of the safety aspects of the installation. The OEM must make sure that they give users of equipment adequate instruction for safe operation of the equipment – including an Operator's Manual, warnings, and labelling as required.

Throughout this section there are safety messages. Please read and understand these safety messages before installing the engine into equipment.

For more advice and guidance consult JCB Power Systems Applications department.

17.3 SCR System

17.3.1 Schematic Illustration of the SCR System

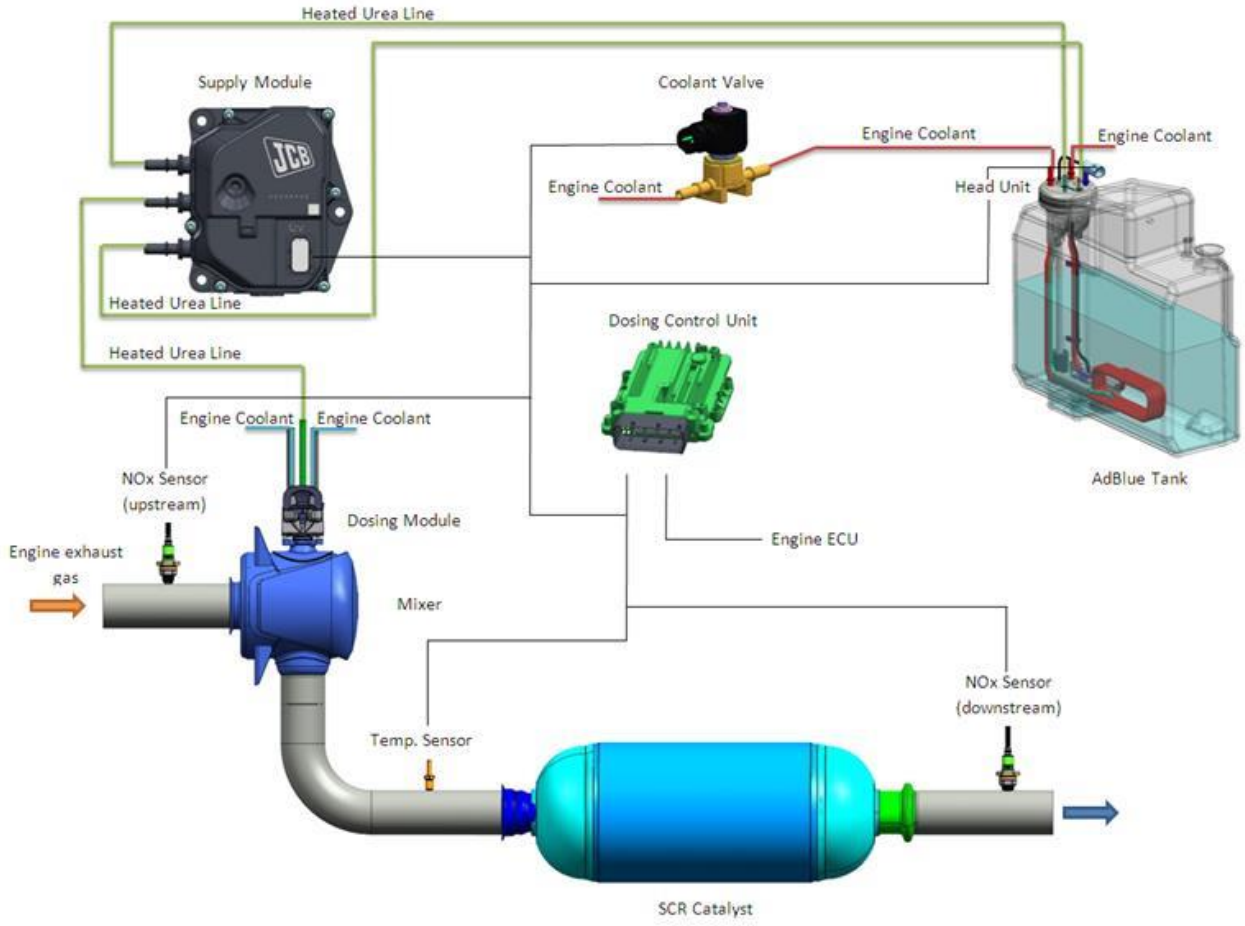


Figure 14: SCR system

17.3.2 Component Overview

DEF Solution

DEF (DIN70070) is an aqueous solution of 32.5% urea to 67.5% deionised water with a freezing point of -11°C. If stored above 30°C for prolonged periods it starts to prematurely degrade, increasing its corrosive properties.

Supply Module

The supply module pumps DEF from the DEF tank to the dosing module. For operation in low ambient temperatures, it uses an integrated electric heater which is capable of defrosting the supply module before operation and stopping it from freezing during operation.

Dosing Control Unit

For any given machine operating condition, the dosing control unit calculates the DEF injection quantity. This regulates the dosing module actuation and the supply module pressure (among other functions) to make sure the correct quantity of DEF is supplied. The correct installation of the upstream temperature sensor combined with the up and downstream NOx sensors are critical to the correct operation of the system. To protect the NOx sensor elements, the sensor probes are heated systematically to bring them up to the

correct operating temperature. At start up, the sensor is operated with a low heating power to protect it from damage which could be caused by contact with condensed water droplets. Once the risk of exposure to condensed water can be ruled out, the element is fully heated and prepared for operation. Temperatures in the sensor probe can reach up to 800 °C.

Communication between the dosing control unit and other and other control units is through CAN bus.

Dosing Module (DEF Injector)

The dosing module injects DEF under a specified pressure into the exhaust flow through the mixer, upstream of the SCR catalyst. The injected DEF decomposes inside the exhaust pipe into ammonia (NH_3) and carbon dioxide (CO_2). The NH_3 produced is the active component in the catalytic reduction of NOx emissions inside the SCR catalyst. The engine generated NOx reacts with the NH_3 to form nitrogen (N_2) and water (H_2O).

Mixer

A mixing component is installed in the exhaust pipe. This homogenises the distribution of DEF in the exhaust stream upstream of the SCR catalyst and allows the decomposition of DEF to ammonia whilst reducing the formation of urea deposits.

SCR Catalyst

The SCR catalyst reduces engine emitted nitrogen oxides (NOx) using ammonia (NH_3) as the reductant on its catalytic surface. To achieve high NOx conversion efficiency, a catalyst temperature of more than 250°C is essential. There are several SCR sizes and configurations (see the aftertreatment Technical Data Sheet for specifications).

DEF Tank & Solenoid Valve

The DEF tank stores the DEF supply. To guarantee DEF availability at low temperatures, the tank is heated. This is implemented by a coolant heated heat exchanger in the tank. To prevent the tank overheating, the cooling water inlet is regulated by a solenoid valve which is operated ‘closed’ when the in-tank temperature has reached the calibrated threshold.

DEF Lines

DEF lines transport the solution around the system. In low ambient environments, these are heated to prevent freezing and allow defrosting. The dosing control unit does the heating control by using the engine control unit’s ambient temperature sensor signal.

Sensing Techniques

The SCR system is monitored by the following sensors:

2 NOx sensors (control of DEF injection quantity and monitoring)

Temperature sensor upstream of the SCR catalyst

Temperature sensor (DEF tank) (control of heating strategy)

Level sensor (DEF tank)

Quality sensor (DEF tank)

17.3.3 Installation Configurations

C ***NOTICE! Protect the dosing and supply modules against stone chipping, mud and debris under all operating conditions.***

C ***NOTICE! Protect the supply module and hydraulic connectors from air flow to help prevent freezing.***

C ***NOTICE! Avoid heat transfer from the engine, gearbox, muffler, exhaust pipes, and so on, into the DEF tank.***

C ***NOTICE! Make sure the routing of the DEF hoses does not lead to additional heat transfer into DEF, especially through engine cooled hoses for cooling the dosing module.***

C ***NOTICE! Make sure you use only DEF compatible materials in the DEF circuitry.***

Description of configurations

- ***68 – 93 kW Top and Rear Mount Aftertreatment***
- ***108 & 129 Top Mount Aftertreatment Arrangement***
- ***Small Tank Module – Suitable for fuel tanks up to 479 litres***
- ***Large Tank Module – Suitable for fuel tanks up to 1500 litres***

17.3.4 Tank Module Installations

The Tank module must be installed within the machine within a position so that the DEF pressure line can be routed without straining and such that in a vertical distance the top of the tank is less than 1.5 meters from the dosing module. Minimum inside bend radius of the pressure line is 60mm. routing of the pressure line should be considered to avoid heat pick up in the line.

In positioning the tank consideration should be given to the temperature around the tank – it is not acceptable for the bulk DEF temperature to exceed a rise above ambient in excess of 10 degrees C

The protection against rocks, debris and splash water for each of the aftertreatment components needs to be assessed by JCB / or trained distributers in the final application.

Diagram showing permissible relative position of the DEF Tank Module to the IPU is shown in Figure 15. Figure 16 shows the details of the siphon requirements for the DEF pressure line to the Dosing Module. The clipping points provided should be used to ensure this requirement is met.

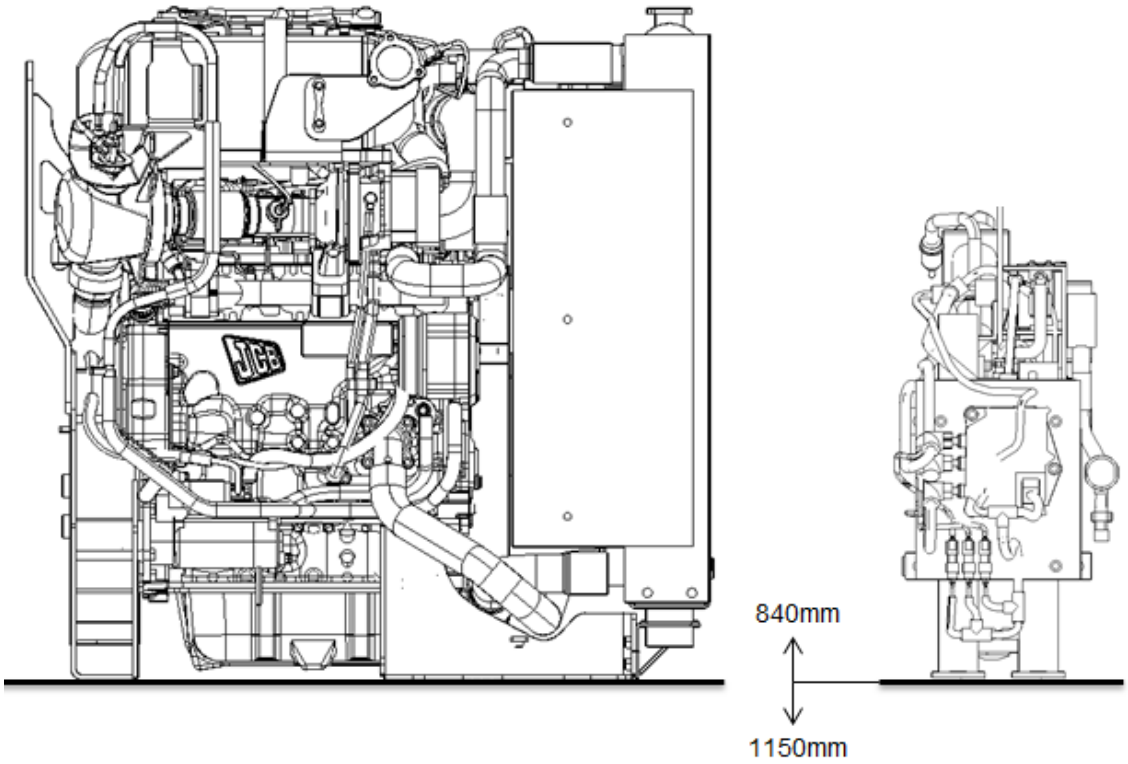


Figure 15: Relative height position of tank module feet to IPU engine feet

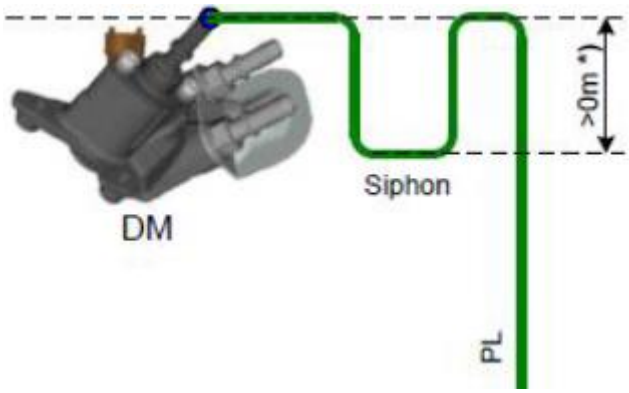


Figure 16: Dosing module siphon requirement

17.3.5 Installation of Hydraulic Lines and Connectors

Heated Lines

To guarantee the functionality of the SCR system at freezing temperatures, all DEF hoses must be heated and insulated. Electric heated DEF hoses are provided by various suppliers in any required length. The longer the line the more the power required for defrost. See after-treatment Technical Data Sheet for heated line power requirements.

The maximum line length is limited by maximum available heating power for the line, insulation of the line and maximum permitted pressure loss in the line. See aftertreatment Technical Data Sheet for maximum pressure loss guidance.

For the fastest defrost times, the line connectors must be straight, heated and heavily insulated.

The use of PA12 (polyamide 12) is recommended as a suitable material for DEF lines.

Pressure Line (PL)

The maximum height of the dosing module above the supply module is limited as shown in Figure 16. The maximum height must be correct to make sure the dosing is accurate.

If the dosing module has to be positioned below the supply module, it must be no lower than 1 meter (reference point to reference point) due to the maximum suction head pressure allowed at the supply module when purging.

Make the dimensions of the siphon so that it can collect any DEF solution remaining in the pressure line after emptying, preventing the dosing module from filling with solution after machine shutdown.

Connecting Sequence

The installation of the system must allow for enough space to connect and disconnect electrical and hydraulic connectors independently. When assembling lines, connect electric connectors before connecting hydraulic connectors. When disassembling the lines, disconnect the hydraulic connectors before disconnecting the electric connectors. This is to prevent DEF coming in to contact with the electrical connectors.

17.3.6 DEF Tank

Tank heating and defrosting is done by a line running through the tank which is linked to the engine coolant circuit. A solenoid valve controls the coolant quantity passing through the tank.

You must incorporate a drain plug into the tank design so you can clean and drain the system.

To avoid false warnings or engine de-rating due to false low DEF levels, the tank design must minimise solution surging.

Tank design may incorporate dead space at the bottom of the tank to stop the sender unit from touching the bottom of the tank.

The tank and DEF must not be exposed to excessive heat sources. If a tank installation close to high heat radiation is not avoidable, you must make sure that temperatures above 60°C do not occur permanently. Otherwise, tank cooling procedures will be necessary.

DEF tanks must be equipped with a ventilation system. This can either be in the form of a tank mounted breather tube or a vented filler cap. In high ambient temperatures some DEF solution may vaporise and create crystals on ventilation system surfaces. Under long term exposure to high temperatures this may lead to the ventilation system becoming blocked so it is strongly recommended that the design allows for the removal and cleaning of the ventilation system.

17.3.7 Filler Neck/Cap

Install the filler neck so you can fill the tank from ground level in accordance with ISO 2860:1992 and be able to install a nozzle diameter of between 19 mm and 24 mm. This allows the tank to be filled through pump nozzle or portable container while reducing the risk of the tank being filled with Diesel (the Diesel nozzle is larger than the tank and the filler neck opening). Despite this precaution, make sure the filler neck for the DEF solution is not mistaken for the Diesel filler neck by the user. Ideally, you must route it to a different area of the machine and somewhere where contaminants from surrounding components are unlikely to fall into the tank.

You may install a strainer to stop debris entering the filler (depending on the machine usage). The strainer must be removable for cleaning when necessary. Filter gauze size must be a maximum of 350 µm.

Route the filler hose so that residual quantities of trapped DEF are able to defrost and not cause a blockage when a refill is needed.

For products sold in the USA, it is compulsory for the filler neck cap to be marked with Diesel Exhaust Fluid (DEF).

17.3.8 Coolant System Integration

Coolant lines are provided on the Industrial Power Unit to pipe coolant flow to and from the dosing module to help prevent the component from overheating. The lines also provide Feed and return coolant hose interfaces. This enables the installer to connect the coolant lines to the Tank Module during installation. The coolant flows through the tank module in cold conditions to de-frost the DEF controlled by the coolant valve. The installer must ensure the feed and return are installed in the correct orientation, shown in Figure 17 and Figure 18.

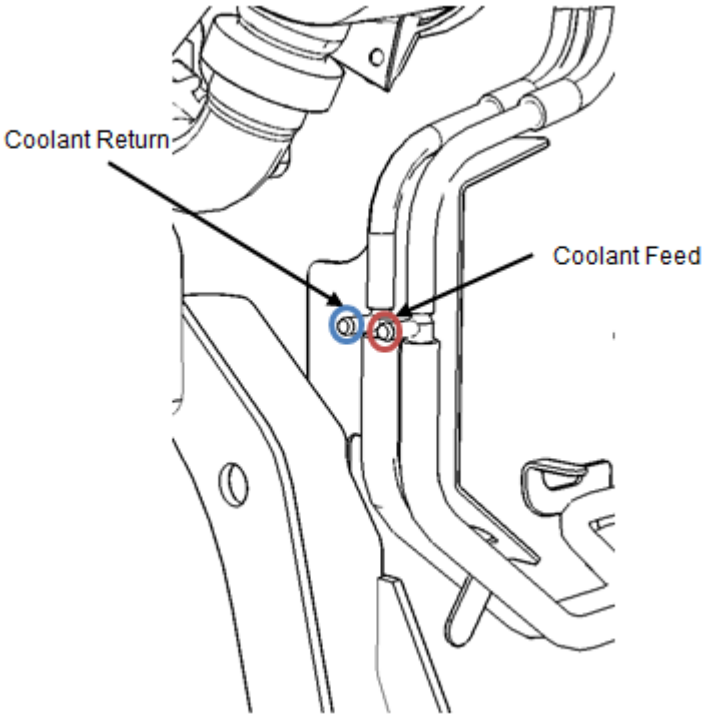


Figure 17: Engine side coolant connection barbs

The hose barbs on the engine side of the cooling system shown in Figure 17 are suitable for the 3/8th coolant hoses supplied. The hoses should be clamped with worm drive clamps or crimp style clamps.

Hoses are supplied with the Industrial Power Units complete with SAE J2044 connections to fit the tank module coolant connections. The engine end can be shortened by the installer to suit the particular installation if required but the line length must not be increased or joined/ broken into otherwise the de-frost performance of the system and consequently the legislative compliance may be compromised

Routing of the hoses should avoid proximity to hot surfaces.

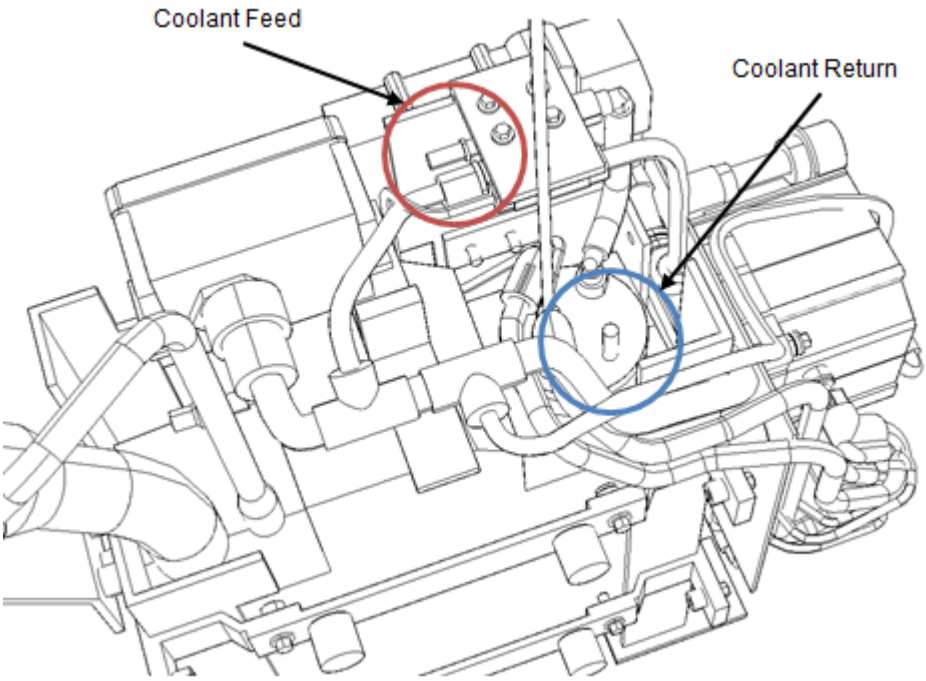


Figure 18: Tank Module side SAE J2044 coolant connections

The Coolant feed from the engine should be used only for the Tank Module connection and must not be used for auxiliary purposes such as operator station heating or auxiliary equipment cooling. If coolant supply is required for auxiliary equipment advice should be sought from JCB power Systems Application Engineering team.

18. OEM Process

18.1 Introduction

The purpose of this section is to provide guidance to the machine manufacturing team relating to the appropriate handling and installation of a JCB engine into a machine or vehicle. This is not intended to replace the formal PFMEA process, rather to inform it and to provide pointers that will help avoid potential issues.
In following the guidance in this document, the OEM installer should benefit from improved assembly line safety, reduced risk of damage to engine or machine, and improved reliability and repeatability of the equipment shipped to the end user.

18.2 Engine Storage

The following guidelines should be followed for the shipment and storage of completed engines:
- Engines should be stored in the as-delivered packaging, under dry conditions with relative humidity in the range 20 to 40%.
- Capping should remain in place on all connections
- Ideally temperatures should be controlled within 10°C to 25°C, and relative humidity between 20% and 40%.
- Wet and corrosive conditions must be avoided
- Maximum storage period should not be exceeded, typically this is six months.

If the engine is to be stored for more than 4 weeks, it should be thoroughly checked over prior to installation to ensure that there is no tendency for engine actuators (turbo or EGR) to stick.
If stored for more than six months, the engine must be cranked over following the procedure for engine storage as laid out in the relevant engine Service manual.

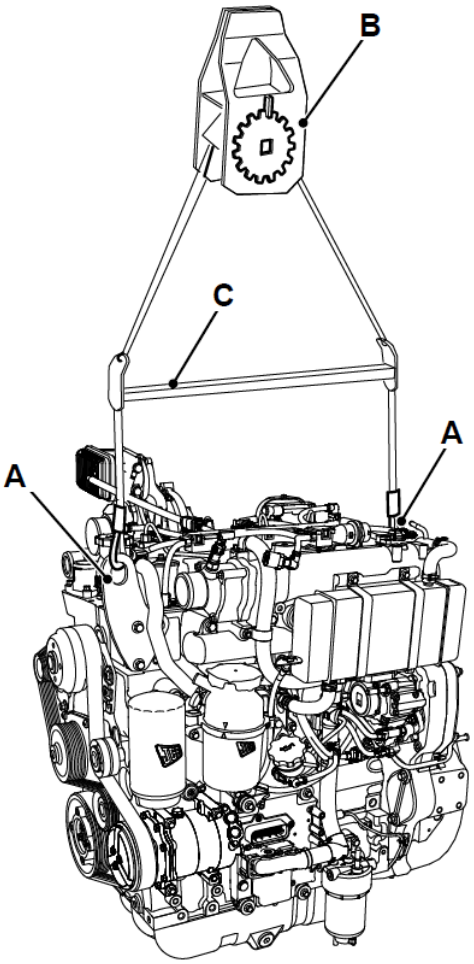
18.3 Other Component Storage

Dress items should be stored in a similar way to the engine, i.e. with caps in place and in a dry and non-corrosive environment. Any transport packaging should remain in place. If decanting to alternative storage, care must be taken to ensure that no damage can occur.
Care should be taken to ensure that electrical items such as ECU's sensors are not dropped or stored in a manner that could lead to them being crushed together. Storage and handling should ensure components are maintained at a minimum distance of 5mm apart at all times.
Fuel system components such as filters and water separators should be handled in such a way as to avoid damage in the form of dents or scratches as this can lead to customer complaint.

18.4 Lifting / Handling

Engine lifting eyes are specified to support the mass of the engine and reasonable engine-mounted PTO mass (up to 50kg) and have been tested in accordance with HSE guidelines. The following should be considered mandatory:
- Always use a spreader bar in an assembly environment, refer to figure 4.1. Length of bar should be 550mm internal length (+/-0.8mm), or otherwise be agreed with JCB Power Systems.
o For 4.4/4.8 litre engines, the JCB part number for the service lifting spreader bar is 892/01382
.
- When refitting lifting eye brackets, ensure both surfaces of the mating joint are clean and free from oil or grease.
- Check the eye to ensure that the part is free from any defect. If in doubt replace the part.
- When fitting bolts, ensure they are clean and free from debris or damage. Fasteners may be lightly oiled but not greased.
- Ensure the correct type, grade and length of bolt is always used.
- Tightening torque specifications must be followed.
- Engines should be kept level in their crankshaft axis during lifting.
- Engines should not be left hanging for extended periods.

If lifting an engine and transmission assembly, it will be necessary to use the lifting eye provided with the transmission, as the rear engine eye is not designed for the purpose of supporting both. It is good practise to either not use the rear eye, or to consider it suitable to provide lateral support only. The transmission lifting point should be such that the load of the transmission is balanced, i.e. no further load is applied to the front engine lifting bracket. If this cannot be achieved, the issue should be identified to the Power Systems Applications engineer so that analysis can be arranged.



A Lifting bracket mounting bolts
B Lifting equipment
C Spreader bar

Figure 4.1: Engine spreader bar

18.4.1 DEF System handling, control and identification

DEF system components are heavily controlled by legislation, and there is a duty assigned to both the engine manufacturer and the equipment installer. Components are mostly serialised and it is vital that the right components are fitted to the right machine, not only by part number but as a kit.
In practise Power Systems will supply engines with a kit of the correct parts. The responsibility of the equipment installer is to:
- Ensure robust storage and handling processes are in place to ensure the engine and the allocated kit of components are installed on the same machine.
- Ensure that records are kept to show that engine and kits are correctly handled and installed.
- Allow JCB Power Systems or their agents to periodically inspect the equipment assembly process and associated records.

- Have records available for inspection by either EU and/or EPA/CARB as appropriate for the end destination of the machines being assembled.

If further clarification of the exact requirements is required please contact JCB Power Systems.

18.5 Fitting Engine Covers or Installing items to the gear driven PTO's

JCB engines are supplied to a level of assembly which provides maximum flexibility to the OEM installer with minimum need to alter other components. In most cases the gear driven PTO's are supplied with bolted covers in place of the PTO unit. Sealing of PTO units is typically achieved by O-ring, meaning that gaskets would not be required. However this is not always the case and the OEM Manufacturing Engineer should check with their Design department.
It is important to ensure that any cap or PTO device is fully inserted prior to tightening fasteners. The bolts should be of the appropriate grade and torqued to an agreed standard. It is strongly recommended that flanged bolts are used, but failing that bolts and plain washers are required to avoid galling of the bolt head into the material of the cover or PTO device.
JCB recommend that the Design office of the OEM verify the required tightening torque by completing their bolted joint calculations. If 8.8 bolts are used, dry, with zinc plating, JCB would use the nominal torque laid out in Table 5.1.

Bolt type	Torque [Nm]
M6 x 1.0	9
M8 x 1.25	22
M10 x 1.5	43
M12 x 1.75	74

Table 5.1: Nominal tightening torques for dry assembly of zinc plated grade 8.8 bolts

18.6 DEF and Fuel System Cleanliness / capping

Optical sensors such as used in the Adblue header unit must be maintained in a manner so as to keep them free from dust or grease.(Including avoidance of fingerprints on the optical unit)

18.6.1 DEF and Fuel tanks

Diesel fuel and DEF injection systems are complex in a number of ways. It is important to ensure that both the tanks and fluids are properly prepared so as to minimise the risk of early life failures.
All fuel and DEF system components, including liquid storage tanks, should be kept clean and dry. Diesel tanks should be oiled internally if not painted or otherwise coated to protect them from build-up of rust. Both diesel and DEF tanks should be clean at manufacture and capped until such time as they are installed in the machine.

18.7 Assembly Best Practice

This section is intended to provide some insight into JCB Power Systems assembly process, in anticipation that parallels can be drawn by the customer Manufacturing Engineer.
JCB's approach is fundamentally as follows:
To ensure reliability of the engine and installation it is in the interests of both JCB and the engine installer to have some common ground on assembly techniques.

- "No faults forward"; the engine will pass through further stations to a rework area if an issue is identified during assembly
- Components assembled on an Operation by Operation basis, with suitable dunnage used to store parts next to the assembly line.
- Where an Operation requires a choice in components, those components will be bar coded so that the correct part is scanned and fitted.

- - D.C tools are used to ensure the correct torque and the correct numbers of fasteners are torqued. Where snug torques are required, these are controlled in the same way.
- - Different joints within a similar operation may be controlled by variation in bolt head size, and the d.c. tool station monitors for the correct tool and provides an indication as to which tool is required when.
- - Sub assemblies are pressure tested before a component label is installed, i.e. the part cannot be labelled unless it has passed a pressure test.
- - Engine labelling and flashing are completed at the same station to ensure engine is flashed before being labelled. Controls then relate to the label to ensure engines do not leave the facility unless the correct software is on the ECU.
- - Upon completion of the assembled engine, coolant circuit is pressure tested for integrity prior to hot test.
- - Hot test uses oil and coolant which are doped to reflect different colours under UV light. Upon completion of hot test the engine is subjected to a UV assessment prior to final lacquer application.
- - Until lacquer is complete, the transport label is not attached, preventing unfinished product being accidentally shipped.

The above is considered current best practise, and is subject to continual improvement. JCB appreciate that it is not practicable to provide computer controlled assembly to a large proportion of the world's off highway equipment. However the above points should be considered when planning assembly of a new machine.

18.8 Attachment of OEM equipment to engine (Other than PTO)

JCB engines are assembled on a no-faults forward basis, with d.c. tooling to both provide correct torque and record that the torque was achieved on each fastener. Hot test and UV checks are used to assure the quality of the engine as shipped from the Dove Valley or Ballhabgar plants.
To maintain this through to the finished machine, removal and reassembly of any existing bolted joints are discouraged and must be agreed with JCB as part of the Application Sign Off process. In any case where a bolted joint is disturbed a suitable control method is required to ensure the correct fastener torque is applied and the action either marked on the bolt or otherwise recorded. For larger manufacturers it is anticipated that this would be achieved by a similar d.c. tool to that used in the original assembly.
Details of the assembly equipment used by JCB Power Systems may be requested, although the company is unable to provide specific advice.
Under no circumstances should items such as remote oil drain or cast iron components be attached to the engine without agreement from JCB on the detailed assembly process.

18.9 Coolant Hoses

Coolant connections should be designed to have a small interference under all circumstances in accordance with DIN standards. As such there may be some difficulty for some personnel in assembling hoses to the spigot. JCB use and have good experience with P-80 THIX Rubber Lubricant Gel, which may be used safely as a lubricant to aid assembly without risking hose blow-off. As with all lubricants, the material should be used in as small a quantity as possible. It is the responsibility of the engine installer to verify that this material is compatible with their selected hose materials, and that it meets with relevant safety legislation. An MSDS is attached in Appendix 2.
Suitable clips are required to secure hoses to spigots. Care should be taken to ensure these are suitably positioned along the parallel part of the spigot and not twisted. The clip should typically be not less than 3-5mm from the end of the hose, depending upon diameter.
Where SAE quick connections are used, ensure that the retaining tabs are properly secured upon installation.
Where possible, a vacuum fill technique is recommended for coolant filling.

18.9.1 Hoses relating to Tier4Final / Stage 4 engines (SCR system heating/cooling)

The routing of SCR lines including connection from one line to another is critical, both to ensure that the correct parts are controlled as required but also to avoid risk of air locks impacting system performance. In some cases the ECU diagnostics can take many hours to find issues, so it is essential to ensure the correct assembly.
Ideally coolant lines will be poka-yoke by design. However this is not always practicable. In such cases fixtures, care points and SoP should be constructed in such a manner as to prevent errors in machine build.

18.9.2 CCV hoses

In most cases the CCV system is installed on the engine by JCB, although by exception the engine may be shipped with fittings to support a chassis mounted CCV filter. In most cases the outlet pipe from the CCV system must be installed at the OEM in order to ensure optimal outlet from a machine perspective.
Assembly of the hose must consider the following:
- Pipe routing should be a continuous fall with no kinks or restrictions.
- Outlet must not be obstructed by other components; any retaining chassis clips should be properly positioned and securely fastened.
- Hose clamps must be correctly positioned along the parallel section of the CCV hose spigot, not twisted, and correctly torqued.

18.10 Fluids

Fluids used should be as per the specification defined in the installation manual. Fluids should be stored and handled in such a way as to minimise water or build-up of debris. Tanks should be maintained and regularly inspected, and regular sampling is recommended to monitor and maintain the quality of fluids being put into the engine. It should be noted that coolant and particularly Diesel Exhaust Fluid (DEF) have shelf lives. A suitable FIFO system is required to ensure that the machine can reach at least first service (or DEF refill) before these fluids reach their expiry date.
Diesel fuel should pass through a filter (rating not greater than 100 microns) and water separator prior to being used for machine first fire.
Diesel fuel types and limitations vary by engine type and are available from the respective Service Manual. Care is required at machine assembly to ensure that fuel is of the correct type for the territory to which the machine will be despatched. For example, low temperature fuel may be required if the next stop for the machine is the US mid-west in winter.
DEF / Ad blue must be kept in the temperature range as recommended by the manufacturer (typically between 5°C and 30°C) so as to maintain its shelf life..

NOTE: Under no circumstances should fuel be poured into a new filter; it is likely that dirty fuel will fall into the clean side of the filter. This will increase opportunity for engine damage and risk early life failures.

18.11 Remote Oil Filter Options

Is most common for the engine oil filter to be engine mounted, although options may exist for remote mount for installations where side access is impractical. In such cases, hydraulic hoses and a remote filter assembly will be either supplied by JCB, or designed by the engine customer in liaison with the JCB Applications Engineer.
Incorrect assembly of these parts can lead to issues ranging from poor serviceability to a delay or even failure to build oil pressure. The latter would lead to early engine failure. Thus it is important that the remote oil circuit be correctly installed.

- Hoses fitted to agreed specification and routing, with no twists or kinks.
- Hose clamping in appropriate location and to agreed standard.
- Tightening torques observed and any gaskets correctly installed.

- Correct orientation of filter housing and any additional equipment to support oil filter drain.

NOTE: Priming of any remote oil filter circuit needs to be considered as part of the PFMEA process, and appropriate controls put in place. In practise, this will likely mean an additional 10s period of “dead crank” prior to starting the engine. Please see section 21.2.

18.12 Wiring & Sensors

In order to achieve the ever more stringent emissions requirements, modern engines must be fitted with complex control systems to ensure that they are able to meet the legal requirements for the duration of their lives. In most cases these are controlled via electrical actuators and monitored via sensors, all linked together by a harness or harnesses. The terminals on these harnesses are often quite sensitive to vibration, dust and water ingress and as such it is important that they are installed correctly.

- Incoming materials should be properly checked to ensure no pins are bent or misplaced.
- Harnesses should be properly clipped or retained as per the design specification, with no excess tension applied to any connection.
- ECU and interconnect harness should be correctly installed and fully locked on.
- Drip loops should be correctly installed to protect from water seeping into connectors.
- Any heat shielding should be correctly located and oriented
- Engine harness, if disturbed, should be moved back into the correct position

18.13 FEAD Including Fan Drive

Assembly of the belt drive is necessary to ensure the engine water pump, as a minimum, is driven. As noted previously in this document, JCB engines are assembled in such a way as to provide maximum flexibility at the engine customer’s assembly location. Thus items such as alternator, air conditioning compressor and fan are required to be installed to suit the machine being built.
Assembly of the FEAD and optionally fan drive to the engine should consider the following:

- Ensure the correct components are installed to the engine to suit the machine.
- Assembly process should be suitably controlled to confirm that the correct fasteners are used and the correct tightening torques used.
- A.C compressor connections should remain capped until the system can be connected to the machine, and at that point the correct quantity of lubricating oil added.

NOTE: For EU sales, it should be noted that the engine as shipped is classified as “partially completed machinery” and it is the responsibility of the engine installer to ensure that any FEAD or fan guards, along with heat shields etc. are correctly installed. Design and assembly should be controlled in such a way as to demonstrate safe operation for the end user and associated Service personnel.

18.14 Machine Variant Coding

In the case of electronic engines, the engine ECU is pre-programmed at the factory for parameters such as rating, max fuelling and a large number of performance and emissions related functions. Variant Coding is applied for all machines with common rail engines to ensure the machine has:

- Correct throttle input
- Correct interface to any machine CAN controls
- Machine serial number and other security details

The variant coding is correctly flashed prior to despatch to the OE customer. It is important that the correct engine be installed in the correct machine type, as otherwise it will not operate as required.

18.15 Engine Finish / Paint

Engines leave the JCB factory with a protective clear lacquer, which is sufficient in most applications where the engine is protected by a hood or cover. Further paint processes are not preferred as a deviation from JCB's validated procedures. If it is determined that paint is a firm requirement of the end user the following should be considered when defining the paint process:

- Electrostatic paint spraying – the high voltages involved can cause damage to engine electronic components. As a minimum the engine must be properly grounded (earthed).
- In all cases care must be taken to ensure that correct masking procedures are in place to protect key engine components. This includes, for example electrics, belts, pulley grooves, labels etc.
- Paint on plastic components is likely to suffer cracking due to their flexibility.
- Lifting points should be masked or the lifting eyes left fitted as paint will impact the integrity of a safety critical joint.

Contact your JCB Application Engineer for further information.

18.16 Engine First Start

The following points are considered key to avoiding early life problems when starting a new engine in a machine.

Fuel systems fill and filter venting
The new machine should be filled with enough fuel to ensure that the machine can reach the dealers site without risk of running out of fuel, including an allowance for system fill. This should include all filters and lines as specified for the engine, including territory considerations.
Common rail engines: At initial key-on, the fuel pump will run for a period of time. During this time the outlet manual vent should be kept open until the air has purged from the system.
Mechanical Engines: Air must be bled from the system prior to cranking to avoid damage to fuel injection equipment.

Oil priming
Standard engines may be cranked and started normally on the starter but should be idled for the first fifteen to thirty seconds before the engine is loaded (machine is moved).

For engines with remote oil filter, the same procedure should be followed as above but the engine should be cranked as follows:

- Crank for 10 seconds.
- Wait 30 seconds (allow starter to cool).
- Crank for a further 10 seconds or until oil light extinguishes.
- Connect ESOS or enable fuel injection and start engine.

In all cases, the oil pressure light should be monitored; this will go out within 5 seconds of engine achieving steady idle, and should be cause for further investigation if it does not.
NOTE: Under no circumstances should oil be poured into a new filter; it is likely that dirty oil will fall into the clean side of the filter. This will increase opportunity for engine damage and risk early life failures.

18.17 Machine Hot Test

Prior to hot test the following steps should be completed and noted. The machine assembly process should maintain records of any actions required to remedy issues at this stage.

- Overview of installation; check for damage to any components of engine or machine that could cause a warranty issue
- Battery terminals tight and correct batteries installed
- Coolant level topped up to maximum cold level.

- Engine oil level checked. It should read within 2mm of max on the dipstick. If oil top ups are required the correct oil must be used,.
- Check diagnostics with ignition on to ensure no codes are set. Investigate and remedy as appropriate. Upon completion of remedy, diagnostic codes should be cleared.

The hot test itself should consist of at least 8 minutes of loaded engine operation following a 4-5 minute gentle warmup period. The main purpose of the test is to confirm all machine functions, but engine operation should be considered an integral part of this. Monitor machine performance and the presence of any dashboard lights or diagnostic reports. Loaded operation should be followed by a short period of engine idle (15-60 seconds) prior to stop.
Following hot test, the pre-hot test checks should be repeated, noting that the oil is now warm and will have risen up the stick a little.

NOTE: Engine and associated components will be HOT at end of test. Take appropriate caution when considering process requirements, ensuring proper facilities and time to allow safe handling. For service information refer to engine Service Manual.

18.18 Final packaging and storage

By this stage of the process the engine is simply a component of a machine. However the following considerations should be taken into account when storing the machine ready for despatch:

- Ensure machines are parked in a manner least likely to result in significant rain water pooling on top of engines or in exhaust systems.
- Where possible protect engine bays from very humid or salty environments.
- Ensure machines stored for greater than 4 weeks are started and thoroughly warmed so as to maintain function of all parts of the machine.

18.19 Dealer storage & Engine start

It is recommended that JCB equipment is restarted every 4 weeks and warmed, with all booms and rams being exercised to maintain their condition ready for sale. The engine has similar requirements, and issues may occur if the engine is left un-started for significant periods.
When regularly restarting a machine, or starting after a prolonged period, the water in fuel (WIF) sensor signal should be monitored as water can build up in the fuel tank during storage and rapidly overload the fuel filtration system upon engine start.

19. Material Specification Table

Recommended materials

Metals
Highly alloyed austenitic Cr-Ni-steels and Cr-Ni-Mo-steels, for example in accordance with EN 10088-1, EN 10088-2 and EN 10088-3, or stainless steel 304, 304L, 316 and 316L in accordance with ASTM A240, ASTM A276 and ASTM A312. The outside body and baffles of the exhaust silencers/catalysts must be made from high quality steel such as DX53D + AS120. The exhaust before the dosing module may be of different material due to no contact with DEF. Dosing module mounting points may be made from a different type of metal such as X2CrNi.
AISI 441, EN14509
X2CrTiNb18
Titanium
Ni-Mo-Cr-Mn-Cu-Si-Fe alloys, e.g. hastelloy
Polymers
Polyamide (PA12), free of additives
Polyethylene, free of additives
Polypropylene, free of additives
Polyisobutylene, free of additives
Perfluoroalkoxyl alkane (PFA), free of additives
Polyfluoroethylene (PFE), free of additives
Polyvinylidenefluoride (PVDF), free of additives
Polytetrafluoroethylene (PTFE), free of additives
Copolymers of vinylidenefluoride and hexafluoropropylene, free of additives
Rubber hose / o rings / seals
EPDM
Fasteners
All fasteners must be DEF resistant and made of materials given in this list
NOTE 1: The sequence given in this list does not constitute a ranking of the recommended materials.
NOTE 2: Materials made of plastics can contain various kinds of additives used either for processing or for special kinds of serviceability. These additives can possibly migrate into DEF. For this reason, you need to test the contamination of DEF by additives from plastic materials used in direct contact with DEF.

Non-recommended materials

Materials forming compounds as a result of reaction with ammonia, which may negatively interfere with the SCR converter system: carbon steels, zinc coated carbon steels, mild iron
Non-ferrous metals and alloys: copper, copper alloys, zinc, lead
Solders containing lead, silver, zinc or copper
Aluminium, aluminium alloys
Magnesium, magnesium alloys
Plastics or metals coated with nickel

