2800 Series

Model 2806C-E18

MECHANICAL AND ELECTRONIC INSTALLATION MANUAL

6 cylinder turbocharged diesel engine

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1A

Mechanical installation

Introduction

The information contained within this section provides mechanical installation data for the 2800 Series diesel engine produced by Perkins Engines Company Limited, Stafford, for industrial applications.

It is intended to provide the user with general information for the mechanical installation of an engine/ generating set within an ISO container, canopy or engine room facility.

Because each installation will be different, all factors must be considered and it is therefore recommended that you consult with an approved engine installation engineer before starting. If unsure, please contact the Perkins Applications Department who will be able to provide you with guidance for this procedure.

Perkins Engines Company Limited, Stafford cannot accept any liability whatsoever for any problems resultant from an incorrect installation specification.

You must read, understand and comply with "Safety precautions" on page 2 , with regard to both machinery and personal protection

In addition to the general safety precautions, danger to both operator and engine are highlighted as follows:

Warning! *This indicates that there is a possible danger to the person (or the person and engine).*

Caution: *This indicates that there is a possible danger to the engine.*

Note: Is used where the information is important, but there is not a danger.

The information contained within the manual is based on the information that was available at the time of going to print. In line with Perkins Engines Company Limited policy of continual development, information may change at any time without notice and the user should therefore ensure that, before commencing any work, they have the latest information available.

Users are respectfully advised that it is their responsibility to employ competent persons to perform any installation work in the interests of good practice and safety.

It is essential that the utmost care is taken with the application, installation and operation of any diesel engines due to their potentially dangerous nature.

Careful reference should also be made to other Perkins Engines Company Limited literature including the Technical Data Sheet and the User's Handbook.

Should you require further assistance in installing the engine/generating set, contact the Applications or Service Department.

Perkins Engines Company Limited Stafford,
Tixall Road,
Stafford,
ST16 3UB,
England.

The 2800 Series engine has been developed primarily for use in generating sets. To ensure optimum performance and trouble-free service, the correct selection of generating sets/engines is of the utmost importance during the initial stages. The purpose of the guide is to help the reader to:

- Make the correct choice of power selection.
- Design and build installations which will perform reliably.

Safety precautions

General

For safe installation of the engine it is essential that these safety precautions, and those ***Warnings*** and ***Cautions*** given throughout this manual, are observed and, where necessary, the special tools indicated are used.

All safety precautions should be read and understood before installing, operating or servicing the engine.

Improper installation, operation or maintenance procedures are dangerous and could result in accidents, injury or death.

The operator should check before beginning an operation that all the basic safety precautions have been taken to avoid accidents.

You must also refer to the local regulations in the country of use.

Note: Some items only apply to specific applications.

Guards

- Ensure that guards are fitted over exposed rotating parts, hot surfaces, air intakes, belts or live electrical terminals (high and low tension).

Protection equipment

- Ensure that appropriate protection equipment is worn at all times.
- Always wear protective gloves when using inhibitors or anti-freeze, removing the pressure cap from the radiator or heat exchanger filler, changing the lubricating oil/filter or changing the electrolyte in the battery.
- Always wear ear protection when working in an enclosed engine room.
- Always wear goggles when using an air pressure line.
- Always wear protective boots when working on the engine.
- Always wear protective headgear when working on or underneath the engine.

Naked flames

Ensure that no smoking or naked flames are present when checking battery electrolyte, working in the engine room or when operating or servicing the engine.

Fuel/oil pipes

- Ensure that all pipes are regularly checked for leaks.
- Ensure that all pipes and the surrounding area are regularly checked for spilt oil (and cleaned up where necessary).
- Always apply suitable barrier cream to hands before starting any work.

Shut-down equipment

- Always test that the protection system is working correctly.
- When stopping the engine in case of overspeed, high water temperature or low oil pressure, indicator lights to identify the cause of the shutdown should be provided.
- Heat sensors and smoke detectors should be provided (if applicable).
- Always be in a position to stop the engine (even remotely).

Start-up

- When working on the engine, always ensure that the battery has been disconnected and that any other means of accidental start-up has been disabled.

Electrical equipment

- Always check that electrics are earthed to local safety standards.
- Always disconnect the electrical supply to the jacket water heater (if fitted) before working on the engine.
- Take care to avoid any risk of electric shock.
- Never re-adjust the settings of electronic equipment without reference to the Workshop Manual.

Freezing or heating components

- Always use heat resistant gloves and use the correct handling equipment.

Exhaust system

- Check the system for leaks.
- Ensure that the engine room is correctly ventilated.
- Check that all the guards are fitted.
- Check that the pipework allows the exhaust gas to escape upwards.
- Check that the pipework is supported.

Stopping the engine

1 Disengage the engine load.

2 Run the engine on NO LOAD for 5 to 7 minutes before stopping.

Note: This will allow the circulating lubricating oil to dissipate heat from the bearings, pistons, etc. It will also allow the turbocharger, which runs at a very high speed, to slow down while there is still oil flow through the bearings.

Ensure that the engine is stopped before performing any of the following operations:

- Changing the lubricating oil.
- Filling or topping up the cooling system.
- Beginning any repair work on the engine.
- Adjusting belts (where fitted).
- Adjusting valve clearances.
- Changing air or oil filters.
- Tightening any fixing bolts.

Flammable fluids

- Ensure that these are never stored near the engine.
- Ensure that they are never exposed to a naked flame.

Clothing

- Do not wear loose clothing, ties, jewellery, etc.
- Always wear steel toe cap shoes/boots.
- Always wear appropriate head, eye and ear protection.
- Always wear suitable overalls.
- Always replace a spillage contaminated overall immediately.

Lifting heavy components

- Always use the correct lifting equipment.
- Never work alone.
- Always wear a helmet, if the weight is above head height.

De-scaling solution

- Always wear both hand and eye protection when handling.
- Always wear overalls and appropriate footwear.

Waste disposal

- Do not leave oil-covered cloths on or near the engine.
- Do not leave loose items on or near the engine.
- Always provide a fireproof container for oil contaminated cloths.

Note: Most accidents are caused by failure to observe basic safety precautions and can be avoided by recognising potentially dangerous situations before an accident occurs. There are many potential hazards that can occur during the operation of the engine which cannot always be anticipated, and therefore a warning cannot be included to cover every possible circumstance that might involve a potential hazard, but by following these basic principles the risk can be minimised.

Dangers from used engine oils

Prolonged and repeated contact with mineral oil will result in the removal of natural oils from the skin, leading to dryness, irritation and dermatitis. The oil also contains potentially harmful contaminants which may result in skin cancer.

Adequate means of skin protection and washing facilities should be readily available.

The following is a list of 'Health Protection Precautions' suggested to minimise the risk of contamination:

1 Avoid prolonged and repeated contact with used engine oils.

2 Wear protective clothing, including impervious gloves where applicable.

3 Do not put oily rags into pockets.

4 Avoid contaminating clothes, particularly underwear, with oil.

5 Overalls must be cleaned regularly. Discard unwashable clothing and oil impregnated footwear.

6 First aid treatment should be obtained immediately for open cuts and wounds.

7 Apply barrier creams before each period of work to aid the removal of mineral oil from the skin.

8 Wash with soap and hot water, or alternatively use a skin cleanser and a nail brush, to ensure that all oil is removed from the skin. Preparations containing lanolin will help replace the natural skin oils which have been removed.

9 Do NOT use petrol, kerosene, diesel fuel, thinners or solvents for washing the skin.

10 If a skin disorder appears, medical advice must be taken.

11 Degrease components before handling, if practicable.

12 Where there is the possibility of a risk to the eyes, goggles or a face shield should be worn. An eye wash facility should be readily available.

Environmental protection

There is legislation to protect the environment from the incorrect disposal of used lubricating oil. To ensure that the environment is protected, consult your Local Authority who can give advice.

Viton seals

Some seals used in engines and in components fitted to engines are made from Viton (fluorocarbon).

Viton is used by many manufacturers and is a safe material under normal conditions of operation.

If Viton is burned, a product of this burnt material is an acid which is extremely dangerous. Never allow this burnt material to come into contact with the skin or with the eyes.

If it is necessary to come into contact with components which have been burnt, ensure that the precautions which follow are used:

- Ensure that the components have cooled.
- Use Neoprene gloves and a face mask, and discard the gloves safely after use.
- Wash the area with a calcium hydroxide solution and then with clean water.
- Disposal of gloves and components which are contaminated, must be in accordance with local regulations.

If there is contamination of the skin or eyes, wash the affected area with a continuous supply of clean water or with a calcium hydroxide solution for 15-60 minutes. Obtain immediate medical attention.

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2A

General information

The 2806C-E18TAG1 and the 2806C-E18TAG2 engines form part of the Perkins 2800 Series. They are six cylinder, in-line, turbocharged engines incorporating an air-to-air charge cooling system.

They have been designed specifically for producing electrical power in both the 50Hz and 60Hz ratings and are capable of providing the following net engine power:

Model	Rev/min 50 Hz	Units	Baseload	Prime	Standby
2806C-18TAG1	1500	kW	386	475	553
2806C-18TAG2	1500	kW	433	542	599

Model	Rev/min 60 Hz	Units	Baseload	Prime	Standby
2806C-18TAG1	1800	kW	484	583	591

Full engine specifications can be obtained from the relevant Technical Data Sheets.

Definition of ratings

The following information is a brief summary of important points which should be considered:

The generating set/engine should be properly sized for the installation. Determine the duty cycle: Standby, Prime and Baseload.

Standby Power

Maximum usage: 500 hours per year, up to 300 of which may be continuous running.

NO OVERLOAD AVAILABLE.

Prime Power

Unlimited hours usage.
Load factor: 80% of the published Prime power over each 24 hour period.
10% overload available for one hour in every 12.

Baseload or Continuous Power

Unlimited hours usage.
Load factor: 100% of the published Baseload or Continuous power.
10% overload available for one hour in 12.

Dimensions

Overall dimensions can be obtained from the general arrangement drawing.

Weights

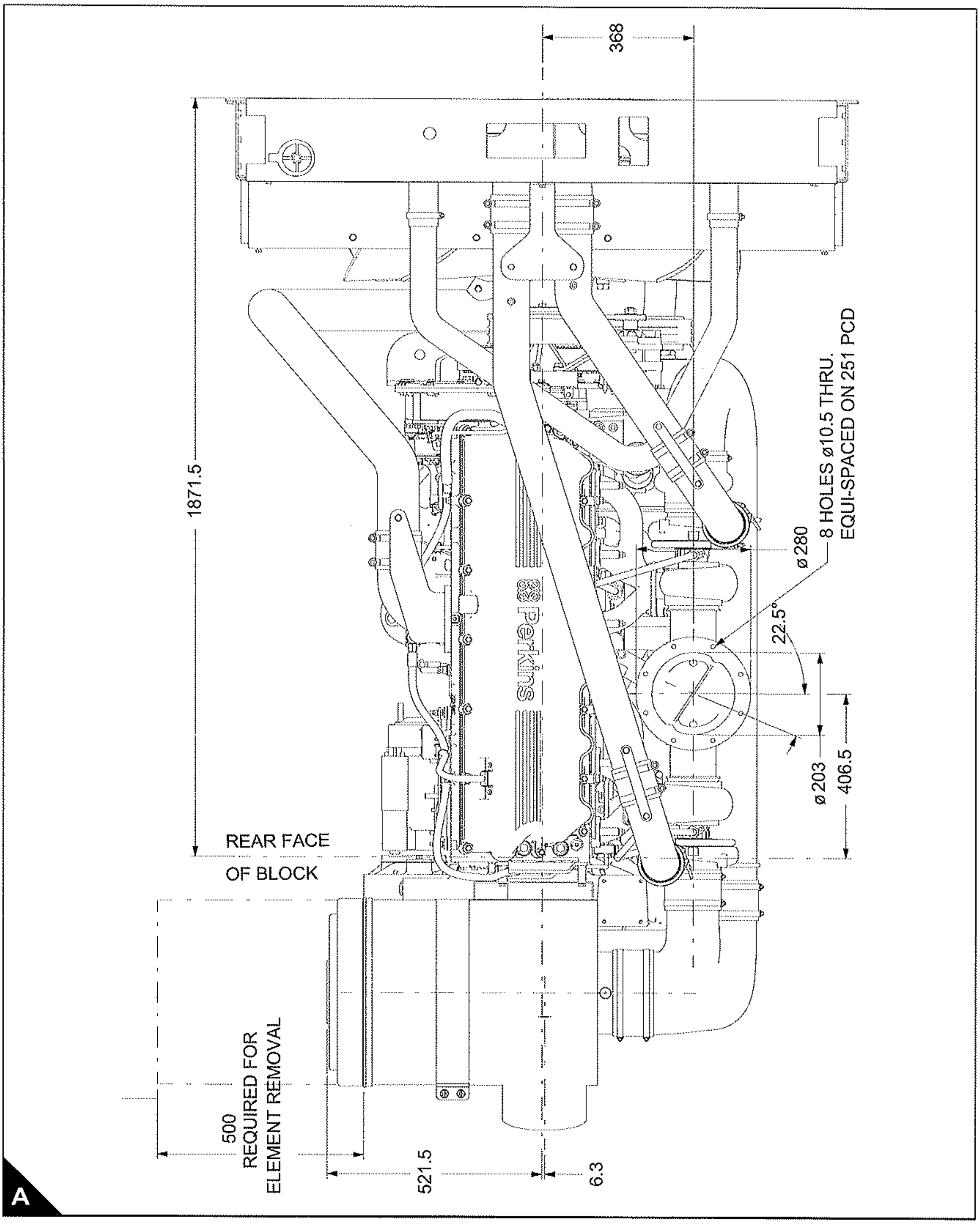
Wet and dry weights can be the obtained from the relevant Technical Data Sheet.

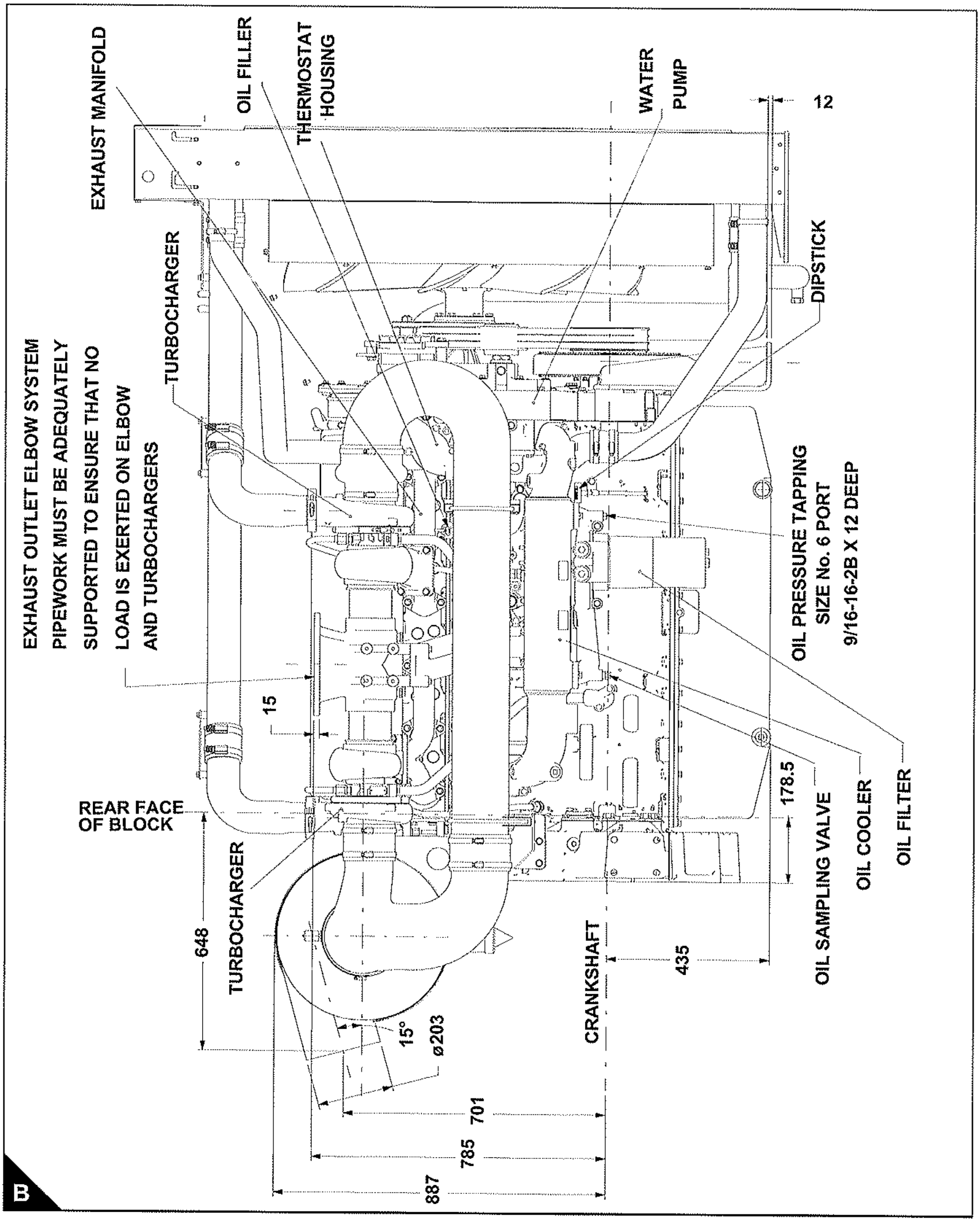
Lifting equipment

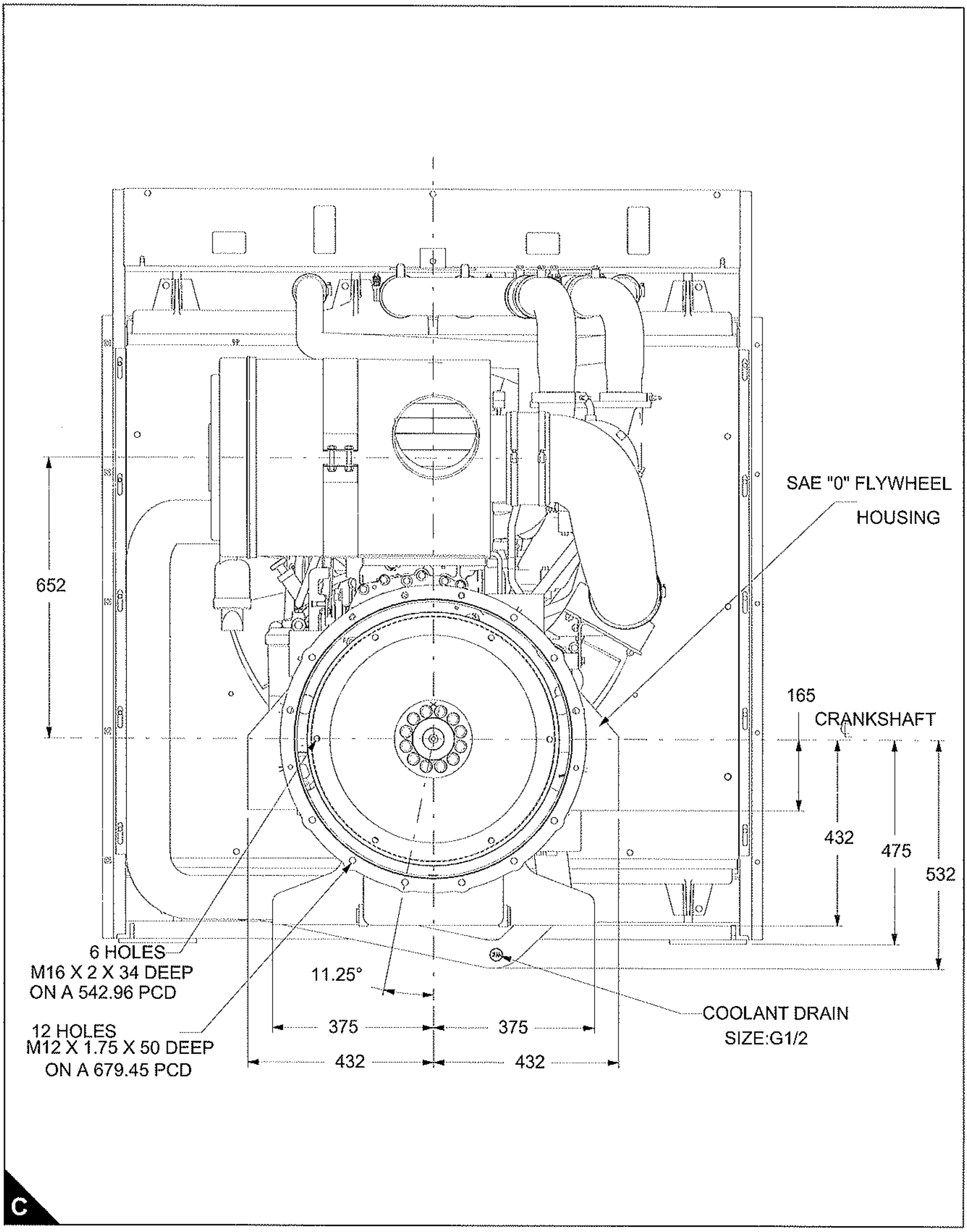
Caution: *Always ensure that the engine is lifted using the correct lifting points and lifting equipment.*

Engine views

These drawing gives approximate dimension only. For installation details, general arrangement drawings contact Perkins Engine Company Limited.




EXHAUST MANIFOLD
OIL FILLER
THERMOSTAT HOUSING
WATER PUMP
12
DIPSTICK
TURBOCHARGER
EXHAUST OUTLET ELBOW SYSTEM PIPEWORK MUST BE ADEQUATELY SUPPORTED TO ENSURE THAT NO LOAD IS EXERTED ON ELBOW AND TURBOCHARGERS
OIL PRESSURE TAPPING SIZE No. 6 PORT 9/16-16-2B X 12 DEEP
15
REAR FACE OF BLOCK
178.5
OIL SAMPLING VALVE
OIL COOLER
OIL FILTER
TURBOCHARGER
648
CRANKSHAFT
435
15°
ø203
701
785
887
B


SAE "0" FLYWHEEL
HOUSING
652
165
CRANKSHAFT
432
475
532
6 HOLES
M16 X 2 X 34 DEEP
ON A 542.96 PCD
11.25°
12 HOLES
M12 X 1.75 X 50 DEEP
ON A 679.45 PCD
375
375
432
432
COOLANT DRAIN
SIZE:G1/2
C

3A

Installation

Foundations

Major functions of a foundation are to:

- Support the total weight of the generator set.
- Maintain alignment between the engine, the generator and accessory equipment.
- Isolate the generator set vibration from surrounding structures.

Ground loading

Initial considerations include generator set weight and material supporting this weight.

The wet weight of the total package must be calculated. This includes accessory equipment and weight of all liquids (coolant, oil and fuel) supported by the foundation.

Weights of liquids		
Liquid	**kg/litre**	**Specific gravity**
Water/Glycol	1,02	1,030
Water	1,00	1,000
Lubricating Oil	0,91	0,916
Diesel Fuel	0,85	0,855
Kerosene	0,80	0,800

Material supporting the foundation must carry the total weight. The table below shows the load bearing capabilities of common materials.

Load bearing capability (Safe bearing load)		
Material	**lb/in^2**	**kPa**
Rock hardtop	70	482
Hard clay, gravel, coarse sand	56	386
Loose medium sand and medium clay	28	193
Loose fine sand	14	96,4
Soft clay	0-14	0-96,4

Firm, level spoil, gravel or rock, provide satisfactory support for single bearing generator sets used in stationary or portable service. Use this support where the weight-bearing capacity of the supporting material exceeds pressure exerted by the equipment package and where alignment with external machinery is unimportant.

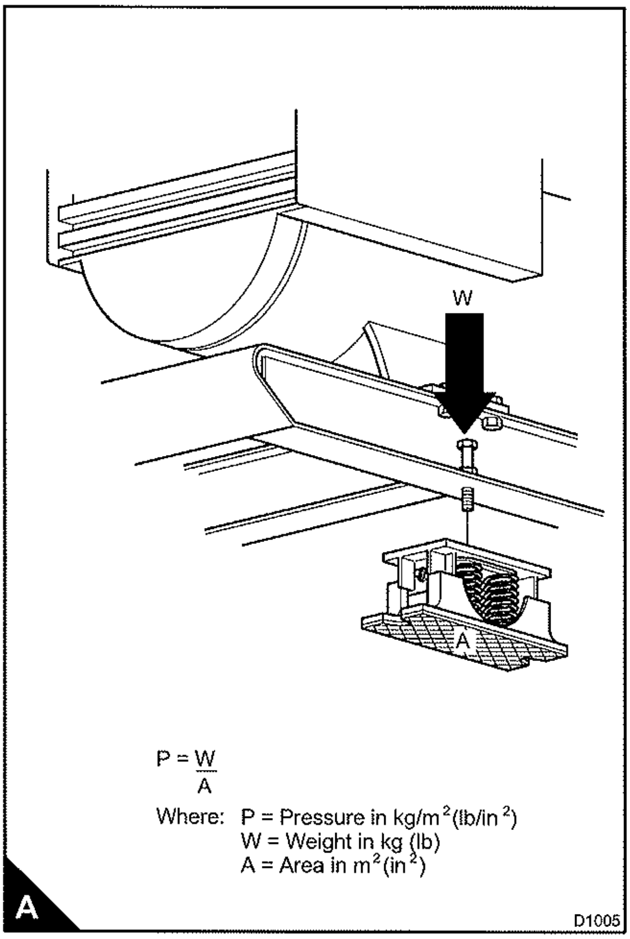
Soil, such as fine clay, loose sand, or sand near the ground water level, is particularly unsuitable under dynamic loads and requires substantially larger foundations. Information concerning bearing capacity of soils at the site may be available from local sources and must comply with local building codes.

Area of load bearing support is adjusted to accommodate surface material. To determine pressure (P) exerted by the generator set, divide total weight (W) by total surface area (A) of the rails, pads, or vibration mounts; see illustration (A).

Pressure imposed by the generator set weight must be less than the load carrying capacity of supporting material.

Where support rails or mounting feet have insufficient bearing area, floatation pads can distribute the weight. The underside area and stiffness of the pad must be sufficient to support the equipment.

Seasonal and weather changes adversely affect mounting surfaces. Soil changes considerably while freezing and thawing. To avoid movement from seasonal changes, extend foundations below the frost line.



Concrete base

Several basic foundations are applicable for generator sets. The foundation chosen will depend on factors previously outlined as well as limitations imposed by the specific location and application.

Massive concrete foundations are unnecessary for modern multi-cylinder, medium speed, generator sets. Avoid excessively thick, heavy bases to minimize subfloor or soil loading. Bases need to be only thick enough to prevent deflection and torque reaction, while retaining sufficient surface area for support. None-parallel units require no foundation anchoring.

If a concrete foundation is required, "minimum" design guidelines include:

- Strength must support wet weight of units plus dynamic loads.
- Outside dimensions exceed that of the generator set by a minimum of 300 mm (1 ft) on all sides.
- Depth sufficient to attain a minimum of weight equal to generator set weight (only if large mass, i.e. inertia block, is specified for vibration control) (A).

Depth sufficient to attain a minimum of weight equal to generator set weight (only if large mass, i.e. inertia block, is specified for vibration control) (A).

$$FD = \frac{W}{D \times B \times L}$$

FD = foundation depth, m (ft)

W = total wet weight of generator set, kg (lb)

D = density of concrete, kg/ft^3 (lb/ft^3)

Note: Use 2403 for metric units and 150 for English units.

B = foundation width, m (ft)

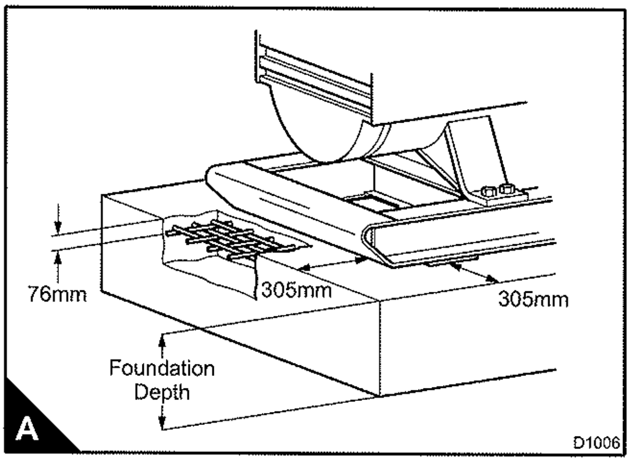
L = foundation length, m (ft)

Suggested concrete mixture by volume is 1:2:3 of cement, sand, aggregate, with maximum 100 mm (4 in) slump and 28-day compressive strength of 20 MPa (3000 lb/in^2).

Reinforce with No 8 gauge steel wire mesh or equivalent, horizontally placed on 150 mm (6 in) centres. An alternative method places No 6 reinforcing bars on 300 mm (12 in) centres horizontally. Bars should clear foundation surfaces by 75 mm (3 in) minimum.

When effective vibration isolation equipment is used, depth of floor concrete is that needed for structural support of the static load. Major rotating and reciprocating components of generator sets are individually balanced and, theoretically, have no imbalance. Practically, manufacturing tolerances and combustion forces impose some dynamic loading on the foundation. If isolators are not used, dynamic loads transmit to the facility floor and require the floor to support 125% of the generator set weight.

If generator sets are paralleled, possible out-of-phase paralleling and resulting torque reactions demand stronger foundations. The foundation must withstand twice the wet weight of the generator set.



Fabricated steel base

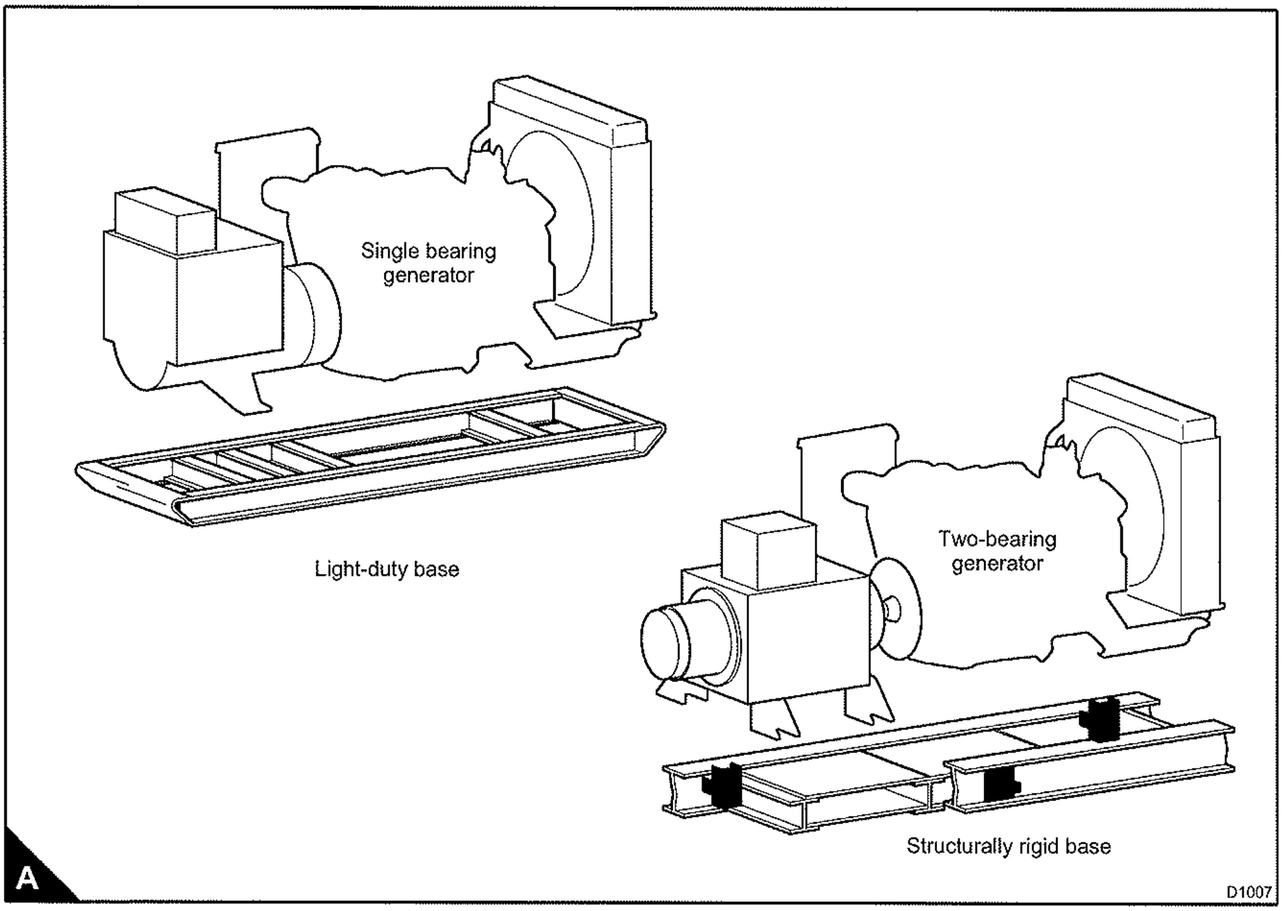
Frequent relocation, initial installation ease, vibration isolation or isolating from flexing mounting surfaces, such as trailers, are major uses for fabricated bases. Do not rigidly connect any base to flexing surfaces.

Bases maintain alignment between engine, generator, and other driven equipment such as radiator fans. Engines with close-coupled single bearing generators maintain alignment by mounting rails or modest bases. Two-bearing generators, generators driven from either end of the engine, tandem generators, or tandem engines, require substantial boxed bases (A). Bases must incorporate sufficient strength to:

- Resist outside bending forces imposed on the engine block, couplings and generator frame during transportation.
- Limit torsional and bending movement caused by torque reactions.
- Prevent resonant vibration in the operating speed range.

Due to thermal expansion, (cast iron 5,5 x 10^{-6} mm/mm/1.8 °C (5.5 x 10^{-6} in/in/1.0 °F)) engines may lengthen by 2,3 mm (0.09 in) from cold to operating temperature. This growth must not be restrained. On single bearing generators, close clearance dowels or ground body bolts must not be used to limit thermal growth. Single bearing generators requiring extremely close alignment, use a ground body bolt at the flywheel end on one side of the engine. No other restraint is permitted.

Mounting feet of two-bearing generators can be dowelled without harm. Slight expansion within the generator is absorbed in the generator coupling.



Vibration

Mechanical systems with mass and elasticity are capable of relative motion. Engines produce vibrations due to combustion forces, torque reactions, structural mass and stiffness combinations, and manufacturing tolerances on rotating components. These forces create a range of undesirable conditions ranging from unwanted noise to high stress levels and ultimate failure of engine or generator components.

Vibrating stresses reach destructive levels at engine speeds where resonance occurs. Resonance occurs when system natural frequencies coincide with engine excitations. The total engine generator-system must be analysed for critical linear and torsional vibration.

Linear vibration

Linear vibration is exhibited by noisy or shaking machines, but its exact nature is difficult to define without instrumentation. Human senses are inadequate to detect relationships between the magnitude of vibration and period of occurrence. A first order (1 x rev/min) vibration of 0,254 mm (0.010 in) displacement may feel about the same as third order measurement of 0,051 mm (0.002 in).

Vibration occurs as a mass is deflected and returned along the same plane and can be illustrated as a single mass spring system (A).

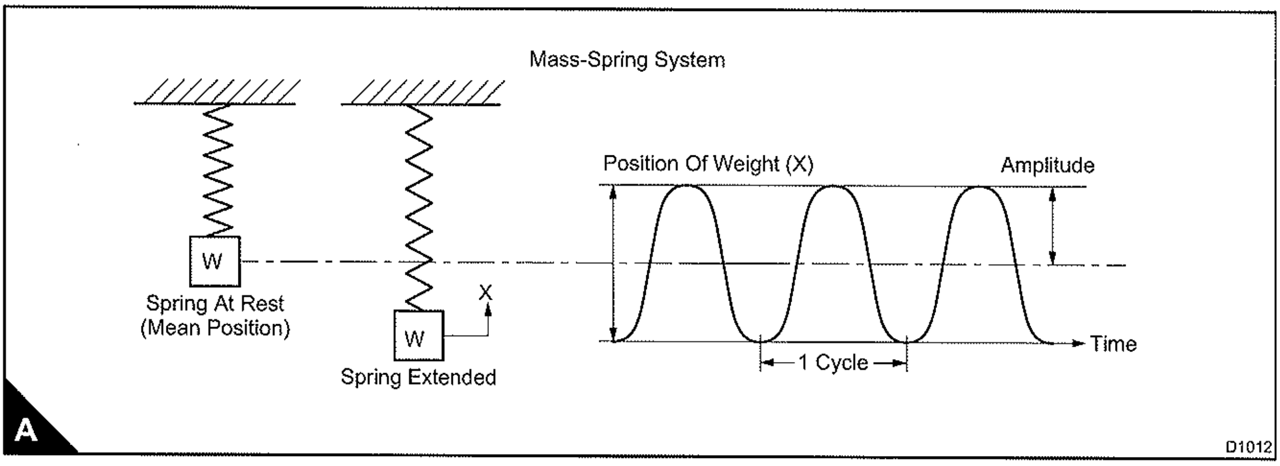
With no external force imposed on the system, the weight remains at rest and there is no vibration, but when the weight is moved, or displaced and then released, vibration occurs. The weight travels up and down through its original position until frictional forces cause it to rest. When external forces, such as engine combustion, continue to affect the system while it vibrates, it is termed 'forced vibration'.

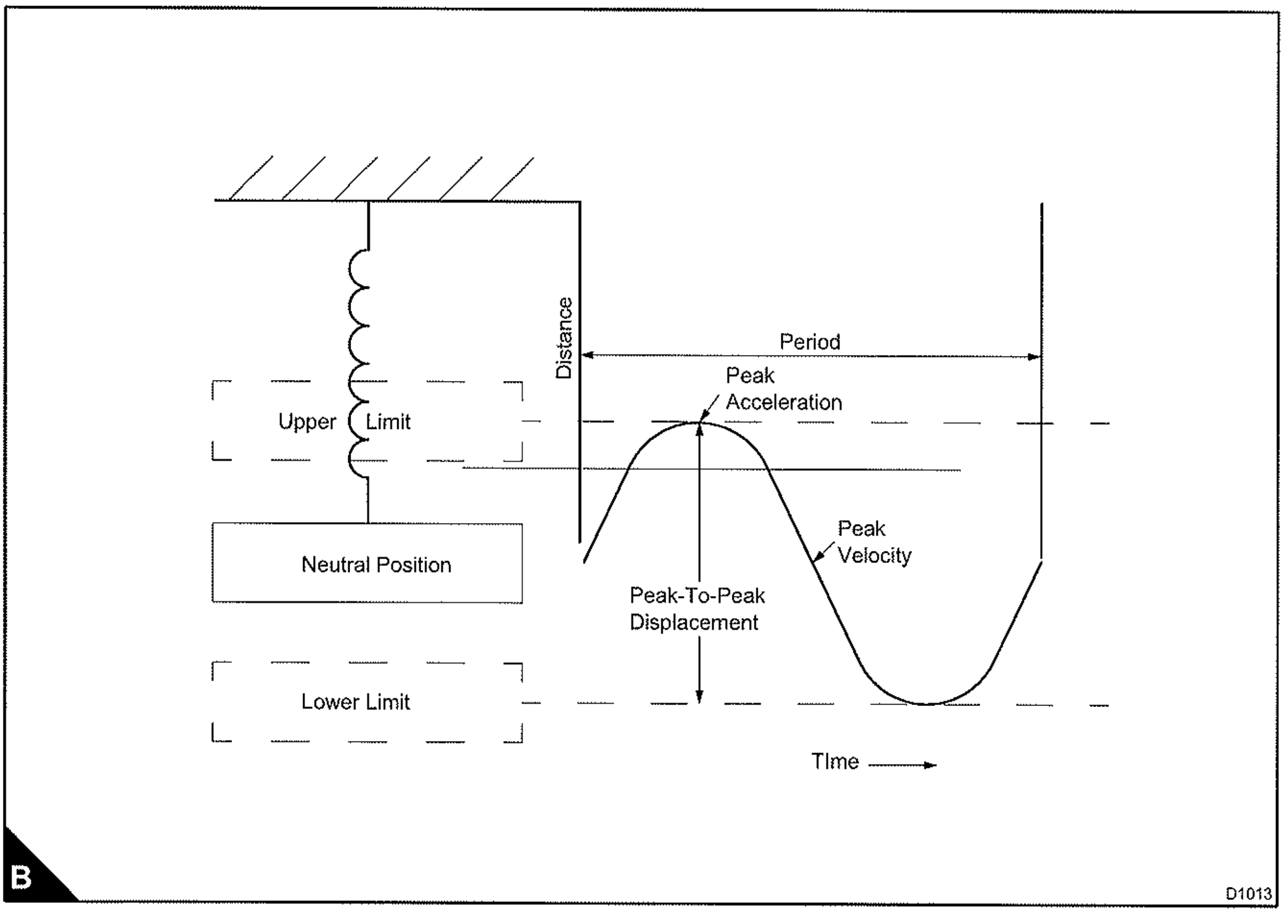
Time required for the weight to complete one movement is called a period (B).

Maximum displacement from the mean position is amplitude; interval in which the motion is repeated is called the cycle.

If the weight needs one second to complete a cycle, the vibration frequency is one cycle per second.

If one minute, hour, day, etc were required, its frequency would be one cycle per minute, hour, day, etc. A system completing its full motion 20 times in one minute would have a frequency of 20 cycles per minute (cpm).





Establishing vibration frequency is necessary when analysing a problem. It allows identification of an engine component or the condition causing the vibration.

Total distance travelled by the weight, from one peak to the opposite peak, is peak-to-peak displacement. This measurement is usually expressed in mils; one mil equals one-thousandth of an inch (0,025 mm (0.001 in)). It is a guide to vibration severity.

Average and root-mean-square (rms) are used to measure vibration (rms = 0,707 times the peak of vibration). These terms are referred to in theoretical discussions.

Another method to analyse vibration is measuring mass velocity. Note that the example is not only moving but changing direction. The speed of the weight is also constantly changing. At its limit the speed is "0". Its speed or velocity is greatest while passing through the neutral position.

Velocity is extremely important, but because of its changing nature, a single point has been chosen for measurement. This is peak velocity normally expressed in inches per second.

Velocity is a direct measure of vibration and provides the best overall indicator of machinery condition. It does not, however, reflect the effect of vibration on brittle material.

Relationship between peak velocity and peak-to-peak displacement is compared by:

$V\ Peak = 52.3\ D\ F \times 10^{-6}$

Acceleration is another characteristic of vibration. It is the rate of velocity change. In the example, note that peak acceleration is at the extreme limit of travel where velocity is "0". As velocity increases, acceleration decreases until it reaches "0" at the neutral point.

Acceleration is dimensioned in units of "g" (peak) where "g" equals the force of gravity:

$980 \times 6650\ mm/s^2 = 386\ in/s^2 = 32.2\ ft/s^2$.

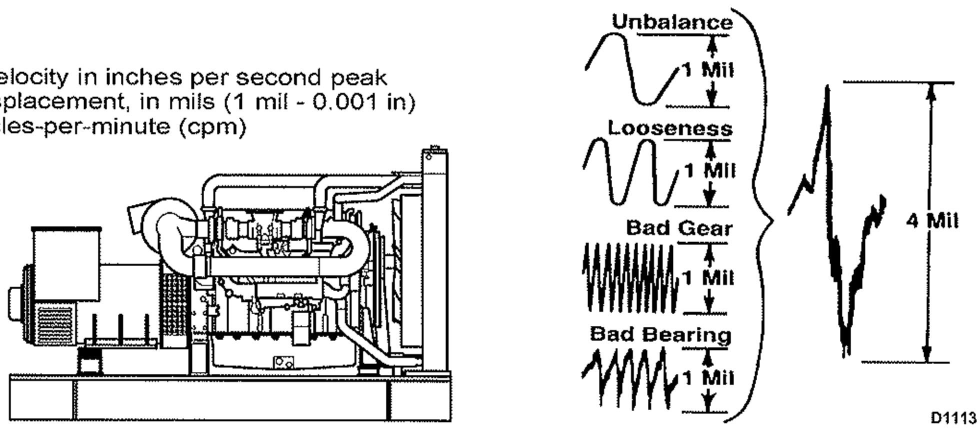
Acceleration measurements, or "g's", are used where relatively large forces are encountered. At very high frequencies (60,000 cpm), it is perhaps the best indicator of vibration.

Vibration acceleration can be calculated from peak displacement:

$g\ Peak = 1.42\ D\ F^2 \times 10^{-8}$

Machinery vibration is complex and consists of many frequencies. Displacement, velocity and acceleration are all used to diagnose particular problems. Displacement measurements are better indicators of dynamic stresses and are, therefore, commonly used. Note that overall or total peak-to-peak displacement, described in (C), is approximately the sum of individual vibrations.

Where:
V Peak = Vibration velocity in inches per second peak
D = Peak-to-peak displacement, in mils (1 mil - 0.001 in)
F = Frequency in cycles-per-minute (cpm)



C

Isolation

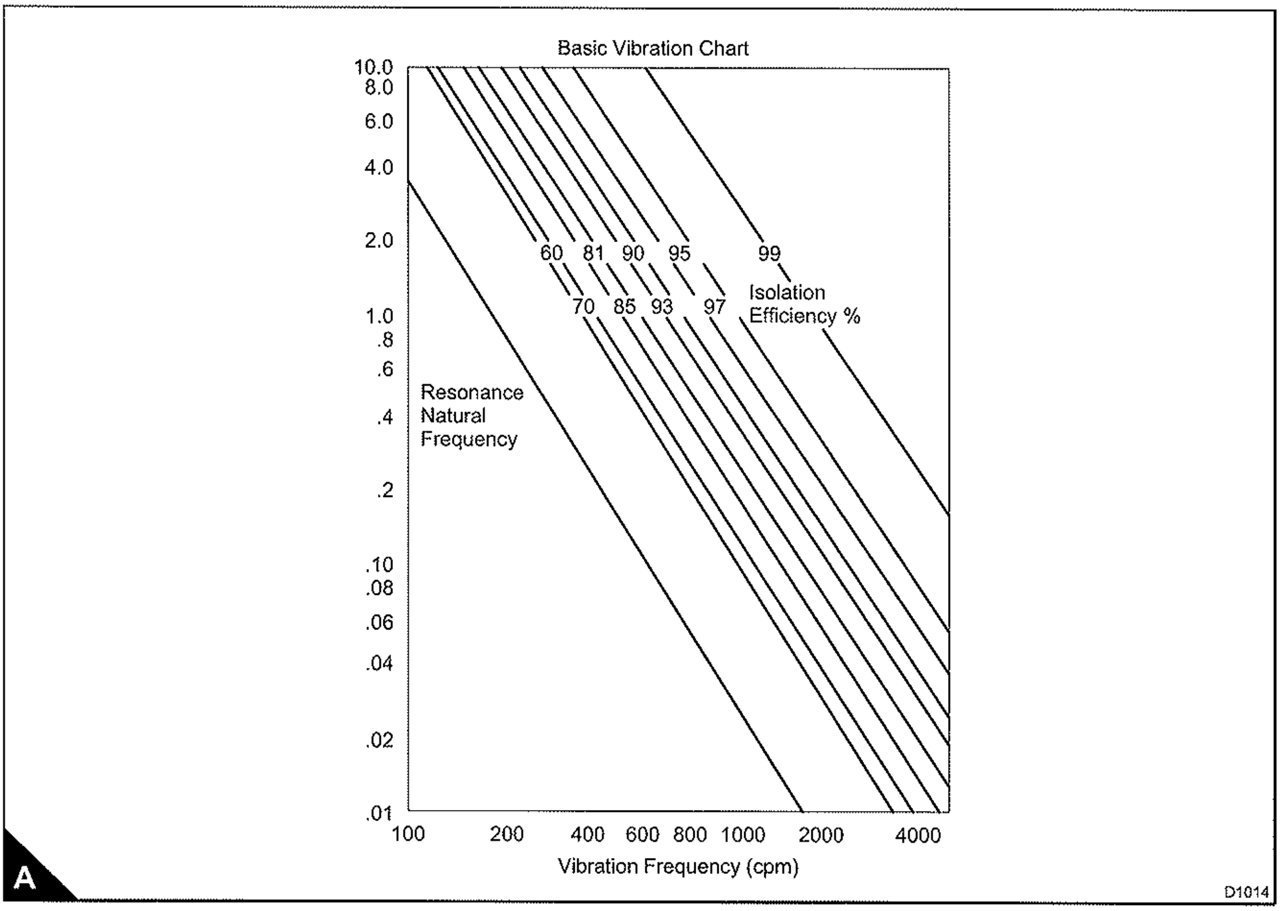
Generator sets need no isolation for protection from self induced vibrations. They easily withstand any vibrations which they create.

However, isolation is required if engine vibration must be separated from building structures, or if vibrations from nearby equipment are transmitted to inoperative generator sets with isolation mounts between the generator set and the base already satisfy these requirements. Running units are rarely affected by exterior vibrations. Methods of isolation are the same for external or self-generated vibrations.

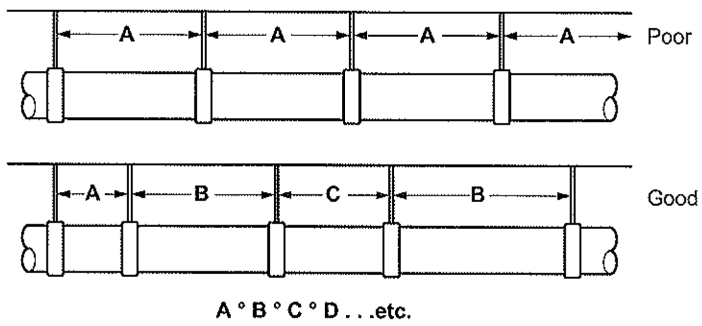
If no isolation is required, the generator set may rest directly on the mounting surface. Factory-assembled units are dynamically balanced and, theoretically, there is no dynamic load. Practically, the surface must support 25% more than the static weight of the unit to withstand torque and vibratory loads. Unless the engine is driving equipment which imposes side loads, no anchor bolting is required. This normally applies to all non parallel generator set mountings. Thin rubber or composition pads minimize the units tendency to creep or fret foundation surfaces

Vibration is reduced by commercially available fabricated isolators or bulk isolators. Both techniques utilize static deflection, with increased deflection resulting in greater isolation. Although internal damping of various materials causes performance differences, the vibration chart (A) describes the general effect that deflection has on isolation. By using engine speed (rev/min) as the nominal vibration frequency, magnitude of compression on isolating materials can be estimated.

The unit can be separated from supporting surfaces by these 'soft' commercial devices, i.e. those which deflect under the static weight. Mounting rails or fabricated bases withstand torque reactions without uniform support from isolators.



Piping connected to generator sets requires isolation, particularly when generator sets are mounted on spring isolators. Fuel and water lines, exhaust pipes and conduit could otherwise transmit vibrations long distances. Isolator pipe hangers, if used, should have springs to attenuate low frequencies and rubber or cork to minimise high transmissions. To prevent build-up of resonant pipe vibrations, support long piping runs at unequal distances (B).



B

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Anti-vibration mountings (AVMs)

The most effective isolators are of steel spring design, see page 12 illustration (A). They isolate over 96% of all vibrations, provide overall economy, and permit mounting of the generator set on a surface capable of supporting only the static load. No allowance for torque or vibratory loads is required. As with direct mountings, no anchor bolting is usually required.

However, when operating in parallel, vertical restraints are recommended and the isolator firmly fastened to the foundation. Spring isolators are available with snubbers for use when engines are side loaded or located on moving surfaces.

Adding rubber plates, beneath the spring isolators, blocks high frequency vibrations transmitted through the spring. These vibrations are not harmful but cause annoying noise.

Rubber isolators are adequate for applications where vibration is not severe. By careful selection, isolation of 90% is possible. They isolate noise created by transmission of vibratory forces. Avoid using rubber isolators with natural frequencies near engine excitation frequencies.

Fibreglass, felt composition and flat rubber, do little to isolate major vibration forces. The fabric materials tend to compress with age and become ineffective. Because deflection of these types of isolators is small, their natural frequency is relatively high compared with the engines. Attempting to stack these isolators or apply them indiscriminately could force the system into resonance.

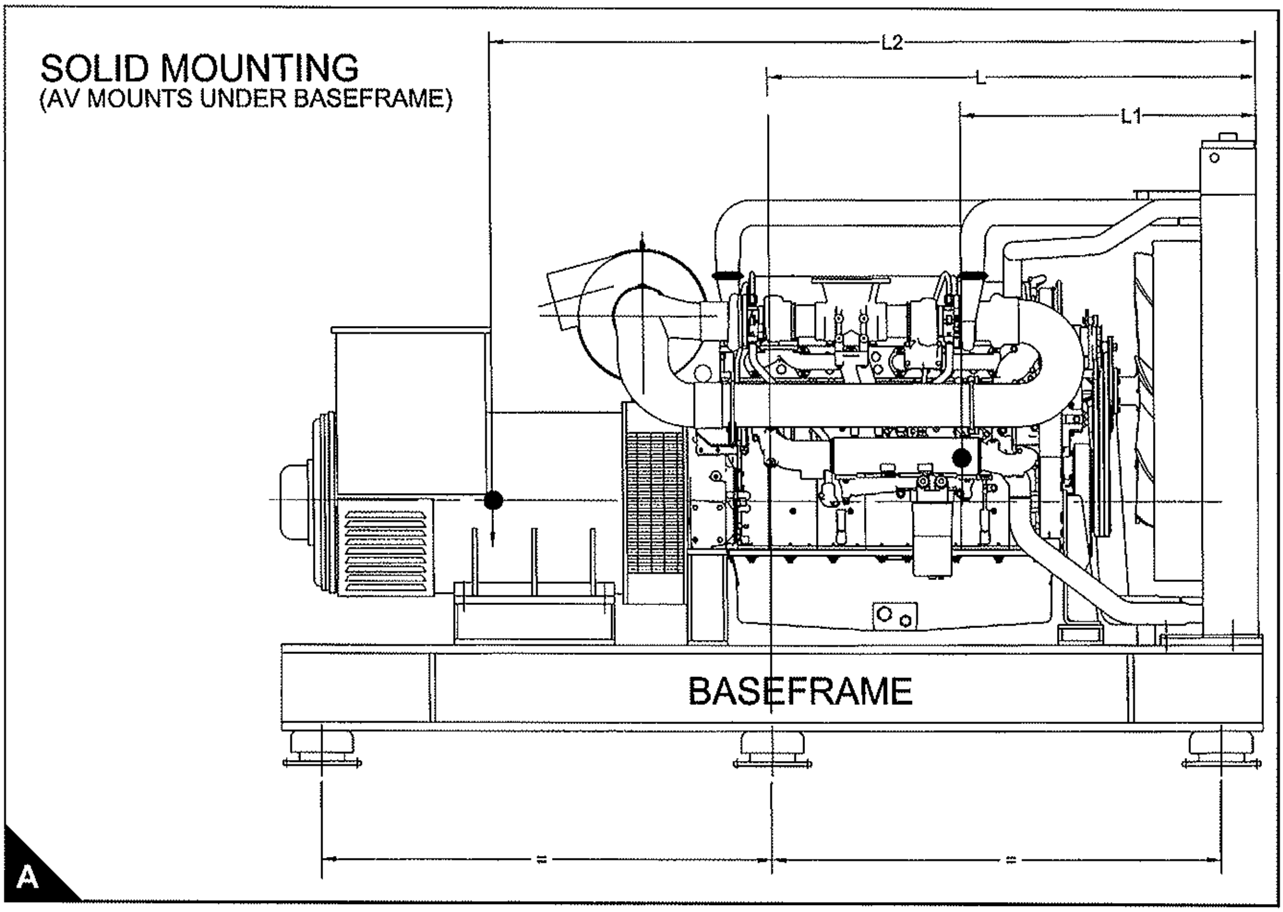
Mounting methods

The engine/alternator assembly may either be flexibly or rigidly mounted to the baseframe.

Solid mounting

$$W \times L = (W1 \times L1) + (W2 \times L2)$$

Therefore: $L = \frac{(W1 \times L1) + (W2 \times L2)}{\text{Total weight } W}$



Flexible mountings

It is important to use a specific type of flexible mounting, to ensure that the mountings are correctly loaded and are suitable for restricting movement, torsional vibration and engine torque.

Normally four mountings are used on most engine/flywheel mounted alternator sets, but the weight distribution may be suitable for standard flexible mounts, refer to the Applications Department at Perkins Engines Company Limited, Stafford. It is not good practice to use additional flexible mounts to provide a 6-point system without first checking their suitability.

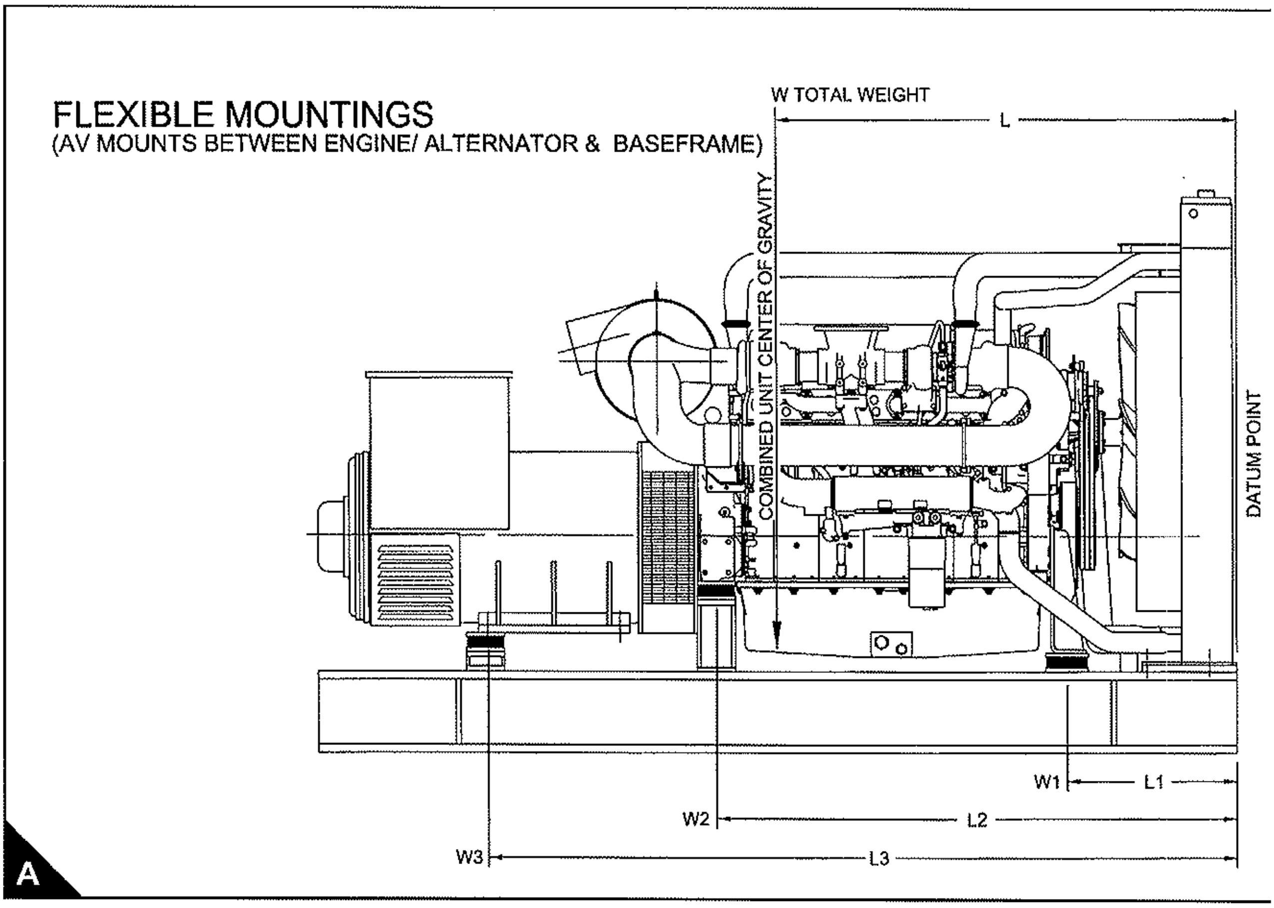
When fitting rear flexible mountings they should be positioned under the alternator mounting pads in a position forward of the centre line of the alternator. The position should be calculated to ensure that the bending moment at the joint face between the crankcase and the flywheel housing does not exceed 1356 Nm (1000 lbf ft).

$$WL = (W1 \times L1) + (W2 \times L2) + (W3 \times L3)$$

$$WL = \frac{W}{3} \times L1 + \frac{W}{3} \times L2 + \frac{W}{3} \times L3$$

$$WL = \frac{W}{3}(L1 + L2 + L3)$$

Therefore: $3L - (L1 + L2) = L3$



Torsional vibrations

Following the introduction of BS 5514, the onus for ensuring that the torsional vibrations of the engine generator mass elastic system are satisfactory has switched from the engine builder to the generator set manufacturer. This service can be supplied by Perkins Engines Company Limited, Stafford upon request.

For a torsional vibration analysis to be performed, the following essential information should be made available:

1 Engine rated power and speed, operating range and overspeed.

2 Speed/torque characteristics of driven equipment.

3 Equivalent dynamic system of all driven parts. If this is unavailable the following data will enable this to be calculated:

- Drawings of all rotating parts.
- Inertias and dynamic flexibilities of flexible couplings.
- The inertias of generator fans, rotors and excitors cannot be extracted from drawings, and inertia figures are therefore important for these parts. The position of each inertia component, its attachment point, and method of attachment to the shaft should be indicated.
- For single bearing alternators, number and thickness of the drive plates, together with details of the fixings attaching them to the shaft hub. For two bearing alternators, define the position of the flexible coupling on the alternator shaft.
- Two bearing alternators rarely present problems, provided that the coupling is the recommended type. The design of shafts for single bearing alternators varies considerably. Torsional vibration analysis is therefore essential to determine whether the alternator is compatible with the engine at the required engine speed.

Note: Perkins Engines Company Limited, Stafford, have made torsional analysis for numerous engine/ alternator combinations and will advise whether a particular combination has been approved, on request.

2806-18 Diesel engine mass and elastic system

Configuration: inline 6 cylinder

Location (from non-driving end)	Inertia kg m²	Stiffness MNm/rad	Shaft diameters mm min O/D	Shaft diameters mm max I/D
Adaptor	0,2326			
		6,379		
Cylinder row 1	0,2720		97	0,0
		4,168		
Cylinder row 2	0,1886		97	0,0
		4,160		
Cylinder row 3	0,2727		97	0,0
		4,209		
Cylinder row 4	0,2680		97	0,0
		4,152		
Cylinder row 5	0,1886		97	0,0
		4,157		
Cylinder row 6	0,2714		97	0,0
		6,340		
Rear	0.0241			

Flywheel 2806-18 all builds - inertia added after “Rear” inertia in table above.

Part No 109-9883 inertia= 4,737^2 Output flange 18” SAE

Torsional vibration damper 2806-18 inertias added to ‘Adaptor’ inertia in table above - other alternatives may be used subject to torsional vibration analysis.

Part No 213-3199 inertia = 0,611kgm^2 Type 409067 (Finned) Single 16”

Seismic inertia inertia=0,624 kgm^2

Effective inertia inertia=0,611 kgm^2

Damper surface area 0,2365 m^2

Part No 203-6100 inertia = 1,0101kgm^2 Type 450060 Single 18”

Seismic inertia inertia=1,120 kgm^2

Effective inertia inertia=1,010 kgm^2

Damper surface area 0,3049 m^2

Continued

Additional engine information

Cylinder bore	145 mm					
Crank pin radius (½ stroke)	91,5 mm					
Connecting rod length	270,76 mm					
Engine capacity	18,13 litre					
Number of cylinders	6					
Reciprocating mass/cylinder	7,927 kg					
Firing order	1	5	3	6	2	4
Firing angle after T.D.C. cylinder	0	120°	240°	360°	480°	600°

Crankshaft rotation is clockwise viewed from the non-driving end.

Note: Inertia values are for GR^2

Flywheel and flywheel housing

Flywheels fitted to generating set engines are machined to an SAE standard. The relationship between the flywheel and housing can be seen on each installation drawing contained in the Technical Data Sheet. The following figures relate to the 2806 engine series:

Flywheel housing size	SAE J620 to suit 18" coupling
Flywheel size	SAE 0
Dimension from housing face to flywheel spigot	25,4 mm

The housing incorporates a facility for a twin starting option if required.

Correct torque figures - coupling to flywheel fixings

Care should be exercised to correctly tighten any fixings used for coupling the engine to the flywheel. The following figures are recommended for the 2806 engine series:

Nominal size 0

SAE number	Nominal Nm (lbf ft)	Maximum Nm (lbf ft)	Minimum Nm (lbf ft)
0	105 (75)	125 (90)	85 (60)

Crankshaft end float

Warning! *Failure to ensure that there is sufficient crankshaft end-float will result in serious damage to the engine within a very short period of time.*

It is important to ensure that crankshaft end-float is checked on the engine after the alternator has been fitted. Failure to do so may cause damage to the thrust bearings and crankshaft in a very short time. This check is equally important for single or twin bearing alternators.

The end-float must be within the following range of limits and must not be restricted by an end loading from the driven system.

Engine	Units	End-float when new	End-float with used bearings
2806C	mm	0,15 to 0,55	0,89 (max)

A dial test indicator (DTI) should be used to check the end-float. With the use of a suitable levering bar the crankshaft can be moved backwards and forwards to record the total indicator reading which should be within the above limits.

Out of balance

During manufacture all rotating engine components are carefully checked for out of balance.

Note: "It is the responsibility of the set builder to ensure that the out of balance of any additional rotating equipment is kept to a minimum."

Radiator mounting

Radiators are supplied loose together with all the necessary pipes and fan guards required.

To protect the radiator from damaging vibrations, the recommended method is to rigidly mount the radiator to the baseframe and to flexibly mount the engine.

Correct positioning of the radiator relative to the engine is important to ensure that the hoses used for air and water pipes have adequate clipping area, that the fan to cowl relationship is maintained for correct airflow and to avoid fan to cowl contact.

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4A

Engine room layout

Installation

Warnings!

- *Use correct lifting equipment.*
- *Do not work alone.*
- *Personal protective equipment must be worn.*

When installing the engine and components in the restricted confines of an engine running room or container, care must be taken that easy access is provided for routine maintenance procedures.

Installation and removal of various parts and components:

- Cylinder heads.
- Coolant pump.
- Oil sump.
- Timing case.
- Starter and alternator.
- Flexible mountings.

Maintenance, inspection and replacement of parts:

- Lubricating oil filter.
- Air cleaner.
- Fuel filter.
- Crankcase breather.
- Dipstick.
- Radiator filler cap and access for filling.

Installation guidelines

1 Avoid plastic and other unsuitable materials for fuel piping and connections, including galvanised pipes and fittings.

2 Keep fuel lines away from hot exhaust pipes.

3 Insulate exhaust systems, from the exhaust elbow onwards, using heat shields, lagging and muffs over flexible sections and keep piping well away from woodwork.

Note: Engine exhaust manifolds and turbochargers must NOT be lagged.

4 Install a fire extinguishing system in the room.

5 Locate batteries in a separate vented compartment or box, with access for routine maintenance, keeping length of starter cables as short as possible.

6 Make provision for draining the oil sump and fit a drip tray underneath.

7 Check that the entrance into the engine room is large enough to allow for the generating set to enter and be removed.

8 Provide adequate lighting and power points.

9 Provide a lifting beam in the roof for maintenance.

10 Make provision for draining the engine cooling system.

11 Ensure that all rotating shafts are adequately guarded for safety purposes.

Initial considerations

When initially deciding upon the size of the engine room the following aspects should be considered:

1 That sufficient space is available to accommodate the power unit and that the load bearing capacity of the floor is suitable for the weight of the power unit.

2 That the facilities in the building are adequate to cater for supplying air for cooling and aspiration.

3 Access to fuel supply and cooling water.

4 That the exhaust emissions from the engine can be dispersed to the atmosphere without exceeding the maximum back pressure.

5 That suitable air intake filters and exhaust system can be accommodated within the engine room without affecting the engine performance, otherwise the engine may need to be de-rated or the filters and silencer repositioned outside the room.

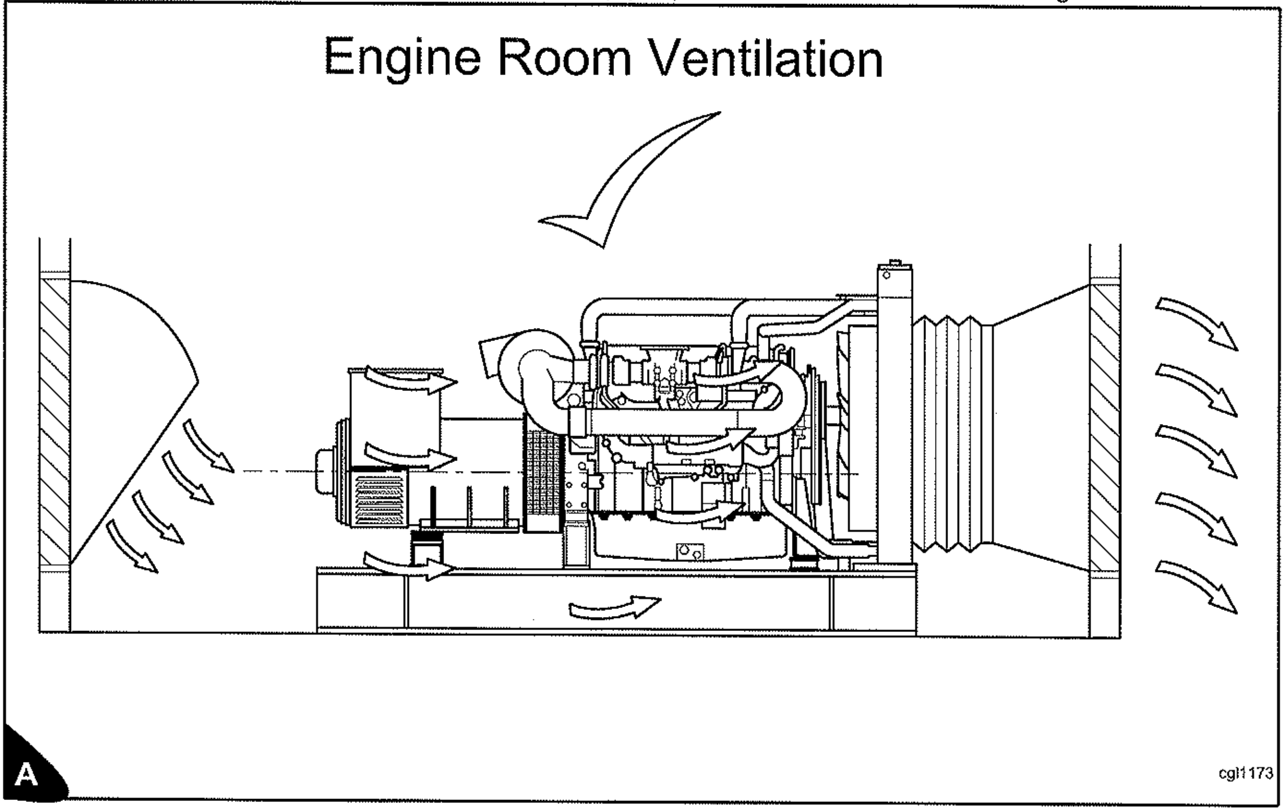
6 If an existing building is to be used, that openings in the wall for inlet and outlet louvre panels can be made without affecting the structural strength of the building.

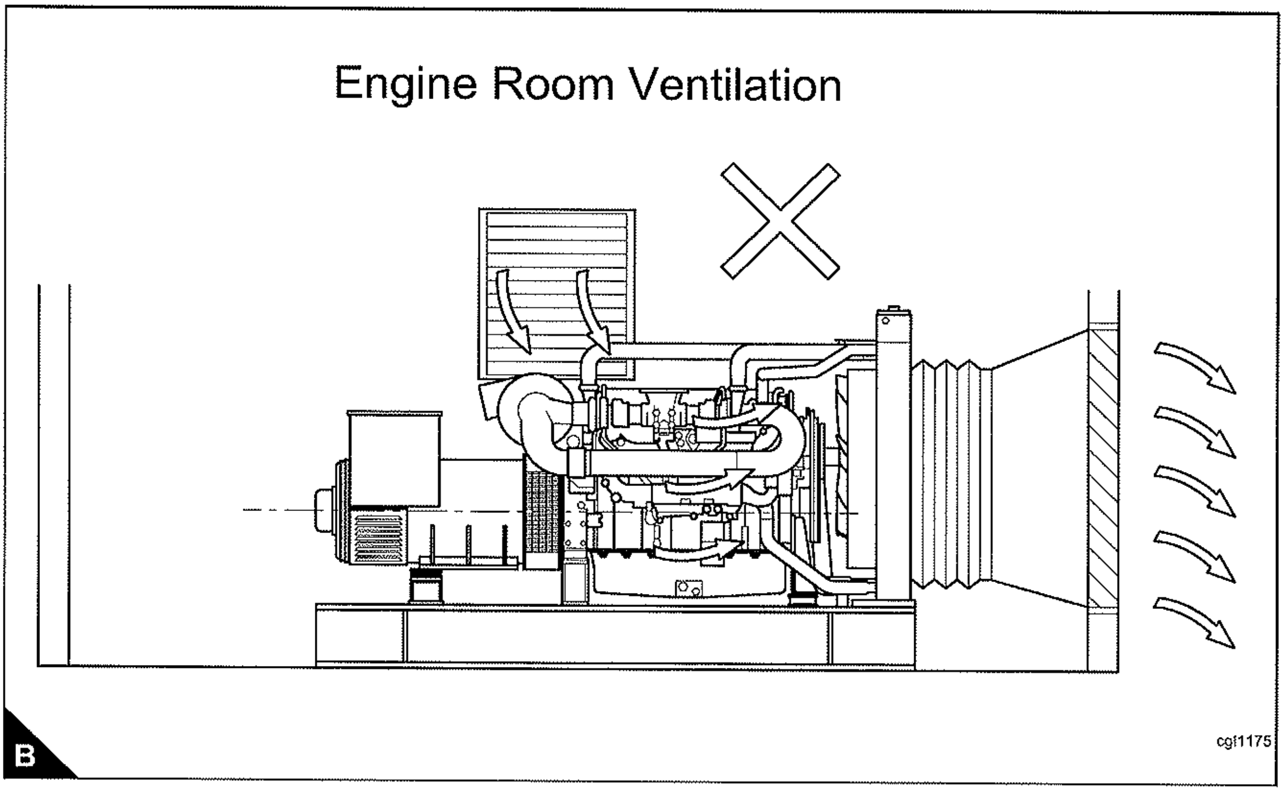
Mechanical noises from the engine, together with exhaust outlet noise, can be insulated by fitting attenuating panels etc., especially when operating in a residential area.When initially deciding upon the size of the engine room the following aspects should be considered:

7 Mechanical noises from the engine, together with exhaust outlet noise, can be insulated by fitting attenuating panels etc., especially when operating in a residential area.

Ventilation - engine room

When a generator set with an integrally mounted radiator, such as the 2806C engine, is installed in an engine room the basic principle is to extract hot air from the room and induce air at the outside ambient temperature with minimum re-circulation. The illustration (A) shows the most suitable position of the engine in relation to the walls of the room. The objective is to get cool air in at the lowest possible point, push it through the radiator matrix and then out of the building. The illustration (B) explains a common ventilation design error.





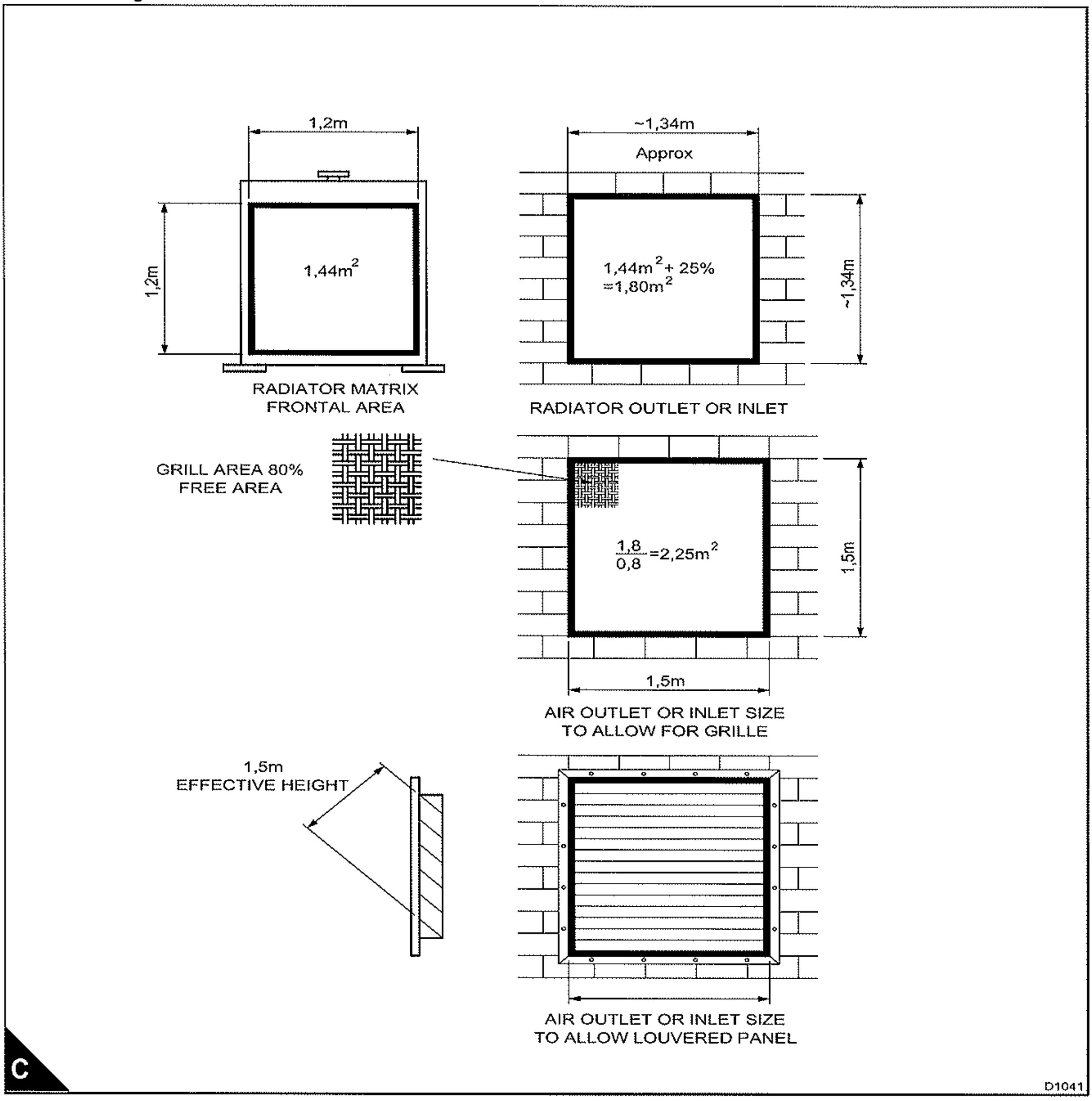
It is unsatisfactory to position the set so that the radiator is adjacent to the opening in the wall. In this case some hot air will be re-circulated back into the radiator fan via the gap between the radiator and the wall.

This will lead to inefficient cooling and could result in overheating problems. The outlet opening in the wall should have a **free flow area** approximately 25% larger than the frontal area of the radiator matrix and be of the same rectangular shape.

A sheet metal or plastic duct is fixed to the opening frame using a flexible connection to the radiator duct flange. The flexible section is particularly necessary when the set is mounted on AVM's.

The inlet air opening should have a **free flow area** at least 25% larger than the radiator matrix.

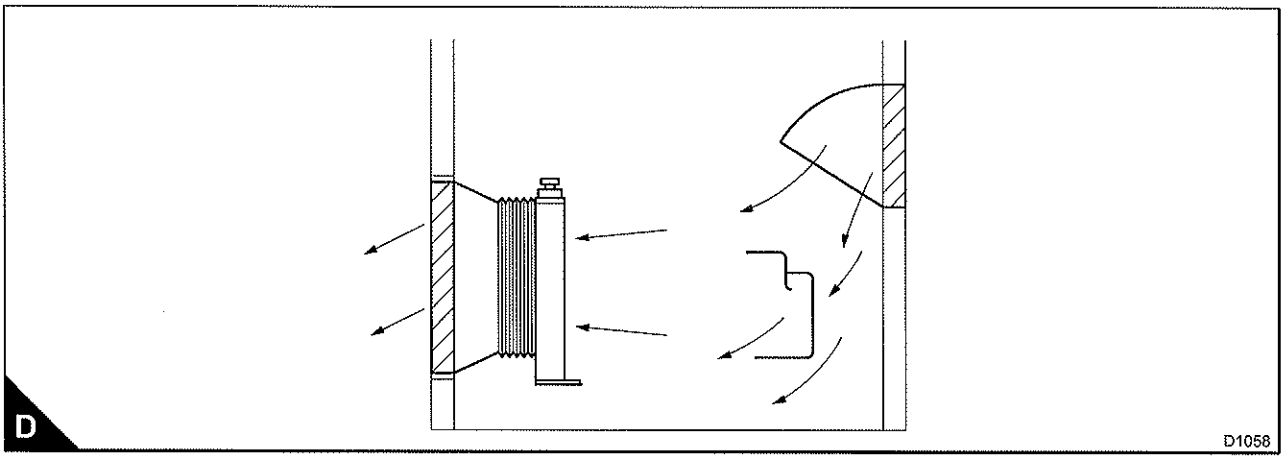
A good example of this can be seen below in (C) where, for a radiator matrix frontal area of 1,44 m^2, the air outlet/inlet opening in the wall should have an area of 1,80 m^2. If a grille is fitted, then the opening should be increased to give 2,25 m^2.



The cool incoming air is drawn over the alternator, which takes its own cooling air from this flow, and across the engine air intake filter and the engine. The radiator fan then pushes the air through the matrix to the outside. There must be no obstruction to airflow immediately in front of the radiator outlet and to deflectors, etc.

However, this is not always possible and (D) shows the air inlet position high in the wall. This system is also acceptable provided that the ducting directs the air to the end of the alternator. It also has the added advantage of preventing heated air from collecting near the ceiling.

Where a high engine room temperature cannot be avoided then the temperature of the induction air to the filter must be checked and the load reduced, or the generating set de-rated accordingly.



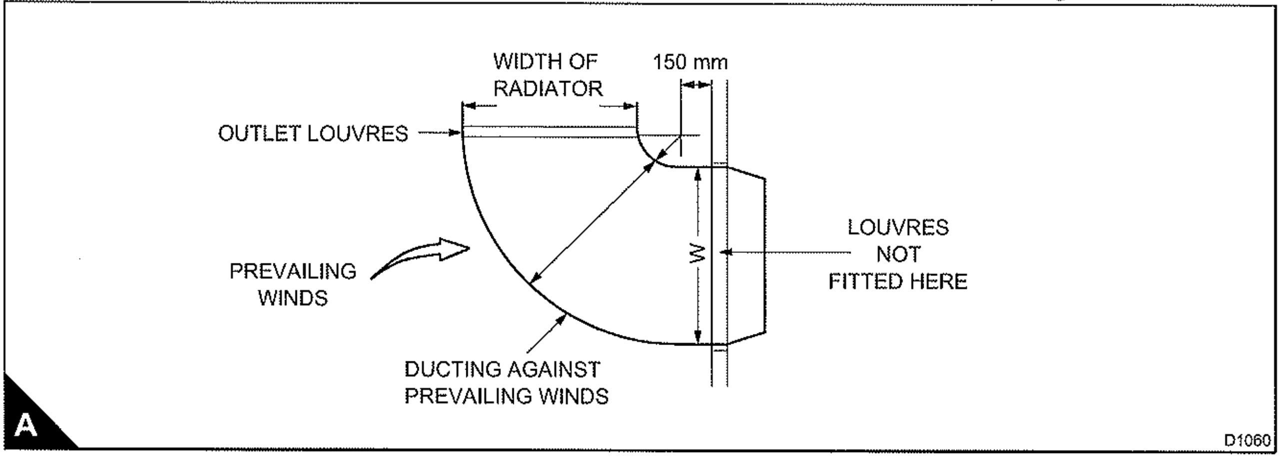
Ducting against prevailing wind

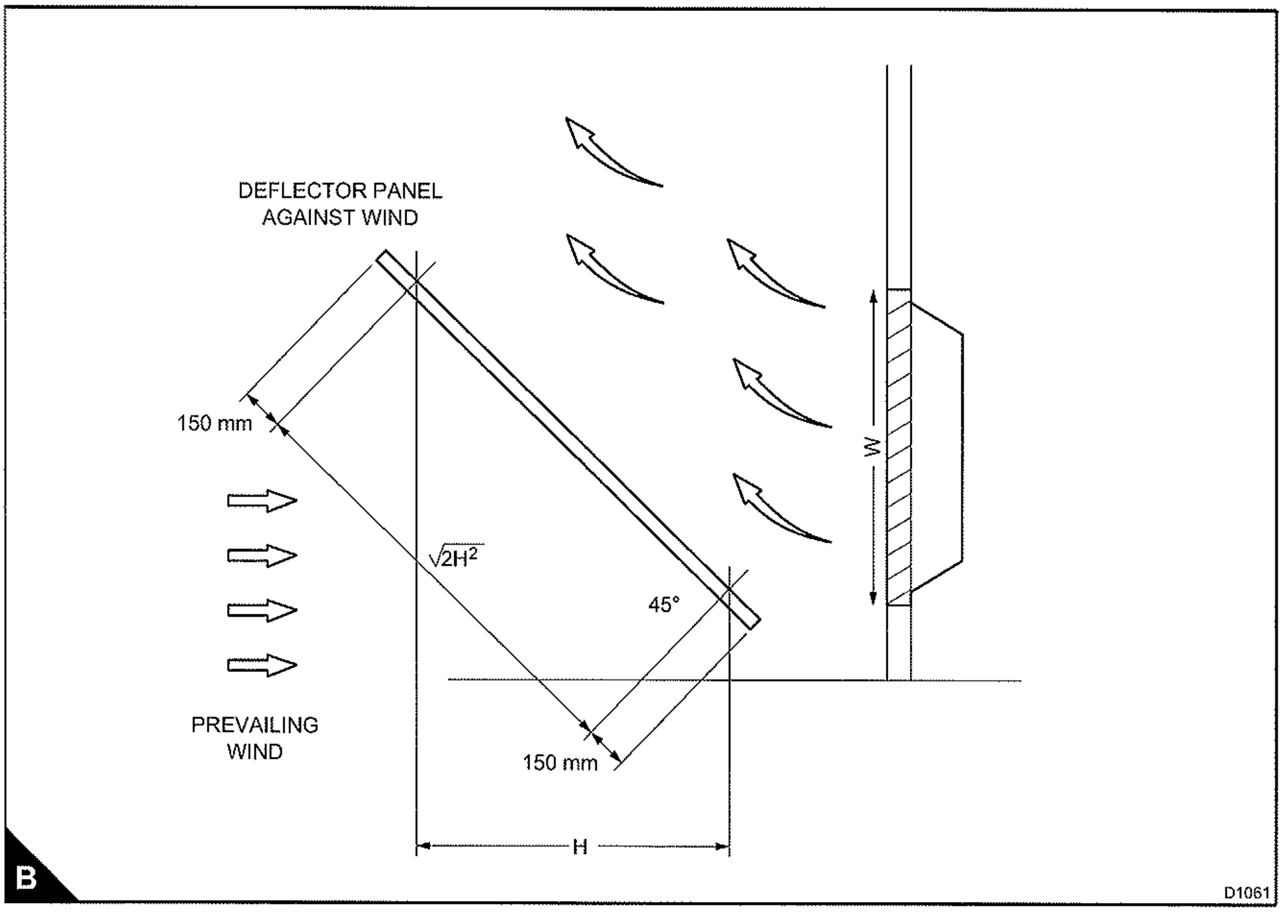
When positioning the air outlet opening, the direction of the prevailing wind must be considered. The 2806 series engines have "pusher" fans which will force air through the opening in the wall via the radiator matrix. If the prevailing wind is blowing into the opening then additional resistance will be placed on the fan, resulting in a reduction in cooling airflow.

Therefore, where possible, the opening should be in a wall which is not affected by the wind. If it is not possible to comply with this condition other methods should be considered such as:

- Outside ducting with the outlet being at 90° to the cooling airflow (A).
- A deflector panel (B).

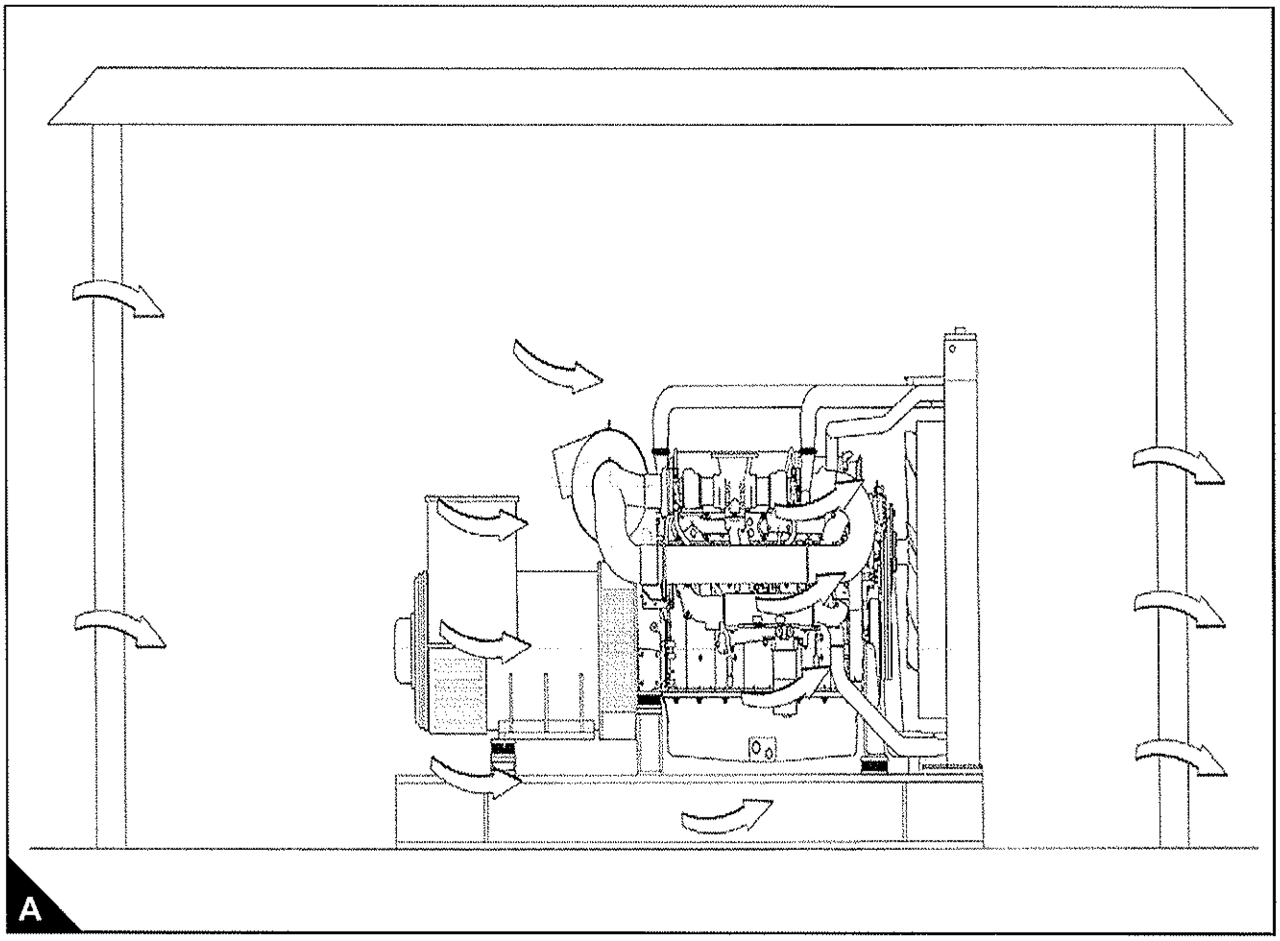
Note: The width of the deflector panel will be between 30% to 40% wider than the opening 'W' as shown.





Ventilation - tropical conditions

To cater for tropical conditions it is quite common practice for the room to have open sides, or to consist only of a roof with supporting columns (A).



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5A

Cooling system

Warning! *All exposed rotating parts and drive belts must be fitted with protective guards.*

Coolant

Coolant mixture

The coolant approved and recommended for use in 2800 Series is POWERPART ELC (Extended Life Coolant). This coolant is pre-mixed and is available in 25 litre containers part number 21820181.

There are many benefits for the use of POWERPART ELC coolant.

- POWERPART ELC (Extended Life Coolant) uses virtually non-depleting corrosion inhibitors for maximum protection for the six basic metal alloys: aluminium, brass, cast iron, copper, solder and steel.
- It has a service life of 3000 service hours or 3 years which ever is sooner.
- Pre-mixed to the correct strength for optimum protection.
- Provides protection to a freezing point of -37 °C (-34 °F).
- Provides additional protection against boiling to 106 °C (223 °F).

Caution: *If the* recommended *coolant and procedures are not used, Perkins Engines Company Limited cannot be held responsible for damage caused by frost or corrosion, or for loss of cooling efficiency.*

Notes:
- POWERPART ELC (Extended Life Coolant) must not be mixed with other products or further diluted
- If frost protection is not necessary, it is still recommended to use the pre-mixed POWERPART ELC (Extended Life Coolant) because this gives a protection against corrosion and cavitation erosion.
- Before changing to POWERPART ELC (Extended Life Coolant) it is important that the cooling system is drained and cleaned. For draining and cleaning the cooling system refer to the relevant User's Handbook for the engine.

If required a safety data sheet is available on POWERPART ELC (Extended Life Coolant), please contact Perkins Help Desk: Fax + 44 (0) 161 776 5100 or Email: specs_help@perkins.com

Note: When ambient temperatures above 43 °C (109 °F) are anticipated, clean soft water with 1% of POWERPART inhibitor 21825735, may be used instead of POWERPART ELC (Extended Life Coolant) to ensure maximum cooling performance from the cooling system.

Water quality

Soft water means de-ionised water, distilled water, rain water or water from a mains supply which has the following requirements:

Chlorides - 40 mg/l max, sulphates - 100 mg/l max, total hardness 170 mg/l max, total solids 340 mg/l max and pH of 5.5 to 9.0.

If in doubt consult the local water treatment and supply company.

If soft water is not used, the coolant system may be affected by the formation of hard deposits which can cause the engine to overheat. This is especially important for engines which have coolant added frequently.

Caution: *The use of products which are not approved for the coolant system may cause serious problems. Coolant mixtures with insufficient corrosion inhibitor can cause erosion and/or corrosion of coolant system components.*

Cooling system

An efficient cooling system is essential to the satisfactory operation of a diesel engine. Perkins, in close co-operation with Denso Marston, has developed a cooling system which will ensure optimum cooling efficiency of the engine.

For cooling system information, refer to the Technical Data Sheet.

Cooling airflow and ventilation

Complete cooling data, including minimum airflow etc., is available in the engine Technical Data Sheet.

For guidance on achieving the optimum cooling airflow and ventilation refer to Chapter 4A, Engine room layout.

6A

Exhaust system

Warning! *All exposed hot surfaces should be fitted with guards or, with the exception of exhaust manifolds and turbochargers, lagged.*

The primary function of the exhaust system is to pipe the exhaust gases from the engine manifold and discharge them, at a controlled noise level, outside the engine room, at a height sufficient to ensure proper dispersal.

Back pressure

Engines give optimum performance when the resistance to exhaust gas flow is below a certain limit. Starting at the engine exhaust outlet flange the total exhaust system should not impose back pressure on the engine greater than that recommended.

Excessive back pressure will cause a lack of complete combustion and deterioration in the scavenging of the cylinders. The result will be loss in power output, high exhaust temperature and the formation of soot. The soot, if oily, could also affect the turbine of a turbocharger. The oily soot would build up on the turbine blades, harden and, as pieces of carbon break off, the turbine wheel would become unbalanced and cause damage to the engine.

Maximum back pressure

The maximum exhaust back pressure figures can be found in the appropriate Technical data sheet.

For back pressure calculations, "Back pressure - exhaust system, , see page 44 for calculations.
Back Pressure is measured after and as close as possible to the turbo charger in a straight length of pipe.

Installation

The exhaust system should be planned at the outset of the installation. The main objectives must be to:

1 Ensure that the back pressure of the complete system is below the maximum limit.

2 Keep weight off the engine exhaust outlet elbows and turbocharger(s) by supporting the system.

3 Allow for thermal expansion and contraction.

4 Provide flexibility.

5 Reduce exhaust noise.

If the engine is on Anti-Vibration mountings or similar, there will be lateral movement of the engine exhaust outlet flange when the engine starts and stops. A flexible pipe should therefore be fitted as near to the outlet flange as is practically possible, A typical installation is shown in (A), see page 40.

If relative movement is expected between the engine and the exhaust system it is important to incorporate flexibility into the system as near to the engine as possible. Due to thermal expansion there will also be movement in the exhaust pipe. The fitting of stainless steel bellows is one method used to alleviate this problem. As bellows only accept deformation parallel due to their longitudinal axis, the preferred method would be to have an arrangement of two short bellows separated by a length of straight pipe 250-400 mm (9.842/15.747 in) long. The movement is then a small angular displacement in each of the bellows.

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Continued

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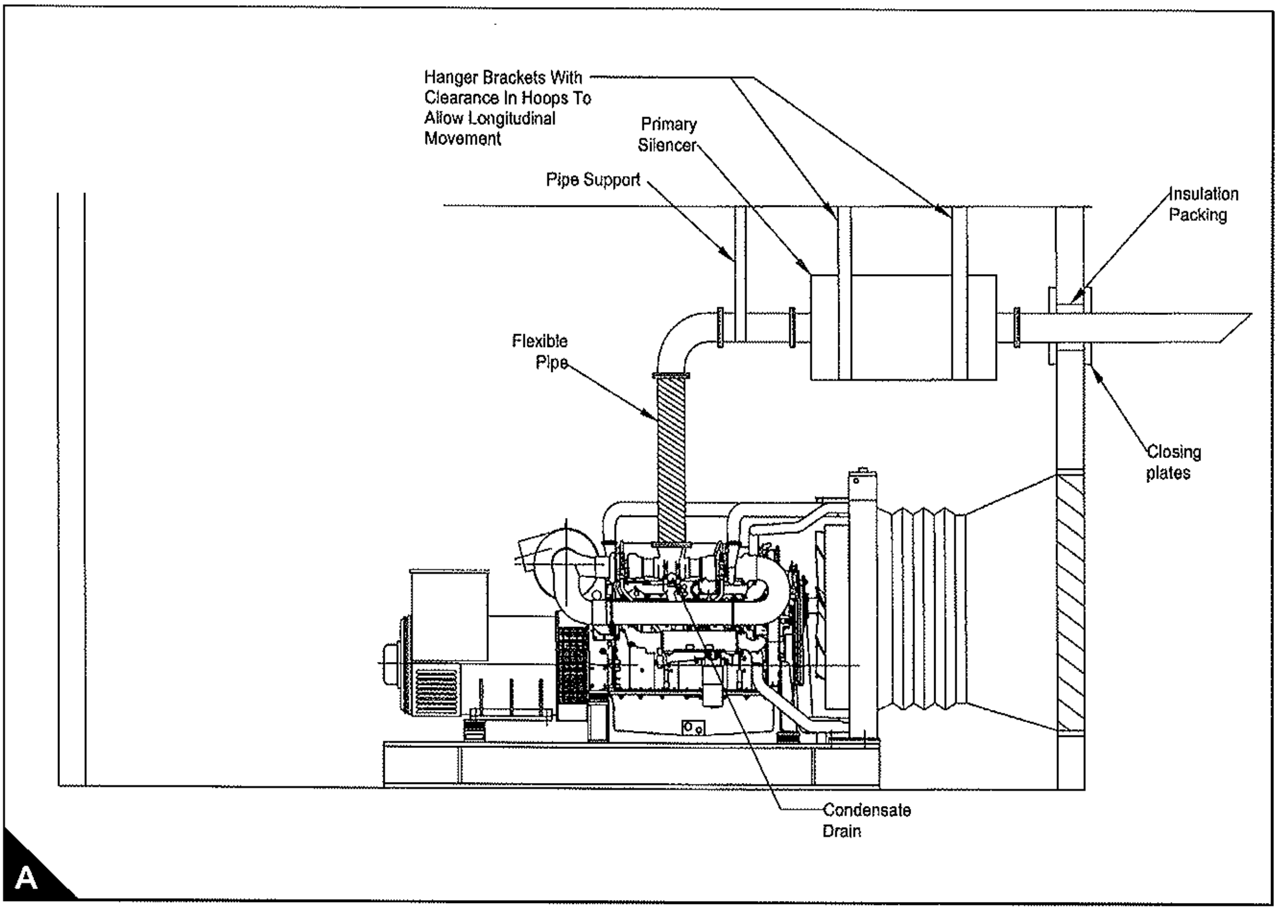
The fitting of stainless steel bellows is one method used to alleviate this problem

Exhaust outlet.



Flanges

The size of the exhaust outlet flange can be found in the General Arrangement drawing from the Applications Department at Perkins Engines Company Limited, Stafford.

Flexible element

Flexible pipe

The flexible pipe is constructed by winding and interlocking formed metal strip, including packing in the process.

It is intended to be used with a slight deviation from straight as the flexibility is by relative movement at the ends of the pipe at right angles to the longitudinal axis. It should never be used to form bends as it will lock rigidly with no flexibility or freedom for expansion.

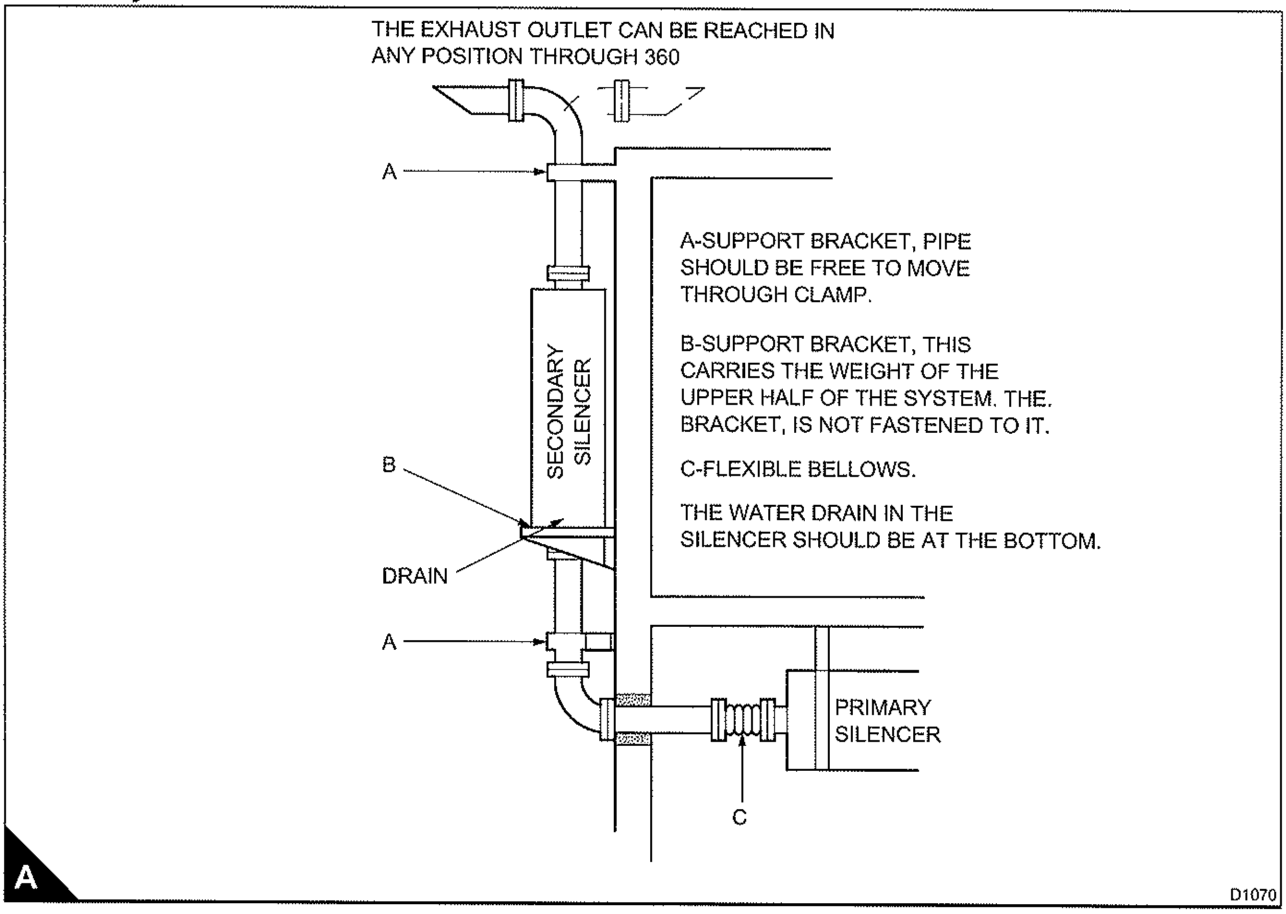
Flexible bellows

The flexible bellows have some degree of lateral flexibility and a fair amount of axial movement to take up expansion and contraction (A).

When installing make sure the bellows are not extended on 'free length'. It is better to install as per manufacturers instructions.

If the exhaust system is long then it should be divided into lengths with one end of each Length fixed and the other end having a bellows unit.

Exhaust system



Expansion

The expansion of one metre of pipe per rise in temperature of 100 °C (212 °F) is 1.17 mm (0.0461 in).
5 metres (236.22 in) of pipe having a temperature rise from 27 °C (80.6 °F) to 600 °C (1112 °F) will expand (5.73 x 1.17 x 5) = 33.5mm (1.3189 in).
This expansion figure shows, by its size, how important it is to correctly plan the exhaust run if long life is required.

Exhaust outlet position

The exhaust outlet outside the engine room must be in such a position that there is no possibility of hot gas entering the cooled air inlet opening. If possible the outlet should be in the same wall as the hot air outlet from the radiator, (A).
If the exhaust outlet terminates vertically a rain shield must be fitted. Usually the outlet pipe goes horizontally through the wall with the underside of the pipe cut away at an angle. If directing the exhaust straight out causes a directional noise problem then a horizontally fitted right angled bend would probably be a simple solution.

Multiple exhaust outlets

If more than one engine is being installed the exhaust from the engines must not be taken into the same flue.
Note: Each engine must have its own separate system and individual outlet.
The reason is that if one engine is stationary when others are running, exhaust gases with condensate and carbon will be forced into the exhaust system of the stationary engine and then into the engine cylinders. Obviously this would cause problems.
It may be considered that a flap valve in each exhaust line near to the flue could be the solution, however exhaust carries carbon and soot deposits which will cause the flap valve to leak. The leak will not be detected until the engine is in trouble. The best policy is to provide separate outlets.
Do not terminate the exhaust outlet into an existing chimney or flue that is used for another purpose. The pulsations in the exhaust could upset the up-draught and create problems with other equipment that relies on the up-draught.
Warning! *There is also the risk of explosion due to unburnt gases.*

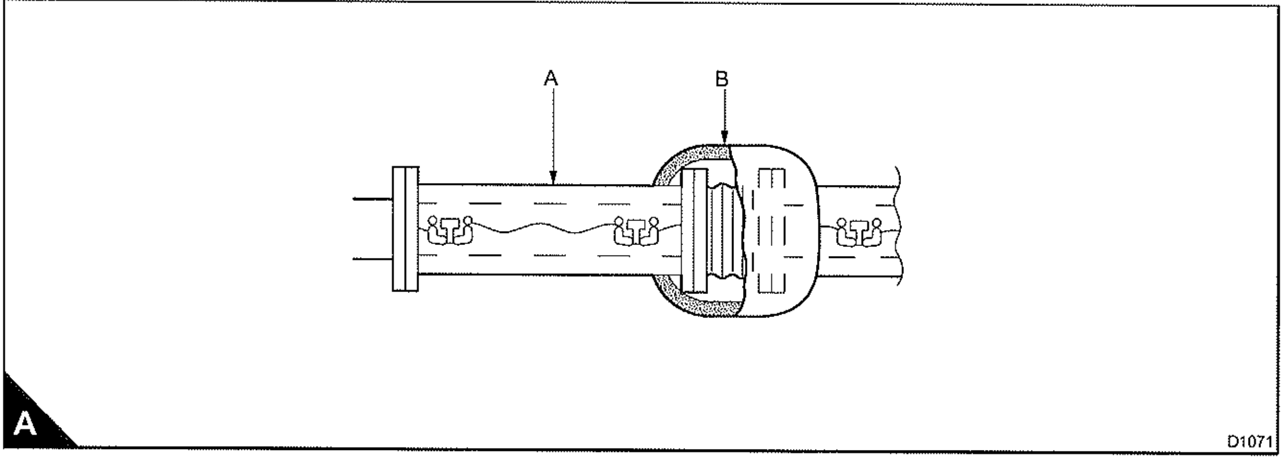
condensate drain

In all exhaust systems there is condensate due to gases cooling and differential temperature between the gases and metal pipes, etc.
If this is ignored condensate could run into the engine, depending on manifold configuration, and bring associated problems.
The exhaust system usually runs vertically from the engine outlet and it is advisable to fit a drain pocket at the bottom bend. A small hole giving a permanent drain would clear the condensate but would allow a small amount of exhaust gases to be blown into the engine room when the engine is running. If this is not acceptable then a permanent open drain pipe should be taken to the outside of the engine room , see page 41, exhaust system.

Lagging

The amount of heat radiated from the exhaust system can create problems with the radiator cooling and ventilation and may lead to a larger radiator, pusher fan and extractor fan. These are costly items and the cheapest and most practical solution is to lag the exhaust system that is inside the engine room. Heat insulating wrappers which clip around the pipe are suitable, 25 mm (0.984 in) to 50 mm (1.97 in) is the usual thickness and can be obtained in suitable lengths from specialist suppliers.
Where pipe flanges or flexible bellows are to be lagged clip-on muffs can be used. The muffs are easily fitted and will not prevent flexible units from doing their intended job.
A - clip-on insulation wrapper.
B - clip-on insulation muff.
Warning! *Do not lag exhaust manifolds or turbo-chargers, to do so would lead to operating deficiencies and*

very quickly cause failure of parts due to thermal stress..



Exhaust silencers

Silencers are used, as the name implies, to reduce the noise level emissions at the exhaust pipe outlet. In general terms the silencer should be installed near the engine exhaust outlet flange or at the end of the system.

If the engine or generating set has acoustic treatment to reduce noise levels it is also necessary to ensure that the exhaust silencers are capable or reducing exhaust noise to the same (or below) noise level being achieved by the acoustic treatment.

There are various types of silencers available as detailed below from different manufacturers.

- The first type is a re-active type silencer which has a series of baffles and perforated tubes and attenuates a high degree of noise in the lower frequency bands. To a lesser degree noise in the high frequency bands is also absorbed. This type of silencer is referred to as a primary silencer

The second type is a triple-chamber type. In the first two chambers initial low restriction expansion and

- diffusion of the hot gas takes place with some attenuation of low frequency noise.

In the third chamber attenuation of the higher frequencies is achieved by the absorption principle.

This again is referred to as a primary silencer.

- The third type is what is known as a 'straight through' silencer and works on the absorption principle. The silencer consists of an outer case with a perforated centre tube. The annular space between case and tubeis packed with heat resisting fibre glass, or similar material.

The exhaust noise is effectively dissipated by the packing through the perforations.

Resistance to exhaust gas flow is negligible and, in calculations for back pressure can be taken as a piece of exhaust pipe the same length and bore size as the silencer.

This type of silencer is usually classed as a 'secondary' silencer and is normally at the end of the pipe system. However, it could be used as a primary silencer if noise level standards are not critical.

Low load operation

Where engines are operated at reduced loads the effects of inefficient combustion may become evident as slobber. To avoid this, and to ensure that the products of combustion are burnt off, operators should strive not to allow the engine to be run at less than 30% load.

Local authority regulations- noise

Local Authorities can, and do, set down noise limits for the different areas that come within their jurisdiction. The combinations and type of silencer to be used are best recommended by the silencer manufacturers who should be brought into design discussions at an early stage.

Back pressure - exhaust system - calculations

The basic engine data required to calculate the back pressure in an exhaust system is shown in the Technical Data Sheet against each engine type, i.e. The gas flow by volume and by mass at the appropriate temperature or a given engine speed and power.

How to use the information

Gas flow by volume (m^3/min)
With this information the velocity through a certain pipe or silencer bore can be calculated using the following formula:

$$\text{Gas Velocity} = \frac{\text{Volume Flow (m3/min)}}{\text{Area of pipe in } m^2 \times 60}$$

Having calculated the gas velocity and obtained the gas volume flow from the Technical data sheet for a sin- ingle exhaust outlet (where twin outlets are required the volume flow should be divided by 2) then, by referring to the silencing equipment suppliers data sheets you will be able to determine the resistance to flow through the silencer in mm Hg.

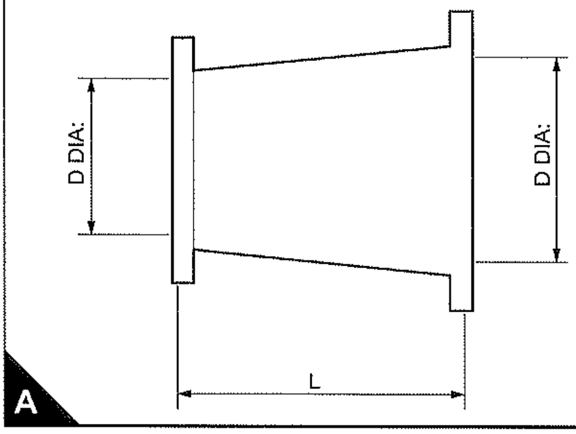
Gas flow by mass (m^3/s)
Using this data the pressure drop through a given length of straight exhaust pipe can be calculated by using the following formula:

$$P = \frac{L \times S \times Q^2}{77319 \times D^5}$$

P = Back Pressure (Kpa)
Q = Gas Flow (m^3/s)
L = Total equivalent length * Straight Pipe (m)
D = Pipe diameter (mm)
S = Specific Gravity of Exhaust Gas (kg/m^3)

Note: When bends are used in the exhaust system then pressure loss is expressed in equivalent straight length of pipe,
Adding the pressure losses through the silencers (or silencer) to the pressure loss through the pipe work will give the total back pressure incurred by the exhaust system.
Caution: *This must not exceed the figure quoted in the Technical Data Sheet against the appropriate engine and rating.*
If a suitable system cannot be obtained with the diameter of pipe suggested it may be that increasing the silencer bore one size would be satisfactory. If not, pipe sizes will also have to be increased. Transition units as shown will be required.

Equivalent lengths of straight pipe



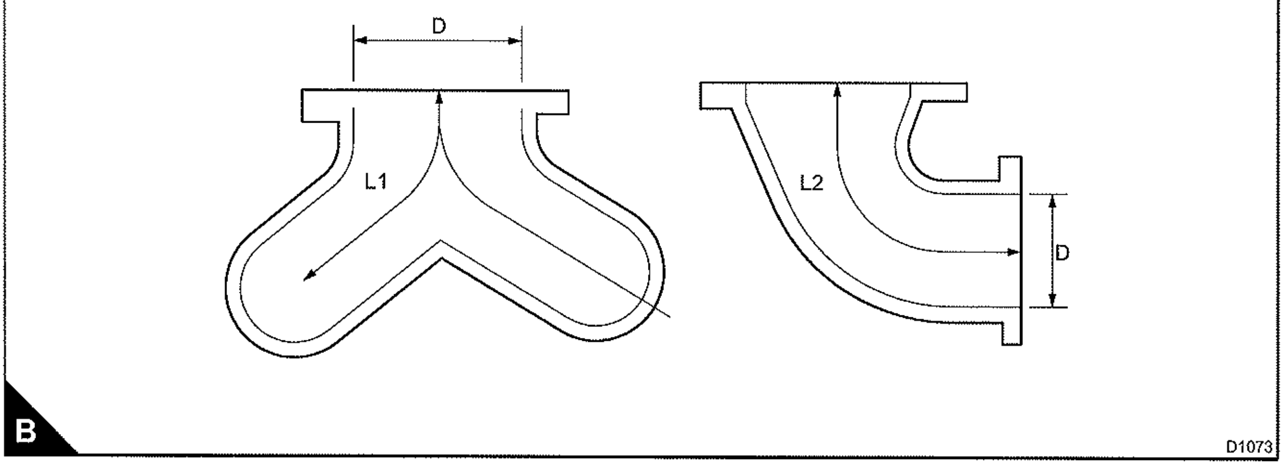
Transition Unit
For use in the pressure formula for equivalent length 'L'
L = 2D (MINIMUM)

Equivalent length (L) of pipe to 'D' diameter is a function of diameter ratio D/d; plus the transition 'L'

D/d	1,05	1,10	1,15	1,20	1,25	1,30	1,35
L	1 x D	2 x D	4 x D	6 x D	9 x D	14 x D	21 x D

Single outlet adaptor
For use in the back pressure formula

D = is single outlet diameter mm.
d = is turbocharger outlet diameter.
Q = is total exhaust gas flow (kg/s).
Q = is branch exhaust gas flow (Q/2) (kg/s).
Elbow length of free centre length of L1 and L2.



Flexible pipe: 2 x Actual length of flexible pipe.
Exhaust bellows: 2 x Actual length of bellow.

Transition unit: (A).

Single outlet adaptor: (B).
90 Degree bend: 15 x Bore of pipe.
45 Degree bend: 6 x Bore of pipe.
Note: Ensure that if the diameter or length is expressed in millimetres you should divide by 1000 after you

Continued

have multiplied by the appropriate factor, as the unit of length in the pressure loss formula is in metres.
Equivalent length L of pipe to D diameter is determined by calculating as follows:
Measure the effective centre line length of one branch pipe from turbo-charger outlet to single outlet i.e. i1 and i2 as shown, plus the equivalent length of bends in each plane i.e. 6 x d bend on i1 and 15 x d for bend on i2, giving a total equivalent length L to d diameter.
Equivalent length L of pipe D diameter will be:
$L = i \times (q/Q)^2 \, (D/d)^{5,33} = i/4 \, (D/d)^{5,33}$

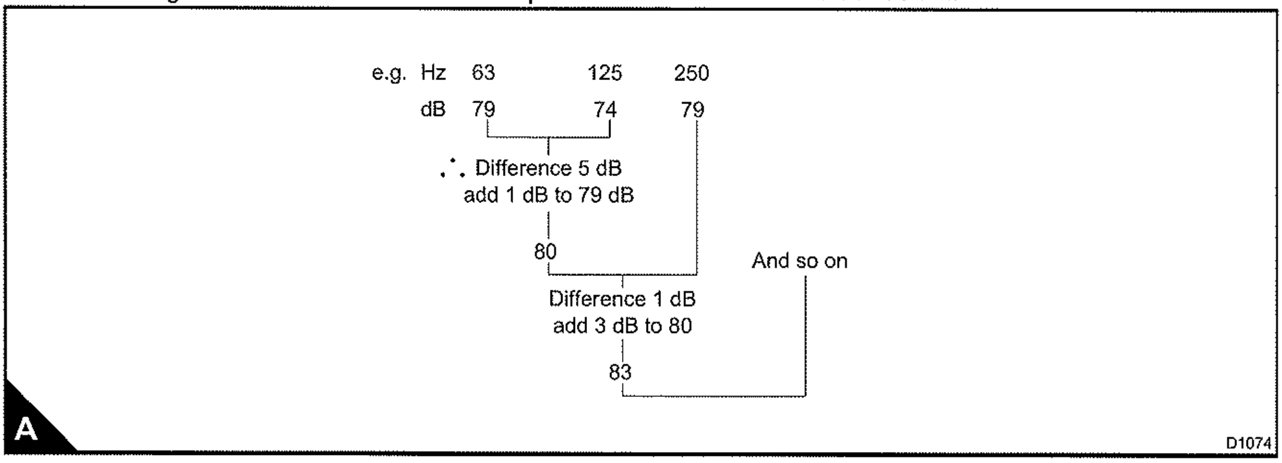
Noise attenuation - exhaust

Warning! *Always wear ear protection when working near a running engine.*
The noise carried by the exhaust gas out of the exhaust manifold of a running engine is very loud and objectionable to personnel. It could prove harmful over a period of time.
The great majority of the harmful noise is in the frequency range or 63 to 8000 Hz. The best choice of silencer is the design that will attenuate most noise within that range. To assess the value of each type of silencer described previously, and a combination of primary and secondary silencers, the following schedules show the

noise attenuating capacity of these type silencers when in the exhaust pipe line of a running engine.
Example
Add together dB values for the separate octave band frequencies take the first pair of figures e.g. at 63 and 125 Hz. The resulting figure has been adjusted in the following manner.

- If the dB values differ by 0 or 1 dB - add 3 dB to higher values.
- If the dB values differ by 2 or 3 dB - add 2 dB to higher values.
- If the dB values differ by 4 to 9 dB - add 1 dB to higher values.

When resulting value is obtained then this is paired with the third value at 250 Hz.

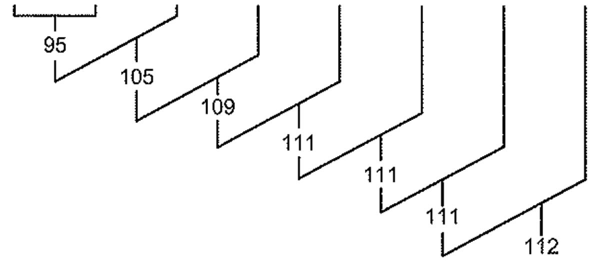


The exhaust noise of a turbocharged engine running at 1500 rev/min was taken in a semi-reverberant field and the octave band centre frequency analysis from 63 to 8000 Hz in decibels - dB - was as follows:

Engine noise level

Sound pressure level

	63	125	250	500	1K	2K	4K	8K
Octave band centre freq. Hz / Open exhaust dB	113	109	113	109	106	100	95	104
(A) Weighting	-23	-16	-9	-3	0	+1	+1	-1
dB (A)	90	93	104	106	106	101	96	103



Overall level - 112 dB (A)
1 Metre from engine exhaust outlet flange

B

D1075

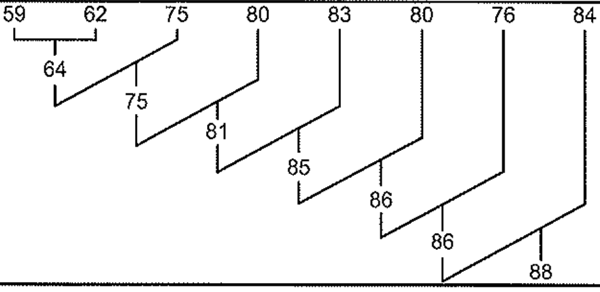
Case 1. Consider typical reactive type silencer (C)

Case 2. Consider typical chamber silencer (D)

Case 3. Consider typical straight through silencer (E)

Sound pressure level

Octave band centre freq. Hz	63	125	250	500	1K	2K	4K	8K
Open exhaust dB	113	109	113	109	106	100	95	104
	31	31	29	26	23	21	20	19
	82	78	84	83	83	79	75	85
(A) Weighting	-23	-16	-9	-3	0	+1	+1	-1
dB (A)	59	62	75	80	83	80	76	84



Overall level - 88 dB (A)
1 Metre from silencer outlet

Sliencer attenuation = 112 - 88 = 24 dB (A)

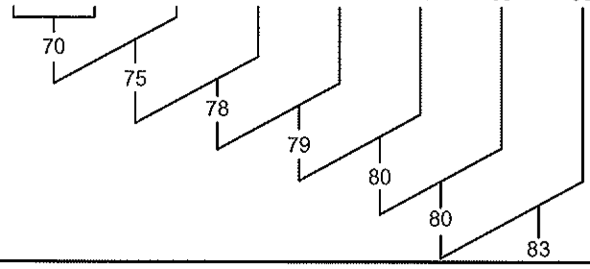
C

D1114

Continued

Sound pressure level

Octave band centre freq. Hz	63	125	250	500	1K	2K	4K	8K
Open exhaust dB	113	109	113	109	106	100	95	104
Silencer dB	22	28	31	32	32	30	27	23
	91	81	82	77	74	70	68	81
(A) Weighting	-23	-16	-9	-3	0	+1	+1	-1
dB (A)	68	65	73	74	74	71	69	80



Overall level - 83 dB (A)
1 Metre from silencer outlet

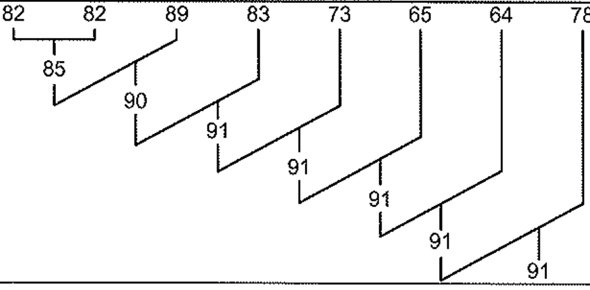
Sliencer attenuation = 112 - 88 = 24dB (A)

D

D1115

Sound pressure level

Octave band centre freq. Hz	63	125	250	500	1K	2K	4K	8K
Open exhaust dB	113	109	113	109	106	100	95	104
Silencer dB	8	11	15	23	33	36	32	25
	105	98	98	86	73	64	63	79
(A) Weighting	-23	-16	-9	-3	0	+1	+1	-1
dB (A)	82	82	89	83	73	65	64	78



Overall level - 83 dB (A)
1 Metre from silencer outlet

Sliencer attenuation = 112 - 88 = 24dB (A)

E

D1116

When including a primary and secondary silencer in the exhaust system a good approximation of the combined

noise attenuation is arrived at as follows:

At each centre band frequency, from the open exhaust noise level deduct the noise attenuation of the primary silencer, then deduct the noise attenuation of the secondary silencer in the following ratio:

- 1/3 of listed dB up to 1 kHz frequency inclusive.
- 1/2 of listed dB above 1 - 8 kHz frequency inclusive.

Case 4. Consider typical reactive and straight through silencer (F).
Case 5. Consider triple chamber and straight through silencer (G).

Continued

Sound pressure level

Octave band centre freq. Hz

Open exhaust dB

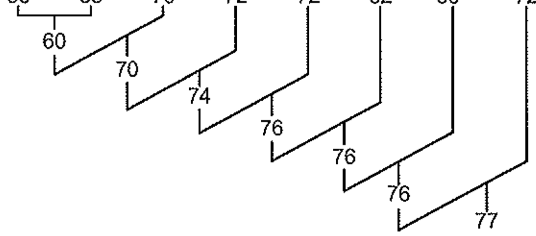
Silencer dB (reactive)

Silencer dB (straight through)

(A) Weighting

dB (A)

63	125	250	500	1K	2K	4K	8K
113	109	113	109	106	100	95	104
31	31	29	26	23	21	20	19
82	78	84	83	83	79	75	85
3	4	5	8	11	18	16	12
79	74	79	75	72	61	59	73
-23	-16	-9	-3	0	+1	+1	-1
56	58	70	72	72	62	60	72



Overall level - 77 dB (A)

1 Metre from silencer outlet

Sliencer attenuation = 112 - 77 = 35 dB (A)

F

D1117

Sound pressure level

Octave band centre freq. Hz

Open exhaust dB

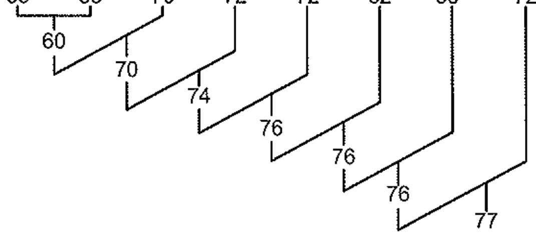
Silencer dB (tripple chamber)

Silencer 6" bore dB (straight through)

(A) Weighting

dB (A)

63	125	250	500	1K	2K	4K	8K
113	109	113	109	106	100	95	104
31	31	29	26	23	21	20	19
82	78	84	83	83	79	75	85
3	4	5	8	11	18	16	12
79	74	79	75	72	61	59	73
-23	-16	-9	-3	0	+1	+1	-1
56	58	70	72	72	62	60	72



Overall level - 73 dB (A)

1 Metre from silencer outlet

Overall level - 112 dB (A)

Sliencer attenuation = 112 - 77 = 35 dB (A)

G

D1118

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7A

Engine breather

Warning! *Personal protective equipment must be worn when handling or cleaning the engine breather/ element.*

All engines are fitted with a breathing system that prevents a build up of pressure in the crankcase. The build up in pressure is caused by blow-by from the pistons. The fumes in the crankcase are vented to atmosphere. The fumes contain contaminants from the combustion process and minute globules of lubricating oil. The-fumes will pollute the atmosphere in the engine room particularly if the radiator and fan are remote mounted.

Breather installation

Warning! *Under no circumstances must the fumes be directed onto the fan intake. This could eventually cause blockage of the matrix, resulting in poor engine performance and overheating. It is also a potential fire hazard.*

It is far better to pipe the fumes to outside the building (A).

Key

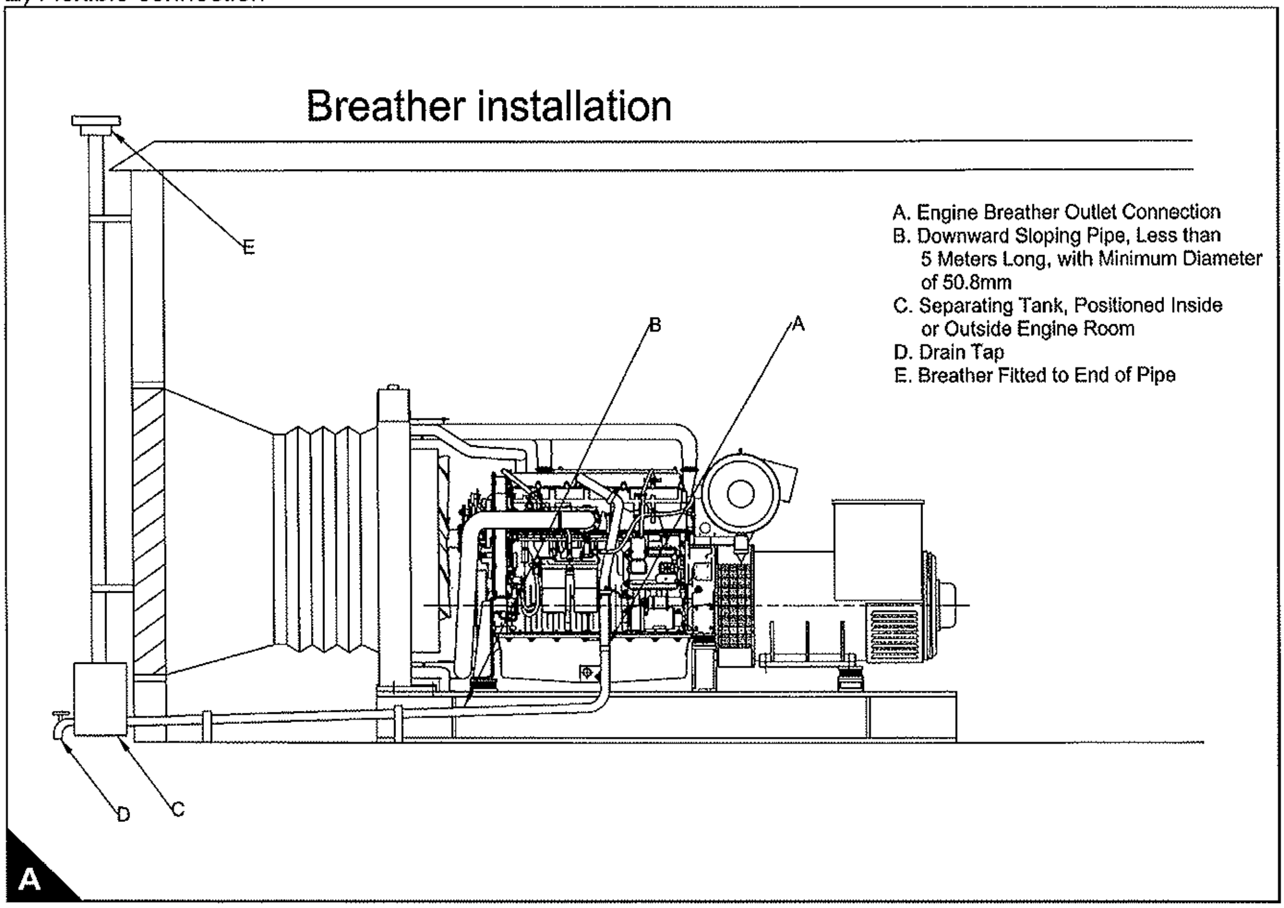
A) Breather assembly.

B) Separating tank, with drain tap C, can be positioned inside or outside the engine room.

C) Drain.

D) Breather fitted to end of pipe.

E) Flexible connection



The pipe diameter should be equal or larger than the stem of the breather on the crankcase, depending on the length of run.

With the engine running on full load the crankcase pressure should be no more than 25 kPa.

Breathing - points to watch

The breather fumes should never be piped directly to be digested by the engine air filters. Harmful contaminants, including acids, would be circulated around the engine with long term harmful effects. In some instances the fumes would have a detrimental effect on the air filter element.

However, should the engine be fitted with a crankcase emission absorber, in which case the contaminants will have been removed, then the fumes from the absorber outlet can be piped into the engine air inlet.

In multi-engine installations, as with the exhaust system the breather pipe from each engine must have its own individual run. If terminating in the same tank the fumes from a running engine could leak back into the stationary engine.

The outlet of the breather pipe should not be sited in a position where fumes could be drawn into the cooling air inlet stream.

If the engine is on anti-vibration mountings a flexible section should be fitted in the breather pipe near the engine.

8A

Induction system

Introduction

The induction system is an important part of an engine installation since it can affect power output, fuel consumption, exhaust emissions and engine life.

All Electropak engines are supplied with mounted air cleaners complete with ducting. The filters are suitably positioned at the rear of the engine to receive cool air; the mounting brackets are designed and tested to withstand engine vibration and the ducts are sized and designed to give a low restriction for airflow into the turbocharger.

Caution: *Under no circumstances should the engine be operated without air cleaners.*

Cooler combustion air may be included by means of ducting from outside the engine running room.

It is essential that air filters remain in the engine room thus preventing ingress of dirt through leaking joints.

Careful attention must be given to mounting and support of air inlet ducting; adequate support of any ducting must be provided so that its weight is not carried by the air cleaner.

Air cleaners

Combustion air must be clean and cool. Engine-mounted, dry type air cleaners are considerably more efficient than oil bath types and remove 99,5% of AC fine dust. Clean filters offer little restriction so total air restriction, including ducting, should not exceed 1,2 kPa (5 in H_2O) of water column. Air cleaner service indicators will signal a filter change when a restriction of 6,2 kPa (25 in H_2O) develops. Ducting must have sufficient strength to withstand minimum restrictions of 12,5 kPa (50 in H_2O), which is also the structural capability of the prime power air cleaner.

	AC Dust (% total weight)	
Micron size	**Fine**	**Course**
0 - 5	39 ± 2%	12 ± 2%
6 - 10	18 ± 3%	12 ± 3%
11 - 20	16 ± 3%	14 ± 3%
21 - 40	18 ± 3%	23± 3%
41 - 80	9 ± 3%	30 ± 3%
81 - 200	0	92 ± 3%

Caution: *Under no circumstances should the engine be operated without air cleaners.*

Ducting

When ducting is necessary to obtain cooler or cleaner air, filters should remain on the engine to prevent harmful dirt from leaking into the engine through ducting joints. When air cleaners must be remote-mounted it is extremely important that all joints are airtight to prevent ingestion of dirt.

Give careful attention to routing and support of air inlet ducting, where overhead cranes are used to service the engines. Provide adequate support for duct work so that its weight is not borne by the air cleaner on engine-mounted air cleaners, or by the turbocharger on remote-mounted air cleaners.

Avoid abrupt transitions in the intake ducting to provide the smoothest possible air flow path. Keep total duct head loss (restriction) below 0,5 kPa (2 in H_2O) for maximum filter life. Any additional restriction will reduce filter life. See the Air intake restrictions section given below.

Design inlet ducting to withstand a minimum vacuum of 12,5 kPa (50 in H_2O) for structural integrity.

If required, all piping must be designed and supported to meet seismic requirements.

Air intake restrictions

Because excessive vacuum on the inlet side of the turbocharger can result in reduced engine performance, the air intake system restriction (including dirty filters, duct work, vents, or the air inlet on NAT/ASP etc.) is limited to a maximum of 6,2 kPa (25 in H_2O). Since the maximum air inlet restriction is limited, it is important to minimise the air inlet systems restriction to 1,2 kPa (5 in H_2O) with clean filters, maximising filter life. External restriction caused by the air inlet system subtracts from air filter life.

Calculate duct head losses by:

$$P\ (kPa) = \frac{L \times S \times Q^2 \times 3{,}6 \times 10^6}{D^5}$$

$$P\ (in\ H_2O) = \frac{L \times S \times Q^2}{187 \times D^5}$$

P = Restriction, kPa (in H_2O)

lb/in^2 = 0,0361 x in water column

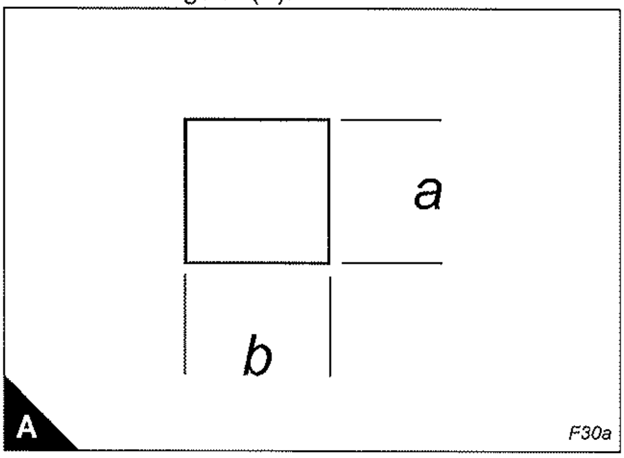
kPa = 6,3246 x mm water column

L = Total equivalent length of pipe, m (ft)

Q = Inlet air flow, m^3/min (cfm) - (found in Technical Data Sheet)

D = Inside diameter of pipe, mm (in)

If duct is rectangular (A).



Then:

$$D = \frac{(2 \times a \times b)}{a + b}$$

S = Density of air, kg/m^3 (lb/ft^3)

$$S\ (kg/m^3) = \frac{352{,}5}{\text{Air Temperature} + 273\ °C}$$

$$S\ (lb/ft^3) = \frac{39{,}6}{\text{Air Temperature} + 460\ °F}$$

To obtain equivalent length of straight pipe for various elbows:

$L = \frac{33D}{X}$ Standard Elbow (Radius of elbow equals pipe diameter)

$L = \frac{20D}{X}$ Long Elbow (Radius > 1,5 Diameter)

$L = \frac{15D}{X}$ Long Elbow

$L = \frac{66D}{X}$ Square Elbow

Where x = 1000 mm or 12 in

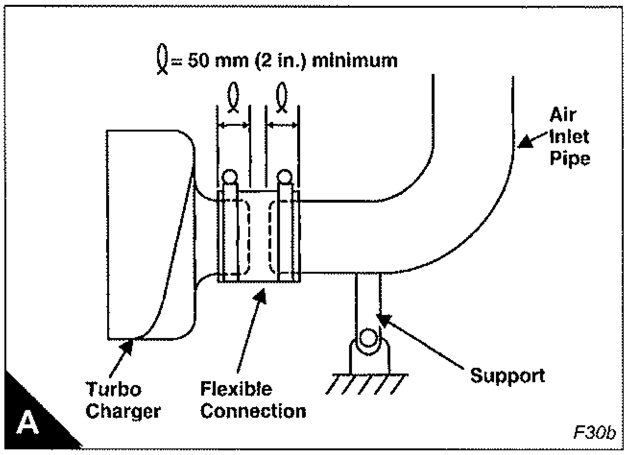
As can be seen, if 90° bends are required, a radius of two times the pipe diameter helps to lower resistance.

Flexible connections

Flexible connections are required to isolate engine vibration and noise from the ducting system. The flex should be as close to the engine as practical. The flex engagement with the air intake duct should be a minimum of 50 mm (2 in) and a maximum of 200 mm (8 in). Care must be used to prevent exhaust pipe heat from deteriorating rubber flex connections.

Turbocharger loading

When remote-mounted air cleaners are used, turbocharger loading from the weight of the air inlet components becomes a concern. Make the flexible connection directly to the turbocharger air inlet, see illustration (A), all duct work to that point must be supported.



Cleanliness

When applying remote-mounted air cleaners, ducting must be devoid of all debris which could harm the turbocharger. Duct construction should not include any components such as rivets, which could loosen and enter the engine.

Install an identifiable blanking plate ahead of the turbocharger to prevent debris from entering during initial installation of the unit. Remove the plate prior to starting the engine and inspect the ducting for cleanliness just prior to initial start-up.

Extreme cold

Heated engine room air may be required (for starting purposes only) in applications at very cold ambient temperatures, -25 °C (-13 °F). This assumes combustion air is being drawn from outside the engine building and the engine is preconditioned with pre-heaters for metal, water and oil temperatures of 0 °C (32 °F). Admitting engine room air must be done without the possibility of allowing dirt or debris into the air inlet system of the engine.

Oil bath air filters

Perkins Engines Company Limited, Stafford, do not recommend the use of oil bath air cleaners. All current engines are turbocharged and it is difficult to select oil bath air cleaners to operate efficiently over the wide range of air flow of turbocharged engines as load varies and also to avoid causing some oil pull-over at maximum power. Oil carried over into the turbocharger can affect durability and performance. The efficiency of an oil bath air cleaner is significantly less than that of a paper element type - oil bath 95-97%, paper element 99.9%. Hence in even moderate dust conditions, a significant amount of dust will pass through the oil bath cleaner.

The other potentially disastrous problem is that the oil bath still permits adequate air flow to reach the engine (although dirt laden) when its oil is used up and replaced by dirt. A restriction indicator is not activated and the engine does not smoke or lose power. Therefore they must be cleaned frequently and without fail. The paper element causes smoke and loss of power when blocked and will activate a restriction indicator which prompts servicing.

9A

Fuel supply system

Warning! *Personal protective clothing must be worn when filling the fuel tanks.*

Recommended diesel fuel

Diesel fuel must conform to one of these specifications:

ASTM D975 No 1-D or No 2-D

BS 2869: Part 2 1998 Class A2

BS EN 590 1997

General fuel requirements are: Maximum sulphur content 0.2%; minimum Cetane number 45.

Fuel cleanliness

The modern, high pressure fuel injection system used on the 2800 Series engine requires a high level of fuel cleanliness to ensure correct operation and reliability.

The fuel must conform to all aspects of the ASTM D975 specification, but in particular to the requirement for number 2-D to have less than 0.05% water and sediment. The fuel should also be free from biological growth. If biological growth is suspected, contact Perkins to discuss a suitable measurement and course of action. For long term storage of fuel, the recommendations given in ASTM D975 must be followed where appropriate.

The use of fuels which do not conform to the above standards can cause: difficulty with starting, poor combustion, deposits in the fuel injectors or combustion chamber, reduced service life of the fuel system and filters, reduced engine life and could affect the warranty. Further details can be obtained from the Applications Department at Perkins Engines Company Limited, Stafford.

Fuel system

The purpose of a fuel system is to provide an ample supply of clean, water-free fuel to the engine and return the excess to the tank. There are two basic systems for the installation of the fuel supply. The system chosen will depend on the amount of fuel required per day and whether personnel are available to perform simple routine jobs.

Fuel tank - daily service

The fuel tank should normally be sized to hold approximately 4000 litres. This will allow for 8 hours continuous running at the Prime Power rating. In the case of the 2800 Series the high temperature of the fuel returning to the day tank must be adequately cooled so that the fuel feeding from the tank to the engine does not exceed a maximum temperature of 55 °C.

One preferred method of installing a fuel tank is on a stand or bulkhead adjacent to the engine. Although the 2806 series engine incorporates its own integral fuel lift pump it is recommended that, if possible, the tank is positioned such that it creates a positive head and good quality feed to the engine. If in doubt, contact the Applications department at Perkins Engines Company Limited, Stafford.

Warning! *Fuel level in the tank must not exceed a height of 4 metres above the fuel lift pump.*

Fuel tanks should have connections for the following purposes:

- Tank filling.
- Float switches.
- Fuel feed.
- Sludge drain.
- Automatic feed (if required).
- Fuel return.
- Level gauge.
- Dump valve.

The tank should be fitted with: a vent pipe in the top tank to equalise the pressure, a filling point and a contents gauge or sight glass.

The fuel supply must be taken from a position approximately 50 mm above the bottom of the tank. This prevents sludge being drawn into the fuel supply. A drain tap is fitted to drain the sludge.

To enable the tank to be isolated, for example: in an emergency or for maintenance, a hand valve should be fitted at the fuel outlet.

Normally it would be necessary to fit a fuel/water separator after the pump. However, as the 2800 Series engine incorporates its own separator this is not a requirement.

Excess fuel from the engine is returned to the tank through the return line.

Note: Should the fuel tank be wanted in the baseframe a check valve must be fitted in the line between the fuel tank and the lift pump. This is especially important in standby installations to avoid the possibility of “drainback” when the engine is static for long periods of time.

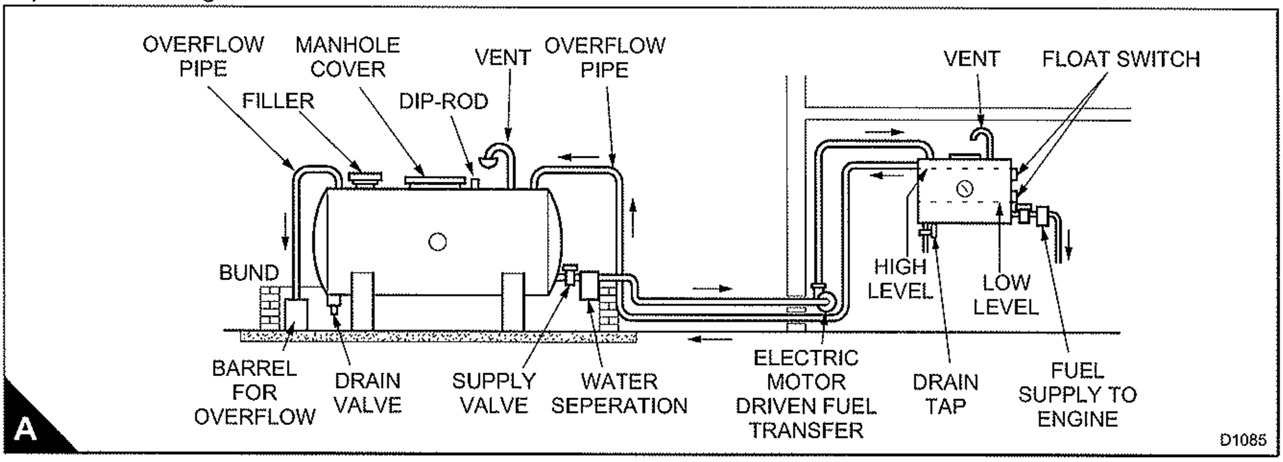
Bulk storage

Fuel supply systems assure a continuous and clean supply of fuel. Bulk fuel is usually stored in large tanks and transferred to smaller tanks (day tank) near engines by electric motor-driven pumps (A).

Large capacity storage tanks allow bulk purchases and minimize dirt contamination. Maintaining full tanks reduces condensation, particularly if fuel is seldom used. Diesel fuel is prone to oxidize and form gums and resins during long-term storage. Water in fuel offers a medium for bacterial growth which may cause filter plugging. Fuel has finite storage life of approximately one year, although this may vary widely depending upon initial quality, contaminant levels and storage conditions. Periodic exchange of fuel and filtering/treating to remove water, scale and bacteria growth will extend fuel life. Tanks may be above or below ground level, but high fuel level generally should not exceed engine injector's height. This prevents possible fuel leakage into the cylinders.

Locate storage tank fill tubes for convenience and safety of filling operations. Vents relieve air pressure created by filling and prevent vacuum as fuel is consumed.

Water and sediment are drawn periodically from the tank and contaminants can be localized by rounding the tank bottom and tilting about 2 degrees toward the drain. Consider ground settling when installing tanks so drain cocks remain low. Avoid seasonal settling by burying tanks below frost lines. In underground tanks, remove water by pumping through a tube placed down the fill pipe. Copper-bearing steel tanks are preferred, but black iron tanks and fittings are satisfactory. Avoid galvanized fittings or tanks because reactions with fuel impurities will clog fuel filters.



If day tanks are not used, bulk tanks must provide a ready fuel supply to the engine-mounted transfer pump. The fuel pump primes 3 m (9 ft), but pipe size, bends and cold ambient temperatures modify this capability.

Using shut-off valves in the delivery line may pull air into the system during shut-down and cause difficult starting. The engine control system provides adequate shut-down options but, if a shut-down solenoid is specified in the supply line, it should be timed to close after the engine stops rotating.

The delivery line carrying fuel to the fuel transfer pump and the return line carrying excess fuel to the tank are no smaller than engine fittings. If the fuel tank feeds multiple engines over 9 m (30 ft) from the engine or temperatures are low, larger fuel supply and return lines ensure adequate flow.

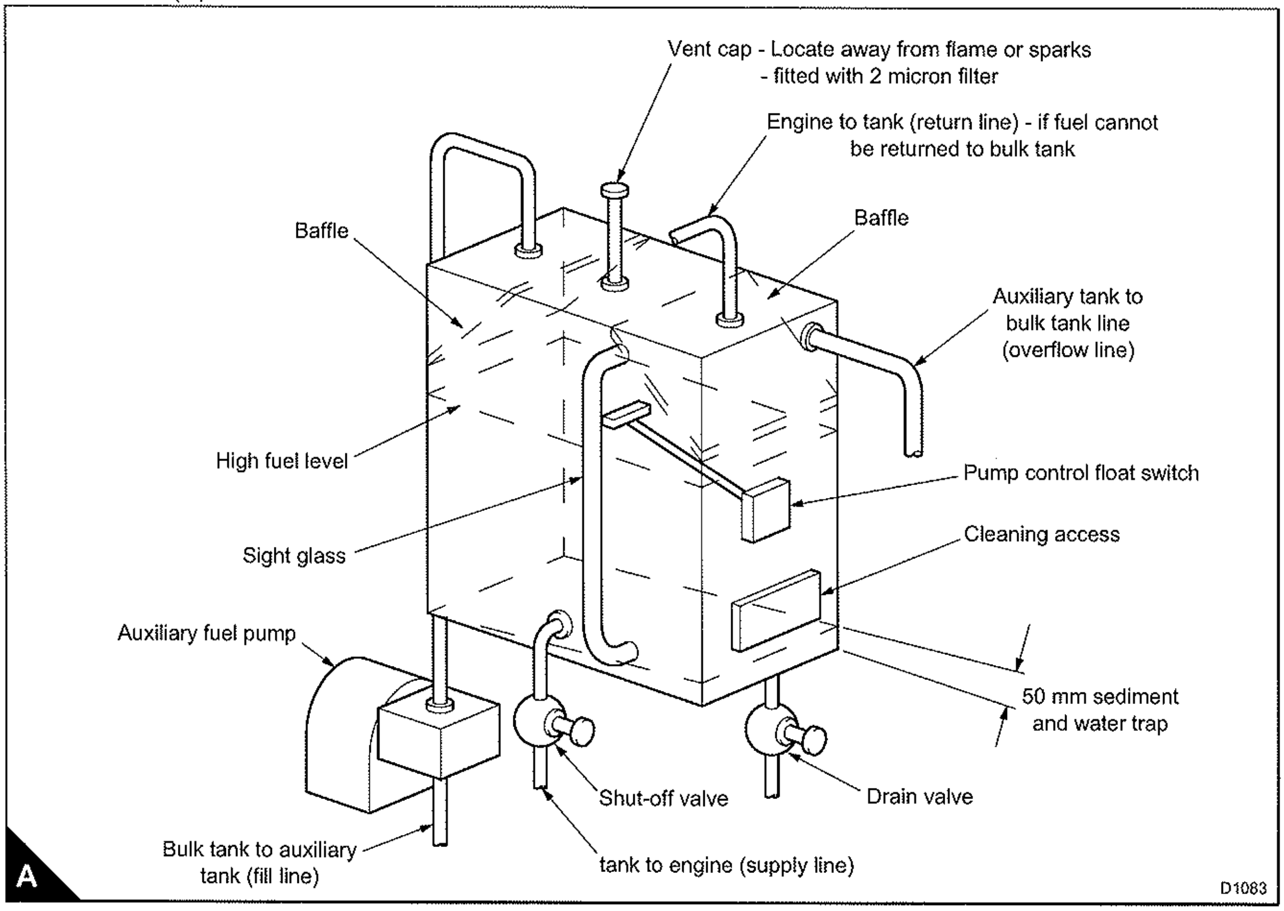
Piping and fittings are sealed to prevent air or dirt contamination. Air in the system causes hard starting and erratic operation.

Fuel lines are black iron pipe steel, or copper tubing; galvanized pipe or zinc-bearing alloys must not be used. The overflow line from the day tank (or, if no day tank is used, the engine fuel return line) is one size larger than the fill line.

The return line enters the top of the tank without shut-off valves. This allows air to pass freely and prevents a vacuum in the fuel system. Fuel suction lines remove fuel about 50 mm (2 in) above the bottom of the tank and at the opposite end to the return line. Joint cement affected by fuel is not used and connections are made without gaskets. Flexible fuel lines between fuel source (bulk storage or day tank) and engine fuel inlet and return isolate vibration.

Auxiliary tanks

Auxiliary or 'day tanks' are desirable if the main fuel tanks are more than 15 m (50 ft) from the engine and/or 1,8 m (6 ft) below the engine. Total suction head should not exceed 3 m (9 ft). Although day tanks do not aid fast starting, they do offer convenient and ready storage. Day tanks also provide a settling reservoir for water and sediment (A).



Auxiliary tanks are located to avoid fuel levels higher than engine fuel injection valves. If overhead mounting is unavoidable, include a 20 kPa (3 lb/in^2) differential check valve in the supply line and a 3,5kPa (0.5 lb/in^2) differential check valve in the return line.

When auxiliary or day tanks are used there is a serious danger of aerating the fuel due to running out or running low on fuel. The diesel system will then pick up aerated fuel from either the fuel return from the engine or incoming make-up fuel from the bulk tank.

On a 2806 engine the fuel circulates at approximately 7,5 l/m through the engine from the lift pump. Consequently the day tank must incorporate chambers or weirs to ensure that the fuel supplied to the engine is not full of entrained air.

The consequences of aerated fuel are: poor starting, low power, high exhaust temperatures and cavitation erosion within the unit injector.

Fuel coolers

The 2800 Series incorporate unit fuel injectors which transfer about 42,2 kJ (40 Btu) per minute per injector into the return fuel. If the fuel tank is insufficient to dissipate this heat, a cooling source must maintain fuel temperatures below 55 °C.

This can be achieved by fitting a correctly sized fuel cooler, either to the front of the radiator or remotely mounted at the side of the engine, or by returning the unburned fuel to the bulk tank. Further advice can be obtained by contacting the Applications Department at Perkins Engines Company Limited, Stafford.

Clean fuel is necessary for dependable engine performance. Engine filters protect the fuel injection pumps and nozzles and are never removed or by-passed.

Filters

Primary filters with 0,30 mm (0.12 in) screens extend engine filter and transfer pump life. Water and sediment traps can be included upstream of the transfer pump, but pump flow must not be restricted.

In warm climates with large bulk storage, diesel fuel requires full filtering every six months to a year. Every two years fuel is completely changed to remove water, scale, bacteria growth, oxidized gum/resins and minimize filter clogging due to fuel separation into components such as asphaltenes.

The 2800 Series engine's 'ECO' system consists of a primary filter/water separator and a main filter element, performance details can be found in the Technical Data Sheets.

Fuel pipes

Caution: *Galvanised pipes should not be used.*

Pipes may be made of seamless steel or copper. They should be well supported and should run as directly as possible between the tank and the engine. Thread sizes are shown on the installation drawing.

It is common to specify the piping by outside diameter sizes and where thick wall pipes are used they should be selected to give an equivalent bore.

Minimum pipe sizes

- Outside diameter: 12,0 mm (0.500 in)
- Inside diameter: 9,6 mm (0.378 in)

In order to prevent any restriction, resulting in an adverse effect on the lift pump, pipe lengths should be kept to a minimum. Proposals for long pipe runs should be submitted to Perkins Engines Company Limited, Stafford for approval.

Final engine connections should entail good quality flexible pipes.

Notes:

- Due to an increased fire risk the use of nylon pipes is not recommended.
- Before final coupling of the fuel pipes to the engine, ensure that they are flushed through thoroughly.
- High frequency pressure fluctuation in the pipelines can cause damage to fuel pressure gauges, where fitted. To prevent this, only gauges with an integral pressure "snubber" already fitted should be used.

Continued

The following additional information describes fuel characteristics and their relation to engine performance.

1 . Cetane number - Index of ignition quality determined by comparing with fuels used as standards for high and low cetane numbers.

2 . Sulphur - Limited to 0.5% without reducing oil change periods. Higher sulphur content requires usage of high total base number (TBN) oils or shortening oil change periods.

3 . Gravity - An index of weight of a measured volume of fuel. Lower API ratings indicate heavier fuel containing greater heat content.

4 . Viscosity - A time measure to resistance of flow. High viscosities cause poor fuel atomization thereby decreasing combustion efficiency. Low viscosity may not provide adequate lubrication to the fuel system components.

5 . Distillation - This involves heating crude to relatively high temperatures. Vapour drawn at various temperatures produce fuels of different types. Lighter fuels, such as gasoline, are drawn off first and heavier fuel last.

6 . Flash point - Lowest temperature fuel will give off sufficient vapour to ignite when flame is applied.

7 . Pour Point - Lowest temperature fuel will flow or pour.

8 . Water and sediment - Percentage by volume of water and foreign material removed by centrifuging.

9 I. Carbon residue - Percentage by weight of dry carbon remaining when fuel is burned until no liquid remains.

10 . Ash - Percentage by weight of dirt, dust, sand and other foreign matter remaining after combustion.

11 . Corrosion - A polished copper strip is immersed in fuel for three hours at 50 °C. Fuel imparting more than slight discoloration is rejected.

The customer should order as heavy a distillate fuel as engine and temperature conditions permit. Fuel costs can represent approximately 80% of the total operating costs for engines operating high hours per year. It is good economics to look closely at the largest cost first.

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10A

Lubrication

Lubricating oil recommendations

The lubricating oil used in the 2806-18 engine must be a 15W40 oil which conforms to the API CG-4 specification as a minimum. Oil produced to the higher specification, API CH-4, has greater soot handling capability and wear resistance leading to longer service intervals and/or engine life.

The recommendation is therefore API CG-4 acceptable oil and API CH-4 preferred oil.

Oil change period is 500 hours where fuel sulphur is less than 0.2%. Use of fuels having a higher sulphur level than this will reduce the oil life, which will have to be determined by oil analysis conducted by the customer and a reputable analysis service.

Oil level control

Where cases of extended engine running may occur, some installations require a means of ensuring that the oil in the sump is maintained at a constant level.

The devices generally work on the principle of an oil reservoir supplying oil to a float chamber, usually mounted close to the engine sump, via a flexible hose. As the oil in the sump falls through normal usage, fresh oil from the oil reservoir flows through the float chamber and into the sump bringing the oil level back to normal. A pressure equalising pipe is required from the float chamber to engine to ensure that the pressure in the float chamber is the same as that in the crankcase. For advice on where to fit the pressure equalising pipe please contact the Applications Department at Perkins Engines Company Limited, Stafford.

The float chamber should be positioned correctly to the normal level of the oil in the sump when the engine is running. If this point cannot be clearly identified then a position midway between the maximum and minimum sump oil levels should be used.

With any oil level control used the important procedure of engine oil and filter changes should still be made. The maintenance periods still apply as given in the User's Handbook,

Low oil pressure/high oil temperature

Provision is made for low oil pressure warning and shut-down devices within the engine ECM. However, to meet customer needs, provision is also made within the engine oil filter header for the fitting of an external sender unit.

Likewise, provision is also made for a high oil temperature warning and shut-down sender to be incorporated on the engine. For advice on settings please contact the Applications Department at Perkins Engines Company Limited, Stafford.

Access

Adequate access must be provided for lubricating system servicing facilities such as: oil filters, oil drain and priming pumps, dipsticks and turbocharger priming pipes. Sufficient clearance should, if possible, be left below the engine to allow for possible sump removal without having to lift the engine. The clearance required can be obtained from the engine installation drawing.

Tilt angles (engine operating angles)

The engine is designed to operate up to a maximum angle of 7 degrees both front and rear and also side tilt, and any compound angle resulting from these.

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11A

Sound insulation

Warning! *Personal protective equipment must be worn when working in an engine room.*

Definition of noise

Noise is generally defined as "unwanted sound". Sound itself consists of small pressure variations in the air, the source of which may be either a vibrating structure or a pulsating gas flow.

Noise levels

Noise levels are measured in decibels (dB) through a frequency range of 31.5 to 16,000 Hz and at each octave band centre frequency i.e. 31.5, 63, 125, 250 Hz etc.

The human ear is responsive to noise levels in the frequency range of 63 to 800 Hz. The noise level in dB can be weighted A, B, C, and D to suit different requirements. The accepted norm is the "A" weighting as such an overall noise level closely reproduces the response of the human ear. The most commonly accepted readings are "Sound Pressure Level".

Noise source

A running engine produces mechanical noise: valve gear, fuel pump etc., combustion noise, noise from vibration, noise from air induction and noise from the fan.

Usually the radiator fan noise and the air induction noise is less than the mechanical noise. Noise level readings are obtainable from Perkins Engines Company Limited, Stafford.

Should additional noise reduction be required this can be achieved by acoustic treatment. If the acoustic measures reduced the noise levels in accordance with Perkins figures then the fan and induction noise need not be considered.

Providing a canopy around the engine is economical and gives good results. From a position 1 metre away from the canopy it is possible to reduce the noise overall by up to 10 dB(A). Sound attenuation canopies need to be expertly designed to be effective and it is advised that companies with acoustic treatment experience are consulted.

Introduction

The following notes are offered for guidance in the design of an installation where it is desirable to minimise emitted noise generally.

The measurement of sound levels is a very complicated science as it is influenced by so many varying factors. As these factors (on site) are outside the control of Perkins Engines Company Limited, Stafford, all the information in the section is for guidance purposes only.

Units of measurement

The most widely used unit of sound measurement is the decibel (dB) which expresses, on a logarithmic scale, the ratio between the sound being measured and a reference sound level. This reference level, known as the 'Threshold of Hearing', approximates to the minimum sound audible to a person with very good hearing.

(It should be noted that, as the decibel is a logarithmic unit, an increase 3 dB actually represents a doubling in sound intensity. However, the response of the average human ear is such that an increase of approximately 10 dB is necessary for a doubling in subjective 'loudness' to be perceived).

The accompanying chart illustrates typical levels of various everyday sounds.

The measurement unit specified in most noise legislation is the A-weighted decibel dB(A). This approximately simulates the frequency response of the human ear to noise, by suppression of noise components at very low and very high frequencies and amplification of those in the middle frequency range.

Most commercially available noise meters incorporate electrical weighting networks which enable dB(A) levels to be read directly.

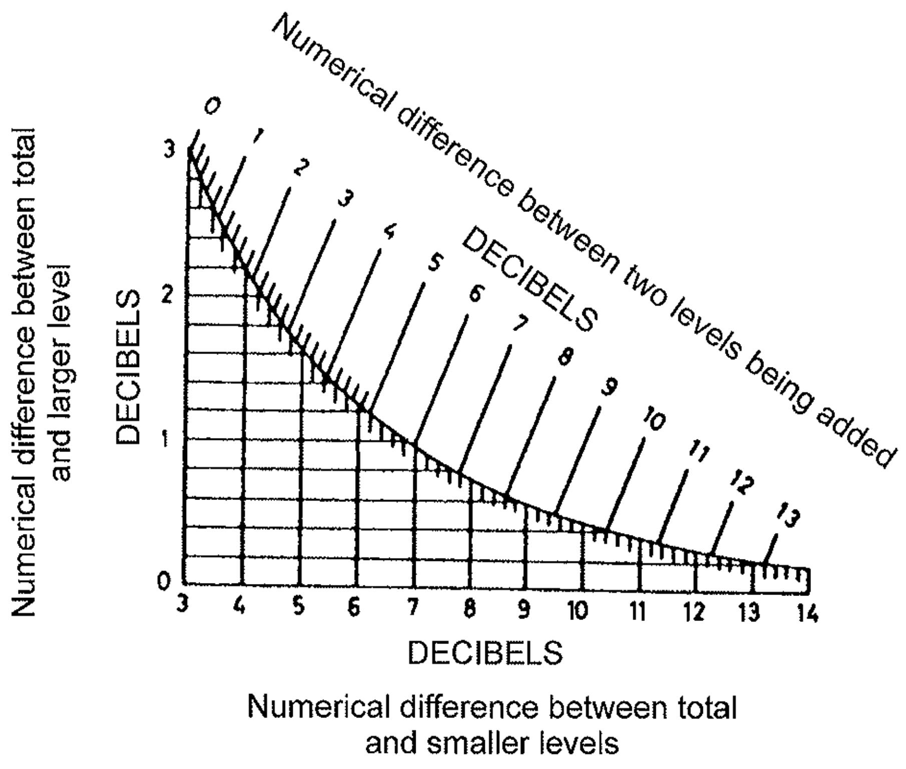
Typical levels of every day sounds

Sound pressure	**dB (A)**
'Threshold of pain'	140
Pneumatic riveter	130
Loud automobile horn at 1m	120
Power mower	110
Diesel engine under full load on test bed at 1m	100
Heavy truck on full throttle at 7.5m	90
Inside small car at 80 KM/H (50 mph)	80
Typical city street noise	70
Typical office	60
Average conversation	50
Quiet residential neighbourhood	40
Very soft whisper	30
Broadcasting studio	20
Sound proof room	10
Threshold of hearing	0

Additional and subtraction of decibels

In noise analysis and reduction work it is often necessary to calculate the effects of combining or eliminating noise sources. However, since the decibel is a logarithmic unit, noise levels cannot be added together arithmetically, for example: 80 dB + 80 dB = 83 dB and not 169 dB. Thus, an increase of 3 dB represents a doubling of sound intensity.

Whilst addition and subtraction of decibels can be done from first principles by the use of logarithm theory, in practice this is not necessary since charts are available for the purpose. Refer to (A), together with instructions for its use.



To combine decibels

Enter the chart with the numerical difference between the two levels being added. Follow the line corresponding to this value to its intersection with the curved line, then left to read the numerical difference between the total and larger level. Add this value to the larger level to determine the total.

Example: Combine 75 dB and 80 dB. The difference is 5 dB. The 5 dB line intersects the curved line at 1.2 dB on the vertical scale. Thus the total value is 80 + 1.2 or 81.2 dB.

With careful attention to some basic factors, emitted noise can usually be reduced to acceptable levels irrespective of whether the engine is installed in a weatherproof canopy or is contained in a substantial building.

Noise from a diesel engine can be transmitted in various ways, for example:

1 Direct mechanical noise from the surface of the engine.

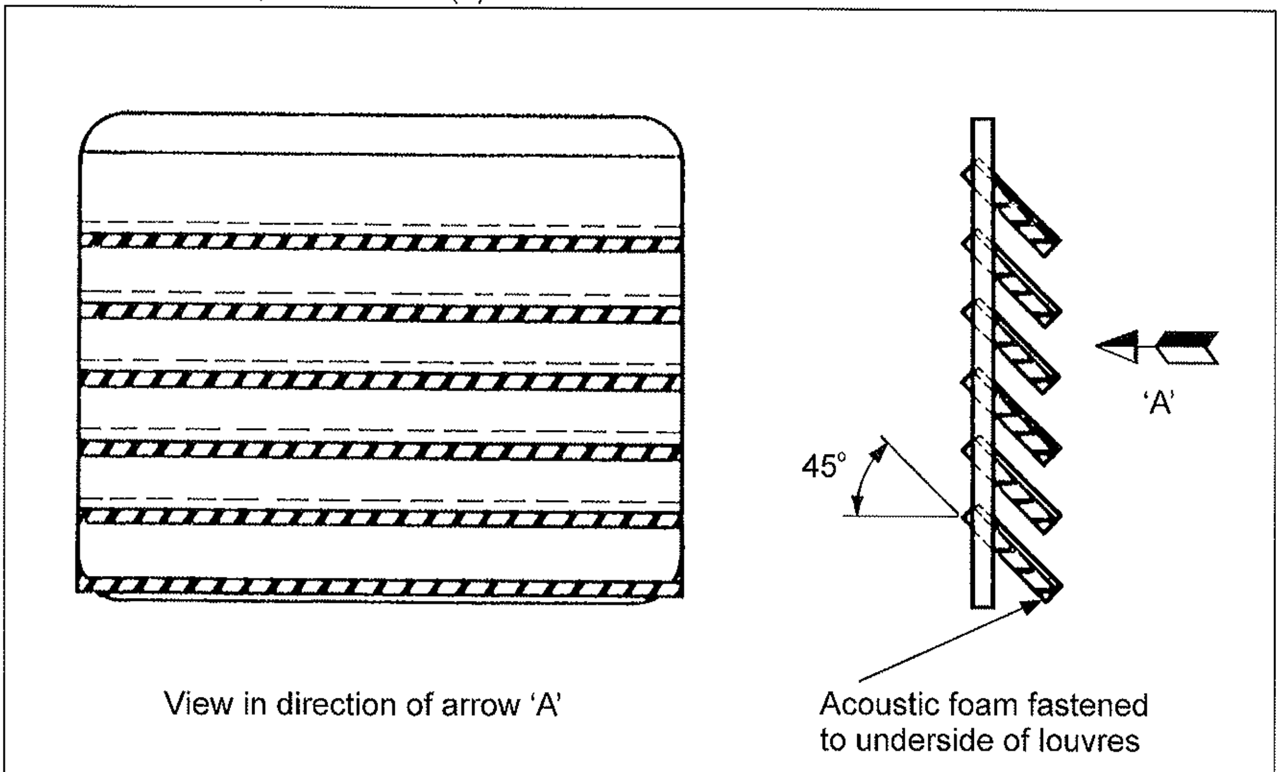
2 Sympathetic vibration of surrounding structures.

3 Resonance by inlet air and exhaust gas flowing through pipes and ducts.

Direct mechanical noise from the surface of the engine can be contained by lining the enclosure internal surfaces, including doors and hatches, with sound absorbing material. Sheets of mineral wool (e.g. Rockwool), 100 mm thick, have been found to be particularly effective. It is important to ensure that all hatches, doors and panels seal well, particularly at corners.

Although it has been shown that the practice of dressing the engine carcase with sound deadening panels can be beneficial, it is not recommended for 'one off' installations where it cannot be cost effective. Furthermore, such panels inhibit engine servicing and maintenance, interfere with cooling airflow and, by absorbing oil and diesel fuel, add to the risk of fire.

Further isolation is possible if splitters are used at the air entry and exit openings. For example panels lined with noise absorbent material can be placed in the direction of flow. Alternatively the effective length of entry and exit passages can be increased by using panels to re-route the airflow. This will reduce the sound level outside the enclosure; see illustration (A).



Typical acoustic louvres

Continued

Any interference of the airflow will inevitably add restriction. It is important to take full account of the additional restriction to ensure that adequate airflow for cooling is maintained. Details of permissible additional restriction are quoted in the Technical Data Sheet for the engine.

Sympathetic vibration of surrounding structures can be reduced by:

1 Flexibly mounting the engine.

2 Ensuring that all large panels which could vibrate, are well stiffened and either flexibly mounted or rigidly supported.

3 Introducing flexible sections into all service connections.

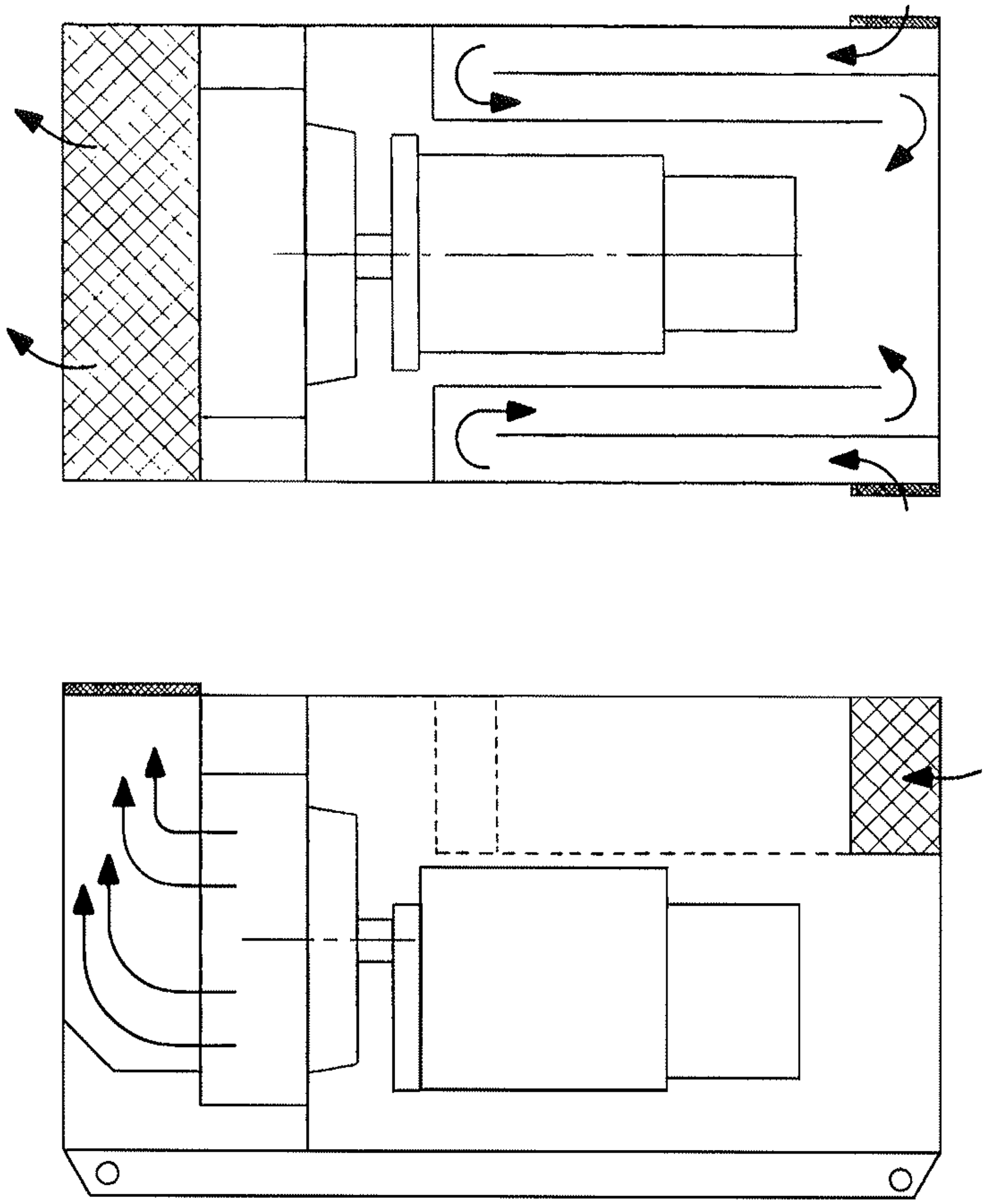
The mounted air cleaners and ducts supplied on Perkins Engines Company Limited, Stafford sealed specification generating set engines (i.e. Electropak) have been selected to ensure that resonance is kept to a minimum level. The air cleaners should be wholly contained within the enclosure to isolate any noise created by air entering and passing through the cleaners.

The correct selection and installation of exhaust silencers will aid noise reduction. If a single silencer is used it should be installed with a tailpipe of length equivalent to ten times the exhaust pipe diameter. Better attenuation is possible if two silencers in series are used. In this case a snubber type primary silencer should be positioned as close to the engine as possible, with a secondary absorption type silencer positioned as for a single silencer system. For further information on the sizing of a suitable exhaust system refer to chapter 6A.

Performance

Figures for sound pressure levels are stated in the relevant Technical Data Sheet.

Continued



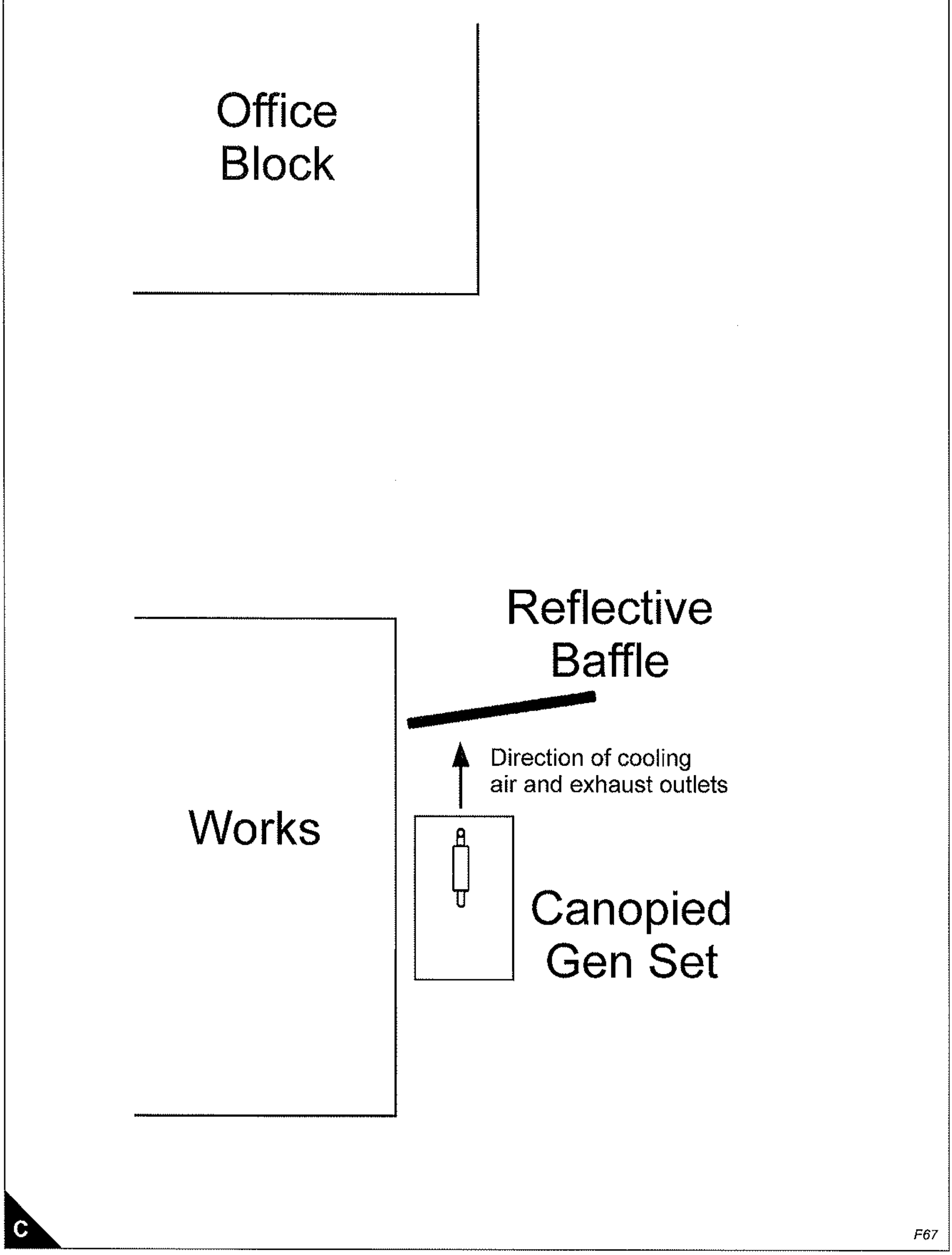
By creating a longer route for air entering and leaving the weatherproof canopy, the emitted noise can be reduced

It is important to ensure that these measures do not impose excessive additional resistance to airflow

B

F66

By careful positioning of a generating set and baffle, the effective noise can be reduced



Engine noise figures

This estimated average sound pressure figure at 1 metre is given on each Technical Data Sheet. These figures are derived from limited test work. As is normal practice, noise cell test work is performed with the exhaust and induction noise sources eliminated, in order to establish figures for the engine itself.

Frequency spectrum figures

To provide data for specialist treatment of generating sets requiring very low overall noise level emission, it is useful to provide a set of figures covering a range of frequencies so that specialist treatment can be more accurately applied.

The following pages contain noise figures related to various frequencies which are given as a guide for various engine models. Various Electropak design changes have taken place which may slightly affect the figures quoted - but they are offered as a general guide and may be updated at a later date, following further test work.

Free and "semi-reverberant" field

If the noise "escaping" from an engine room emerges into a "free field" area then a good approximation of the decaying noise level is that doubling the distance reduces the noise level by 6 dB(A), for example:

At	1 metre	100 dB(A)
	2 metres	94 dB(A)
	4 metres	88 dB(A)
	8 metres	82 dB(A)

However, the area around the engine room may include other buildings or reflective surfaces to make it into a "semi-reverberant field". In this case the decay is likely to be approximately 3 dB(A) per doubling of distance. Once clear of the "semi-reverberant field" the figure of 6 dB(A) can be used in the "free field", for example:

At	1 metre	(Semi-reverberant field)	100 dB(A)
	2 metres	(Semi-reverberant field)	97 dB(A)
	4 metres	(Semi-reverberant field)	94 dB(A)
	8 metres	(Free field)	88 dB(A)

With these simple approximations, the noise paths can be assessed at, for instance, a residential area 100 metres from the noise source.

12A

Governor and controls

In order to maintain the engine at a pre-determined speed, the fuel supply is normally controlled by a governor.

In the case of the 2800 Series, governor control is provided by the ECM, further details of which are contained in the electronics section of this manual.

The engine is capable of meeting the requirements of ISO 8528-5 Class G3 with 8% droop capability.

Load acceptance

Standard load acceptance details can be found in the Technical Data Sheet.

Engine Control Module

The Engine Control Module (ECM) is the management system that controls: speed governing, air/fuel ratio, start/stop sequence, engine protection devices and diagnostics.

There is a password-protected facility for switching from 1500 rev/min to 1800 rev/min.

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13A

Protection devices

Standard protection devices

The following protection devices are fitted as standard and are controlled by the Engine Control Module (ECM):

High coolant temperature	Warning and de-rate/shut-down
Low oil pressure	Warning and shut-down
Overspeed	Shut-down
Underspeed/overload	Warning and shut-down
High inlet air manifold temperature	Warning and de-rate

Optional protection devices

The following protection devices are offered as an optional extra:

High turbine inlet temperature	Warning and de-rate/shut-down
High oil temperature	Warning
Low fuel pressure	Warning
Oil and fuel differential pressure	Warning
Fuel contamination (water)	Warning
Low oil level	Warning and shut-down

Further information is given in the electronics section of this manual.

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1B

Electronic installation

Introduction

General information

The information contained within this section is intended to be used by qualified electrical/electronic personnel, both in the installer's organisation and internally, to assist in the successful integration of the Perkins 2800 Series electronic engines into generating set applications.

The main purpose is to provide information to enable the original equipment manufacturer (OEM) to do the following:

1 To supply an appropriate machine harness and components to interface with the engine harness.

2 To select and apply control, protection, display and diagnostics software features that are appropriate to the machine application.

3 To develop a successful data strategy for communication with the Engine Control Module (ECM) over the Perkins Data Link.

Notes:

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- The OEM who integrates the engine into an application is responsible for ensuring that the end user is provided with sufficient information to ensure safety.
- The information contained in this publication is subject to change without notice.
  Perkins Engines Company Limited will not be held responsible for any loss or damage caused by inaccuracies.

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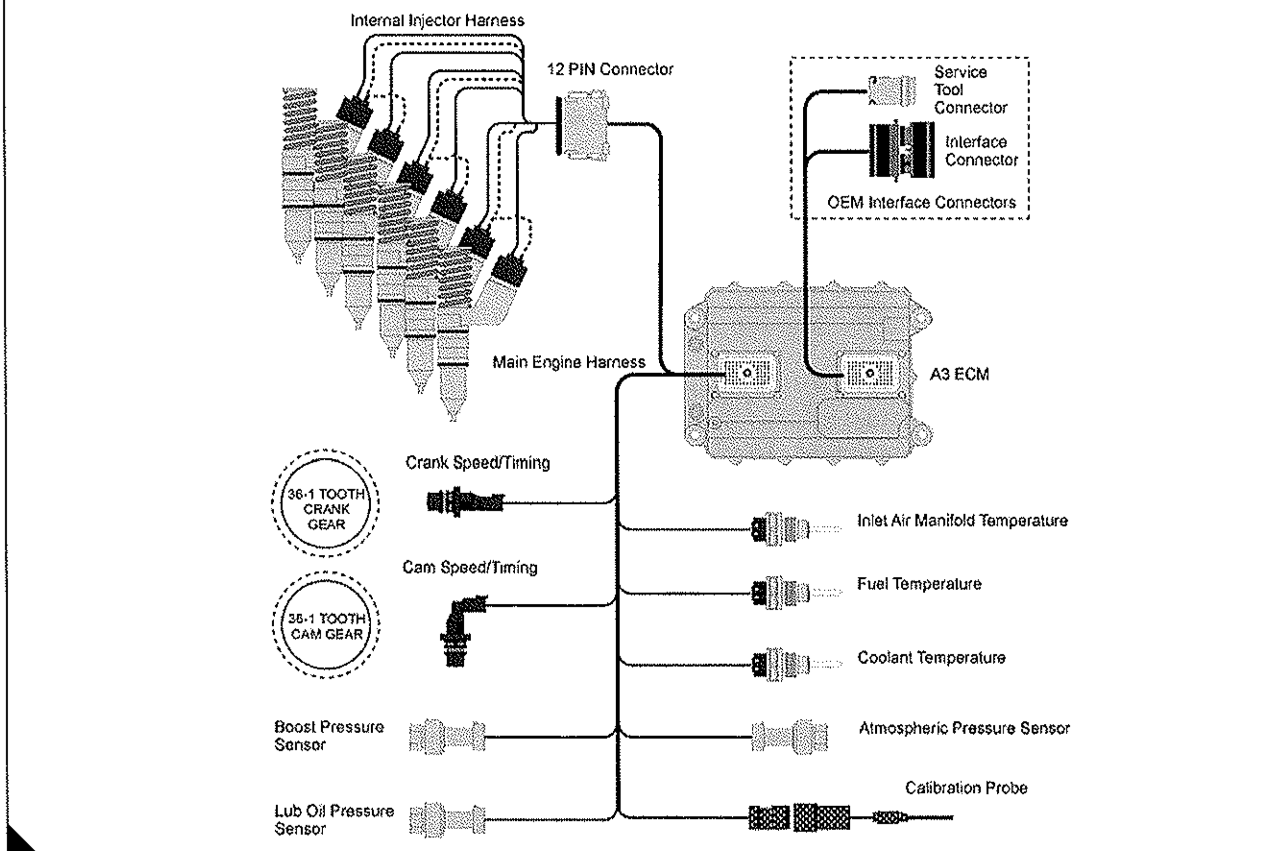
2B

System overview

Engine hardware



Engine Hardware

Injectors

The 2800 Series industrial engines utilise electronic unit injectors. These injectors are mechanically actuated and electronically energised. The injector solenoid is mounted on top of the injector body alongside the rocker and return spring.

Electronic controls

The 2800 Series electronic system consists of the Electronic Control Module (ECM) and engine sensors. The ECM is the computer which controls the engine operating parameters. The software in the ECM controls how the ECM behaves (the software stores the operating maps that define power, rev/min, etc.). The injection pump, fuel lines and fuel injection nozzles used in mechanical engines have been replaced with an electronic unit injector in each cylinder. A solenoid on each injector controls the amount of fuel delivered by the injector. The Electronic Control Module (ECM) sends a signal to each injector solenoid to provide complete control of the engine. The ECM compares a 'Desired Speed' with an actual engine speed derived from pick-ups on the crankshaft and camshaft drives and decides how much fuel to inject in order to achieve the desired speed.

Engine governor

The electronic controls on the engine serve as the engine governor. The electronic controls determine when and how much fuel to deliver to the cylinders based on the actual and desired conditions at any given time.

The governor uses the 'Desired Speed' input (if fitted) or the pre-programmed desired speed and compares this to the actual engine speed determined from the engine speed/timing sensors. Fuelling is then controlled as necessary to keep engine speed constant.

Timing considerations

Once the governor has determined how much fuel is required, it must next determine when to inject the fuel. Injection timing is determined by the ECM after considering input from the Coolant Temperature Sensor, Inlet Air Manifold Temperature Sensor and Turbocharger Boost Pressure Sensor. The ECM determines where top dead centre on cylinder number one is located from the Engine Speed/Timing Sensor signal. The ECM decides when injection should occur relative to top dead centre and provides a signal to the injector at the desired time. The ECM adjusts timing for the best engine performance, fuel economy and white smoke control. Actual or desired timing can be viewed with the service tool.

Fuel injection

The ECM controls the amount of fuel injected by varying signals to the injectors. The injectors will pump fuel ONLY if the injector solenoid is energised. The ECM sends a high voltage signal to energise the solenoid. By controlling the timing and duration of the high voltage signal, the ECM can control injection timing and the amount of fuel injected.

The software inside the ECM sets certain limits on the amount of fuel that can be injected depending on the selected rating and engine operating parameters.

ECM monitoring parameters

The ECM monitors the following engine parameters:

- High coolant temperature - Warning, Action Alert, Shutdown and dedicated output
- Low lubricating oil pressure - Warning, Action Alert, Shutdown and dedicated output
- Overspeed - Warning, Action Alert, Shutdown and dedicated output
- Inlet air manifold temperature - Warning, Action Alert and common outputs
- Fuel temperature warning - Action Alert and common outputs
- Boost pressure warning - Action Alert and common outputs

Refer to Chapter 3B, Software features and Chapter 4B, On-engine electronic hardware, for further details of engine monitoring.

Self-diagnostics

The electronic system has some ability to diagnose itself. When a diagnostic code is generated, the 'Diagnostics' lamp is illuminated and the exact fault should be determined using the service tool. Full information on fault finding the system is given in the Diagnostic Manual.

Data link

The ECM is able to communicate with the service tool via the Perkins Data Link (PDL) and a connector is normally fitted to the wiring harness to enable the service tool to be connected. A J1939 data link is also available in addition to the Perkins Data Link.

3B

Software features

Note that some of the following software features are optional. Please confirm those which have been selected for a specific application.

Engine speed/ratings selection

The ECM is provided with a facility to change the engine rating, duties and speeds within defined limits set by torque limits maps. The rating of the engine is selectable via the speed selection switch input and/or the service tool (service tool selection is customer password protected).

The ECM shall have torque limit maps, as follows:

- 1500 rev/min Prime power
- 1800 rev/min Prime power
- 1500 rev/min Standby power
- 1800 rev/min Standby power

One of the above maps shall become active when the engine function and speed are selected. The function will be selected at the time of engine manufacture or in service via the service/diagnostic tool using the customer password. The ECM is factory password protected to prevent flashing with software that contains torque limit maps that differ from the power ratings originally supplied with the ECM.

Speed input selection

This external input is provided to switch between the following:

- If the ECM has been configured in the service tool to run at Prime Power ratings, the speed selection input will switch between 1500 rev/min Prime Power and 1800 rev/min Prime Power.
- If the ECM has been configured in the service tool to run at Standby ratings, the speed selection input will switch between 1500 rev/min standby & 1800 rev/min standby.

This input is a low-side switch input and shall be connected to ground to select the 1800 rev/min rating.

Note: A customer password is required to enable this input via the service tool. If this input is enabled and not connected then the nominal engine speed will default to the 1500 rev/min rating independent of the rating selected in the service tool.

Desired engine speed bias

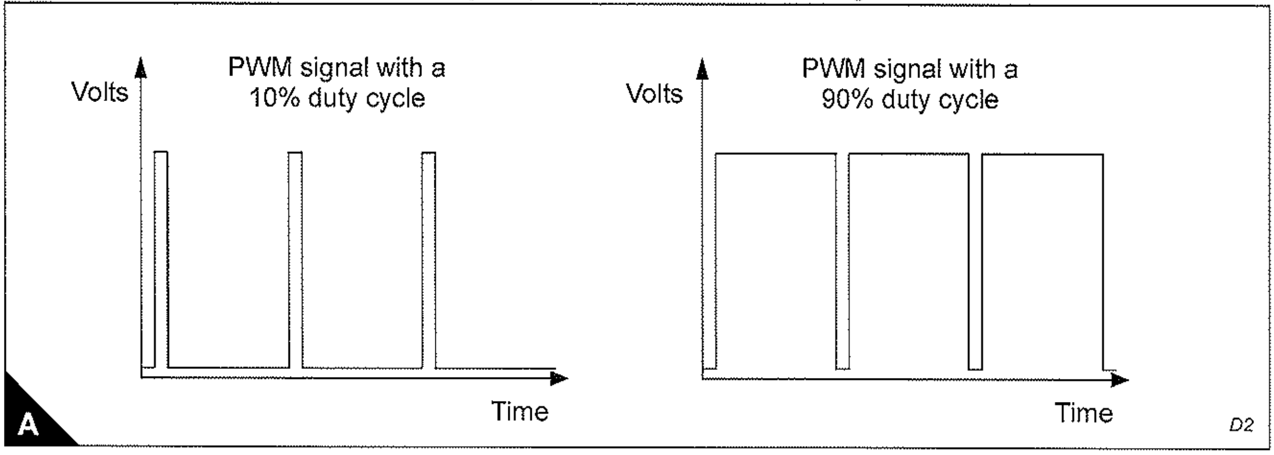
The speed trim/load demand input shall adjust the nominal desired engine speed setting.

The ECM is provided with 3 speed adjustment inputs for load sharing/synchronising i.e. a PWM input, an analogue input and a digital (push-button or relay) input. The service tool is used to enable either the analogue or PWM input via a customer password. Changing between analogue and PWM input selection is only possible when the engine is stationary.

PWM speed bias

The PWM input is a single ended nominal 500 Hz with a duty cycle of 10-90%. The duty cycle range equates to a desired speed adjustment of between -24% and +8% of rated speed. The 0% shall equate to the nominal desired speed setting.

Note: The PWM speed adjustment range is pre-set and cannot be changed.



Analogue speed bias

The analogue speed adjustment is nominally a 0 to 5V analogue voltage input. The voltage is referenced to the ECM analogue ground reference voltage. The input range for the analogue speed input is 0.5 to 4.5V. The speed range of the analogue control is determined by the settings from the service tool.
The maximum is +/- 150 rev/min.

Digital speed bias

Digital speed control enables the engine speed to be controlled by digital loadsharing and synchronising equipment and the engine can interface directly with manual synchronising selector switches or push-buttons. To provide this facility the ECM incorporates speed raise/lower inputs and a digital speed control enabled switch as follows:

- Digital speed control enable.

A switch input when closed enables the speed to be adjusted using the digital speed raise/lower inputs.
The input is a low side input, connected to ground to enable.

- Digital speed control ramp rate.

This parameter is adjustable via the service tool and determines the rate of change of engine speed using the raise/lower digital inputs, it is scaled in steps of rev/min/sec.

- Digital speed control - raise speed.

This switch raises the engine speed at a rate defined by the digital speed control ramp rate. The adjustment range is +/- 150 rev/min of nominal speed, this range can be set using the service tool.
This input is a low side input, connected to ground to enable.

- Digital speed control - lower speed.

This switch lowers the engine speed at the rate defined by the digital speed control ramp rate.

The adjustment range is +/- 150 rev/min of nominal speed, this range can be set using the service tool.

This input is a low-side input, connected to ground to enable.

The digital speed control is capable of being enabled at any time i.e. not password protected but the selection only comes into effect when the engine is stationary.

Engine control/protection

Starting and stopping

Wiring for engine start/stop control is supplied by the OEM.

The main power feed for the ECM is permanently connected to the battery via the emergency stop switch(es). Interrupting the main power feed to the ECM will stop fuel injection to the engine but should only be used as an emergency stop.

The ECM is provided with two run/stop inputs: 'key switch' and 'injection disable'. This allows the system to be wired up to the control panel in one of two ways to suit either stand-alone operation or remote monitoring operation:

- In 'Stand Alone' configuration, the 'injection disable' input will be wired such that it is permanently in the 'run' state whilst the 'key switch' input will be connected to the control panel and switched to either the 'run' state or 'stop' state. When switched to 'stop' the ECM will stop the engine and then switch into 'sleep' mode to minimise battery drain.
- In 'Remote Monitoring' configuration the 'key-switch' input will be wired such that it is permanently in the 'awake' state whilst the 'injection disable' input will be connected to the control panel and switched to either the 'run' or 'stop' state. This will allow the engine to be started and stopped by enabling or disabling fuel injection but the ECM will remain 'awake' at all times whilst the main power feed is live, thus allowing interrogation of data within the ECM whilst the engine is not running.

To start the engine, power is first supplied to the ECM in the above manner. The engine will then start once it has cranked above the minimum cranking speed.

To stop the engine, the 'ignition' input to the ECM is switched to the 'off' state as described above. The ECM immediately stops firing the injectors and shuts down in a controlled manner. The injector driver power supply is internally isolated, data stored in volatile memory is transferred to non-volatile memory, and the processor is shut down.

The key switch input is a high-side switch input and should be connected to battery +ve to switch the ECM into fully operational mode.

Injection disable shall be a high-side switch input and should be connected to battery +ve to enable the injectors.

Emergency shut-down

For emergency situations, interrupting the main battery power supply to the ECM stops the engine. This causes the system to stop firing injectors instantaneously.

Shutdown by this means is not recommended as a standard shutdown procedure as communication with the ECM will be lost and output drivers will be de-energised.

Basic engine protection

The engine has protection in three stages:

- Warning
- Action Alert
- Shutdown

Where applicable, the engine protection can be overridden by the critical condition mode, refer to "Critical protection override" on page 87.

All alarms and shutdown faults are broadcast over the Perkins Data Link. The ECM monitors engine temperatures, pressures and speed as detailed below. If any one them exceeds a trip point for a period of time longer than a delay period, the ECM logs the event and switches on the indicator outputs.

The following list identifies the Action Alert and Warning channels being monitored:

- Lubricating oil pressure.
- Coolant temperature.
- Overspeed.
- Inlet manifold air temperature.
- Boost pressure.
- Fuel temperature.

To allow for heat soak situations, temperature protection is disabled for a period of time after engine start. The oil pressure protection is disabled whilst the engine is cranking.

When the ECM instigates a Warning, Action Alert, or Shutdown output for either the lubricating oil pressure, coolant temperature or overspeed fault conditions, the ECM also switches on the dedicated alarm output.

If the engine is in a Warning condition and the fault deteriorates further to the shutdown limit then the ECM logs the fault and shuts down the engine, as detailed below. If the engine shutdowns on oil pressure, coolant temperature or overspeed the respective alarm output will be energised.

The three fault levels are defined as follows:

Warning

The Warning alarm is to inform the user that the engine is approaching a critical condition.

If the engine goes into the Warning condition, the event will be logged in the ECM's memory, a fault code will be transmitted over the diagnostics link and the hardwired Warning output will be energised. Once in the Warning mode the fault code and output will remain whilst the condition exists. The fault will remain in the ECM's memory until cleared by a service tool. The Warning alarm point will be set to a factory default in production. The Warning settings may be altered using the service tool (within pre-defined limits).

Action Alert

The Action Alert alarm is to inform the OEM equipment that the engine is approaching a critical condition and should be stopped in a controlled manner or load reduced. Further running of the engine may result in an immediate shutdown.

If the engine goes into the Action Alert condition, the event will be logged in the ECM's memory, a fault code will be transmitted over the diagnostics link and the hardwired Action Alert output will be energised. Once in the Action Alert mode the fault code and output will remain whilst the alarm condition exists. The fault will remain in the ECM's memory.

Shutdown

If an engine parameter reaches the Shutdown condition i.e. lubricating oil pressure, coolant temperature or overspeed, the ECM will log the fault and shutdown the engine.If the engine goes into the Shutdown condition the event will be logged in the ECM's memory, a fault code will be transmitted over the diagnostics link and the hardwired Shutdown output will be energised. The Shutdown condition will latch in until the ECM is reset.

Critical protection override

If the particular operation of the engine is in a critical application (i.e. safety critical standby generator) the protection system can be overridden to ensure the continuation of the electricity supply during engine fault conditions.

The Critical Override will be set by a switch input from the OEM (i.e. switched to battery + to disable critical override). The Critical Override input shall be enabled in the service tool via a customer password.

When activated the ECM will log the condition and continue to run the engine in all fault conditions with the exception of Overspeed shutdown and Emergency shutdown. If the engine enters a fault condition the ECM will log the event in memory. The ECM will record the number of faults overridden. Whilst in critical override, the ECM will still energise the Warning, Action Alert and Shutdown outputs as required.

It is not possible to clear logged shutdown events from the logged events screen which occur when the ECM is operating in Critical Override mode.

It should be noted that any warranty given on the engine becomes void if the engine is run in a fault condition with the Critical Override enabled as the engine could run to destruction.

When operating to critical override mode the oil pressure and coolant temperature events will be displayed in the "critical events" screen of the service tool.

Standard warning outputs

The ECM provides individual outputs to drive warning lamps or relays to indicate each of the following fault conditions.

1 Diagnostic Fault
2 Coolant Temperature
3 Low Oil Pressure
4 Overspeed
5 Action Alert
6 Warning
7 Shutdown

If the ECM detects a coolant temperature warning the Coolant Temperature output will be energised and the Warning output energised, likewise if the ECM detects a low oil pressure warning, the Oil Pressure output will be energised and the Warning output energised etc. If the Action Alert alarms are enabled then when the ECM detects a coolant temperature condition, the Coolant Temperature output will be energised and the Action Alert output energised etc.

If the engine shuts down on low oil pressure the Low Oil Pressure output and Shutdown output will be energised, likewise for a coolant temperature or overspeed shutdown i.e. the dedicated output and the shutdown output will be energised.

Shutdown reset

Following an engine shutdown, the fault can be cleared by operation of the Shutdown Reset input or powering down the controller.

The input is a low-side switch input and is connected to ground to reset.

Powering down the ECM can be achieved either by the operation of the key switch into sleep mode or totally isolating the power supply feeds to the ECM.

Note: It is not possible to reset the ECM using the Reset input until the engine has come to rest.

Altitude derate

The only derate programmed into the ECM is based on altitude. The ECM automatically derates the engine power based on an established derate strategy and provides an indication via the service tool that the engine is in a derate condition.

Diagnostic

Any fault with the protection sensors on the engine instigates a diagnostic code and communicates to the operator via the Diagnostic output that there is a fault. This gives an indication to the operator that the engine protection has been compromised and that prolonged running of the engine in this condition may result in engine failure. The output is generally be used to drive lamps or relays.

The following sensors are monitored for out of range, open/short circuit etc:

Lubricating oil pressure, Boost pressure, Inlet manifold air temperature, Fuel temperature, Coolant temperature, Engine speed and Desired speed input.

It should be noted that the Diagnostic output differs from the Warning and Shutdown outputs. These outputs refer to the operation of the engine whilst the Diagnostic output refers to the 'health' of the electronic and software system.

If a diagnostic fault develops on the lubricating oil pressure or coolant temperature sensors i.e. a Shutdown protection sensor has been compromised, this instigates an engine shutdown, (unless in critical protection override as described on the previous page). If a diagnostic fault occurs with either engine speed sensor whilst the engine is running, the engine continues to run using the other timing sensor for reference.

Governing

Rev/min governing

A rev/min governor is responsible for controlling fuel quantities delivered per injection to the engine in order to maintain the demanded engine speed whenever possible. The engine speed demand may come from one of three sources as described in Chapter 2B, System overview. This is used in conjunction with the engine speed signal to maintain engine speed.

Droop/isochronous selection

The engine governing is selectable between droop and isochronous operation. The selection can be made either in the service tool or by an external switch. The service tool is provided with the option of choosing between Isochronous, Droop or External input. A customer password is required to enable the external droop switch input. The droop percentage is configurable via the service tool (0-8%). The engine governing defaults to Isochronous unless overridden in the service tool or set via the external switch input.

When the external switch selection is enabled the engine will govern in accordance with the switch position (default to isochronous). This input is a low side input, connected to ground for droop control.

Note: If the external input selection is enabled but not made then the ECM governs isochronously. If droop operation is required, to set the no load speed, the analogue/PWM speed bias should be selected, since the digital speed control reverts to rated speed on ECM power cycles.

Boost fuel limiting

The quantity of fuel per injection is precisely measured and will take into account the current intake manifold pressure so as to limit fuel to available air.

Boost fuel limiting provides engine protection giving increased reliability, longer engine life and reduces black smoke emissions.

Logging

Engine hours

A total of the engine operating hours is maintained by the ECM. This is the time fuel has been injected and does not include ignition ON times when the engine has not been started or has been stalled.

This log provides lifetime information for an engine that may be used by installers and Perkins alike for analysis of engine wear.

The total cannot be reset via a service tool and will therefore give an accurate indication of the total time the engine has been operated.

4B

On-engine electronic hardware

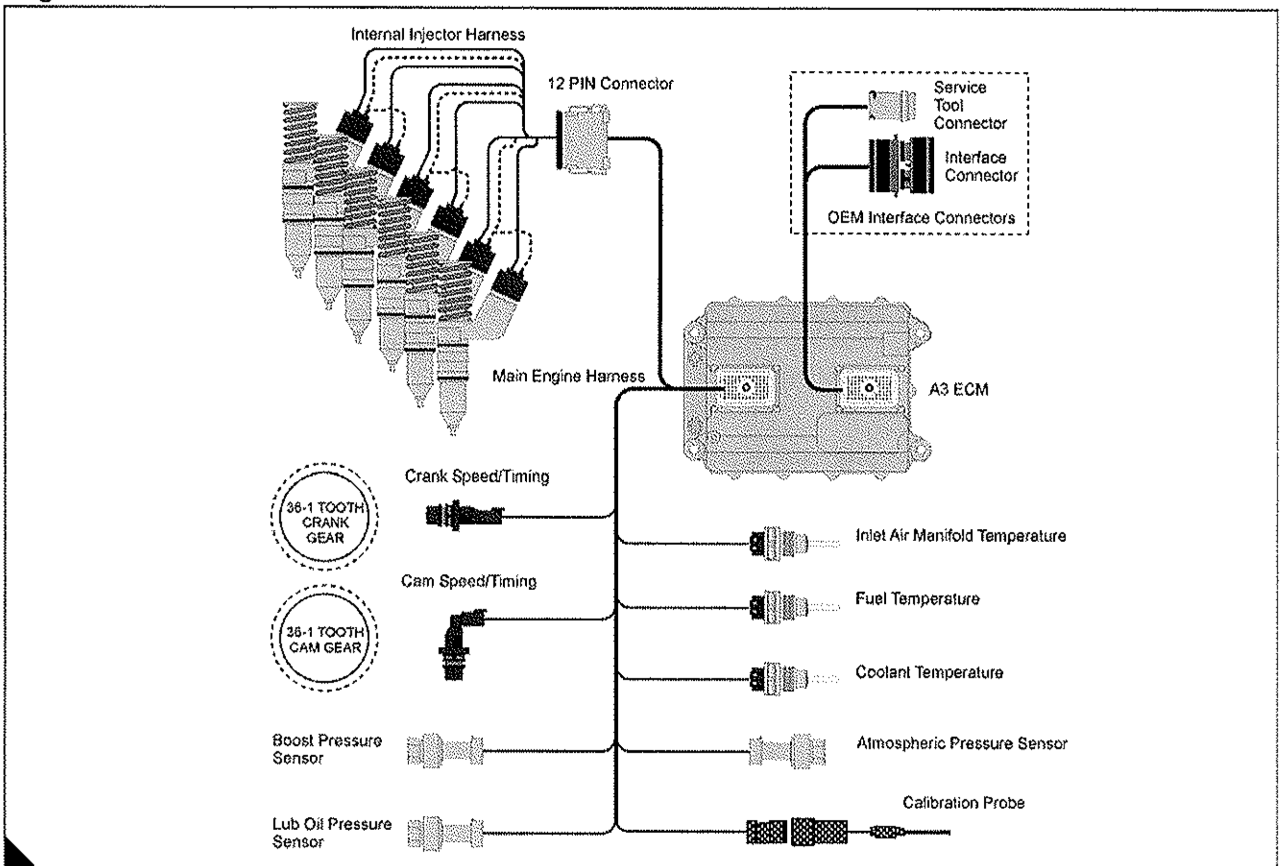
Engine Control Module (ECM)

The A3 ECM is based on the Motorola MC68336 processor. The ECM is fixed directly to the engine on vibration isolating mounts. The ECM is a sealed unit and contains no customer serviceable parts. It has two 70-pin connectors into which the engine harness and the OEM harness are connected. Inputs and outputs to the OEM system are normally routed though the 'machine interface connector' on the engine harness.

Engine harness

The only electrical interface for the customer is the machine interface connector. It is not acceptable for the engine installer to splice into, or change, the engine harness or sensors in any way.

Engine hardware



Engine Hardware

Engine sensors

Intake manifold pressure sensor

This is an active sensor with an output between 0 and 5 volts. The ECM will recognise the output to be valid (OK) if it is between 0.5 volts (representing a pressure of 52 kPa Abs) and 4.5 volts (472 kPa Abs).

Sensor diagnostics will detect a fault if the input voltage is outside this range for more than 2 seconds continuously.

Intake manifold temperature sensor

This is a thermistor type sensor with an output between 0 and 5 volts. The ECM will recognise the output to be valid (OK) if it is between 0.2 volts (representing a pressure of -40 °C) and 4.9 volts (+150 °C).

Sensor diagnostics will detect a fault if the input voltage is outside this range for more than 2 seconds continuously.

Engine oil pressure sensor

This is an active sensor with an output between 0 and 5 volts. The ECM will recognise the output to be valid (OK) if it is between 0.5 volts (representing a pressure of 106 kPaA) and 4.5 volts (795 kPaA).

Sensor diagnostics will detect a fault if the input voltage is outside this range for more than 8 seconds continuously.

Engine coolant temperature sensor

This is a thermistor type sensor with an output between 0 and 5 volts. The ECM will recognise the output to be valid (OK) if it is between 0.2 volts (representing a pressure of -40 °C) and 4.9 volts (+150 °C)

Sensor diagnostics will detect a fault if the input voltage is outside this range for more than 8 seconds continuously.

Camshaft position sensor (engine speed and timing)

This is a magnetic type sensor that measures both camshaft speed and position. The sensor will measure speeds when the output is greater than 0.4 V peak to peak. The sensor detects the passing of teeth on a wheel. These teeth are spaced occupy 1/36 of the circumference of the wheel. One additional tooth facilitates the position measurement, so there are a total of 37 teeth.

Crankshaft position sensor (engine speed and timing)

This is a magnetic type sensor that measures both crankshaft speed and position. The sensor will measure speeds when the output is greater than 0.4 V peak to peak. The sensor detects the passing of teeth on a wheel. These teeth are spaced occupy 1/36 of the circumference of the wheel. One tooth is missing to facilitate the position measurement, so there are a total of 35 teeth.

Calibration sensor

This sensor is only fitted when timing calibration of the system is required in service.

Communications connector

A communications connector is available on the engine harness (certain engines may not have this facility). This allows connection of diagnostic service tool to the PDL without disconnecting the main harness.

The 9 pin connector fitted to the engine harness will be of Deutsch type HD10-9-96P-B009. The connector required on a service tool is therefore a Deutsch HD16-9-96S.

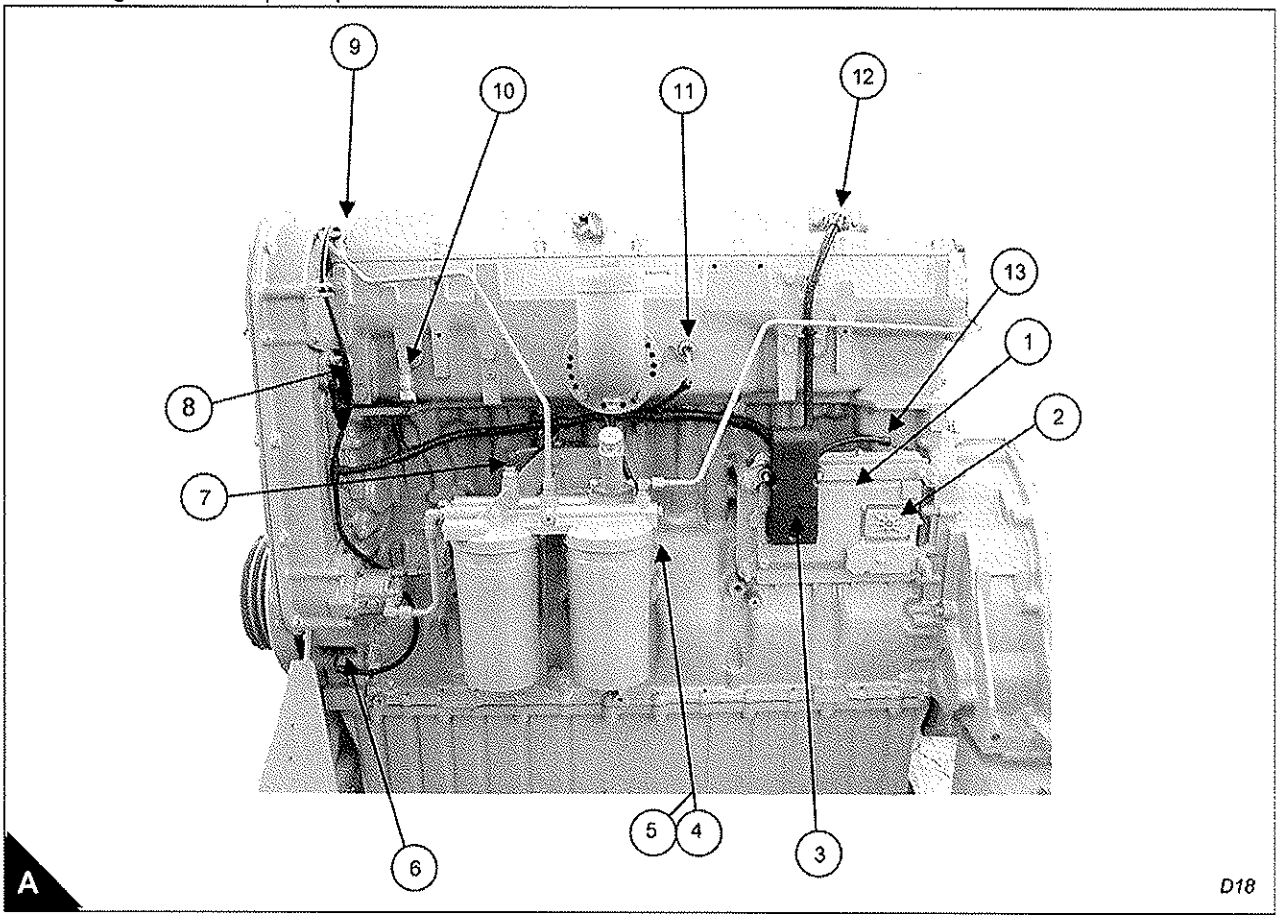
The pin allocations are as follows:

Pin	Description
A	Battery +
B	Battery -
C	CAN screen
D	PDL +
E	PDL -
F	CAN -
G	CAN +
H	J1587 - (not connected)
J	J1587 + (not connected)

Note: Although the communications connector looks very similar to the industry standard J1939 connector, it is wired to the Perkins standard. If equipment from any other manufacturer is plugged in, it may cause damage.

Sensor and connector location diagram

1 Electronic Control Module (ECM)
2 J1/P1 Machine connector
3 J2/P2 Engine connector
4 Atmospheric pressure sensor
5 Oil pressure sensor
6 Crankshaft position sensor
7 Fuel temperature sensor
8 Camshaft position sensor
9 Coolant temperature sensor
10 Boost pressure sensor
11 Intake manifold air temperature sensor
12 Electronic unit injector connector
13 Timing calibration pick-up connector



5B

Digital communications

Supported links

Perkins Data Link (PDL)

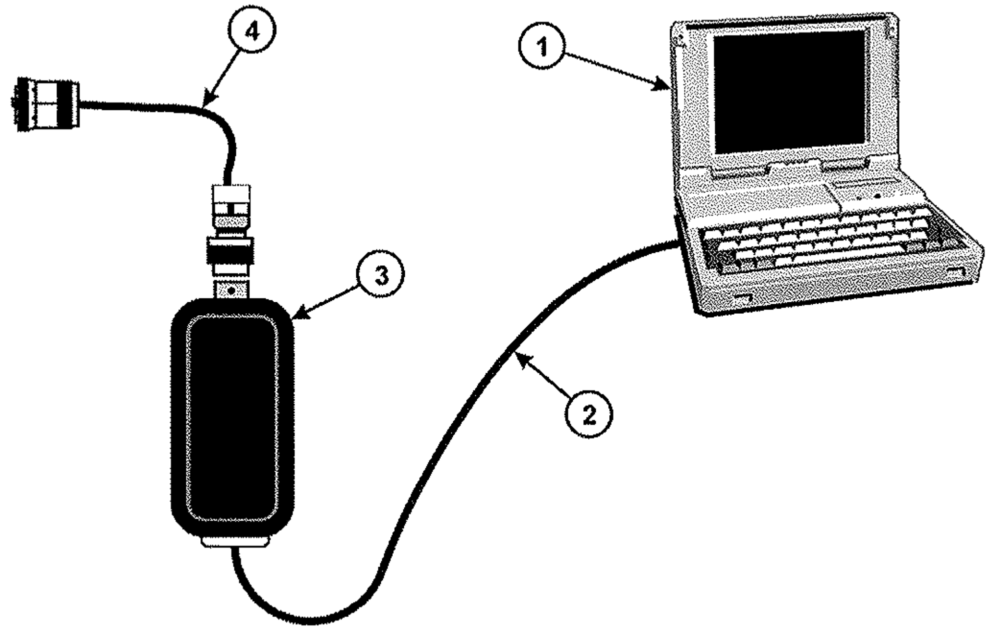
A proprietary communications protocol is used to communicate with the Perkins EST. It may also be used to communicate with other compatible devices.

J1939 link for machine control and customer diagnostics

The J1939 link is used for the hand held Diagnostic Code Reader and may be used to communicate with other compatible devices.

Diagnostic and configuration tools

Electronic Service Tool (Perkins EST):
1 PC with TIPSS-EST software
2 RS232 cable
3 Communications adaptor
4 Service tool harness



A

D15

This tool is designed for use on a laptop computer to communicate with the ECM via a communications interface. The following functions are available on the electronic service tool:

Active diagnostic codes

Provides information to warn the operator of a potential problem and indicates to the service technician the nature of the problem.

Logged diagnostic codes

Provides a list of diagnostic codes logged by the ECM. These codes are similar to the active diagnostic codes except they are logged over time.

Logged event codes

Provides a list of event codes logged by the ECM.

These codes indicate to the manager or technician how the machine/equipment is being operated. These codes are similar to the logged diagnostic codes, except that the event represents the symptom of the operational problem.

File manager

Displays file names and descriptions and allows access to data saved.

Status tool

The status tool monitors ECM data as it occurs. When running the Status tool for the first time, you must select a group of parameters to monitor.

Summary screen

The ECM Summary screen allows you to view all of the useful ECM and Perkins EST software information.

This screen is automatically displayed each time that you start Perkins EST or establish a new connection through the Connect function under the Data Link menu.

Totals

The Totals screen allows you to view the current total values for the different parameters listed.

Data log recorder

Data log recorder allows you to capture or log performance data, which aids in diagnosing potential problems. Includes a pre-trigger capture of data and an auto-trigger capture when specific conditions occur.

Data log viewer

Data log viewer allows you to either view the logged data from data log recorder graphically or export the file to view as a *.txt file.

Real time graphing

Real time graphing monitors ECM data and displays it in graphical form as it occurs.

When running real time graphing for the first time, you must select a set of parameters to graph.

Configuration tool

The configuration tool allows you to view and change the ECM's configurable information

The ECM replacement function

The ECM replacement function allows you to copy configuration parameters from an existing ECM to another ECM, for physically changing the ECM on a machine.

Once an ECM has been programmed by the ECM replacement function, the data on the screen is cleared. This keeps you from programming more than one ECM with the data from another ECM

WinFlash

The WinFlash program enables the service technician to program the flash memory of onboard ECMs. Selecting this menu option initiates the Perkins EST WinFlash program.

This program also runs from the Perkins EST group box in Windows.

Further information

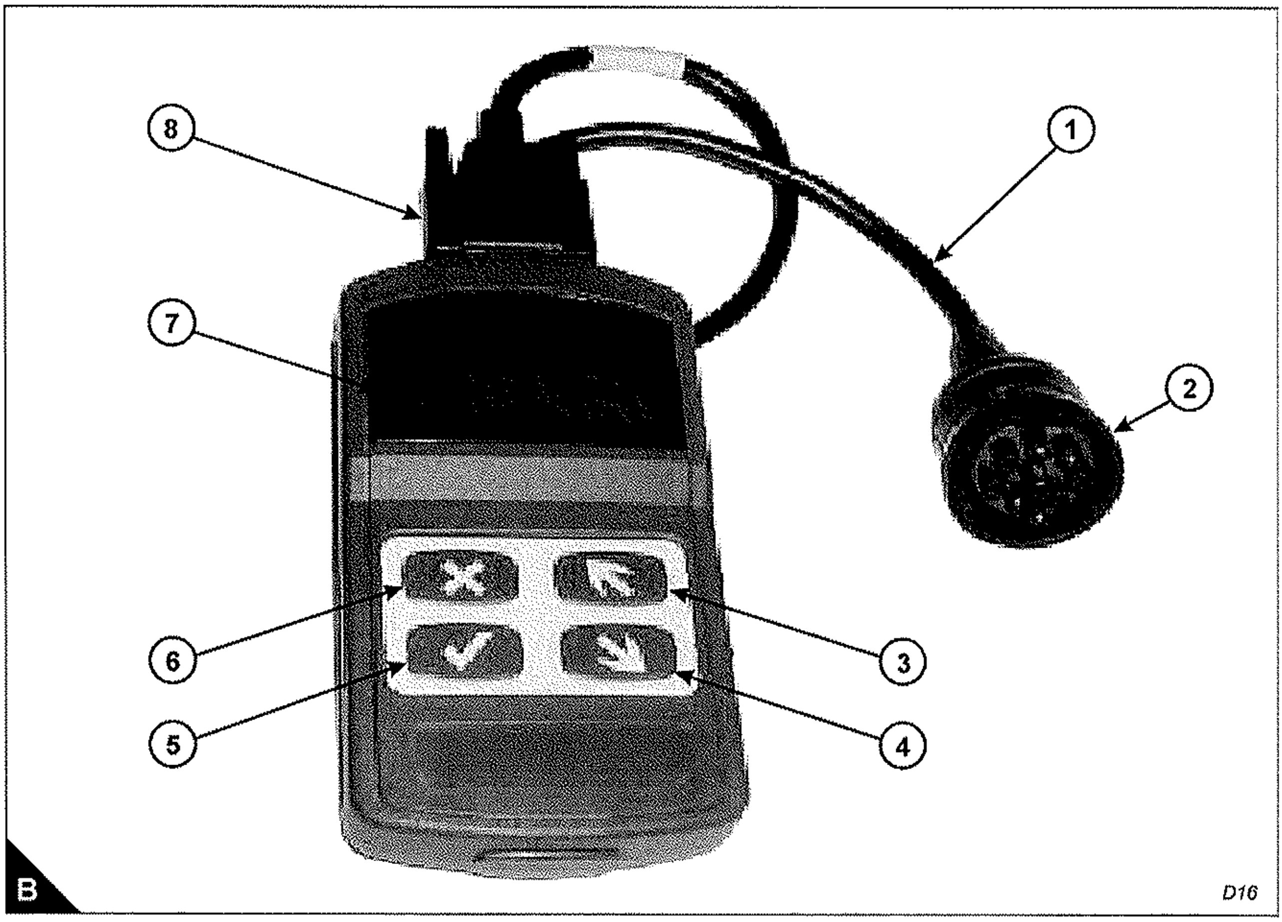
Refer the Perkins EST service tool manual.

Diagnostic code reader

The Diagnostic Code Reader is a self contained hand held device for basic diagnostics.

It communicates via the CAN bus and can:

- Read the Active diagnostic fault codes from the engine
- Read limited engine parameters
- Show the status of the warning lamps.



Diagnostic code reader with connection cable

Components (B)

1 Connection cable
2 Deutsch plug
3 Control key
4 Control key
5 Control key
6 Control key
7 Display screen
8 Connection plug

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6B

Power supply, grounding and power supply protection

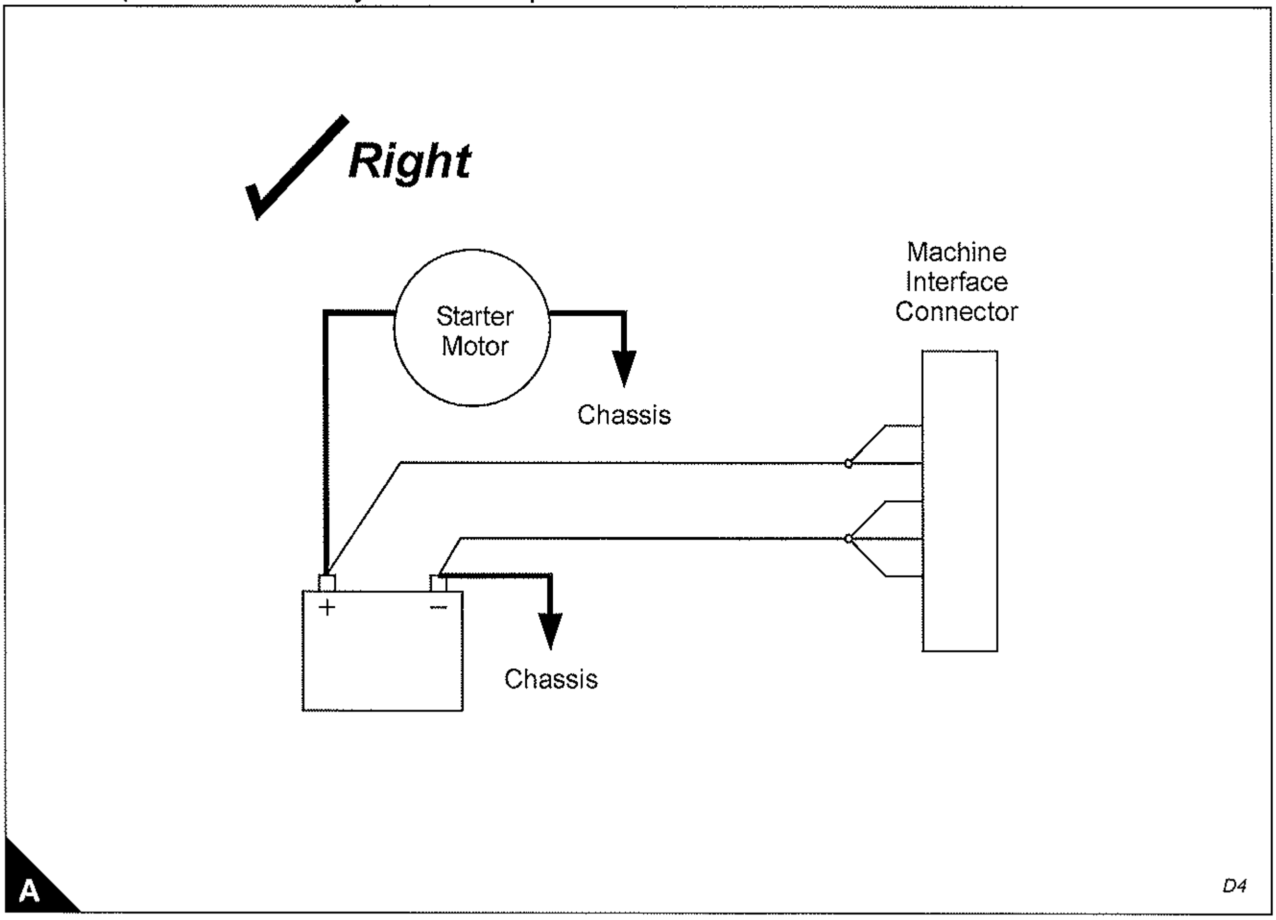
Voltage and current requirements

General power supply requirements of the ECM

Note: The ignition key switch does not cut the power supply to the ECM. The ECM operates in sleep mode when the ignition key switch is OFF.

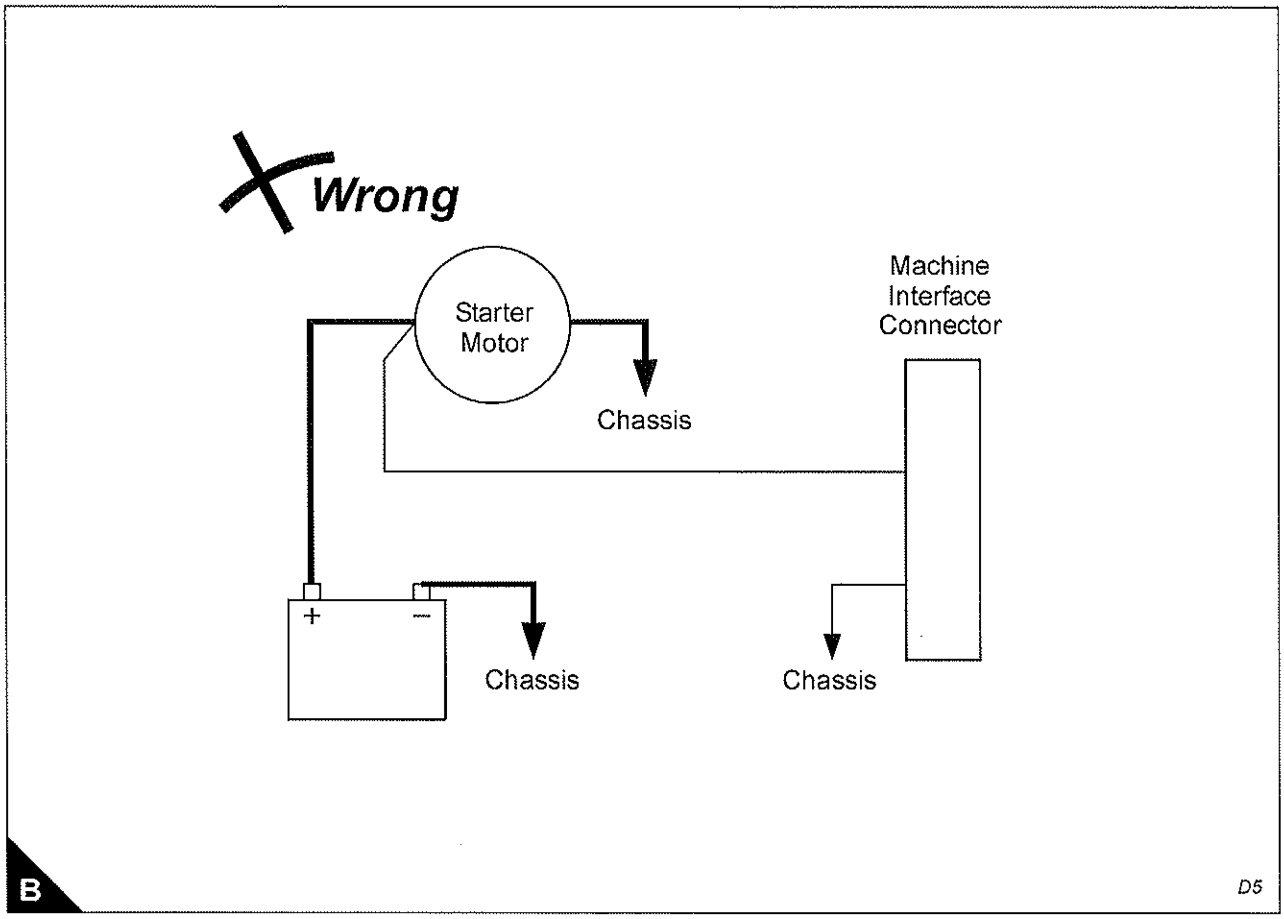
The ECM is capable of withstanding the normal temporary under-voltage power supply situations that can occur during starting/cranking. Attention should be given, however, to the correct battery rating and to the correct cable sizing. The power supply to the ECM should preferably be taken from the battery and not from the starter motor terminals. The reason for this is that there is a voltage drop across the starter motor cable.

Note: Where there is more than one Machine Interface Connector pin designated for a power supply function, then all pins MUST be connected. For example ECM battery positive supply is on J1 pins 48, 52 and 53. It is **NOT** acceptable to wire to only one of these pins.



- Positive wires connected direct to battery, not via starter motor.
- Power supply wires go to three positive pins and three negative pins on the MIC.
- Negative is wired to the battery rather than return through chassis.

Continued



- Positive wired via starter motor. High volt drop to ECM on starting.
- Single pin on ECM used for each of positive and negative supply. Possibly exceeding pin ratings and possibly causing risk of arcing or over heating.
- Return through chassis - risk of conducted noise and also additional voltage drop.

24V applications

For 24V applications the supply voltage should be in the range 18V to 32V although at an ambient temperature of 25 °C the ECM will survive for at least 2 minutes on a supply voltage of 48V. The normal maximum current draw current draw of the ECM in a typical application will be 4 Amps. The ECM current draw in sleep mode will not exceed 10 mA.

Circuit breaker

A 16 amp circuit breaker must be provided by the OEM to protect Perkins supplied hardware.

Welding - Warning

Welding can cause damage to the on-engine electronics. The following precautions should be taken before and during welding.

- Turn the engine off.
- Disconnect the negative battery terminal from the battery. If the machine is fitted with a battery disconnect switch then open the switch.
- If welding to the engine, then remove the ECM.
- If welding onto the machine chassis then ensure that the earth clamp is placed as close to the welding point as possible and NOT near the ECM.
- If it is necessary to weld near to the ECM mounting point, remove the ECM from the engine to avoid damage by radiation from the welding arc.

Electrostatic paint spraying - Warning

The high voltages used in electrostatic paint spraying can cause damage to on-engine electronics. The damage can manifest itself through immediate failure of components, or by weakening electronic components causing them to fail at a later date.

The following precautions should be taken when using electrostatic paint spraying techniques on engines.

- Connect all pins of the chassis connector directly to the spraying booth ground.
- Connect the engine block to ground at 2 points. Ensure that good screwed connections onto bright metal are used.

Jump starting - Warning

Jump starting an engine can cause higher than normal voltages to appear across the battery terminals. Care must be taken that this does not exceed the recommended maximum voltage for the ECM used.

Charging alternator voltage surges on “load dump”

In certain conditions, if the battery charging alternator accidentally becomes disconnected from the battery during operation, voltages spikes of around 200 volts may occur. Voltage spikes of this size may damage the on-engine electronics and therefore must be eliminated at source.

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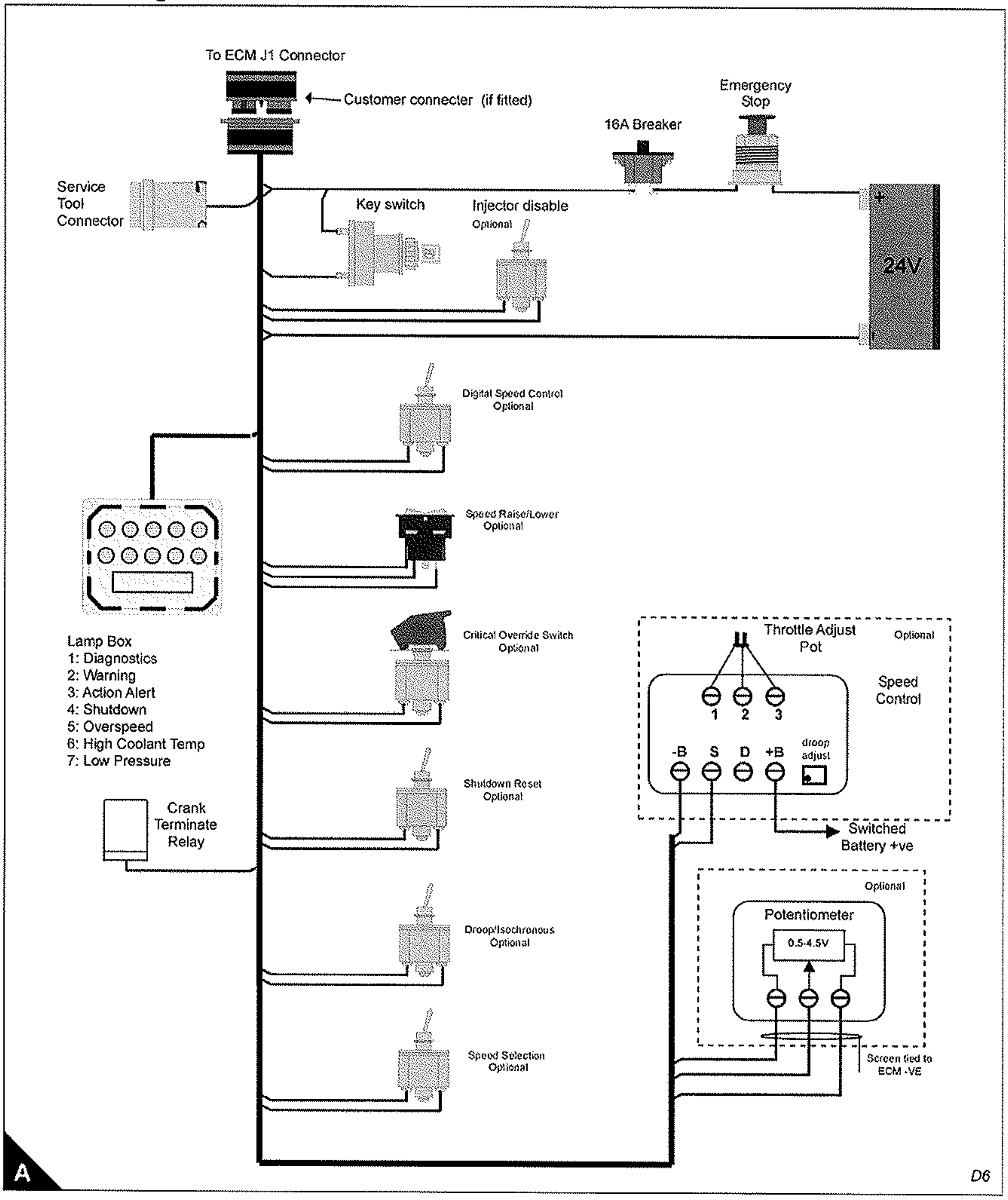
7B

Machine harness

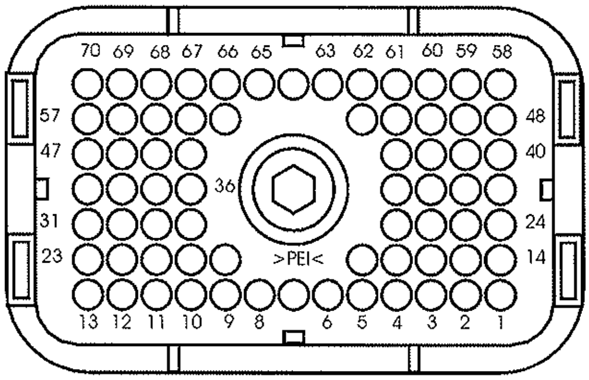
Interface diagram



Connectors - engines NOT fitted with a machine interface connector

The ECM J1 connector is the only connection between the machine harness and the engine system.

The diagram (A), which is not to scale, shows the pin positions of the AMP connector when viewed from the wire entry side.



A

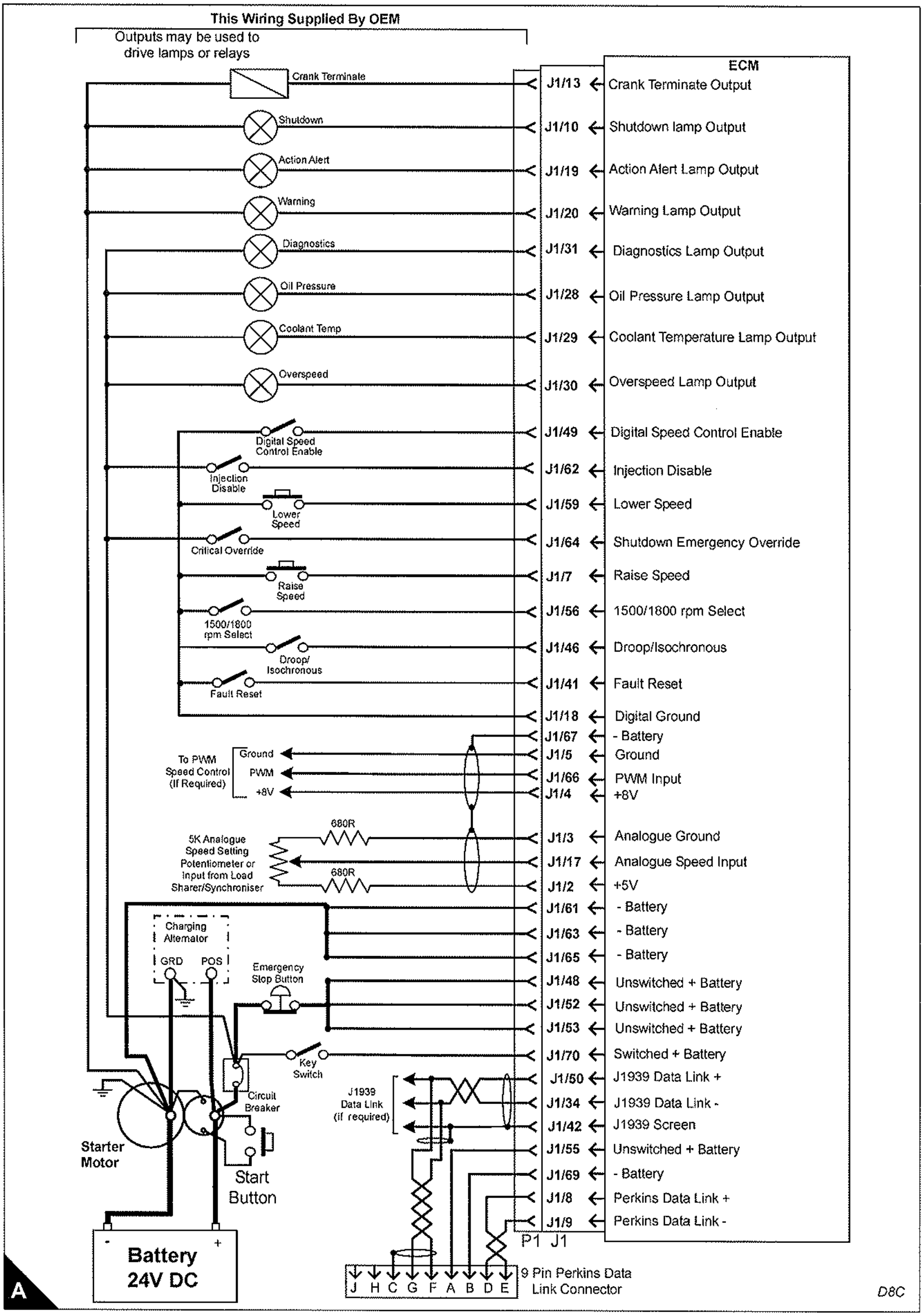
Wire side

D7

Colour coding for connection diagrams

Key letter	Colour
N	Brown
U	Blue
R	Red
P	Purple
G	Green
W	White
Y	Yellow
B	Black
O	Orange
K	Pink
A	Grey

OEM connection diagram



Connectors - engines fitted with a machine interface connector

The engine is supplied with a harness connecting the ECM J1 connector to a Deutsch DRC12-40PA connector and a communications connector.

A matching connector for OEM wiring is required, complete with pins. The connector pins must be crimped to the interconnecting wires using an approved tool and the pins inserted into the connector in the correct positions. The crimping tool is available as part of a Harness Service Kit available from Perkins.

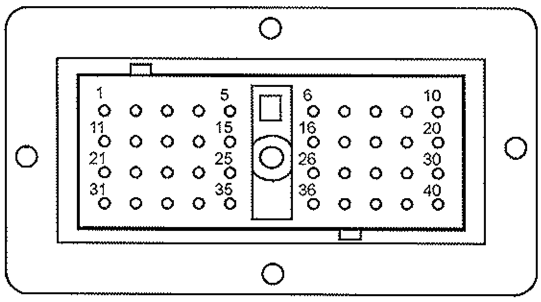
Note: The pins must NOT be soldered to the wires.

The connector is designed so that the wires are automatically sealed from moisture when inserted so it is not essential they be enclosed. However, better mechanical protection is achieved if the wires are enclosed in conduit.

For pin designation please refer to (A).

Refer to the Deutsch DRC Series Technical Manual for more information relating to the specification, application and fitting of this connector.

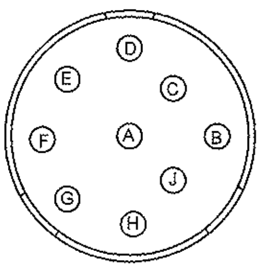
Machine interface connector



A

D9

Communication connector



Deutsch 9 Pin Perkins Data Link Connector

B

Pin allocation for communications connector

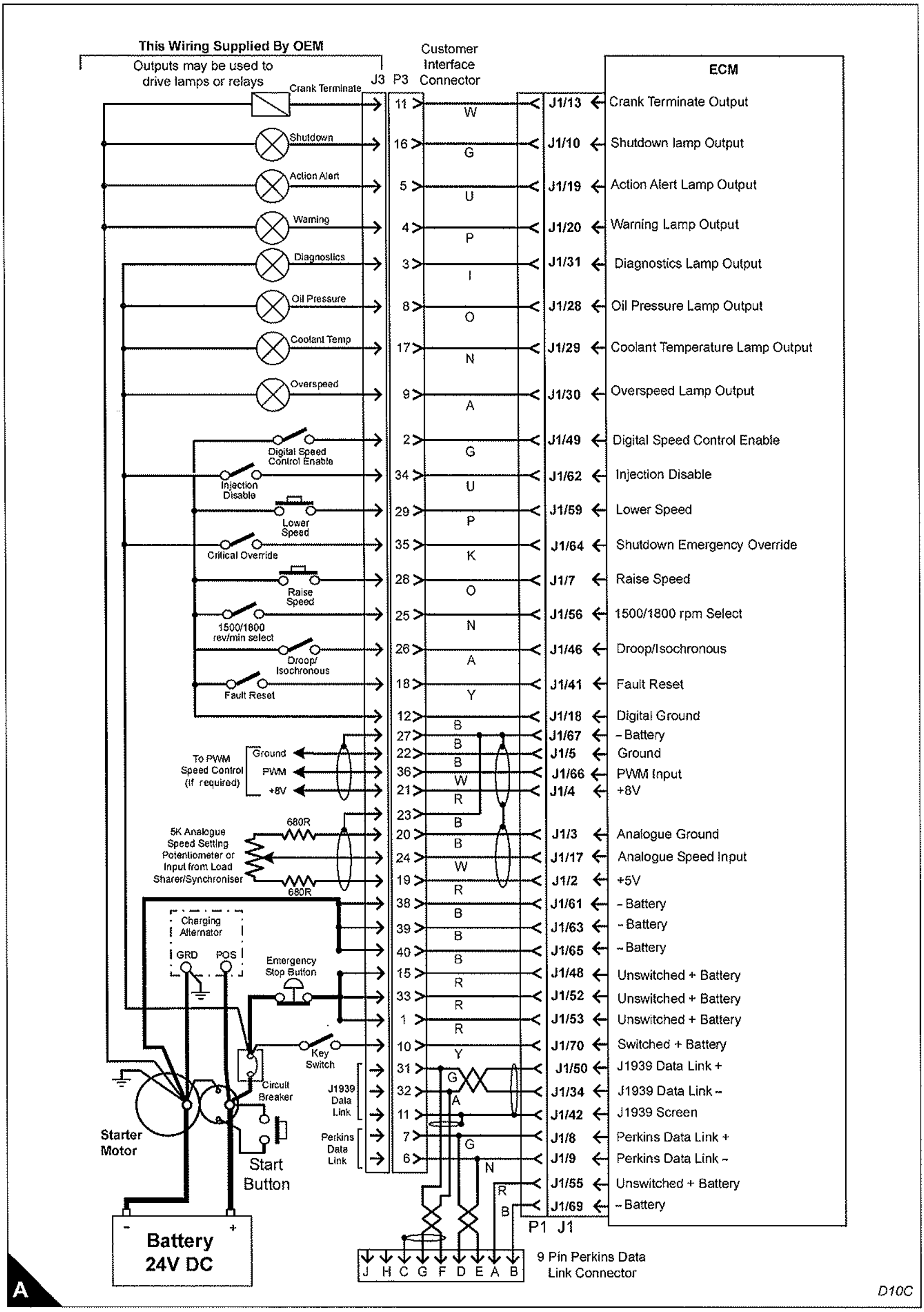
Pin No.	Description
A	Battery +
B	Battery -
C	CAN Bus Screen
D	Perkins Data Link +
E	Perkins Data Link -
F	J1939 CAN -
G	J1939 CAN +
H	Not used
J	Not used

Note: Only the connections required for the application will be used.

D17

Note: Although the communications connector (B) looks very similar to the industry standard J1939 connector, it is wired to the Perkins standard. If you plug in equipment from any other manufacturer, it may cause damage.

Machine wiring schematic (all options)



Harness wiring standards

General recommendations for machine wiring harnesses

The following is general "good practice" for wiring harnesses. These do not replace in any way any industrial standards or requirements of legislation:

- Connectors should be horizontally mounted rather than vertically mounted to prevent ingress of water/ chemicals.
- Wires should not bend too close to the seals of connectors. Bends can prevent good sealing.
- Use the correct diameter of wire for the seals.
- Wires should not be so tight that they put strain on connectors, but nor should they be so slack that they can flap, or can easily get caught.
- Ideally, harnesses should not rub at all. The only points of contact should be clamps and connectors. If this is not possible then as a minimum they should not touch components which are hot, which move or vibrate, or which have sharp edges.
- If screened cable is used, the screens should be connected to ground at one point only.
- Conductors carrying high currents, particularly when these are AC or switched currents should be physically separated from conductors carrying small signal currents.
- Pins to the Machine interface connector that are not used in an application should not be used. This will help to prevent these conductors acting as aerials.
- If the length of the machine harness (i.e. engine to control panel) is greater than 2 metres, it is recommended that the complete harness be screened to ensure EMC compliance.

Cable sizes

All wiring should be a minimum of 1,0 mm^2 cross sectional area flexible cables, with the exception of the speed control screened cable which should be a minimum of 16/0,2 mm stranded conductors.

Screened cables MUST be used for the speed control input and it is recommended that the remaining cables have an over-all screen in order to ensure EMC compatibility.

Wiring layout

The wiring between the engine and the OEM's panel must be laid well away from any power cables to avoid interference pick-up. The cables must have adequate mechanical protection and should be supported adjacent to the connector to prevent strain and movement.

Battery cables

The battery cables must have a total minimum cross sectional area of 70 mm^2 for a maximum length of 6 metres.

Twisted pair cables

Twisted pair type cables should be used for digital communication signals (PDL and CAN). If cable runs are long, or the application requires a high immunity to electromagnetic interference, then screened cable should be considered.

For twisted pair cables there should be a minimum of 1 twist per 25 mm (1 inch).

Speed control hardware

Either a digital (push-button), an analogue or a Pulse Width Modulation (PWM) speed setting system may be used. The method of speed control is selected using the service tool.

If no external speed control is required and the digital speed control option is installed, the 'Digital Speed Control Enable' Switch input pins should be open circuit and speed will then be fixed at the selected value i.e. 1500 rev/min or 1800 rev/min.

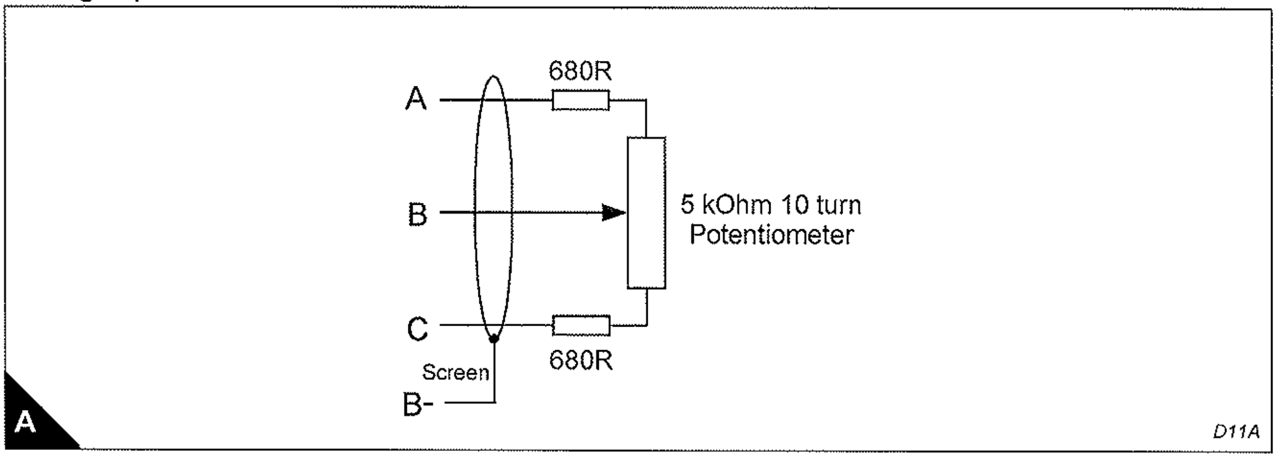
Analogue speed control potentiometer or speed signal

Optional component requirements

An analogue potentiometer may be used for speed control. The configuration is as the diagram below.

The cable to the potentiometer MUST be screened.

Analogue potentiometer connections



Key	Terminal description	Connection to ECM
A	5Vdc Supply from the ECM	VS_5_200MA
B	Accelerator position output	Analogue Input 2
C	Return 0V	VS_RETURN

Electrical requirements

The potentiometer should be mounted OFF the engine and wired such that the output voltage increases for desired speed increase.

A potentiometer of no greater than 5 kΩ should be used. The potentiometer should have a linear resistance characteristic (position proportional to output voltage).

To avoid noise, the return path must be to the analogue ground and not via the chassis and the cable MUST be screened.

Diagnostic zones

There is a diagnostic zone at both min and max travel where the ECM can detect if the speed input has a short circuit/open circuit on any connection. To achieve this the speed control output voltage at 100% should be less than 4.5V and the voltage at 0% demand should be greater than 0.5V. This requirement can be met by fitting resisters in series with the potentiometer (A).

Speed control range

The control range of the analogue speed input can be set using the service tool, maximum range +/- 150 rev/min.

PWM sensors for speed control

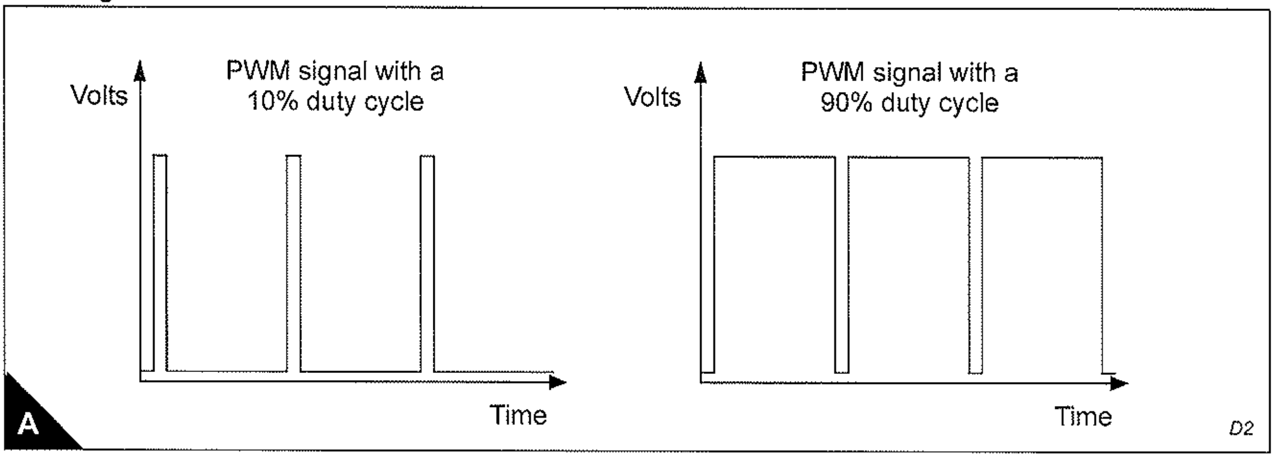
Optional function

The sensor output is a constant frequency signal whose pulse width (duty cycle) varies with desired speed. The PWM signal is expressed as a percentage (A).

This type of speed control is normally part of a load sharing/automatic synchronising system. The output is required to be 8V 500Hz with a PWM output from 5% min to 95% max duty cycle.

The speed control range of the PWM input is fixed at –24% to +8% of rated speed.

PWM signal



Digital speed control

Optional function

The digital speed control allows engine speed to be controlled from raise and lower speed control push-buttons or relay contacts. To enable digital speed control, the 'Digital Speed Control Enable' switch must be open.

The range of the digital speed control may be set using the service tool with a maximum speed range of +/- 150 rev/min.

When the digital speed control is enabled, the ECM defaults the desired engine speed to equal the rated speed, (1500/1800 rev/min). If the power is cycled to the ECM the digital speed control desired speed will revert to rated speed, i.e. on power cycle the ECM does not retain the previous set point speed.

Digital inputs

Ignition key switch

Optional but either an **ignition key switch** or a **fault reset switch** should be fitted to facilitate fault reset.

The ignition switch does not switch off power to the ECM. The ECM remains connected to the battery via a circuit breaker, even when the ignition is switched off.

The ECM does not have an output that controls the starter motor, so provision must be made by the Installer for the starter motor to be controlled by the ignition key switch where required.

The key switch should be wired in accordance with the appropriate diagram above.

The current ratings for the ignition switch contacts are dependent on the starter motor circuit design.

Injection disable

Required.

A switch connected to this input disables the injectors when the switch is open and is the preferred way of stopping the engine since it leaves the ECM fully powered up and able to communicate with the Service Tool. Switch to B+ to enable injection.

Fault reset

Optional - see ignition key switch above.

This switch is used for clearing faults after an engine shutdown, switch to ground for fault reset. Faults can also be cleared by turning the ignition switch to the OFF position.

The negative of this switch should be connected to the switch ground as shown in the diagrams. It should not be returned via the machine chassis ground.

Droop/isochronous

Optional.

Switch to ground for droop governing. Enabling of this switch input and percentage droop is set using the service tool.

The negative of this switch should be connected to the switch ground as shown in the diagrams. It should not be returned via the machine chassis ground.

1500/1800 rev/min selection

Optional.

Switch to ground to select 1800 rev/min. Enabling of this input is controlled via the service tool.

The negative of this switch should be connected to the switch ground as shown in the diagrams. It should not be returned via the machine chassis ground.

Digital speed control enable

Optional.

Input switch open to enable Digital Speed Control. This input should be linked to ground if analogue or PWM speed controls are required.

The negative of this switch should be connected to the switch ground as shown in the diagrams. It should not be returned via the machine chassis ground.

Raise speed

Optional.

Input for Raise Speed push-button or relay contact, connect other side of switch to ground. Only available when digital speed control is enabled.

The negative of this switch should be connected to the switch ground as shown in the diagrams. It should not be returned via the machine chassis ground.

Lower speed

Optional.

Input for Lower Speed push-button or relay contact, connect other side of switch to ground. Only available when digital speed control is enabled.

The negative of this switch should be connected to the switch ground as shown in the diagrams. It should not be returned via the machine chassis ground.

Critical override

Optional - requires factory approval for implementation.

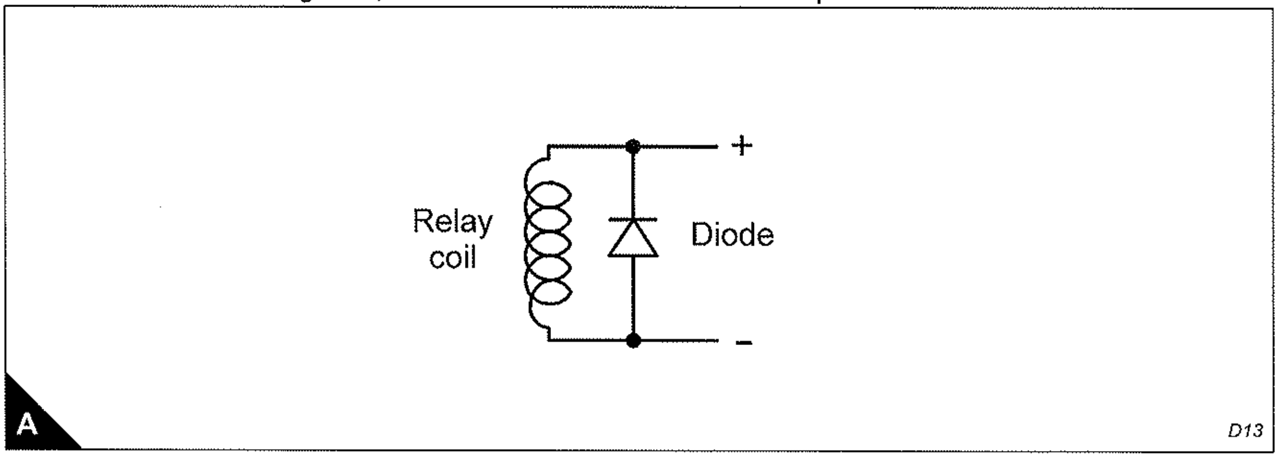
Input for Critical Override switch, open circuit for Critical Override (except Overspeed), connect to battery + to activate fault shutdowns. Only available when Critical Override is enabled via the service tool.

Digital outputs

The OEM connection diagrams show all of the digital outputs connected to lamps but they may alternatively be connected to relays or PLC inputs. If connected to relay coils, a diode must be connected across the relay coil to suppress any voltage spikes (A).

Notes:

- Use of the digital outputs is optional but if these outputs are left open circuit, this will be reflected in active diagnostics appearing on the Service Tool diagnostic screens.
- Also, if these outputs are used to feed LED indicators or inputs, the impedance of these loads maybe too high to prevent the ECM from diagnosing an open circuit condition and LED indicators may glow dimly when the output is off.
- To avoid incorrect diagnosis, the load resistance across these outputs should not exceed 5 kR.



Shutdown

This output is a high side driver (switches internally to B+), current rating 1.5 amp. The output is on when the engine is in the Shutdown condition (even when Critical Override is active).

Action Alert

This output is a high side driver (switches internally to B+), current rating 1 amp. The output is on when the engine is in the Action Alert condition. It will normally be used by the OEM to initiate a controlled shutdown of the equipment.

Warning

This output is a high side driver (switches internally to B+), current rating 1 amp. The output is on when the engine is in the Warning condition. It will normally be used by the OEM to alert the operator that the engine requires attention.

Diagnostic

This output is a low side driver (switches internally to ground), current rating 0.3 amp. The output is on when a diagnostic condition exists. It will normally be used by the OEM to alert the operator that the engine requires attention.

Oil pressure

This output is a low side driver (switches internally to ground), current rating 0.3 amp. The output is on when a low oil pressure condition exists. The relevant Warning, Action Alert or Shutdown output will also be active.

Coolant temperature

This output is a low side driver (switches internally to ground), current rating 0.3 amp. The output is on when a high coolant temperature condition exists. The relevant Warning, Action Alert or Shutdown output will also be active.

Overspeed

This output is a low side driver (switches internally to ground), current rating 0.3 amp. The output is on when an overspeed condition exists. The relevant Warning, Action Alert or Shutdown output will also be active.

Crank terminate

This output is a high side driver (switches initially to B+), current rating 1.5 amp. The output is on when the engine is above the crank terminate speed (programmable from the Service Tool). With the engine running, this output switches off when either the key/switch or injection disable switches are opened, or when the ECM shuts down the engine.

8B

Automatic synchronising and load sharing systems

For some synchronising and load sharing units, it will be necessary to use an interface module to convert the synchronising/load sharing units output signals into the 0.5 to 4.5 volt input signal required by the EMS analogue speed input. An example of a typical automatic synchronising and load sharing system using an interface unit (A).

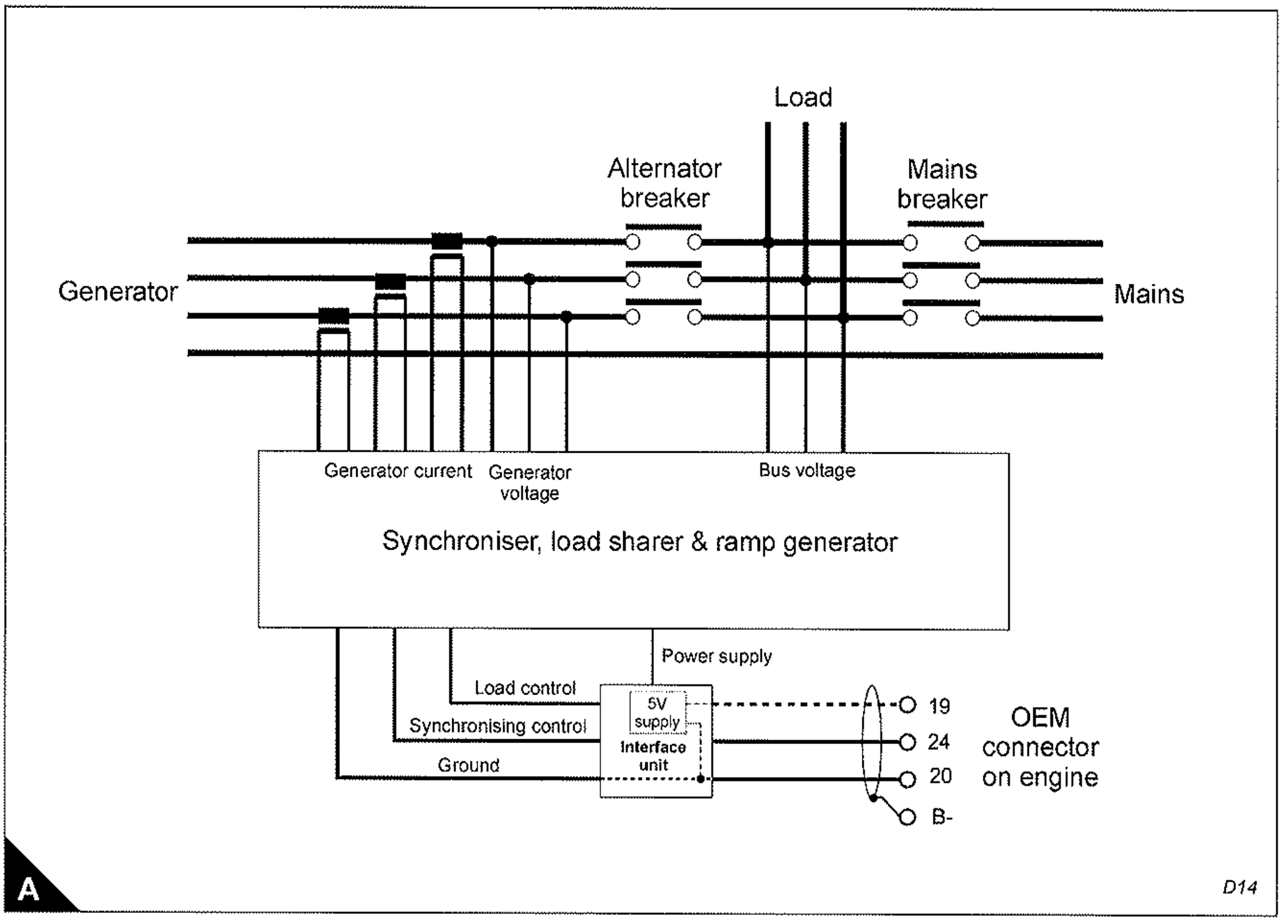
The load sharing system should be equipped with a ramp generator to ensure that the load is applied slowly to limit any load overshoot which may occur on start-up.

The interface unit must have the following functionality:

- Nominal output of 0.5 to 4.5 volt for full speed control.
- A preset potentiometer to enable the correct output voltage to be set to give an engine speed of 1500 rev/min or 1800 rev/min at no load.
- When being driven by the synchroniser or load sharing unit, a minimum change in output of +/- 500 mV from the preset speed rev/min steady state output voltage to ensure adequate speed or load response from the engine.
- For optimum stability, the interface unit should contain its own 5 volt regulated supply from which the speed reference is derived. If this is provided, it is not necessary to utilise the 5 volt supply from the ECM.

Note: The cable to terminal 19 of the OEM connector is not required if the interface unit has its own 5 volt reference supply.

Typical synchronising/load sharing and interface diagram



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9B

Glossary

Glossary of terms

ECM

Engine Control Module.

CAN

A Communications protocol - there are several variants of the CAN protocol. J1939 will be used in the future by the ECM to communicate with service tools and displays.

EMC

Electromagnetic compatibility. Electronic devices must comply with international standards for emissions of, and susceptibility to, radiated noise.

FMI

Failure Mode Identifier (SAE J1939 terminology).

OEM

The person or organisation who install the engine into a machine.

J1939

A communications protocol developed by SAE - Operates over CAN.

J1587

A communications protocol developed by SAE. It is not used on this engine but the document is referenced.

Machine

Is used to mean the application for which the engine is used.

PDL

Perkins Data Link.

PGN

Parameter Group Number.

SAE

Society of Automotive Engineers.

SPN

Suspect Parameter Number (SAE J1939 terminology).

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10B

J1939 Supported parameters

The data transmitted on the J1939 bus is in the format described in the SAE documents J1939-71 (for the opening parameters) and J1939-73 (diagnostic information). For more detail please refer to the SAE specifications.

Engine parameters - J1939-71

Electronic engine controller #1: EEC1	
Transmission repetition rate	Engine speed dependent
Data length	8 bytes
Data page	0
PDU format	240
PDU specific	4
Default priority	3
Parameter group number	61 444 (00F004 $_{16}$)
Byte: 4,5 Engine speed	
SPN	190
Resolution - lower byte	0.125 rev/min per bit gain, 0 rev/min offset
Resolution - upper byte	32 rev/min per bit
Data range	0 to 8031.875 rev/min
PDL PID	$0040

Electronic engine controller #3: EEC3	
Transmission repetition rate	250 ms
Data length	8 bytes
Data page	0
PDU format	254
PDU specific	223
Default priority	6
Parameter group number	65 247 (00FEDF $_{16}$)
Byte: 2,3 Engine's desired operating speed	
SPN	515
Resolution - lower byte	0.125 rev/min per bit gain, 0 rev/min offset
Resolution - upper byte	32 rev/min per bit
Data range	0 to 8031.875 rev/min
PDL PID	$0046

Engine hours	
Transmission repetition rate	On request
Data length	8 bytes
Data page	0
PDU format	254
PDU specific	229
Default priority	6
Parameter group number	65 253 (00FEE5 $_{16}$)
Bytes: 1 to 4 Total engine hours	
SPN	247
Resolution	0.05 h/bit gain, 0 offset
Data range	0 to 210,554,060.75 hours
PDL PID	$005E

Engine temperature	
Transmission repetition rate	1 s
Data length	8 bytes
Data page	0
PDU format	254
PDU specific	238
Default priority	6
Parameter group number	65 262 (00FEEE $_{16}$)
Byte: 1 Engine coolant temperature	
SPN	110
Resolution	1 °C/bit gain, -40 °C offset
Data range	-40 to 210 °C
PDL PID	$0044
Byte: 2 Fuel temperature	
SPN	174
Resolution	1 °C/bit gain, -40 °C offset
Data range	-40 to 210 °C
PDL PID	$F51D

Continued

Engine fluid level/pressure	
Transmission repetition rate	0.5 s
Data length	8 bytes
Data page	0
PDU format	254
PDU specific	239
Default priority	6
Parameter group number	65 263 ($00FEEF_{16}$)
Byte: 4 Engine oil pressure	
SPN	100
Resolution	4 kPa/bit gain, 0 offset
Data range	0 to 1000 kPa
PDL PID	$0054

Fuel economy	
Transmission repetition rate	100 ms
Data length	8 bytes
Data page	0
PDU format	254
PDU specific	242
Default priority	6
Parameter group number	65 266 ($00FEF2_{16}$)
Byte: 1, 2 Fuel rate	
SPN	183
Resolution	0.05 l/h per bit gain, 0 offset
Data range	0 to 3212.75 l/h
PDL PID	$F525
Byte: 7 Throttle position	
SPN	51
Resolution	0.4%/bit gain, 0% offset
Data range	0 to 100%
PDL PID	$0015

Continued

Ambient conditions	
Transmission repetition rate	1 s
Data length	8 bytes
Data page	0
PDU format	254
PDU specific	245
Default priority	6
Parameter group number	65 269 ($00FEF5_{16}$)
Byte: 1 Barometric pressure	
SPN	108
Resolution	0.5 kPa/bit gain, 0 kPa offset
Data range	0 to +125 kPa (0 to +18.1 lb/in^2)
PDL PID	$0053

Inlet/exhaust conditions	
Transmission repetition rate	0.5 s
Data length	8 bytes
Data page	0
PDU format	254
PDU specific	246
Default priority	6
Parameter group number	65 270 ($00FEF6_{16}$)
Byte: 2 Boost pressure	
SPN	102
Resolution	2 kPa/bit gain, 0 offset
Data range	0 to 500 kPa
PDL PID	$0055
Byte: 3 Intake manifold 1 temperature	
SPN	105
Resolution	1 ^{o}C/bit gain, -40 ^{o}C offset
Data range	-40 to 210 ^{o}C
PDL PID	$F511

Vehicle electrical power	
Transmission repetition rate	1 s
Data length	8 bytes
Data page	0
PDU format	254
PDU specific	247
Default priority	6
Parameter group number	65 269 ($00FEF7_{16}$)
Byte: 5, 6 Electrical potential (voltage)	
SPN	168
Resolution	0.05 V/bit gain, 0 V offset
Data range	0 to +3212.75v
PDL PID	$F013

Electronic engine controller #4: EEC4	
Transmission repetition rate	On request
Data length	8 bytes
Data page	0
PDU format	254
PDU specific	190
Default priority	7
Parameter group number	65 214 ($00FEBE_{16}$)
Byte: 3, 4 Rated engine speed	
SPN	189
Resolution	0.125 rev/min per bit gain, 0 offset
Data range	0 to 8031.875 rev/min
PDL PID	$F85C hh

Diagnostic codes J1939-73

The diagnostic codes that will be supported by the ECM will be the DM1, DM2 and DM3 sections of the SAE J1939-73 specification.

See Appendix A for details of diagnostic codes supported.

4.1.1 DM1 - Active diagnostic trouble codes	
Transmission repetition rate	Variable - refer to J1939-73
Data length	Variable - refer to J1939-73 and J1939-23
Data page (DP)	0
PDU format (PF)	254
PDU specific (PS)	202
Default priority (P)	6
Parameter group number (PGN)	65 226 (FECA)
Byte 1 - Lamp status	
Bits 8-7 Malfunction indicator lamp	01=ON, 00=OFF PDL PID $F264
Bits 6-5 Red stop lamp	01=ON, 00=OFF PDL PID $F2B3
Bits 4-3 Amber warning lamp	01=ON, 00=OFF PDL PID $F038
Bits 2-1 Protect service lamp	01=ON, 00=OFF PDL PID $F316
Byte 3 - SPN Least significant bits	
Bits 8-1 SPN, 8 least significant bits (most significant at bit 8)	
Byte 4 - SPN Second byte	
Bits 8-1 SPN, second byte (most significant at bit 8)	
Byte 5 - SPN (3 most significant bits) and FMI	
Bits 8-6 SPN, 3 most significant bits (most significant at bit 8)	
Bits 5-1 FMI (most significant at bit 5)	0 to 31
Byte 6 - SPN conversion method and occurrence count	
Bit 8 SPN conversion method	ECM uses 1
Bits 7-1 Occurrence count	0 to 126 (127 = not available)

Appendix A - Diagnostic codes

J1939 SPN-FMI	Diagnostic code description
J0651-11	Injector cylinder No1 fault
J0652-11	Injector cylinder No2 fault
J0653-11	Injector cylinder No3 fault
J0654-11	Injector cylinder No4 fault
J0655-11	Injector cylinder No5 fault
J0656-11	Injector cylinder No6 fault
J0678-3	ECM 8 volt DC supply voltage above normal or shorted high
J0678-4	ECM 8 volt DC supply voltage below normal or shorted low
J0091-8	PWM Throttle position sensor abnormal signal
J0100-3	Engine oil pressure sensor shorted high
J0100-4	Engine oil pressure sensor shorted low
J0110-3	Engine coolant temperature sensor shorted high
J0110-4	Engine coolant temperature sensor shorted low
J0168-2	Battery voltage intermittent
J0172-3	Inlet manifold air temperature sensor shorted high
J0172-4	Inlet manifold air temperature sensor shorted low
J0174-3	Fuel temperature sensor shorted high
J0174-4	Fuel temperature sensor shorted low
J0190-2	Engine speed sensor loss of signal
J0190-11	Engine speed sensor mechanical fault
J0234-2	Incorrect ECM software
J0228-13	Engine timing calibration required
J0620-3	5 volt sensor power supply, voltage above normal or shorted high
J0620-4	5 volt sensor power supply, voltage below normal or shorted low
J1111-2	Check configurable parameters
J0102-3	Turbocharger outlet pressure sensor shorted high
J0102-4	Turbocharger outlet pressure sensor shorted low
J0108-3	Atmospheric pressure sensor shorted high
J0108-4	Atmospheric pressure sensor shorted low
J0723-2	Secondary engine speed sensor intermittent of signal
J0723-11	Secondary engine speed sensor mechanical fault

Appendix B- Event codes

J1939 SPN-FMI	Event code description
J0100-17	Low oil pressure (Warning)
J0100-18	Low oil pressure (Action Alert)
J0100-01	Low oil pressure (Shutdown)
J0102-15	High boost pressure (Warning)
J0102-16	High boost pressure (Action Alert)
J0110-15	High coolant temperature (Warning)
J0110-16	High coolant temperature (Action Alert)
J0110-00	High coolant temperature (Shutdown)
J0172-15	High inlet air temperature (Warning)
J0172-16	High inlet air temperature (Action Alert)
J0174-15	High fuel temperature (Warning)
J0174-16	High fuel temperature (Action Alert)
J0190-15	Overspeed (Warning)
J0190-16	Overspeed (Action Alert)
J0190-00	Overspeed (Shutdown)
J1108-31	Critical override enabled