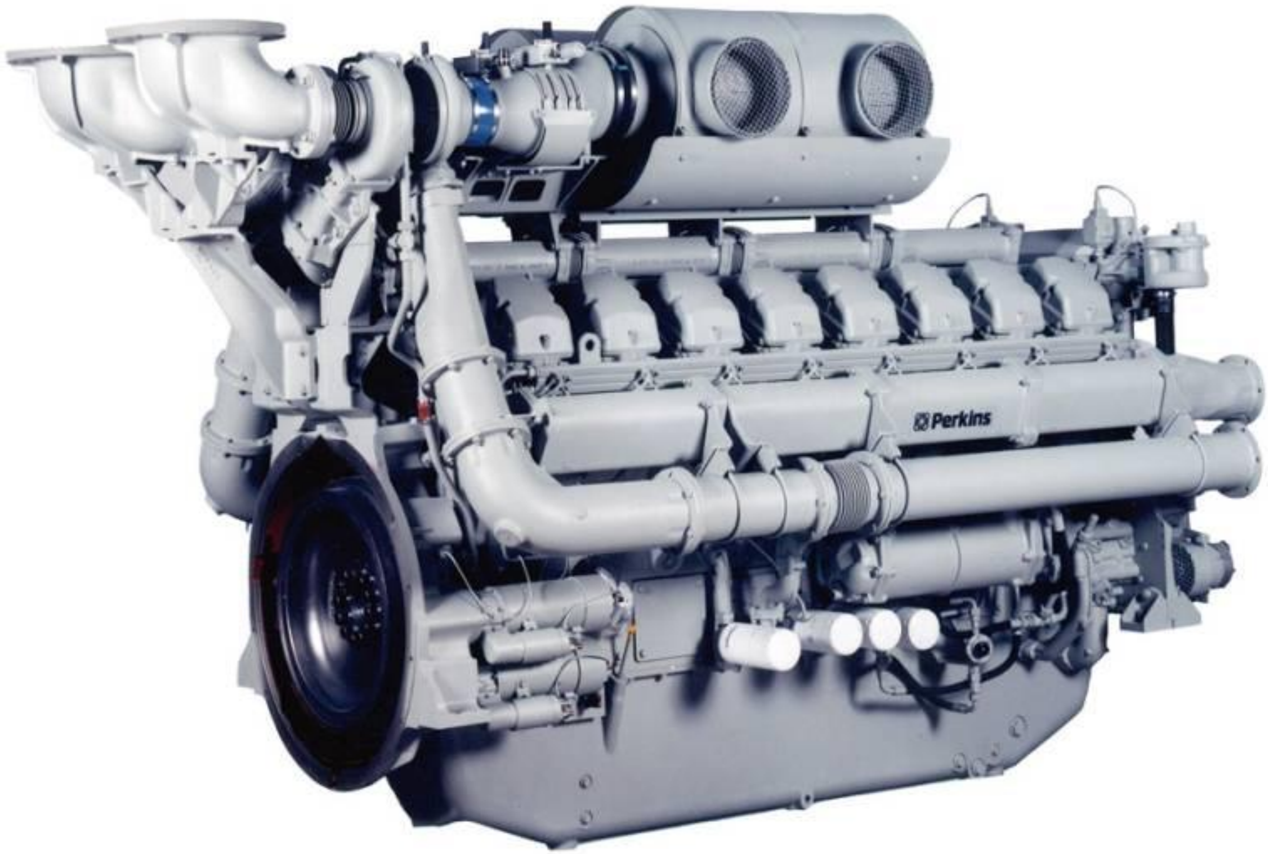
Application Considerations

4016 Series Diesel

Application Considerations

- **Please Note :**
- This Product Training information is distributed for informational purposes only
- It is to provide the user with sound general information for installing an engine/generating set within an engine room/canopy facility
- It is for guidance and assistance in the application of an engine with recommendations for correct and safe procedure
- It may not be construed as creating or becoming part of any Perkins Engines contractual or warranty obligation

Installation Considerations



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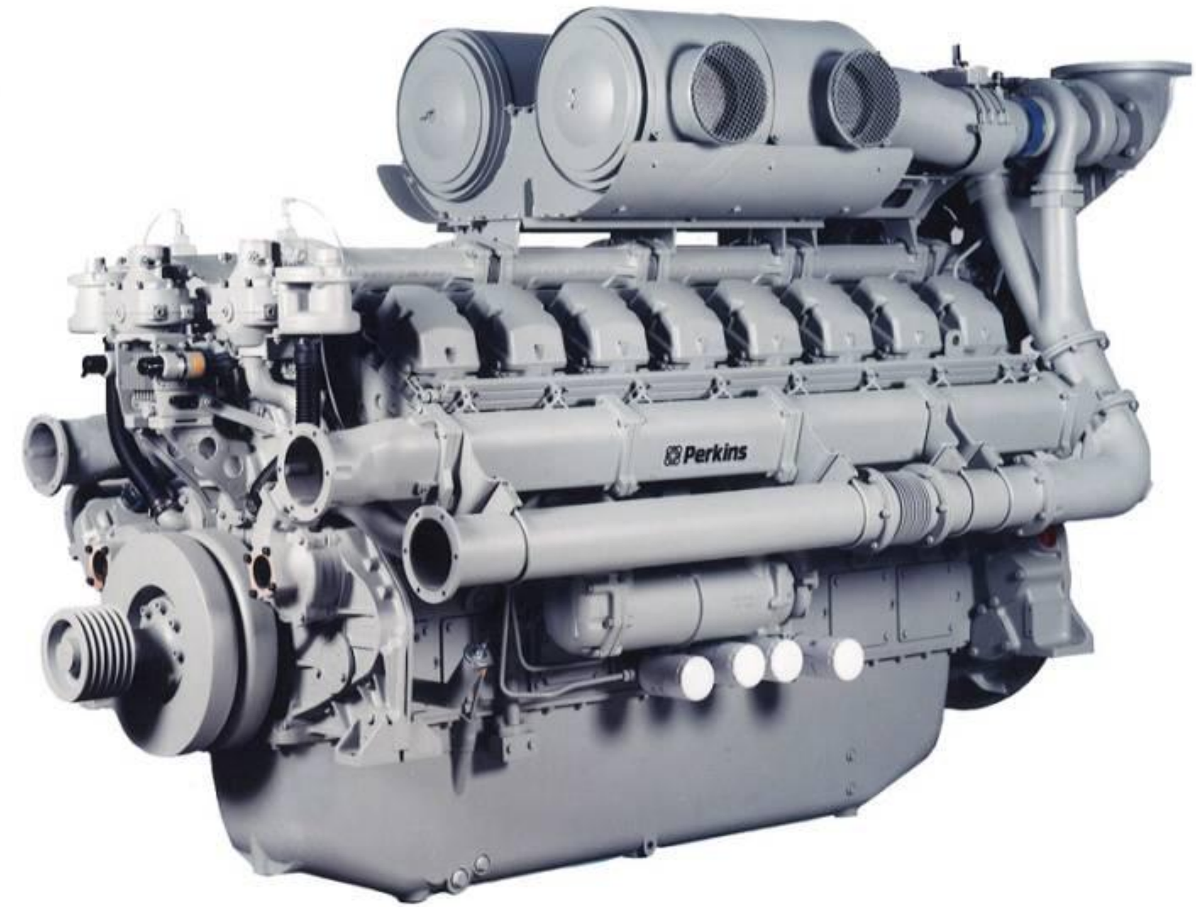
Installation Considerations



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Installation Considerations

Installation Considerations



Installation Considerations

- Torsional Compatibility
- Flywheel Housing and Flywheel
- Engine Room Foundations
- Mounting
- Engine Room Layout
- Ventilation
- Cooling System
- Cold Start
- Exhaust System
- Fuel System
- Crankcase Ventilation
- Electrical Systems
- Air Induction System
- Noise
- Governor
- Multiple Gensets Installation



Installation Considerations

Torsional Compatibility



Torsional Vibration

- **Torsional Vibration Analysis (TVA)**
  - ISO 8528 places the onus of ensuring torsional compatibility on the generating set manufacturer
  - Information required = Inertia’s of rotating components, shafts, pulleys, etc., and dimensions and stiffness of shafts
  - Perkins can offer TVA and this should be requested on Order Control Document (OCD) as it is a charge-able option
  - Perkins provide the full Mass Elastics of the 4016 for OEM’s wishing to conduct their own TVA

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Torsional Vibration

Perkins 4016 diesel and 4016 gas engine mass / elastic system

Issue-2 Updated on 6th September 1999 by E. Cheers

CONFIGURATION – 60^0 Vee 12 Cylinders

LOCATION (from non-driving end)	INERIA kgm^2	STIFFNESS MNm/ radian	SHAFT DIAMETERS mm min O/D	max O/D
Adaptor	0.505		115.00	0.000
		4.492		
Cyl. Row 1	0.714		118.07	0.000
		5.970		
Cyl. Row 2	0.714		118.07	0.000
		5.970		
Cly. Row 3	0.714		118.07	0.000
		5.970		
Cly. Row 4	0.714		118.07	0.000
		5.970		
Cyl. Row 5	0.714		118.07	0.000
		5.970		
Cyl. Row 6	0.714		118.07	0.000
		8.982		

Flywheel 4016 diesel and 4016 Gas Series all builds – Inertia added after rearmost cylinder inertia in table above
Part No. SEV250F/1, Inertia = 9.570 kgm^2, Output flange 18" SAE

T.V. Damper standard fitments – inertias added to 'Adaptor' inertia in table above – other alternatives may be used subject to T.V. analysis.

4012 Gas Type 508078 single 20" – Manufacturer - " Hasse &Wrede"

4012-46 Diesel Type 508078 Twin 20" – Manufacturer - " Hasse &Wrede"

Damper Details :	Single damper	Double Damper
Siesmic Ring inertia	2.4240 kgm^2	4.8480 kgm^2
House/case Inertia	1.1240 kgm^2	2.2480 kgm^2
Effective inertia	2.3360 kgm^2	4.6720 kgm^2
Damper surface area	0.4040 m^2	0.8080 m^2

Additonal engine information	
Cylinder bore	160.0 mm
Crankpin radius (1/2 stroke)	95.0 mm
Connecting rod length	336.0 mm
Engine capacity	61.123 Litre
Number of cylinders	12
Reciprocating mass/cylinder	10.14 kg

Firing order	1A	1B	3A	3B	7A	7B	5A	5B
Firing angle after T.D.C. cyl. 1	0°	60°	90°	150°	180°	240°	270°	330°
(continued)	8A	8B	6A	6B	2A	2B	4A	4B
	360°	420°	450°	510°	540°	600°	630°	690°

Where A bank is on the Left side viewed from the non-driving end of the engine and crankshaft rotation is clockwise viewed from the non-driving end.
Note – inertia values are for GR^2



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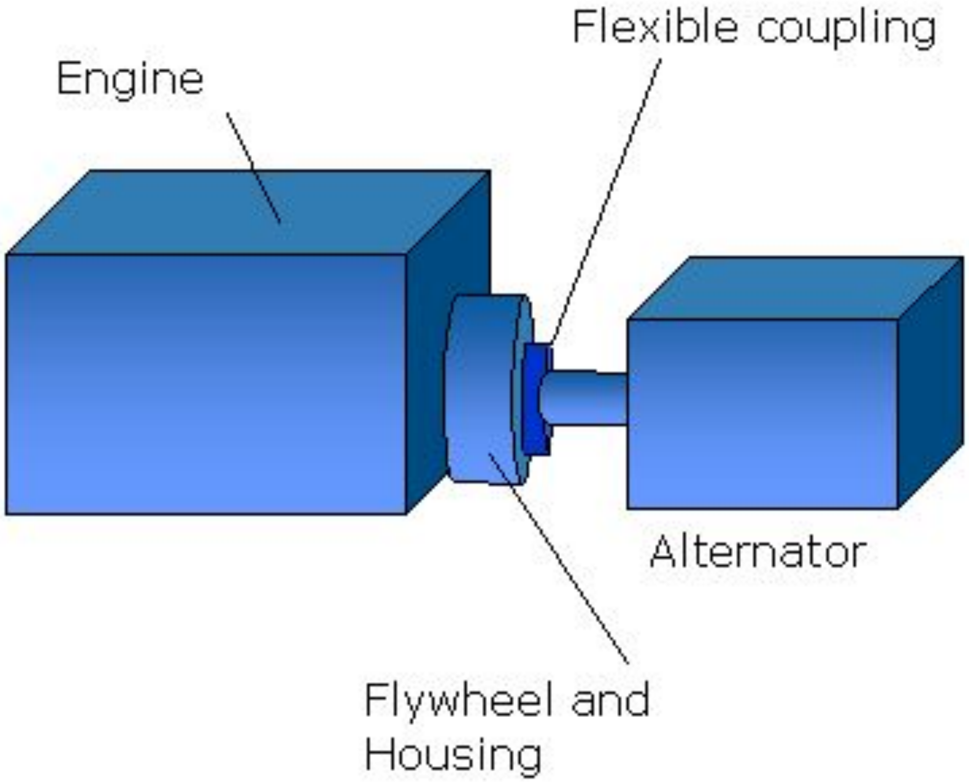
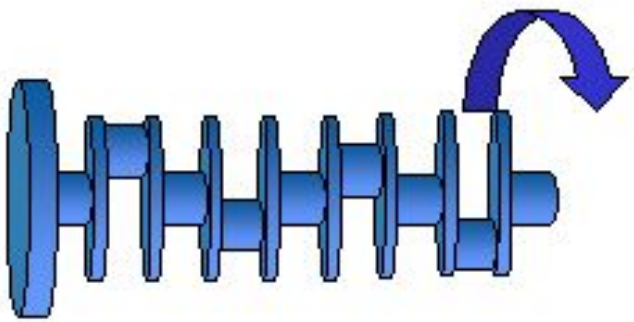
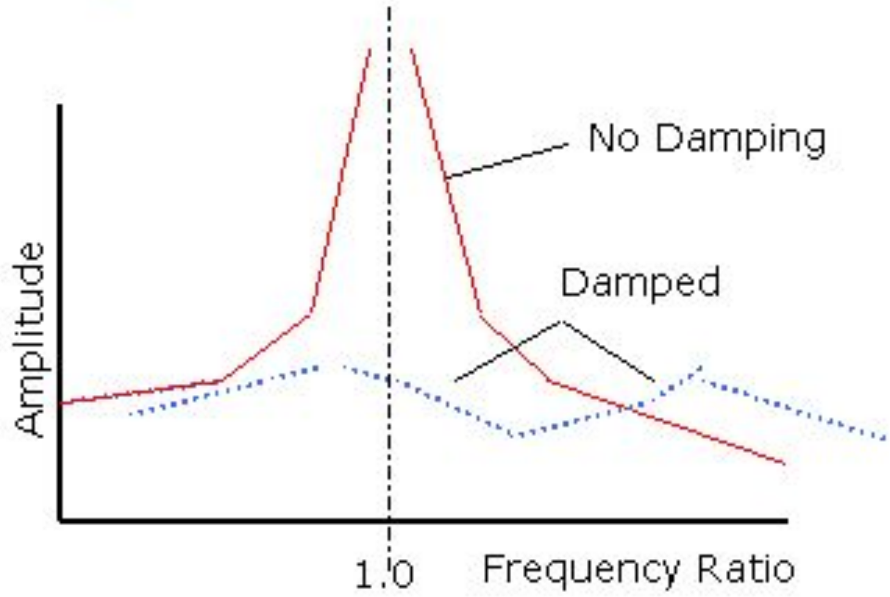
Torsional Vibration



Typical Arrangement

Torsional Vibration





During the 720° cycle the instantaneous gas pressure varies for each cylinder, hence the torque at any point during the cycle also varies. This causes the crankshaft to 'roll' about its mean rotating position. The other effect is small instantaneous movements between the various masses.

Torsional Vibration occur when harmonic torque components are applied in phase with the natural frequencies of the shaft at certain speeds. The amplitudes of movement can build up on resonance to many times those due to the slow application of of these torques. In severe cases it can lead to shaft failure e.g. torsional stress fatigue.

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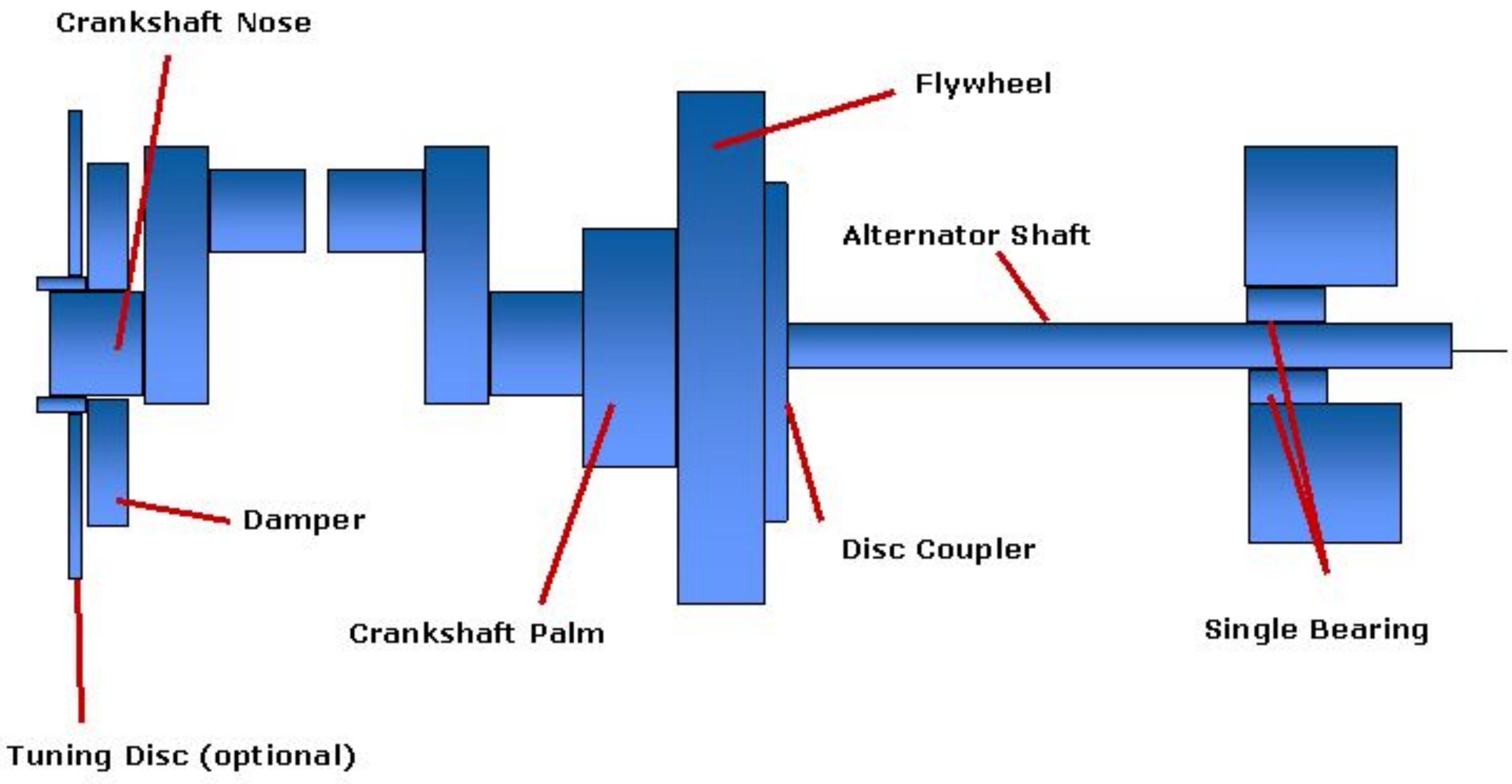

Single Bearing Layout Arrangement



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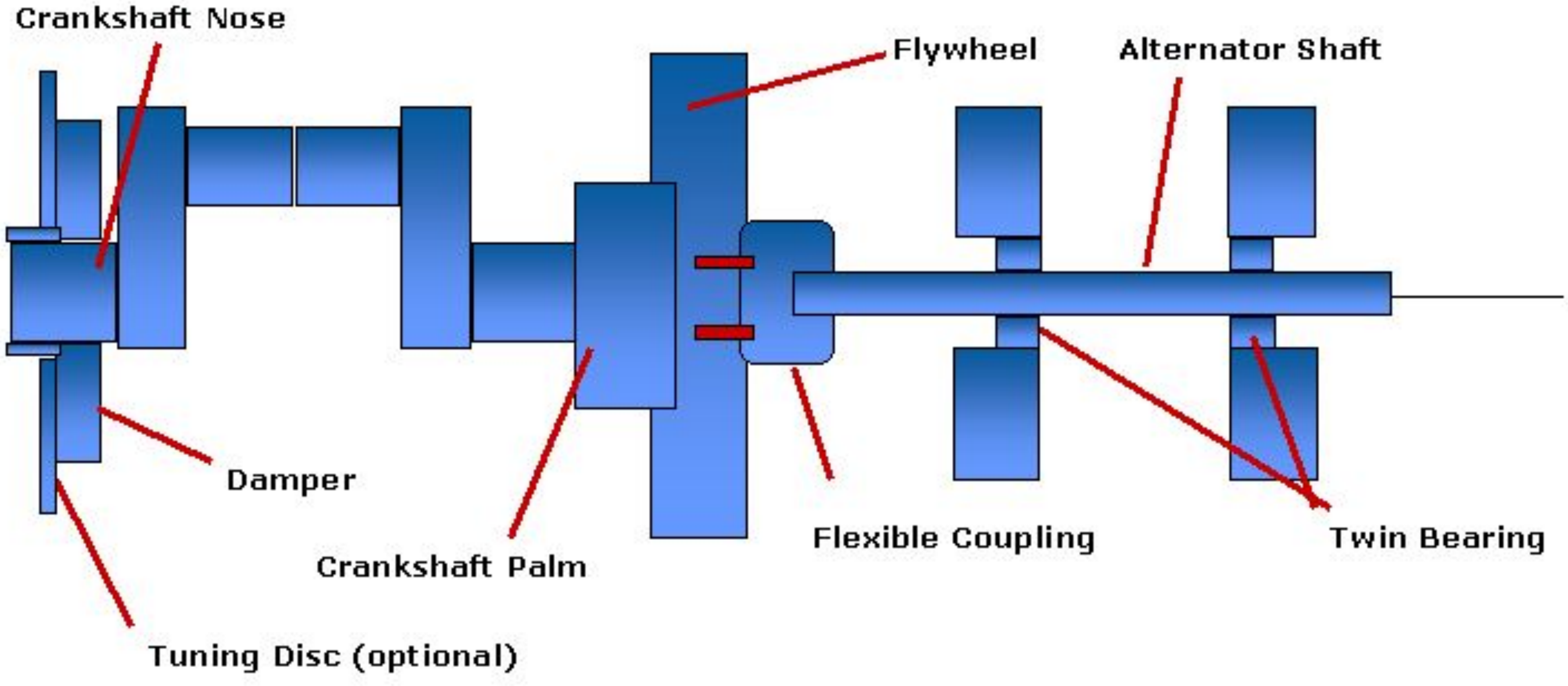
Torsional Vibration



Twin Bearing Layout Arrangement

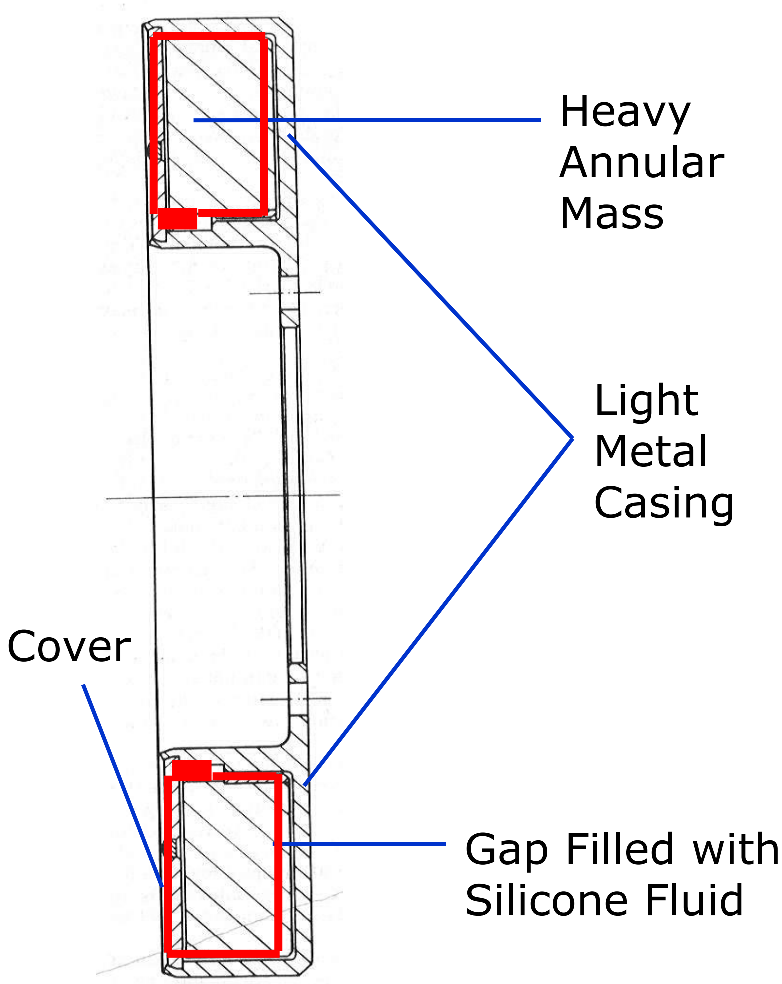


Torsional Vibration

- **TV Analysis Results**
  - Stress Limit for the crankshaft
  - Damper Heat Load = 110° C for Standby ratings
  - Vibrating amplitude at crankshaft nose
  - Limit = 1° at full load rated speed
  - Vibratory Torque (to check coupling bolts)



TV Dampers



Viscous Dampers are used on fixed speed applications like gen-sets. As a consequence they are used on all the Stafford range of engines.

At low vibrations the heavy annular mass moves with the casing but at large vibration amplitudes the damper mass slips in relation to the casing. The energy absorbed is dissipated as heat.

Applications Considerations

Flywheel Housing and Flywheel



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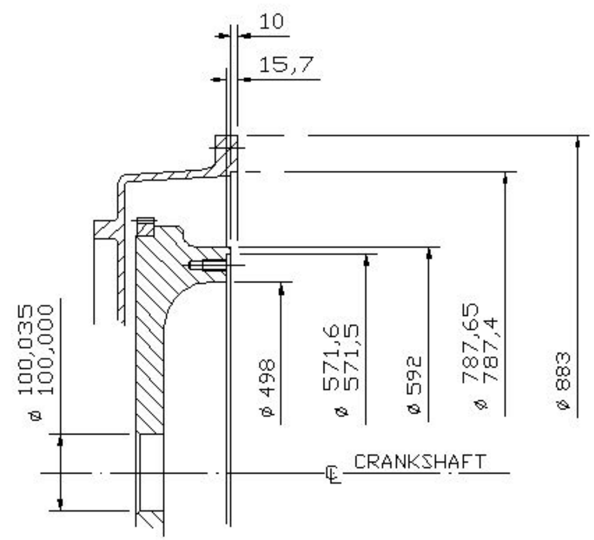
Flywheel Housing and Flywheel

- **Flywheel Housing and Flywheel Size**
  - 4016 Supplied with :
    - SAE J617 Size 00 - Flywheel Housing
    - SAE J620 Size 18 - Flywheel



DETAIL OF SAE 518 FLYWHEEL
AND SAE 00 FLYWHEEL HOUSING



Applications Considerations

Engine Room Foundations



Engine Room Foundations

Type of Foundation

- The engine floor/foundation where the underbase/bearers are fixed is of great importance as it must:
  - Support the static weight of the units and withstand any stresses or vibrations when the engine is running,
  - Be sufficiently rigid and stable so that there will be no distortion which would affect the alignment of the engine and driven unit
  - Absorb vibrations originating from the running units and prevent them being transmitted to the surrounding floor and walls etc.



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Engine Room Foundations

- **Subsoil - Site**

- The site subsoil must have a bearing strength capable of supporting the weight of the complete set plus the concrete foundation on which it will stand

- If the bearing strength of the subsoil is in doubt advice should be taken from a qualified civil engineer to enable the type and size of concrete foundations to be determined



Engine Room Foundations

- **Fixed Concrete Block**
- The fixed concrete block is a proven method
- The recommended plan size of the fixed concrete block is to allow between 300/450 mm surround on all sides of the set
- The surface of the block is usually proud of the normal floor line by 'h�because between 100/230 mm and forms a plinth
- Each genset must have its own individual plinth



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Engine Room Foundations

- **Fixed Concrete Block**
- The depth of the concrete block is calculated as follows:

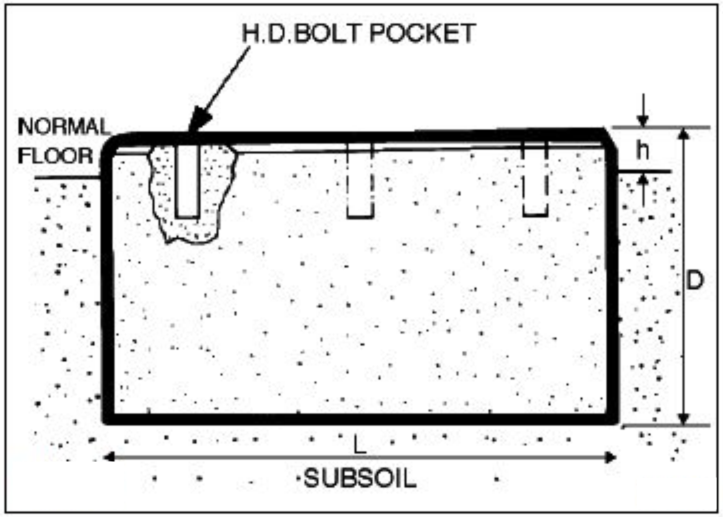
$$D = \frac{W}{d \times B \times L}$$

- D = Depth of concrete block in metre
- W = Total weight of generating set in kg
- d = Density of concrete in kg/m^3
- **NOTE:** 2403.8 kg/m3 if accurate figures are not known.
- B = Breadth of concrete block in metre
- L = Length of concrete block in metre



Engine Room Foundations

- **Fixed Concrete Block**



- After determining the depth of concrete required for the weight and stability of the running set, the subsoil has to be checked to see if it will carry the total weight (set plus concrete block) and withstand the forces involved



Installation Considerations

Engine Mounting

Mounting Systems

- **Purpose Of Mounting Systems**
  - To secure the engine into the installation
  - Provide adequate support in order to avoid mechanical failure
  - To allow adequate movement to give engine freedom to move with out of balance forces
  - Provide adequate damping and suppression of engine vibration

Mounting Systems

- **Engine Mountings**

- The type of mountings depend upon the type of installation in which the engine is to be used and the final drive arrangement

- The engine can be fitted with either solid or flexible mountings, depending on the type of foundation or application

- If the engine is solidly or flexibly mounted, the exhaust, radiator and fuel pipe connections must also be flexible



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Mounting System

- **Types Of Mounting Systems**
  - Flexible Mounting Systems
  - Solid Mounting System

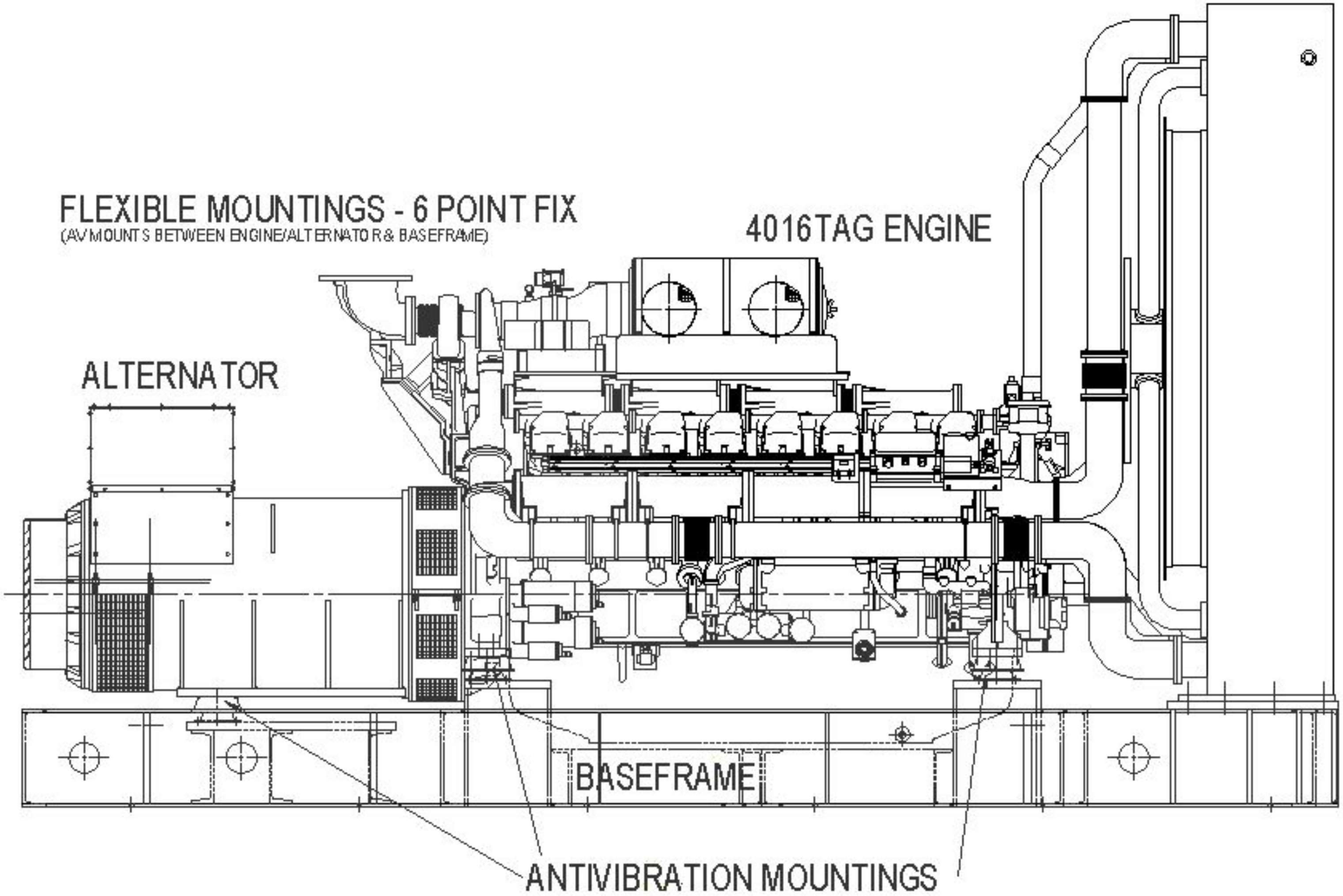


Mounting Systems

- ## Types Of Mounting Systems - Flexible
  - Flexible mounting enable the supporting baseframe to be isolated from genset
  - Vibration, the forces generated by the genset being counteracted by allowing the genset itself to move bodily on anti vibration mounts between the genset and baseframe
  - Flexible mounting is not the preferred method for 4000 Series Vee Form engines, and AV mount recommendations must be followed
  - Flexible mounts can be 6-point or 8-point fixes



Mounting Systems



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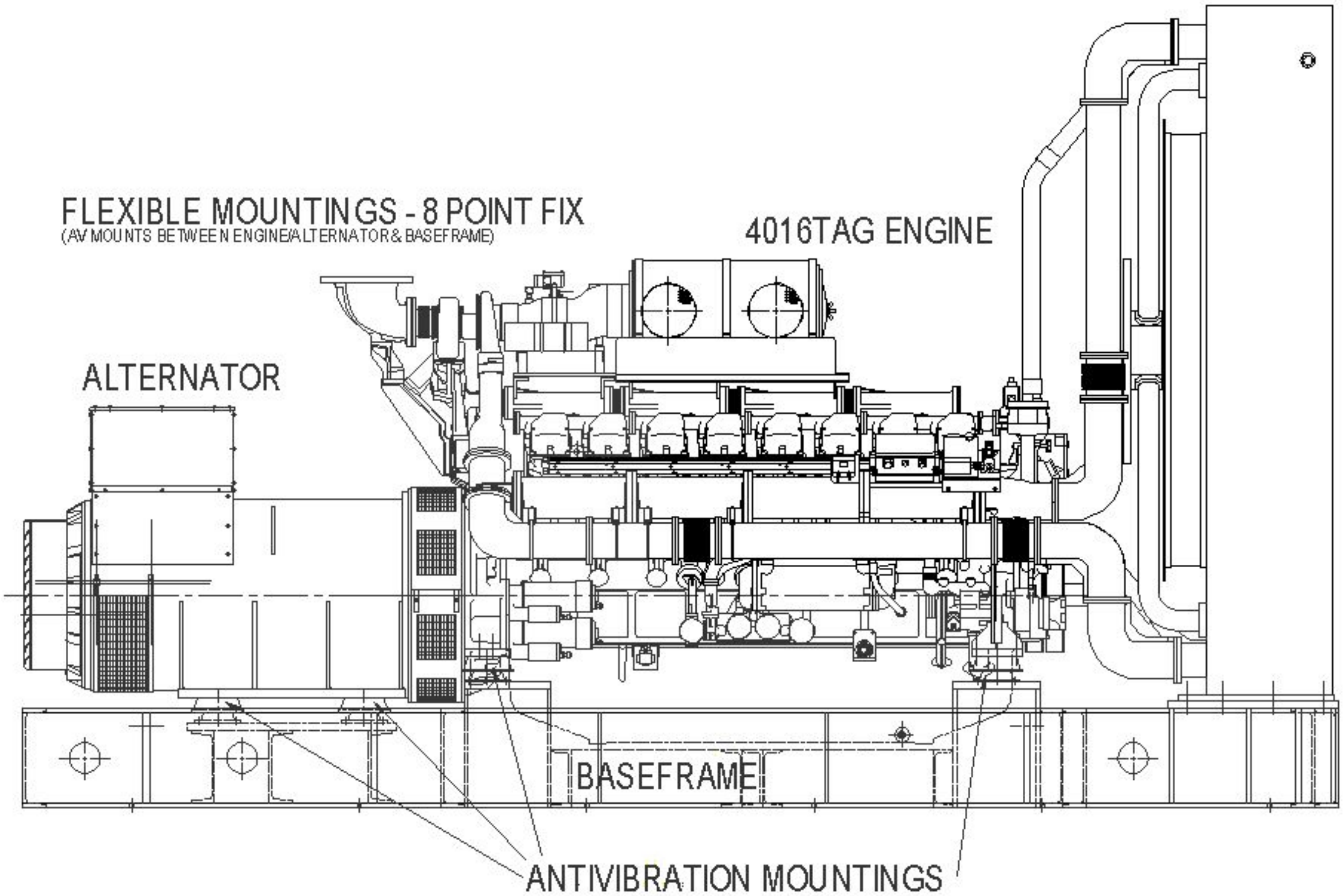
Mounting Systems





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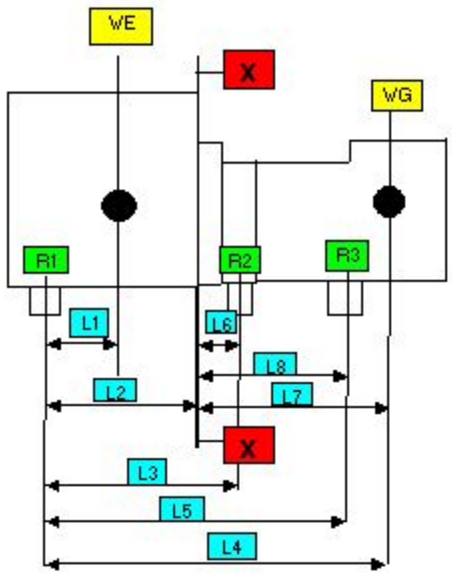
Mounting Systems

Location of Mounts

- With flexible mounting the location of the mounts are predetermined by the mounting feet on the engine
- The location of the rear mounts (under the alternator) should be calculated to ensure that the bending moment at the joint face between the crankcase and flywheel housing does not exceed 1356Nm
- A calculation is available from Perkins to calculate the bending moments for 6-point fixes, 8-point fixes do not require bending moments to be calculated



Mounting Systems



CODE	VALUE	UNITS
VE		KG
VG		KG
VT	0	KG
R1	#DIV/0!	KG
R2	#DIV/0!	KG
R3	#DIV/0!	KG
RT	#DIV/0!	KG
L1		MM
L2		MM
L3		MM
L4		MM
L5		MM
L6		MM
L7		MM
L8		MM

OEM	
ENGINE TYPE	
ALTERNATOR TYP	
CALCULATED BY	
DATE	

TAKING MOMENTS ABOUT R1 TO FIND R3

R3 = (WE.L1)+(WG.L4)/L3(L5/L3)+L5 — R3 = #DIV/0!

R2 = (L5/L3).R3 — R2 = #DIV/0!

R1 = (WE+WG)-(R3+R2) — R1 = #DIV/0!

WT CHECK RI+R2+R3 - WE+WG = 0 — VT CHECK = #DIV/0!

THE BENDING MOMENT (MX) BETWEEN THE FLYWHEEL HSG AND CYL BLK

(R1*L2)-(WE.(L2-L1))*9.81/1000

MX = #DIV/0! Nm

CHECKING THE BENDING MOMENT (MX)

((R2*L6)+(R3*L8))-(WG*L7)*9.81/1000

MX = #DIV/0! Nm

MX CHECK = #DIV/0!

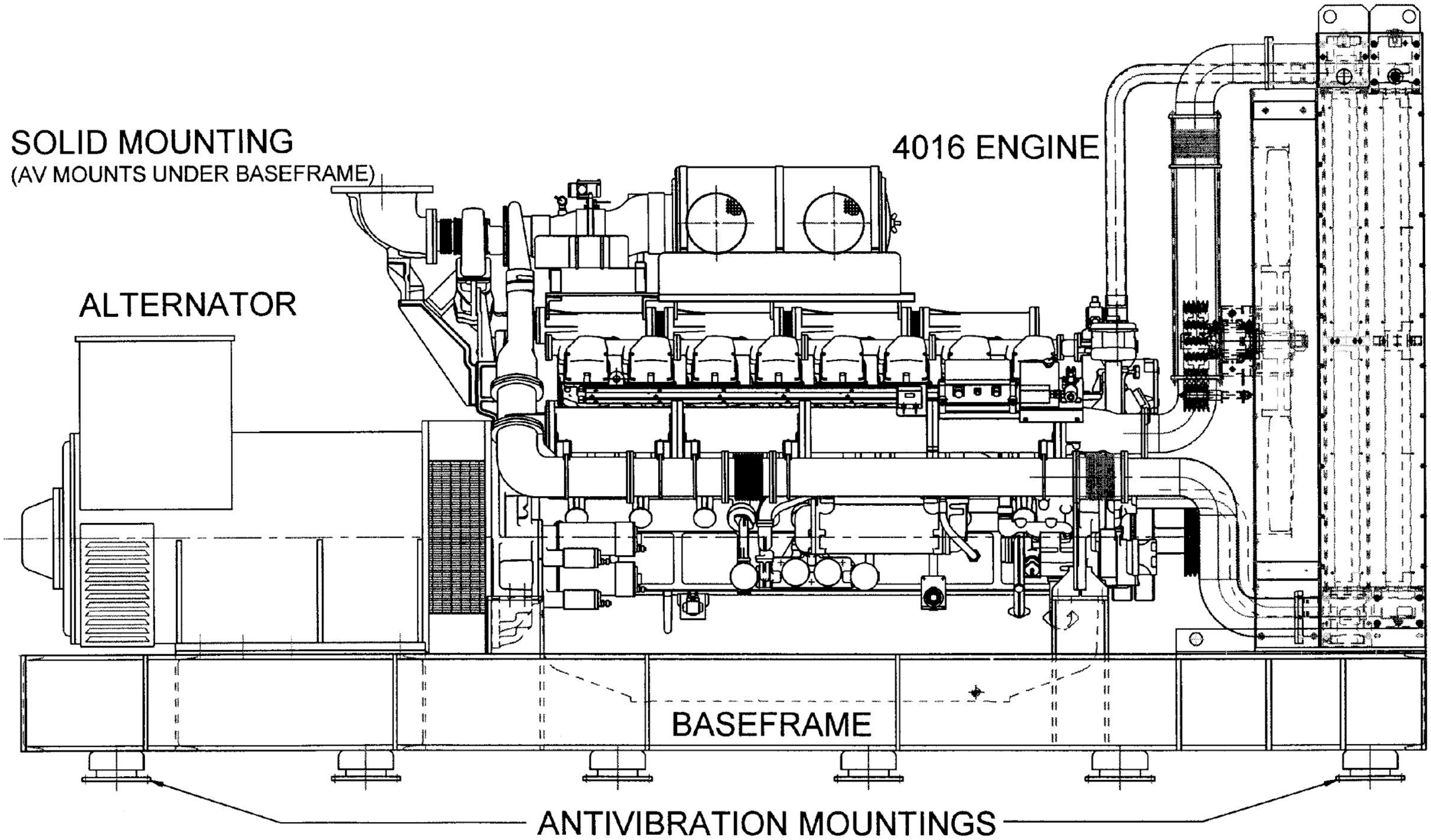


Mounting Systems

- **Types Of Mounting Systems - Solid**
  - Solid mounting are used where the movements of a flexibly-mounted genset is not acceptable
  - The genset itself is an integral part of the genset baseframe structure
  - Allows the genset and baseframe to move bodily on anti vibration mounts between the frame and floor



Mounting Systems





Mounting Systems

- **Locations Of Mounts**
  - With solid mounting the anti vibration mounts should be symmetrically arranged about the combined centre of gravity of the bolted equipment

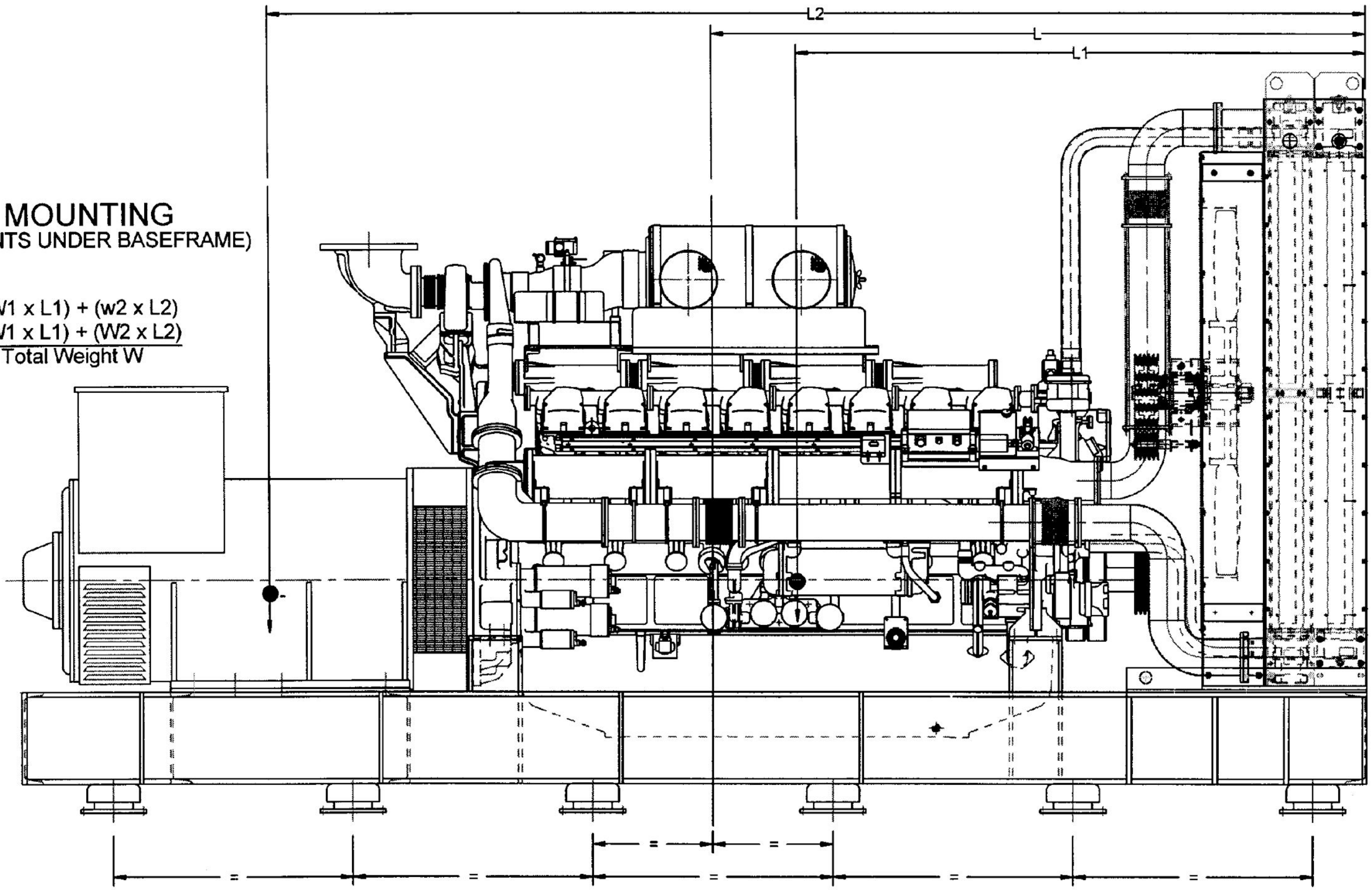


Mounting Systems

SOLID MOUNTING
(AV MOUNTS UNDER BASEFRAME)

$W \times L = (W1 \times L1) + (w2 \times L2)$

$\therefore\ L = \dfrac{(W1 \times L1) + (W2 \times L2)}{\text{Total Weight } W}$



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Mounting Systems

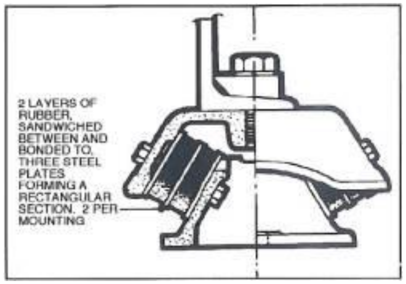
- **General Considerations**
  - No restraints from exhaust pipes, hoses, linkages, etc
  - Are the mounts fitted correctly and used as they were designed to be used
  - Was the mount manufacturer involved in the design of the mounting system



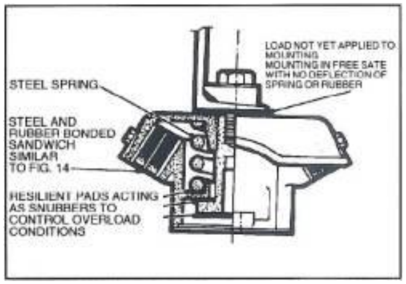
Mounting Systems

Types Of AV Mounts

- Rubber without adjustment - First grade natural rubber to metal bonded rectangular elements inclined to achieve maximum load and deflection of compression and shear loading



- Steel Spring and rubber without adjustment - helical steel spring, inclined rubber springs of first grade natural rubber to metal bonded elements



- Not Solid Rubber Pads without casings



Applications Considerations

Engine Room layout



Engine Room Layout

- **Access for Routine Servicing**
  - Installation and removal of various components :
    - Cylinder heads
    - Coolant pump
    - Oil sump
    - Timing case
    - Starter and alternator
    - Flexible mountings



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Engine Room Layout

- **Access for Routine Servicing**
  - Maintenance, inspection and replacement of parts :
    - Lubricating oil filter
    - Air cleaner
    - Fuel filter
    - Lubricating oil filler
    - Crankcase breather
    - Dipstick
    - Radiator filler cap and access for filling



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Engine Room Layout

- **Installation Guide lines**
  - Avoid plastic and other unsuitable material for fuel piping and connections, which can corrode or chafe and leak fuel
  - Keep fuel lines away from hot exhaust pipes
  - Insulate exhaust systems, using heat shields or lagging
  - NOTE : Dry engine exhaust manifolds must not be lagged
  - Install a fire extinguishing system in the engine room
  - Make provision for draining the oil sump and fit drip tray underneath
  - Check entrance is large enough to allow engine/alternator to be removed
  - Provide adequate lighting and power points
  - Lifting beam in roof for maintenance
  - Provision for draining engine cooling system
  - All rotating shafts are adequately guarded for safety purposes



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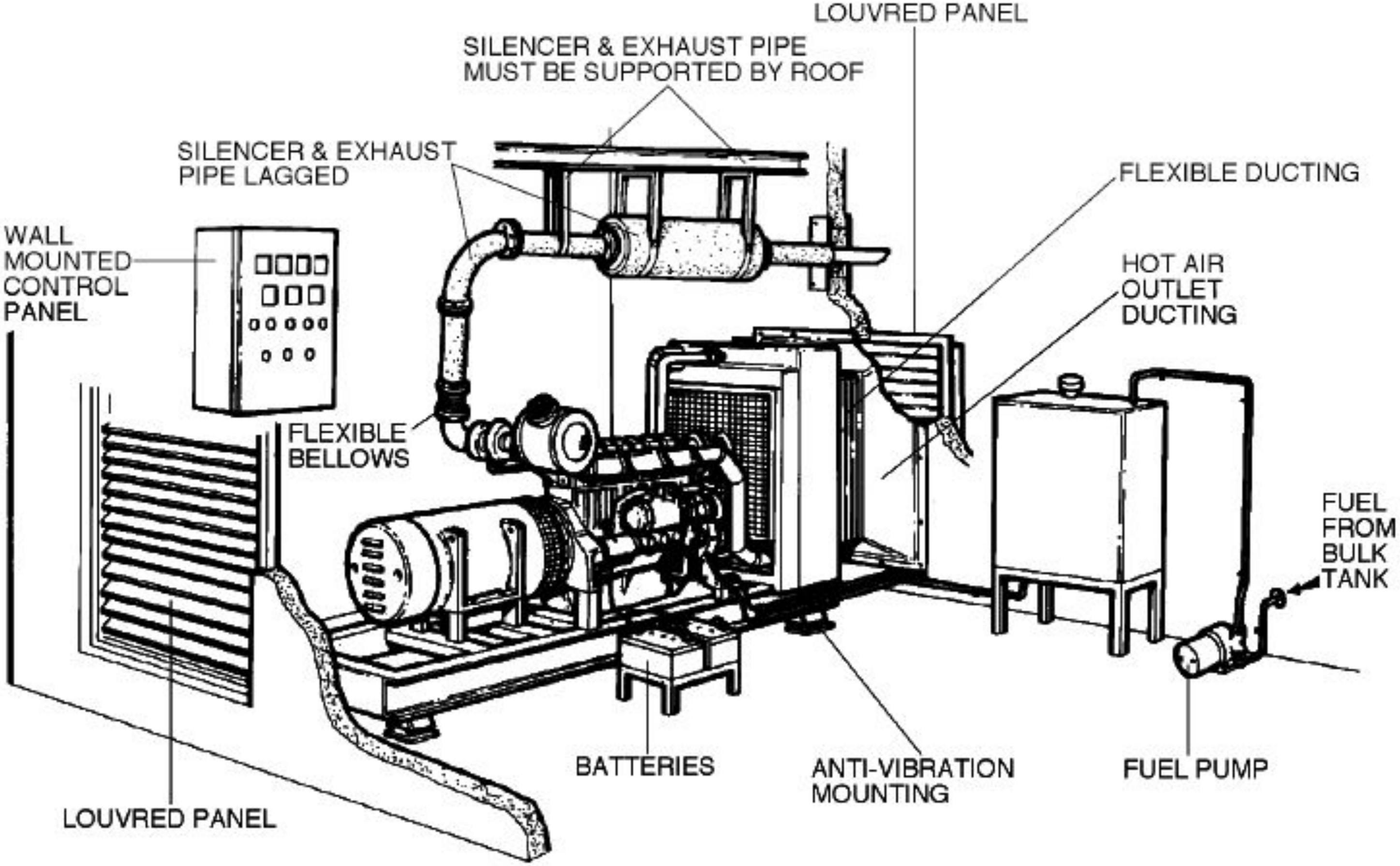
Engine Room Layout

- **Typical Engine Room Layout**
  - Hot air from the radiator ducted outside the engine room and not allowed to re-circulate
  - Exhaust system to be support from roof and flexible bellows fitted used to isolate engine and exhaust system
  - Hot air outlet ducting, fuel connections and electrical connections must be flexible type to the engine and alternator
  - The daily fuel tank is supplied from a bulk tank housed remotely from the engine room
  - The starter batteries are to be kept fully charged during none running periods by a static charger, which can be incorporated in the control panel



Engine Room Layout





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Installation Considerations

Ventilation



Ventilation

- **Ventilation**

- Basic principal is to extract hot air from the room and induce air at the outside ambient temperature with minimum re-circulation

- The object is to get cool air in at the lowest point, push it through the radiator matrix and out of the building

- Radiators must be ducted to the opening

- It is unsatisfactory to position the set so that the radiator is adjacent to the opening in the wall



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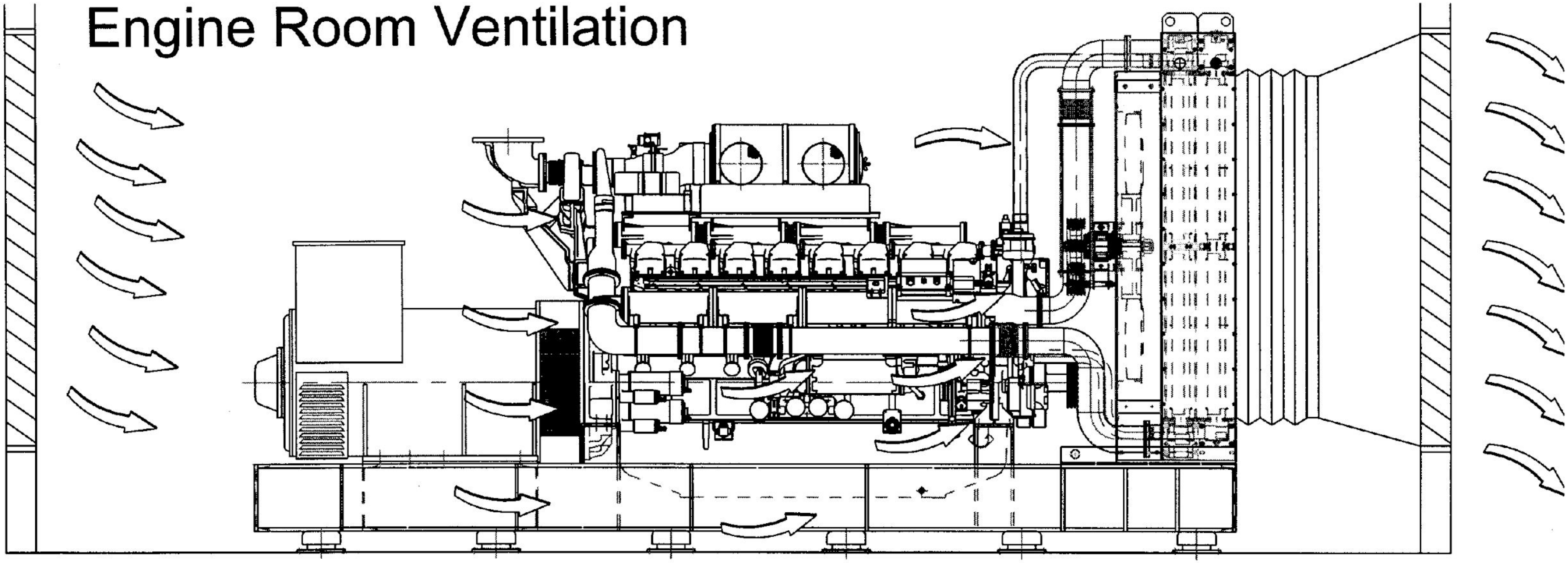
Ventilation



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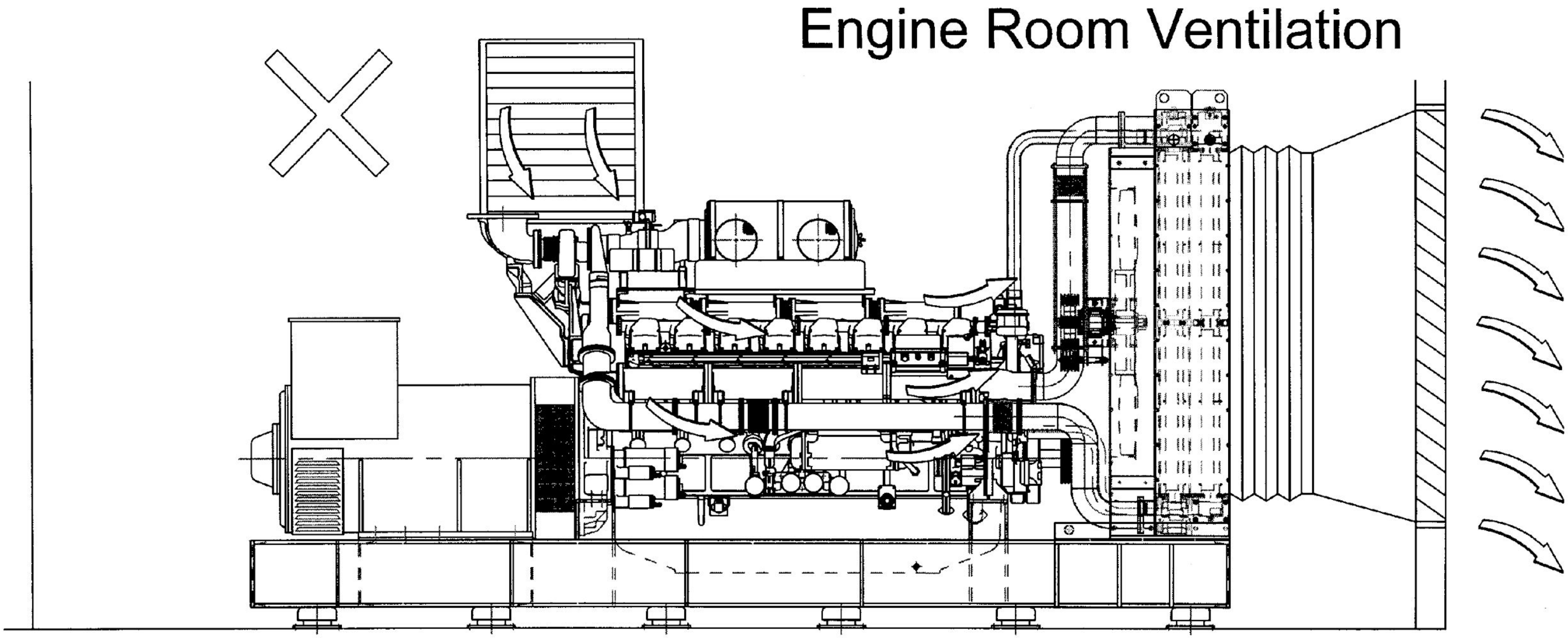
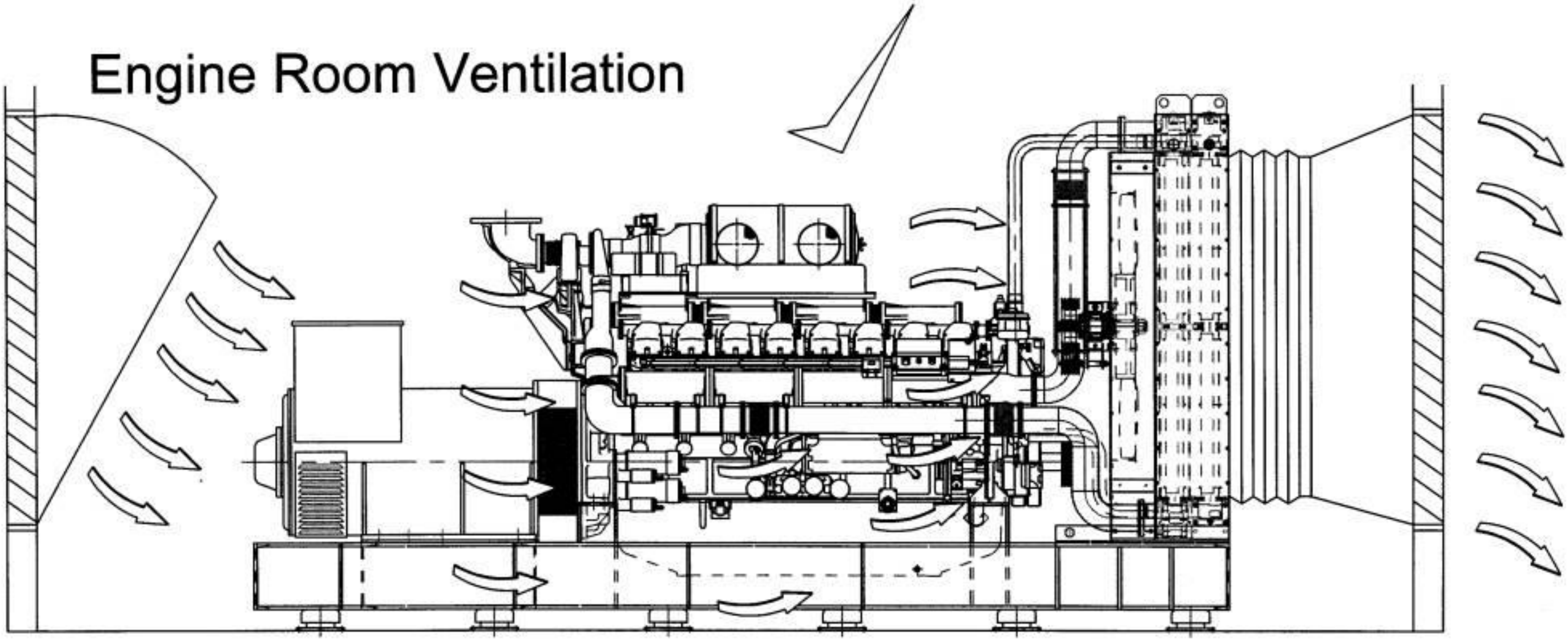
Ventilation





Ventilation



Ventilation

- **Outlet/Inlet Sizes**

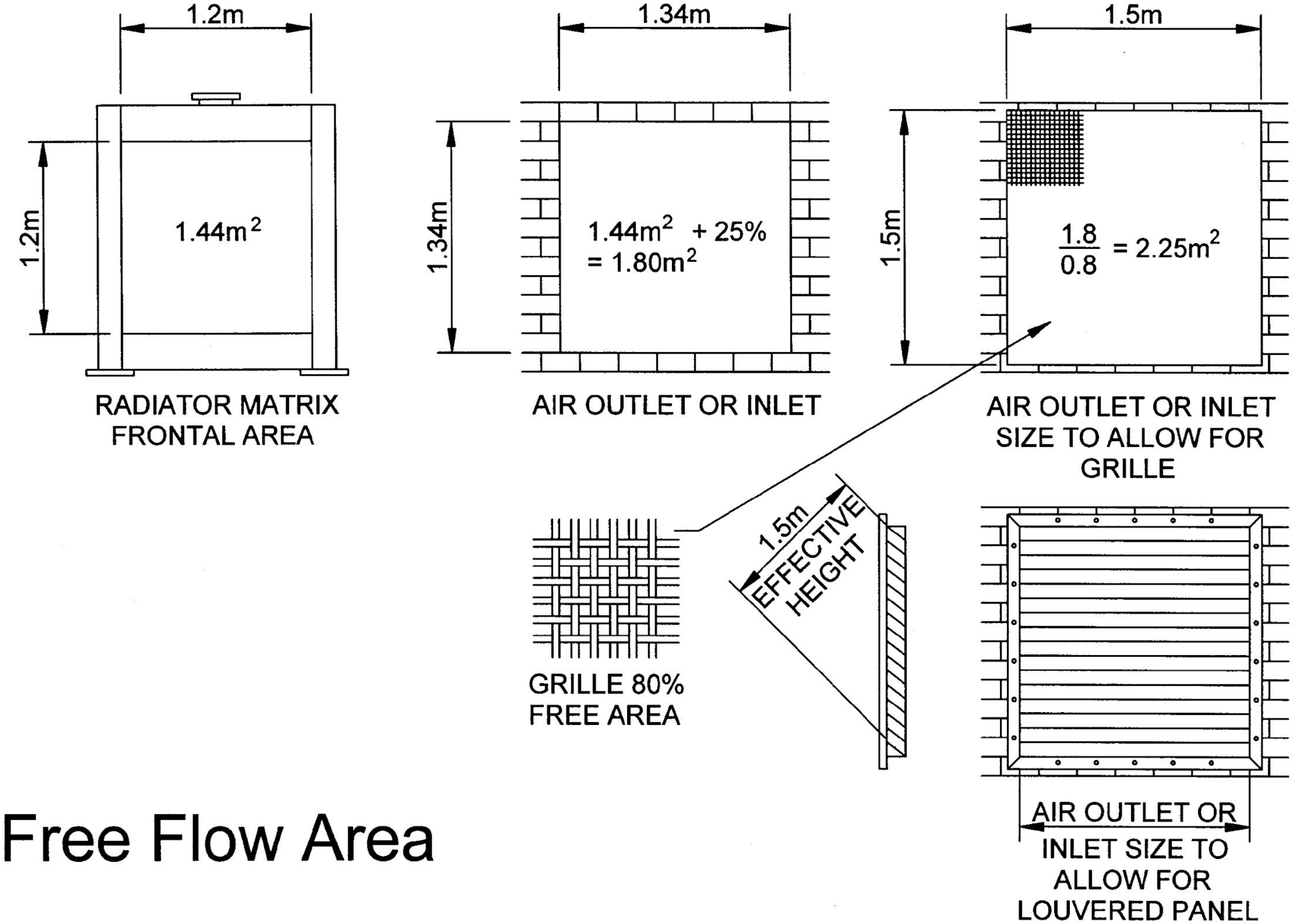
- The outlet opening should have a free flow area approximately 25% larger than the radiator matrix

- Radiator ducting must have a flexible section to isolate vibration and movement. This is particularly important when the set is mounted on AVM’s

- The inlet should also have a free flow area approximately 25% larger than the radiator matrix



Ventilation



Free Flow Area



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Ventilation

- **Extract from Institute of Heating & Ventilation Engineers Guide & Wood Practical Guide to Fan Engineering**

Extracts from I.H.V.E guide and Woods Practical Guide to Fan Engineering

This document is not a design reference for systems but is only intended to give guidance regarding the elements which need to be considered.

In addition to the resistance of straight ducts, all duct fittings will introduce additional resistance

The total duct resistance is the summation of all individual resistances of the most resistive run. As stated previously, it is important that the total duct resistance is maintained within the maximum system resistance figure quoted by the radiator manufacturer.

The following points should be borne in mind on duct installations:

(a) Sudden changes in cross-section should be avoided.
(b) Bends should be gradual or fitted with splitters or turning vanes.
(c) The ducting should have as few changes of direction as possible.
(d) Branch ducts should be swept in or angled to the main duct.
(e) Grilles louvres and diffuser applications should be in accordance with the manufacturer's recommendations.

The elements of total pressure drop are added together round the system and may be classified as follows:

Losses at entry to the system from atmosphere
Losses due to friction in duct lengths.
Losses at changes of duct area or shape,
Losses at bends and changes of direction,
Losses at division of flow into branches.
Losses caused by obstructions, grilles and louvres.
Losses in filters, radiators, and other useful elements.
Losses at discharge from the system to atmosphere
Change in atmospheric pressure from inlet to outlet

The importance of correct design of duct fittings, particularly bends, cannot be overemphasised and the radii of bends should be made as large as possible to give minimum resistance. Where there is no alternative to a short or square bend, splitters or turning vanes should be fitted

Bends are a prolific source of unnecessary loss—and unwanted noise. As shown by the high K values in Table M below a sharp throat is the worst feature—it is good practice never to make the throat radius less than half the width of the duct. If there is no room for a decent throat radius the loss may be reduced by fitting various types of vane to organise the direction change of air. The high loss of a sharp bend is caused by separation of flow at the throat, and unless a length of duct follows the bend, none of the high velocity pressure thus generated will be recovered — resulting in a spectacularly large outlet loss.

Interaction between bends which are close to one another affects the loss in the second bend. Sharp bends must be spaced at least two diameters apart, or else the losses will be greatly increased for the reasons discussed in the last paragraph. To insure against underestimating the losses, diffusers and expanders should be spaced three diameters from bends.

In addition to the duct resistance of the straight ducts, all duct fittings will introduce additional resistance and Table M shows typical factors involved for various duct fittings. The factor *K* is used in the following formula to give the fitting resistance.

$P = 0.6 \times K \times V^2$

Where

P = Resistance loss (Pa).
K = Factor obtained from Table M.
V = Velocity (M/s) at the appropriate point of the fitting section.

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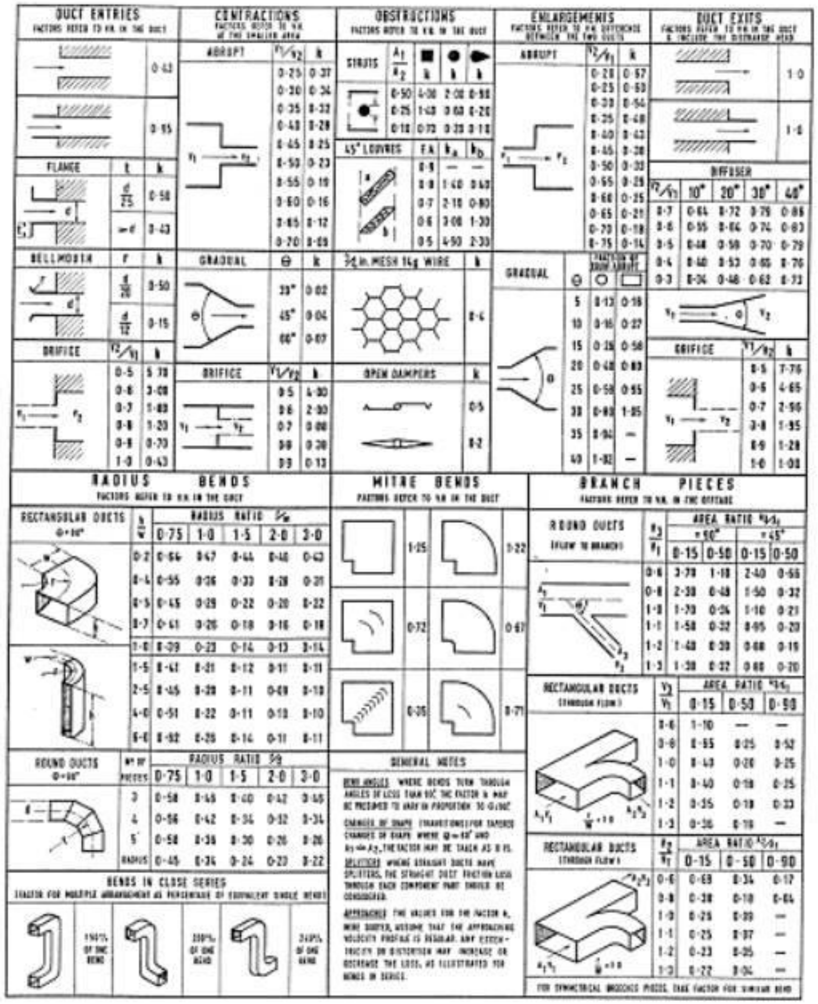
Ventilation

- **Extract from Institute of Heating & Ventilation Engineers Guide 1965**



I.H.V.E. Guide 1965



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Ventilation

- **Duct Resistance**
  - Radiator duct allowance must not be exceeded.
  - Exceeding the duct allowance can cause the fan to run in a stalled condition.
  - Running a fan in stall will lead to fan failure.
  - Airflow must be measured at the radiator outlet matrix to determine actual flow.
  - Measured flow must be at least the design minimum flow.
    - If minimum design airflow is achieved with minimal margin at core face it is unlikely that sufficient airflow will be available once front attenuation and louvers are replaced.



Ventilation

- **Airflow Measurement**
  - PROCEDURE

    The anemometer measurement should be taken with the engine running at constant speed and no load. The anemometer used should have an operating range up to at least 15 M/s and we recommend a vane (rotating propeller) type unit with a head of 100 mm diameter.

    Airflow measurements should be taken at the front face of the radiator core; it may be necessary to remove components of the system to gain access to this area. Note it is not considered possible to obtain valid airflows in front of a louver, as not only is the flow area unknown but also the precise direction of airflow is very difficult to establish.

Ventilation

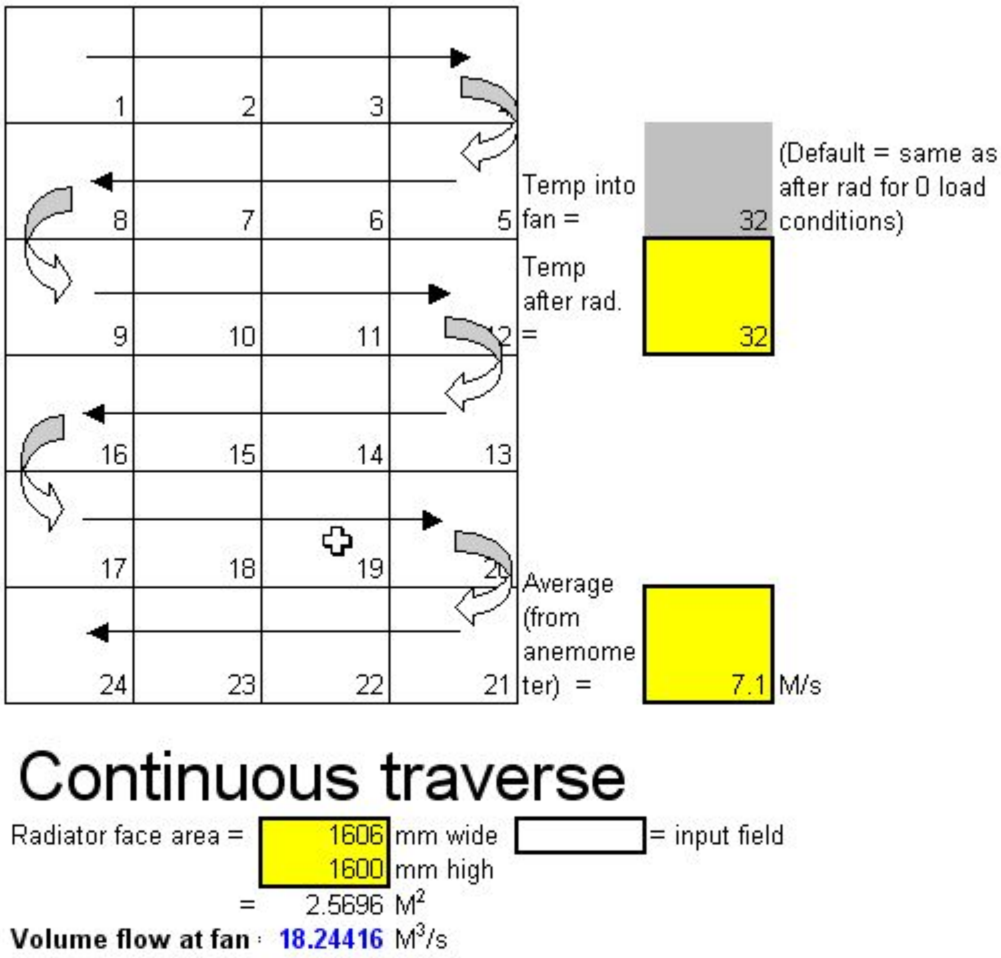
Continuous Traverse

Carry out a moving traverse over the radiator face (averaging anemometer)

To do this, position the anemometer at one corner of the radiator, hold the anemometer head about 80~100 mm away from and square with the radiator face. Start recording/logging and traverse the anemometer across the whole of the radiator face moving the head continuously at a steady speed of about 300mm/s. When the whole of the face has been traversed stop recording/logging.

Check that reading is OK and accept result.

Repeat the traverse until 3 readings have been obtained.



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Ventilation

Spot Measurements

Spot measurements (single reading anemometer)

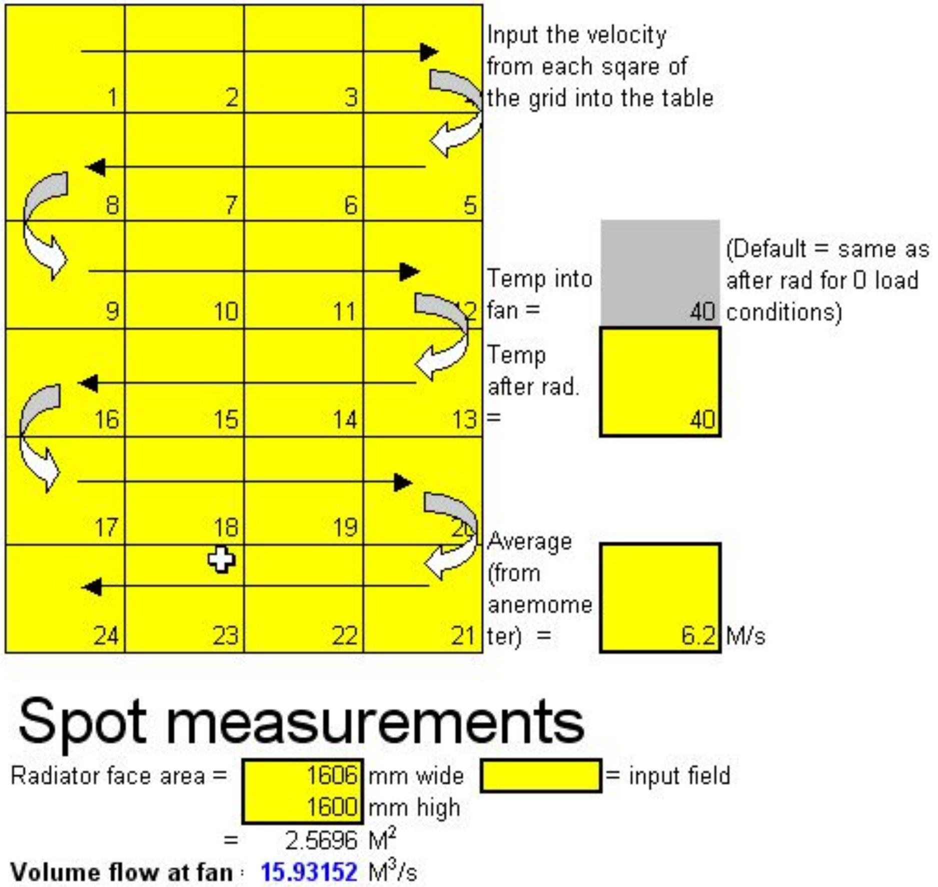
This method assumes an anemometer capable of taking single readings, or logging single readings is used.

The radiator face should be divided into a grid of squares approximately 200 x 200 mm. The squares can be marked onto the face of the radiator using chalk, a paint marker pen or similar to give guidance for measurement locations.

To do this, position the anemometer at one corner of the radiator, hold the anemometer head about 80~100 mm away from and square with the radiator face. Recording/log the first square and then move to the next, repeating the measurement. Repeat this for the whole of the radiator face. When the whole of the face has been measured stop recording/logging.

Check that reading is OK and accept result.

Repeat the measurements until 3 readings have been obtained.



Ventilation

- **Calculation of results**

The measured values from either method can then be input to a spreadsheet to calculate the volumetric flow. The volume flow is simply (air velocity (M/s) x radiator core face are area (M^2)).

Ventilation

▪ Ducting Against Prevailing Wind

- Radiator fan is a “pusher” type
- If the prevailing wind is blowing into the opening additional resistance will be put on the fan with a resulting reduction in cooling air flow
- Where possible the opening should be in a wall not affected by prevailing wind
- If the above condition is not possible other methods should be considered :
  - Outside ducting with outlet being 90^{o} to cooling air flow
  - A deflector panel



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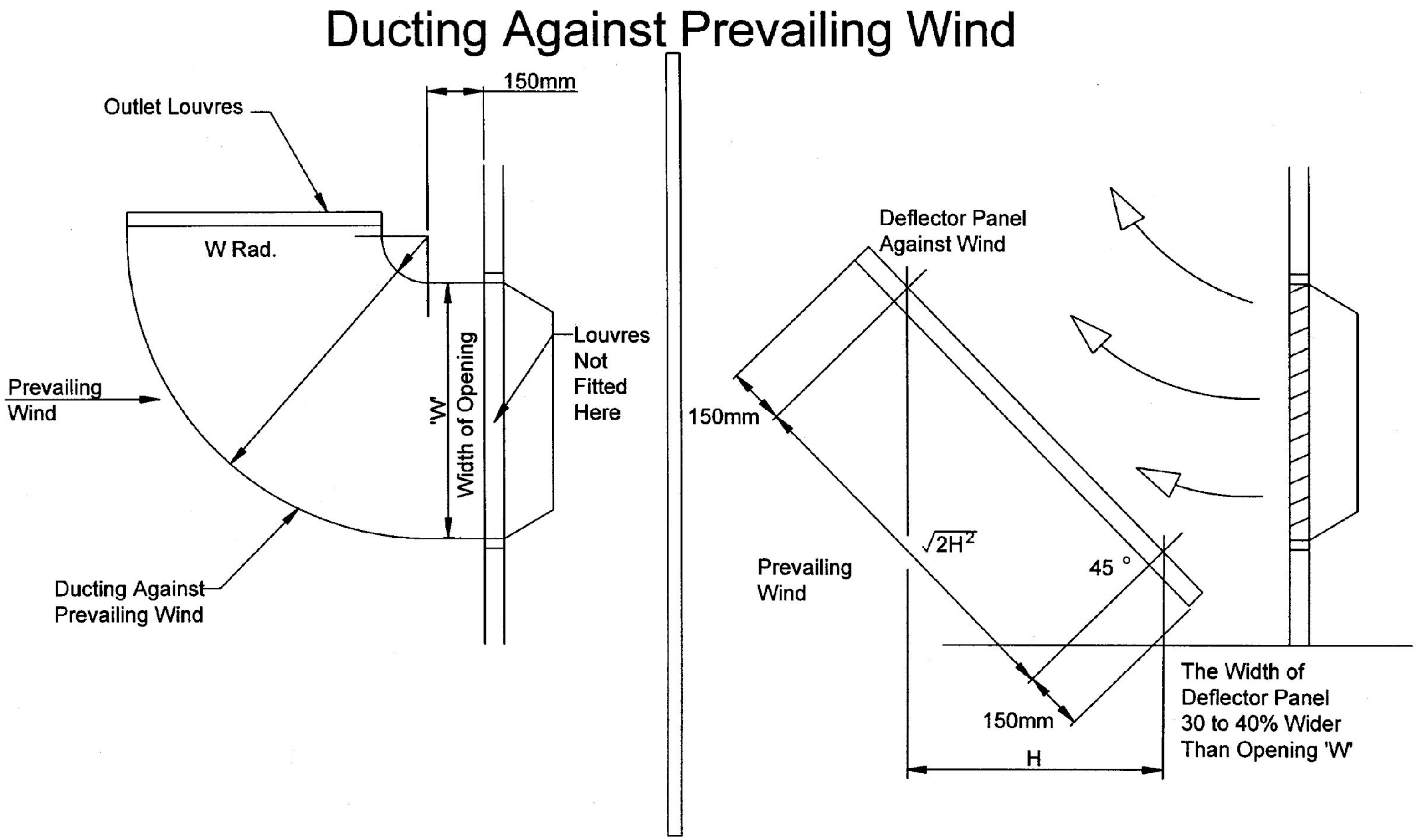
Ventilation



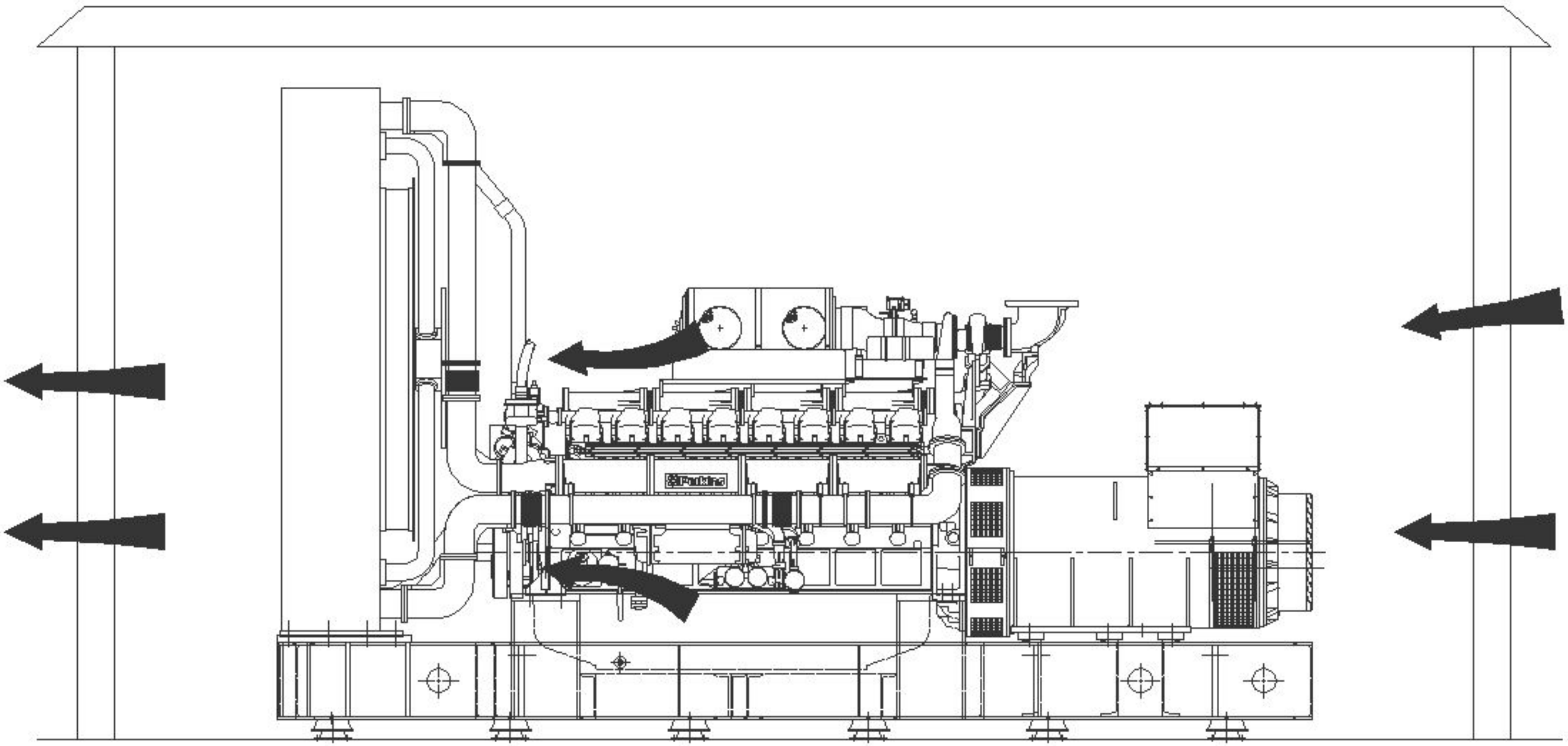
Ventilation

- **Ventilation – Tropical Conditions**
  - To cater for tropical conditions common practice is for the engine room to have open side, consisting of only a roof, with supporting columns
  - This type of cover is not suitable for protection against driven rain, dust or sand



Ventilation

VENTILATION





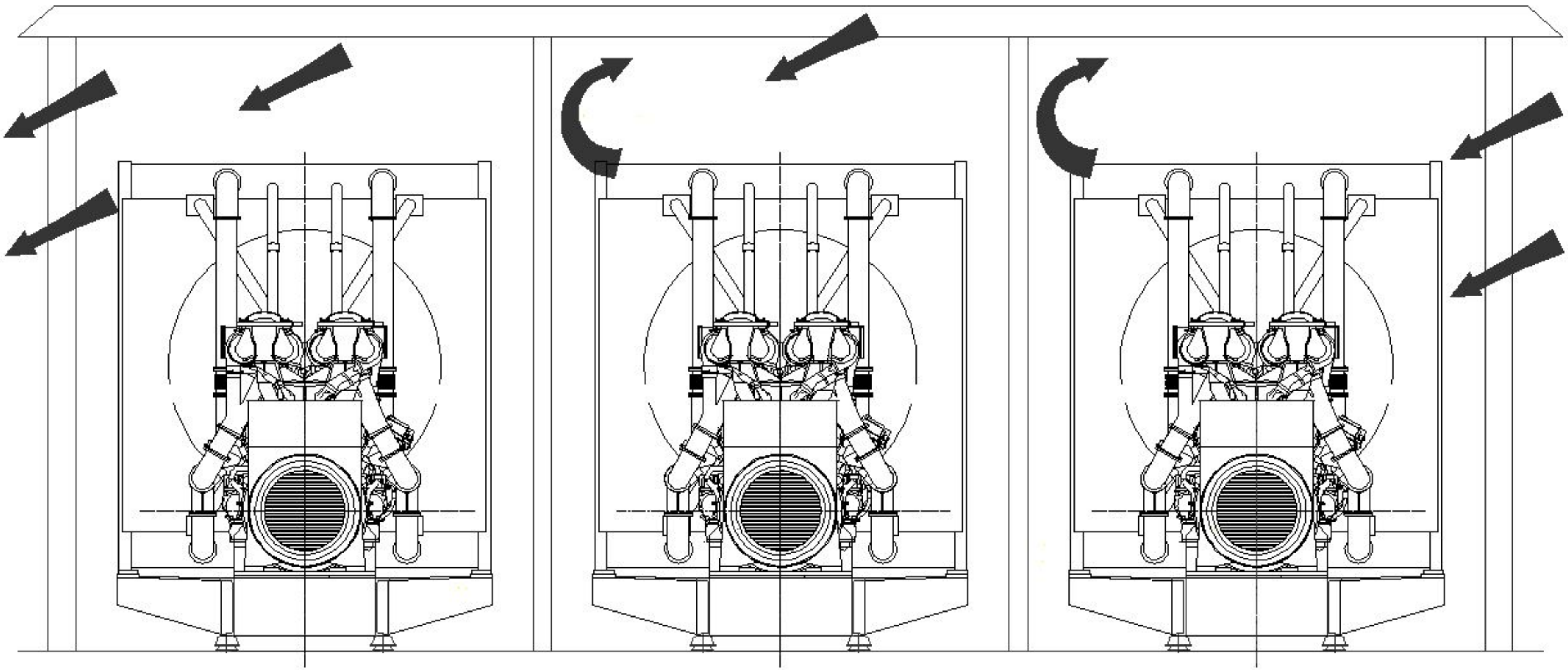
Ventilation

- ## Ventilation – Tropical Conditions
  - Where multiple gensets are installed in an open sided building it is imperative that partitions are fitted to prevent the prevailing wind blowing the radiated heat from one genset onto the next and so on. Allow access for maintenance or only enclose the side facing the prevailing wind.



Ventilation

VENTILATION



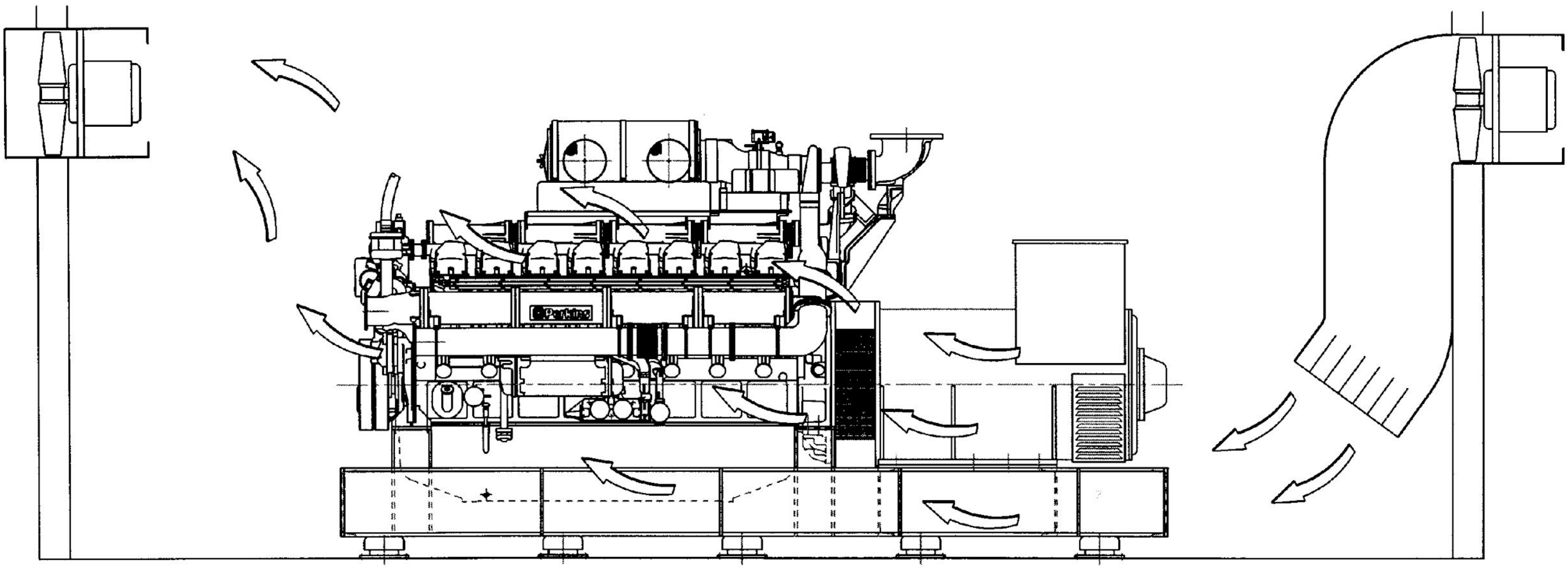
Ventilation

- **Forced Ventilation – Remote Radiator**
  - Exhaust in engine room to be sufficiently lagged so radiated heat is minimal
  - Two electric fans :-
    - One to push air into the engine room, if the fan is situated above the genset, a duct should be used to direct the incoming air to the rear of alternator
    - One fan to extract air, which should be mounted next to and above the engine
  - Recommended engine room is maintained at a maximum temperature of 38°C.
  - If ambient temperature exceeds 38°C, then a temperature rise of no more then 8°C above ambient should be maintained



Ventilation

ENGINE ROOM WITH FORCED VENTILATION



Ventilation

- **Forced Ventilation Calculation**
  - To determine the temperature rise in the engine room requires the airflow to be calculated :-
  - Airflow =

$$\frac{TCR}{W \times 0.0167 \times RT}$$

- Airflow = m^3/min
- TCR = Total radiated heat (kWth)
- W = Density of air at fan inlet (kg/m^3)
- RT = Rise in temperature (^oC)

  - Total heat dissipated is the heat radiated from the engine, alternator and any other heat source
  - Combustion airflow requirement to be added to the above figure



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Ventilation

- **Engine and (Typical) Alternator Radiant Heat to the Engine Room (kWt) – Standby Ratings**

Engine Type	Engine Speed (rpm)		Alternator Speed (rpm)	
	1500	1800	1500	1800
4016TAG	125	NA	72.7	NA
4016TAG1A	127	NA	75.8	NA
4016TAG2A	172	NA	82.7	NA
4016TWG2	166	NA	80.6	NA



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Installation Considerations

Exhaust System



Exhaust Systems

- **Exhaust System Installation**
  - Keep weight off the turbocharger and exhaust outlet elbow by supporting the exhaust system
  - Provide flexibility between the engine outlet and exhaust system
  - Allow for thermal expansion and contraction
  - Exhaust pipe connections must be leak free
  - Drainage of exhaust system
    - A small drain hole should be incorporated in the lowest part of exhaust
    - On vertical stacks a flap should be fitted or turned through 90 degrees to give horizontal outlet and so protect from rain ingress



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Exhaust Systems

- **Do Not :-**
  - Pipe multiple engine exhausts into a common system – Each engine must have it’s own separate system and individual outlet
  - Use an existing stack that is used for other purposes. Engine pulsations can upset updraft required by boiler systems
  - Use existing disused chimneys unless their integrity has been checked
  - Do not lag exhaust manifolds or turbochargers, this will lead to operating deficiencies and failure of parts due to thermal stress



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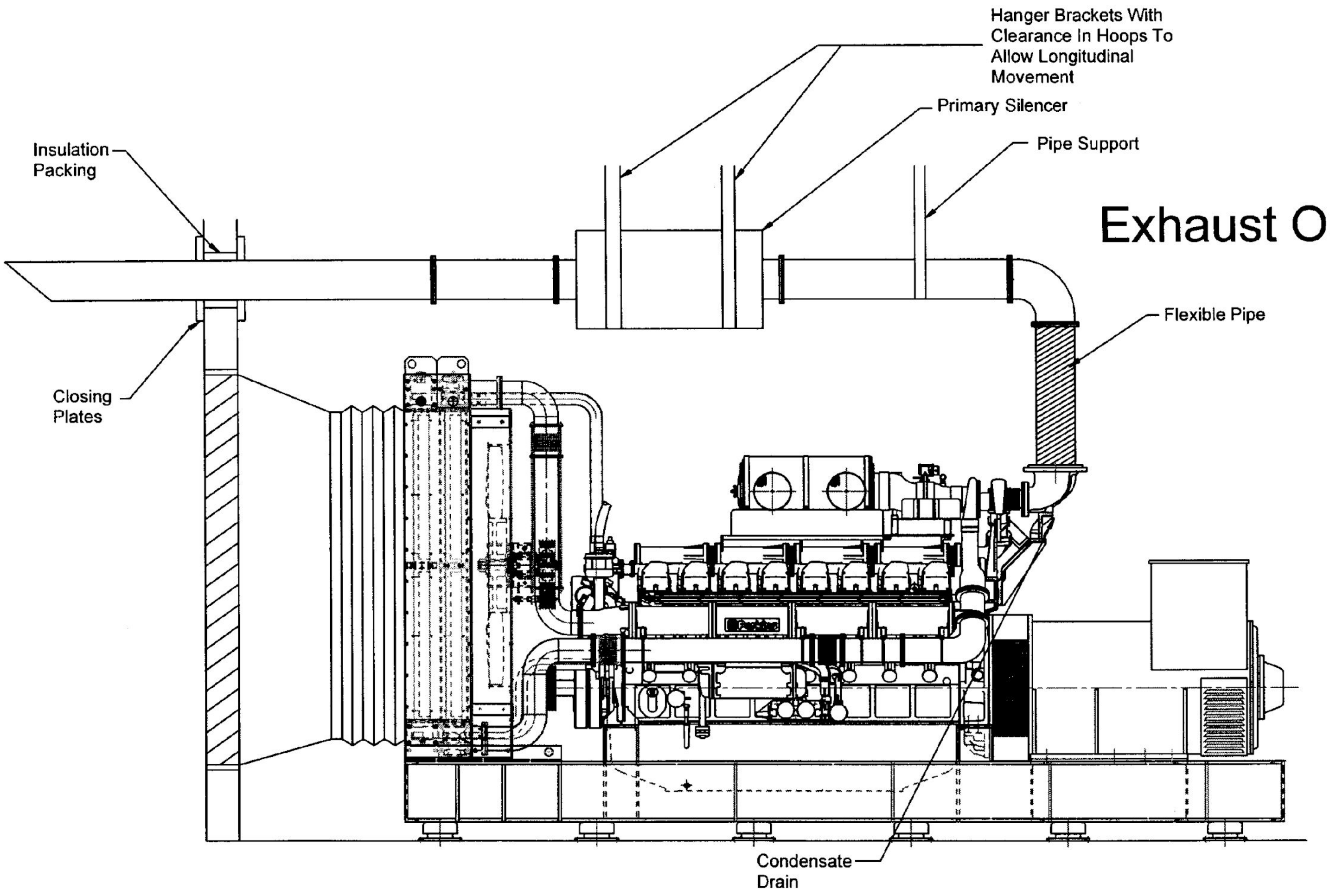
Exhaust Systems

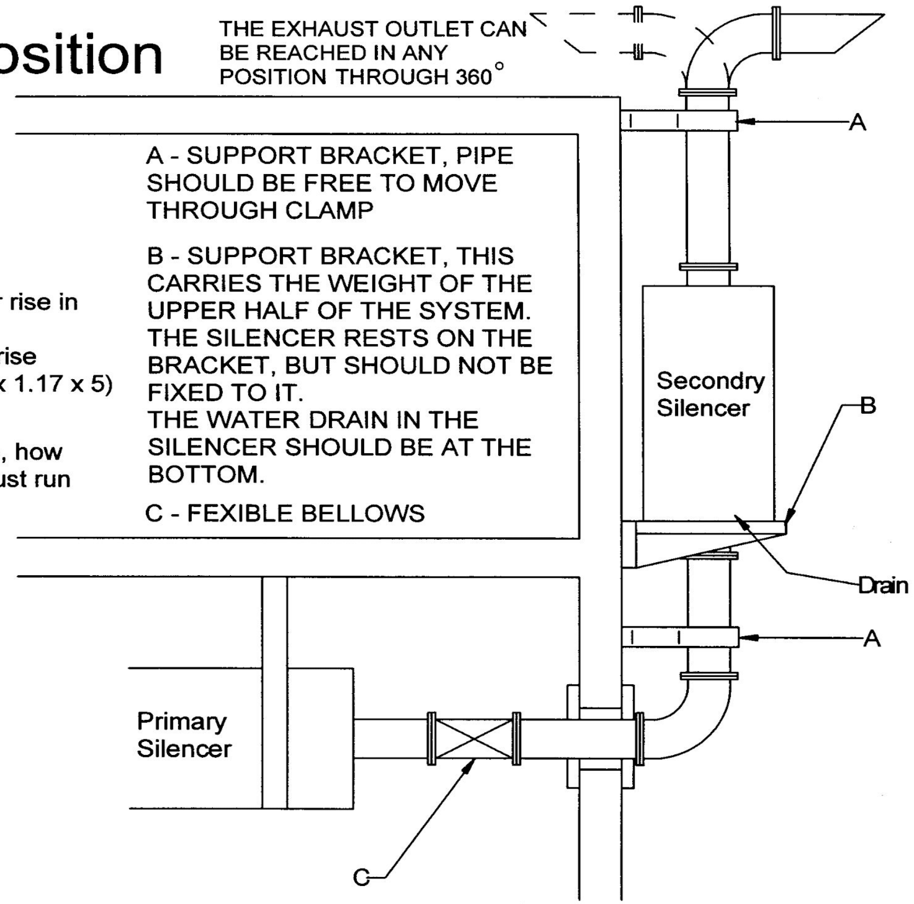


Exhaust Systems

Exhaust Outlet Position

EXPANSION
The expansion of one meter of pipe per rise in temperature of 100 °C is 1.17mm.
5 meters of pipe having a temperature rise from 27 °C to 600 °C will expand (5.73 x 1.17 x 5) = 33.5mm.

This expansion figure shows, by its size, how important it is to properly plan the exhaust run if long life is required.





Exhaust Systems

Exhaust System Terminating in Chimney

- Engine twin exhaust outlets may be piped in to one common individual exhaust pipe
- Engine to have individual outlet in chimney
- Individual exhaust pipe outside engine room are positioned downwards at 5° to 10° angle, to prevent condensate running back towards the engine exhaust outlet
- Inlet to chimney is upwards 30° to 45°
- Condensate drain fitted in the lowest part of the individual exhaust pipe



Exhaust Systems

- **Exhaust Systems Terminating in Chimney - Multiple**

  - Individual exhaust pipes to enter chimney at different heights, with 1.0meter vertical distance between each outlet
  - Maximum of 4 x individual exhaust outlets in one single chimney
  - Minimum area of chimney >/= 6 x the sum of the area of the individual exhaust pipes terminating in the chimney
  - For further details please refer to Product Bulletin A1/12/66 August 2012 and schemes D1481 and D1482



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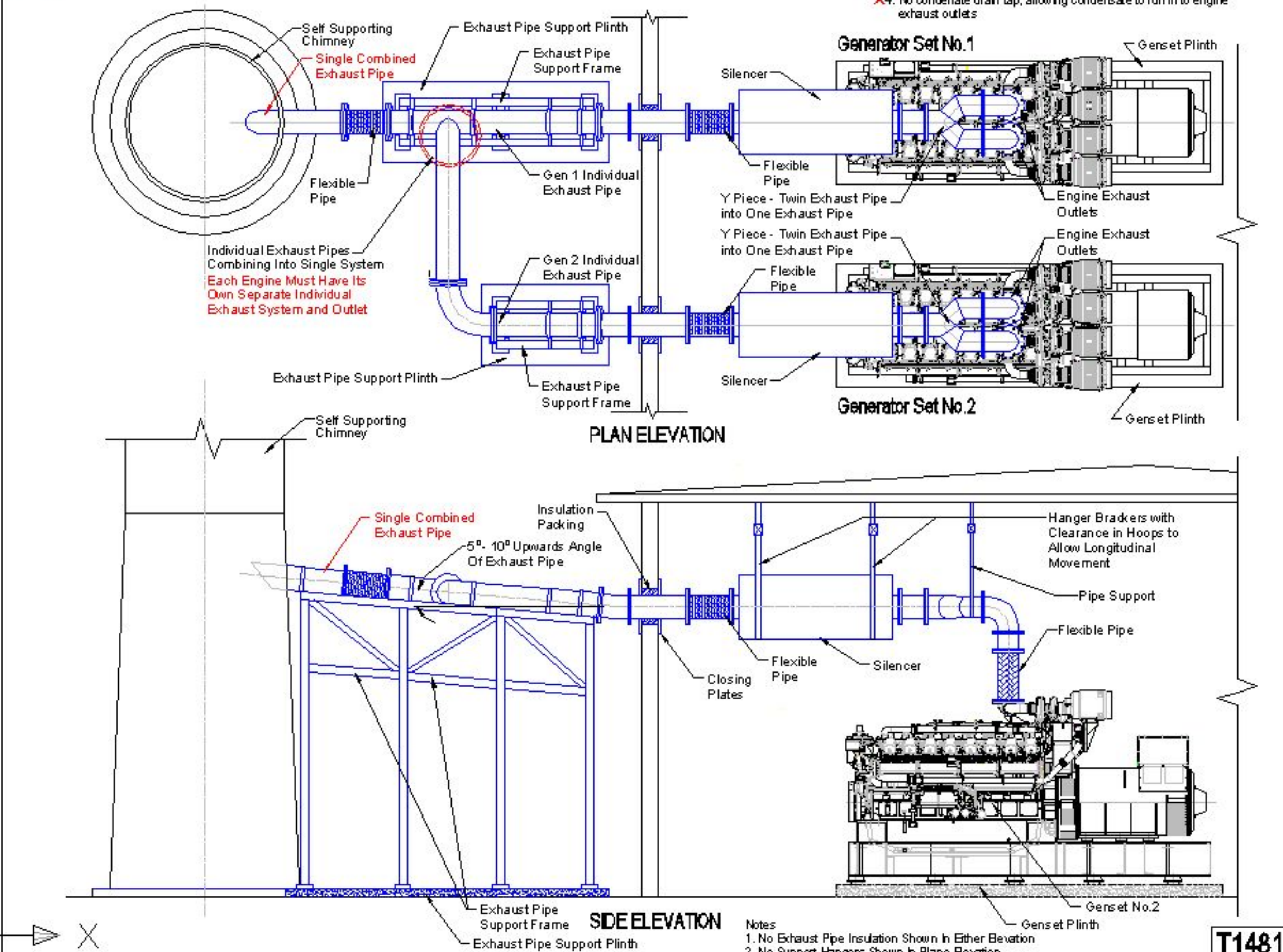
Not Recommended Exhaust Pipe Layout When Terminating In A Chimney

Applicable to All 4000 Series : 4016-61TRG Shown

Summary

1. Engine twin exhaust outlets piped to one common individual exhaust pipe
2. Genset No.2 exhaust pipe is connected to Genset No.1 exhaust pipe
3. Exhaust pipe positioned upwards at 5° to 10° angle
4. No condenate drain tap, allowing condensate to run in to engine exhaust outlets



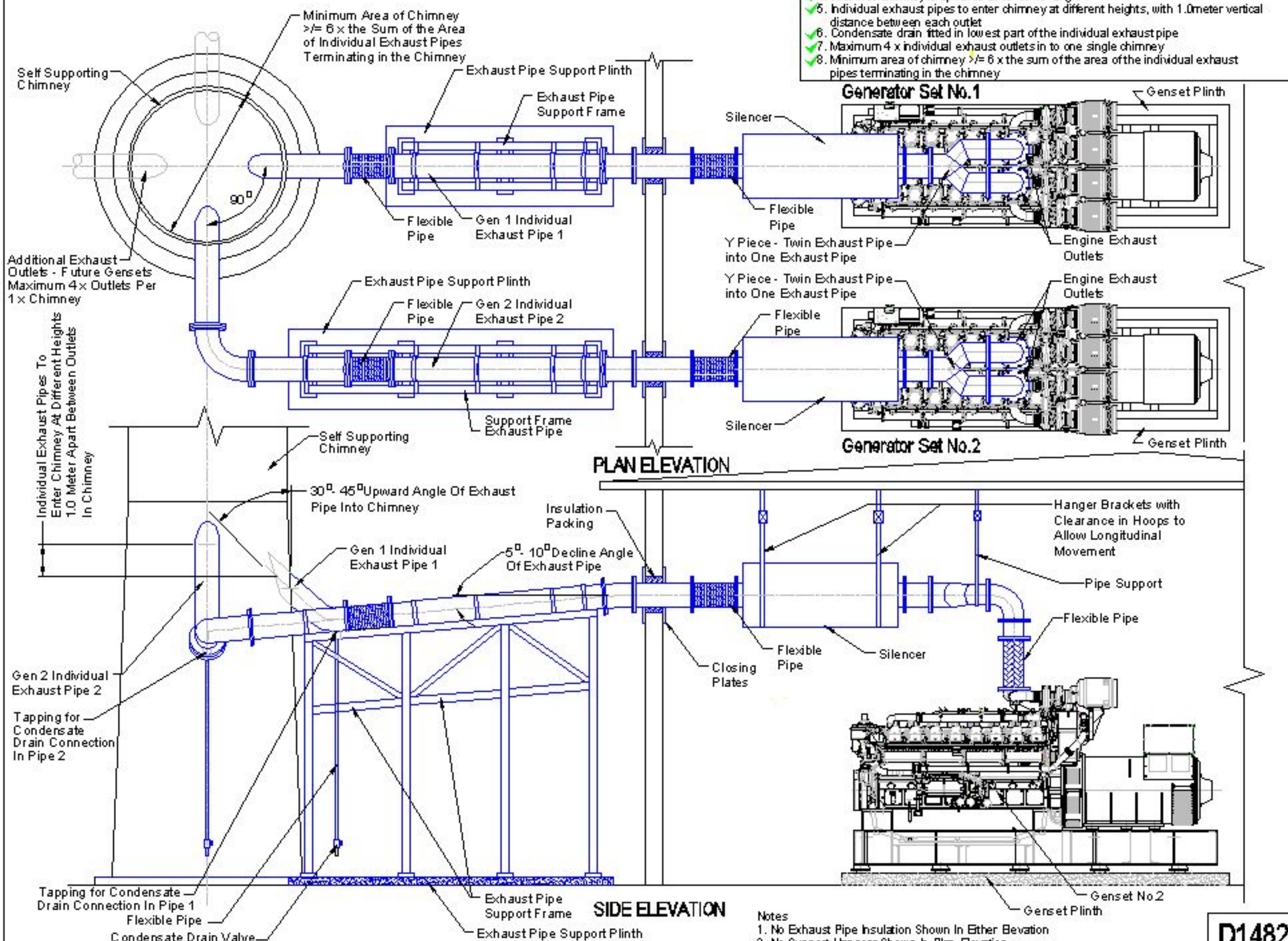
Notes
1. No Exhaust Pipe Insulation Shown In Either Elevation
2. No Support Hangers Shown In Plane Elevation

Recommended Exhaust Pipe Layout When Terminating In A Chimney

Applicable to All 4000 Series : 4016-61TRG Shown

Summary

1. Engine twin exhaust outlets may be piped to one common individual exhaust pipe
2. Each engine has its own separate system, including silencer and individual outlet in the chimney
3. Individual exhaust pipes outside engine room are positioned downwards at 5° to 10° angle
4. Inlet in to chimney is upwards at 30° to 45° angle
5. Individual exhaust pipes to enter chimney at different heights, with 1.0meter vertical distance between each outlet
6. Condensate drain fitted in lowest part of the individual exhaust pipe
7. Maximum 4 x individual exhaust outlets in to one single chimney
8. Minimum area of chimney >/= 6 x the sum of the area of the individual exhaust pipes terminating in the chimney

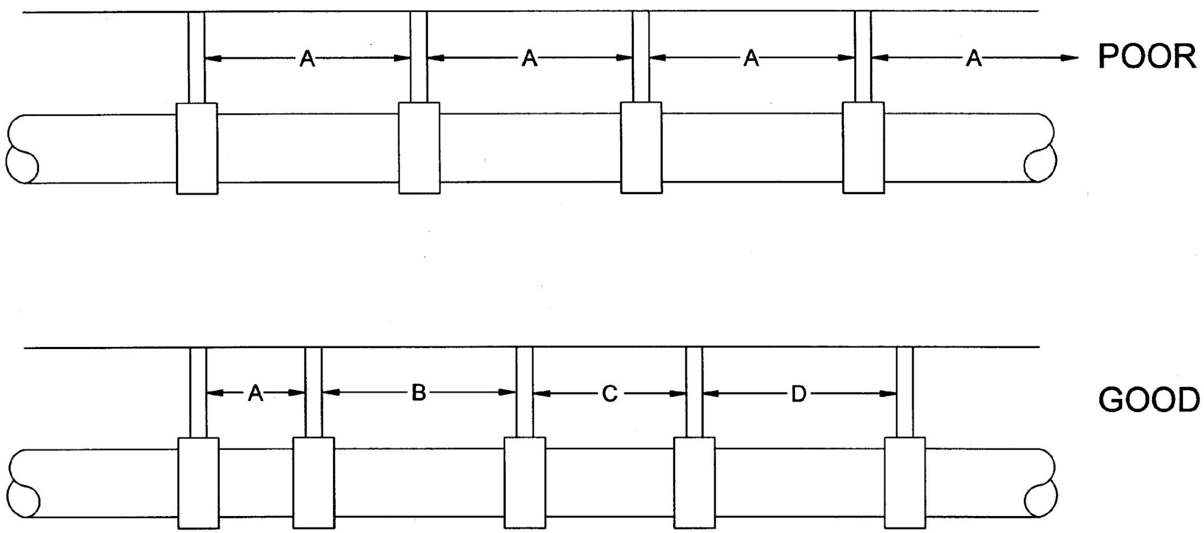


Notes
1. No Exhaust Pipe Insulation Shown In Either Elevation
2. No Support Hangers Shown In Plan Elevation

D1482

Exhaust Systems

- **Piping :-**
  - To prevent build-up of resonant pipe vibrations, long piping runs should be supported at unequal distances



$A \neq B \neq C \neq D$.........etc.



Exhaust Systems

- **Exhaust System Installation**
  - The exhaust system should avoid touching or passing close to ;
    - Lub oil and fuel filters, fuel tank and LP/HP fuel systems
    - Radiator, sump and air cleaner
    - Engine wiring and sensors



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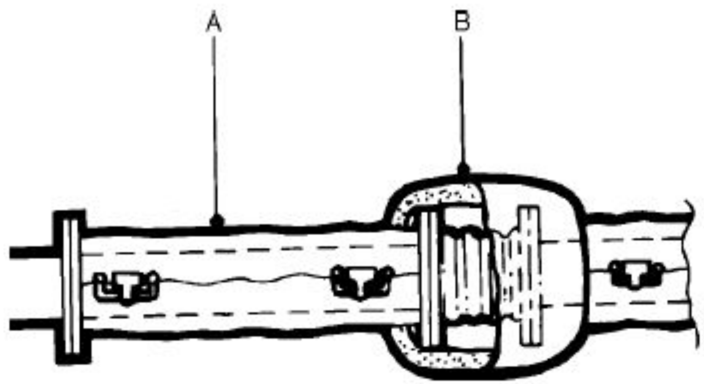
Exhaust Systems

Exhaust System Lagging

- To reduce radiated heat from the exhaust pipework within an engine room, it is recommended the pipework is insulated with insulating wrappers 25mm to 50mm thickness.



A. Clip-on insulation wrapper
B. Clip-on insulation muff

- Do not lag exhaust manifolds or turbochargers, this will lead to operating deficiencies and failure of parts due to thermal stress



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Exhaust Systems

- **Back Pressure**
  - The exhaust system will produce a certain resistance to the flow of exhaust gases
  - The back pressure for the total system must be kept within the limit of each engine maximum :-

Engine Type	Maximum Allowable Exhaust Back Pressure at 1500rpm (kPa)	Maximum Allowable Exhaust Back Pressure at 1800rpm (kPa)
4016TAG/TAG1A	9.35	NA
4016TAG2A / TWG2	6.65	NA



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Exhaust Systems

- **Back Pressure Calculation**
  - Back pressure of a proposed exhaust system can be calculated by using :-
  - $$P = \frac{L \times Q^2}{D^{5.33}} \times 1187 \times 10^9$$

- P = Back pressure (mmHg)
- *Q* = Gas flow (kg/s)
- L = Total equivalent length * straight pipe (M)
- D = Pipe diameter (mm)

- Back pressure losses through silencer(s) must be added to the above to obtain total system losses



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Exhaust Systems

- **Effects of Excessive Exhaust Back Pressure**
  - Too high a back pressure leads to:
    - Loss of power: approx. 0.5% decrease for each 3.3kPa above maximum level
    - Poor fuel economy: fuel consumption increases by approx. 0.5% for each 3.3kPa above maximum level
    - High combustion temperature: 2.5% increase in exhaust gas temperature for each 3.3kPa above maximum level
    - These conditions produce over-heating and excessive smoke from the installation, and reduce the lives of the valve heads and valve seats
    - Because of the above the 5kPa limit on the 4012-46 Series must not be exceed, the exhaust pipe internal bore will have to be increased or pipe run length reduced
    - Perkins do not produce exhaust back pressure derate charts



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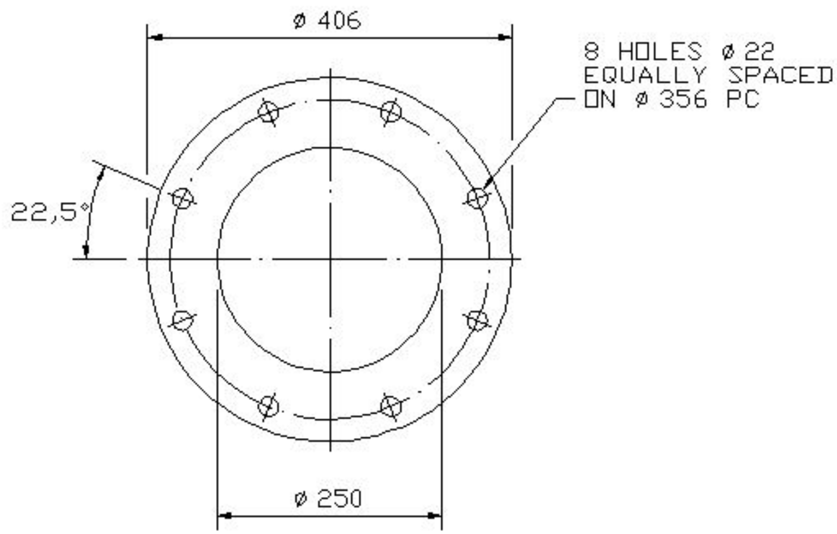
Exhaust Systems

- **Exhaust Outlet Flange Size**
  - 4016 Supplied with :
    - Twin 250mm BS 10 Table ‘D’ Outlet Flanges



DETAIL OF EXHAUST OUTLET FLANGE
(B.S.10 TABLE D)



Installation Considerations

The Cooling System



Cooling System

Cooling System Requirements

- Pressure cap setting 70kPa is maintained in the system
- 98°C top tank
- Ambient clearance
  - 50% Glycol 50°C Tropical
  - 50% Glycol 35°C Temperate
  - Tested at 110% operating load
- Maximum oil temperatures at sump :
  - 80°C Normal
  - 105°C Maximum

Cooling System

Radiator

Engine Type	Engine Speed (rpm)	Radiator Type	Airflow (m3/min)	Duct Allowance (Pa)	Part No.
4016TAG	1500	Tropical	1914	155	584/342FC
4016TAG1A	1500	Tropical	2394	165	432-0046
4016TAG2A	1500	Tropical	2430	150	432-0046

Note : Product Bulletin 72/13 June 2013

-584/365FC cooling group changed to 432-0046 from 13th May 2013 onwards.

- The fit, form and function and performance of the radiator has no change and is like for like as the current architecture, the changes are to the fan blade angle and as a result there is a longer drive belt and a smaller diameter pulley



Cooling System

- **Radiator**
  - **Construction**
    - Fin and tube
    - Pusher fan
  - **Mounting**
    - Solid direct to baseframe



Cooling System

- **Air To Air Charge Cooler**
  - Reduces induction air temperature
  - Air to air radiator in front of coolant radiator
  - High efficiency - High air to air temperature difference
  - Engine driven fan pushes air through each section in series, through the charge air section first
  - Considered an integral part of the engine



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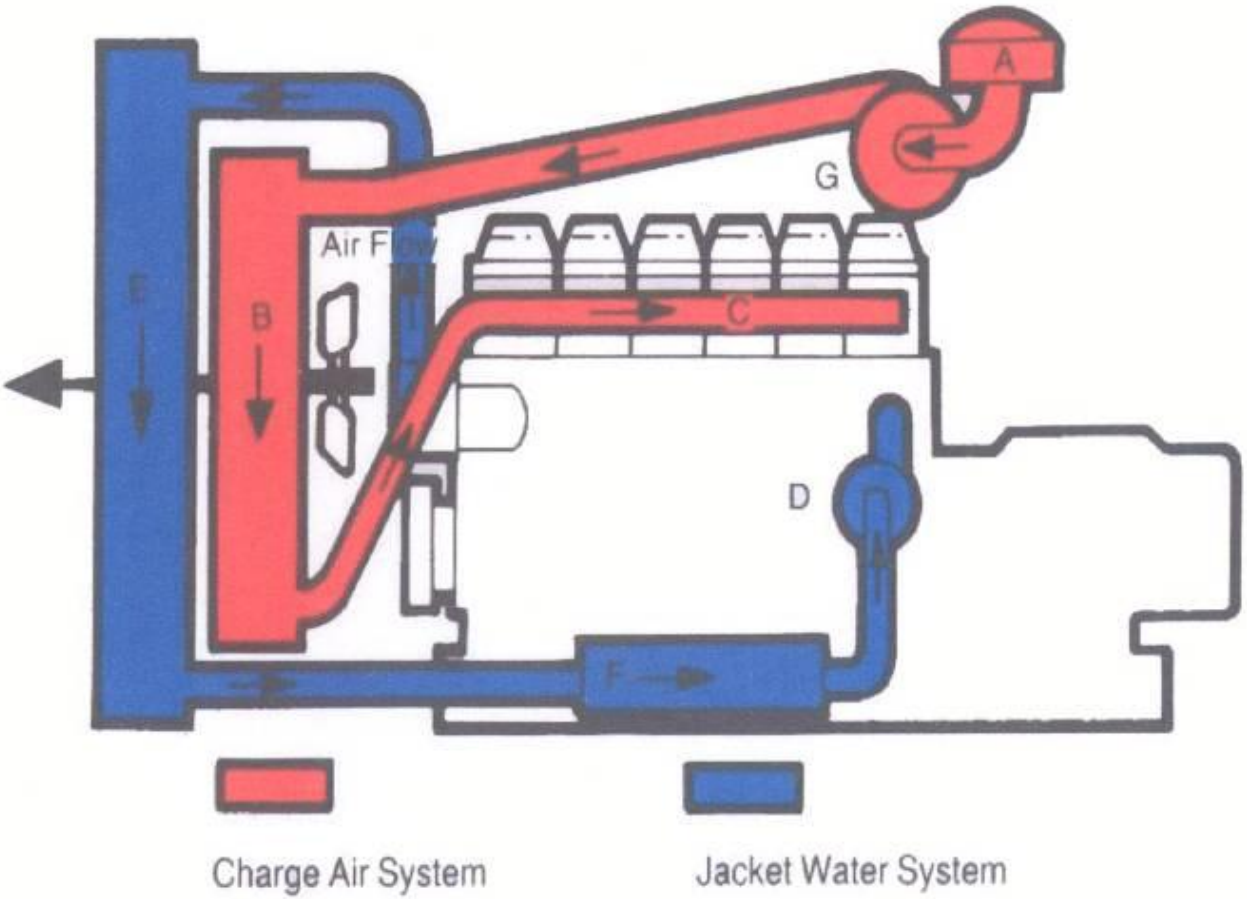
Cooling System

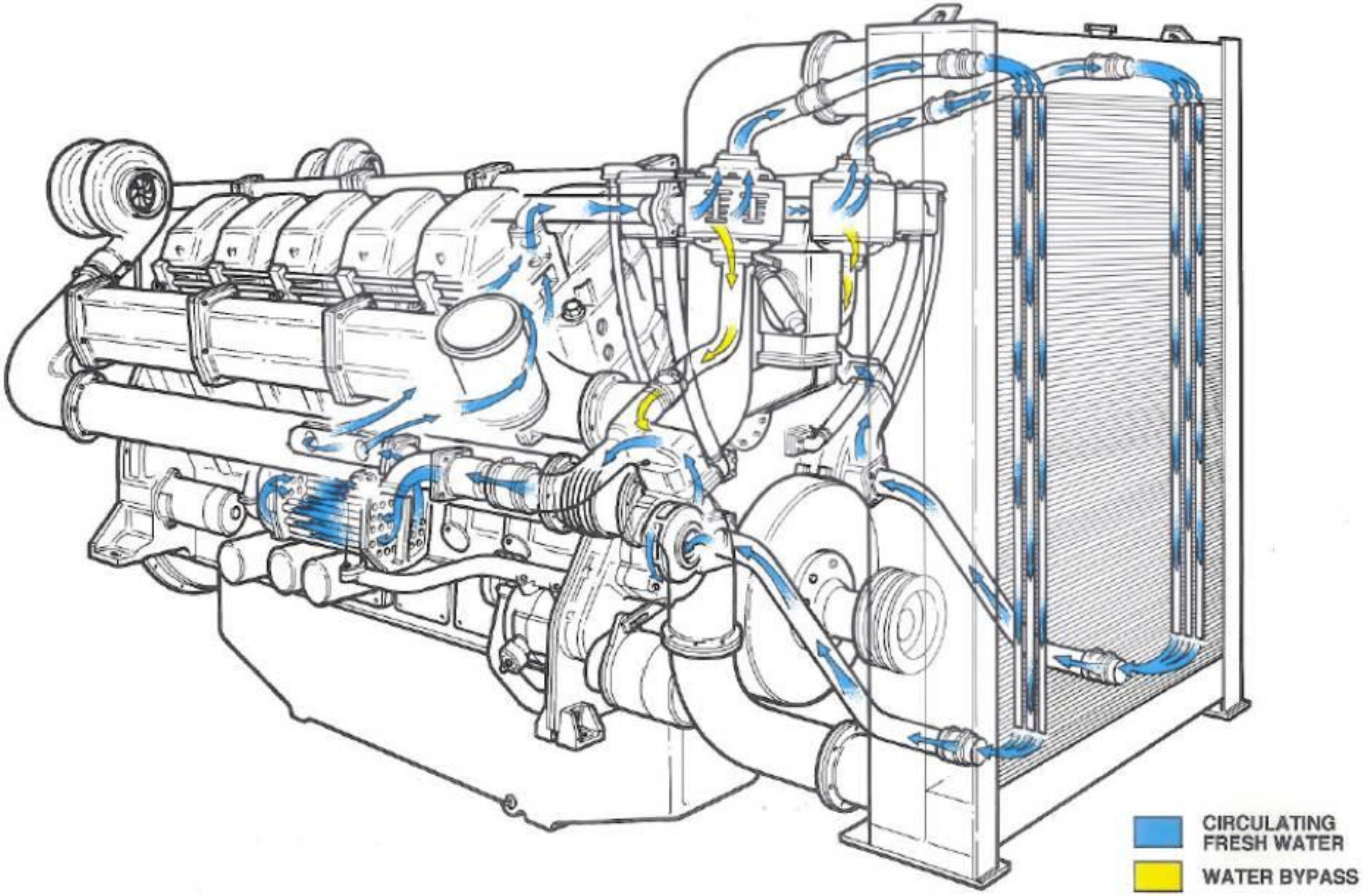
- **TAG - Radiator Cooled**



- **A Air cleaner**
- **B Air cooled charge air cooler**
- **C Air inlet manifold**
- **D Jacket water pump**
- **E Jacket water radiator**
- **F Lubricating oil cooler**
- **G Turbocharger**



Cooling Systems

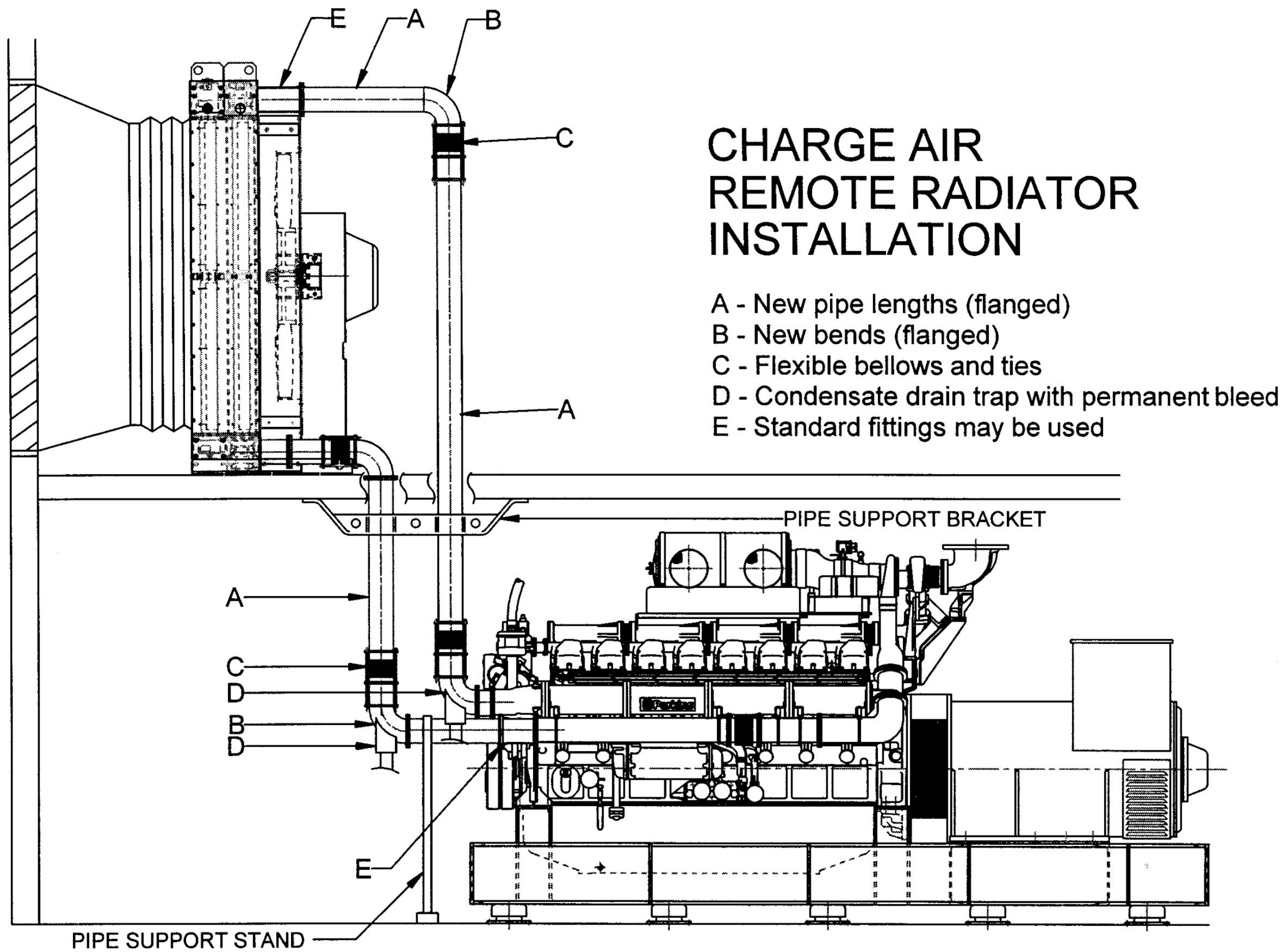




Cooling System

- **Air to Air Charge Cooler – Remote**
  - Opening in wall the same as set mounted radiators
  - Maximum length of charge air pipework to and from the radiator is 5 meters
  - Flexible bellows with ties required on additional pipework to and from radiator
  - Connections to be air tight to prevent boost air leaks
  - Condensate drain traps with permanent bleeds at the lowest point in each pipe run to and from radiator, to remove condensate from pipes

Cooling Systems



Cooling System

- **Water Pipe and Pressurized Make-up/Vent System – Remote**
  - Coolant pipes to and from radiator to have rubber hose connections
  - Make-up and expansion tank to be incorporated in the system
  - Capacity of make-up and expansion tank should be large enough to allow expansion of the water in the system, which is 5 to 6% of the total water volume
  - Top of header tank no more than 7meters above the coolant pumps, with pressurized make-up tank no more than 0.5meters
  - Pipe size to be increased so no additional resistance to the flow is more than 6.5 to 10kPa



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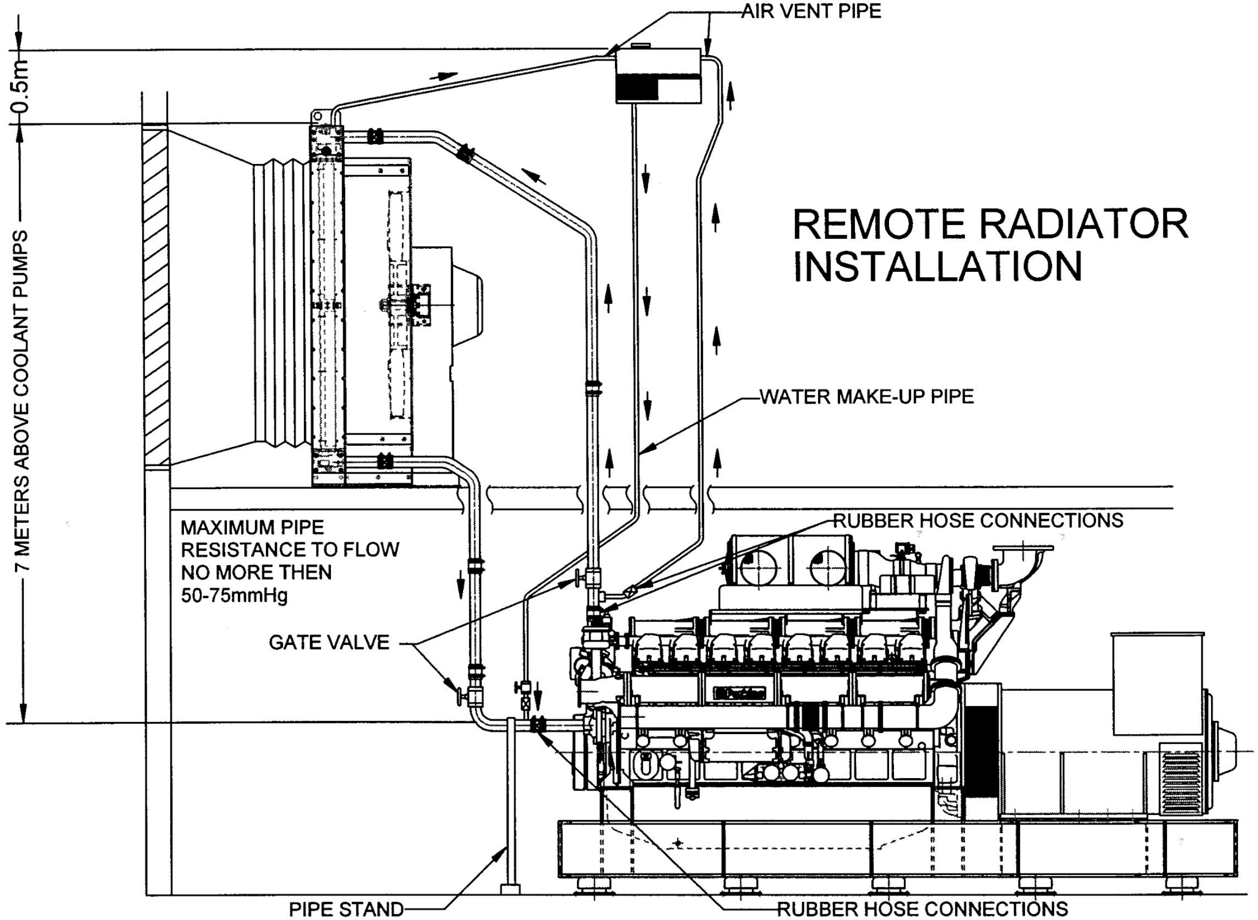
Cooling System





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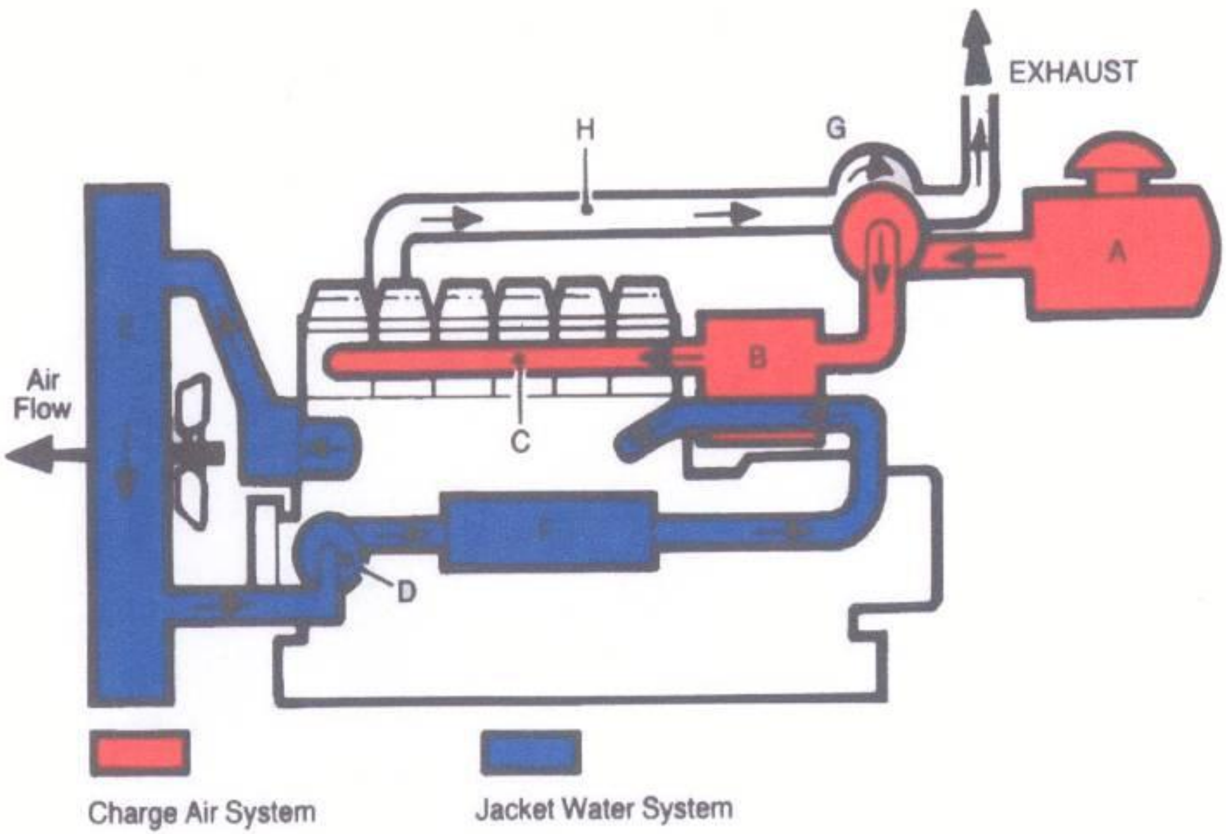
Cooling System

- **TWG – Radiator Cooled**



A Air cleaner

B Water cooled charge air cooler

C Air inlet manifold

D Jacket water pump

E Jacket water radiator

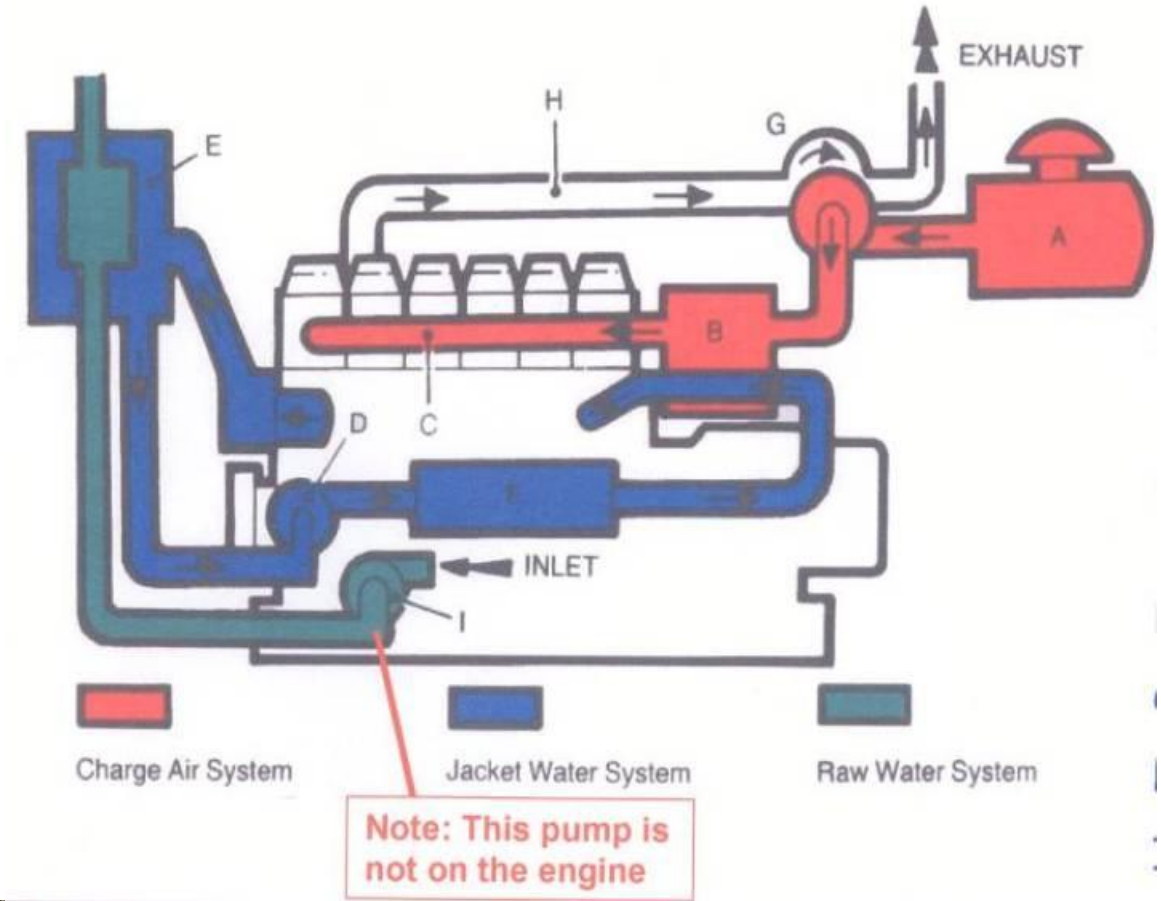
F Lubricating oil cooler

G Turbocharger

H Exhaust manifold

Cooling System

- **TWG – Heat Exchanger Cooled**



A Air cleaner

B Water cooled charge air cooler

C Air inlet manifold

D Jacket water pump

E Jacket water heat exchanger

F Lubricating oil cooler

G Turbocharger

H Exhaust manifold

I Raw water pump

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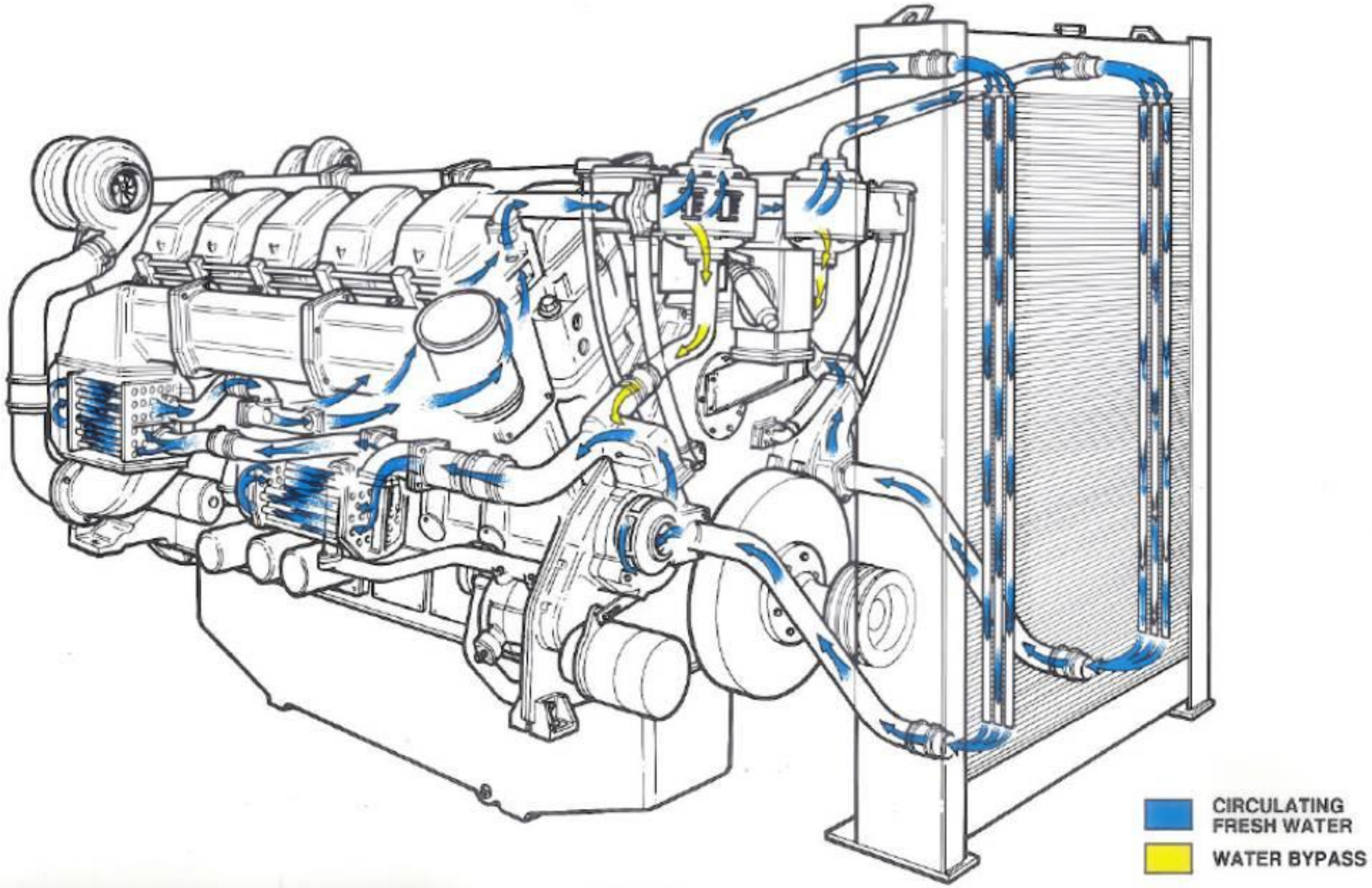
Cooling Systems





Cooling System

- **Protection**
  - Antifreeze
    - 50% mixture
      - Inhibited ethylene glycol or inhibited propylene glycol
  - Corrosion Inhibitor – in ambients above 10^{o}C
    - Perkins inhibitor 1% by volume



Cooling System

- **Ambient Clearance**
  - Stable Top Tank Temperature - Ambient = Rise Over Ambient (ROA)
  - Limiting Coolant Temperature - ROA
  - = Ambient Coolant Clearance
  - Jacked open thermostats (ensure fitted correctly)



Cooling System

▪ Blocked Open Thermostats

- Always block thermostat open to 11.5mm
- Use an 18mm long spacer tube

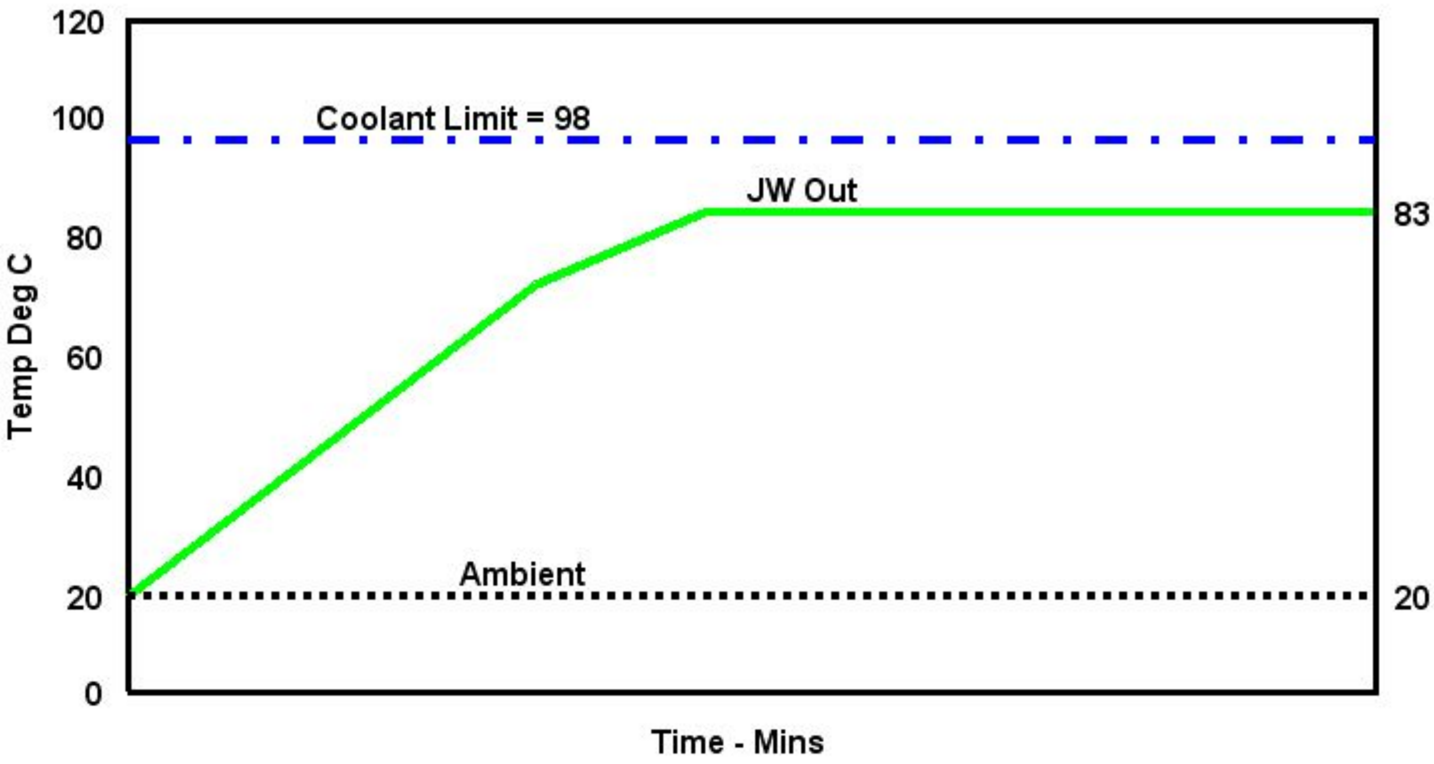
- Drill wax capsule to disable thermostat

- Do not run without thermostat
  - Inaccurate coolant restriction
  - Inoperative bypass blanking will damage engine



Cooling System

- **Coolant Test Results**



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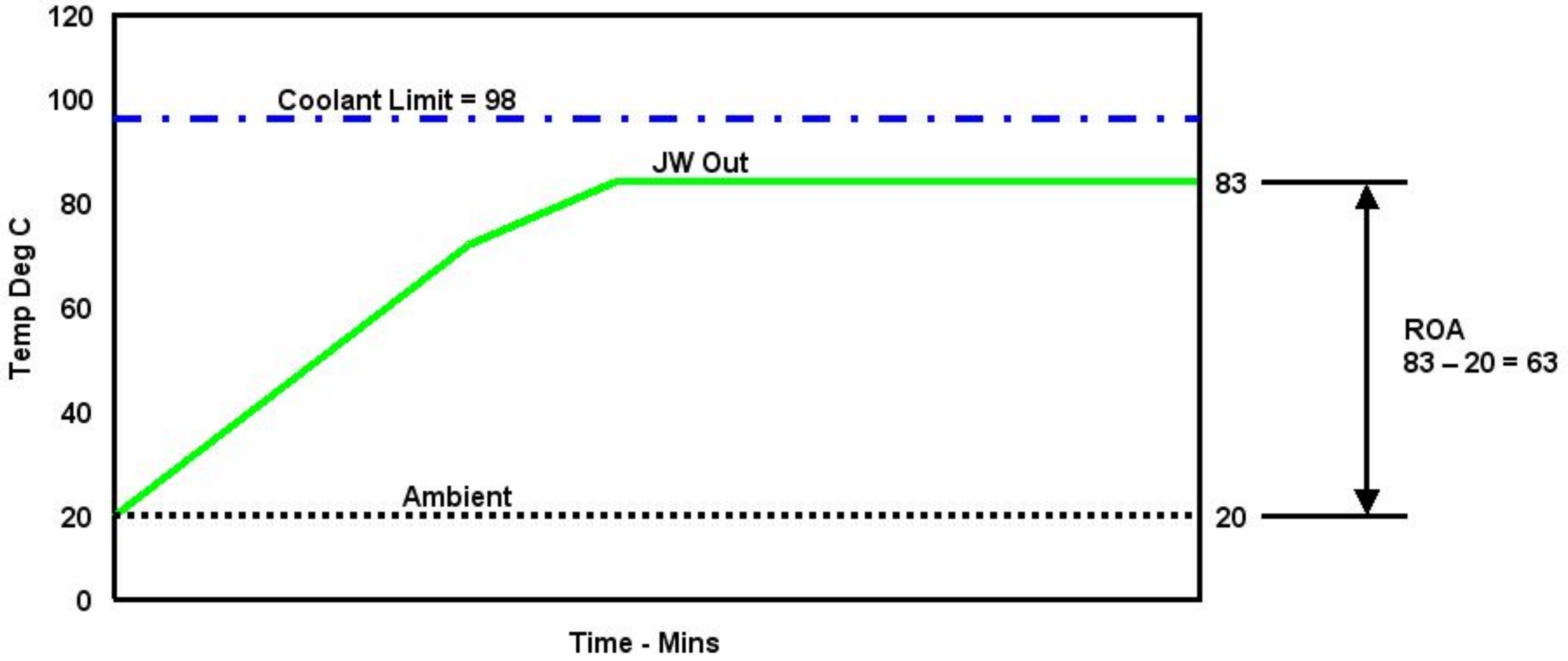
Cooling System

- **Coolant Test Results**



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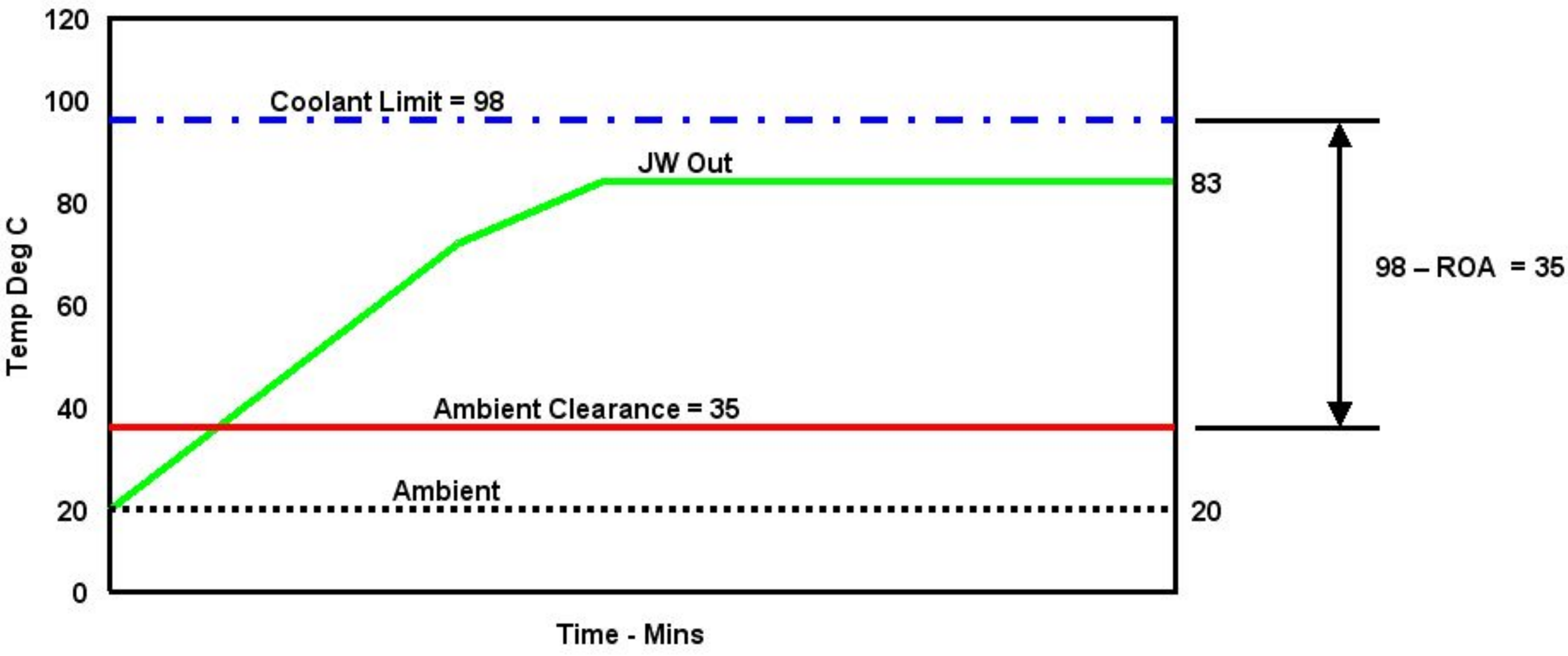
Cooling System

- **Coolant Test Results**





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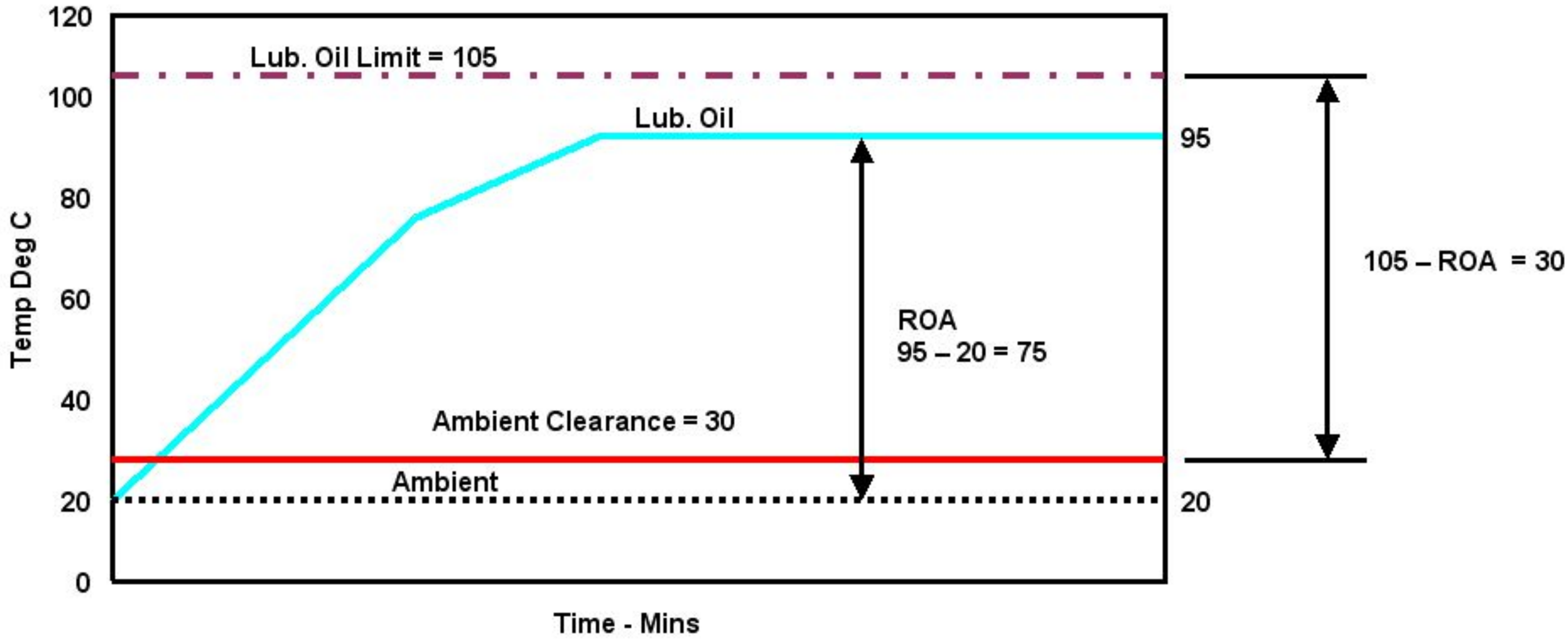
Cooling System

- **Lub. Oil Test Results**



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Cooling System

Testing / Measurements

Temperature Probes	Quantity
T.I.T.	4 (Min. 2)
Exhaust OUT	2 Optional
Jacket Coolant OUT	2
Jacket Coolant IN	2
Inlet Manifold	2
Boost from turbocharger	2
Fan (Air IN Cooling Group)	6 Minimum
Air to Filter	2 Minimum
Ambient	1 Minimum
Lub. Oil IN	2 Optional
Lub. Oil OUT	2

Pressure Senders	Quantity
Inlet Manifold	2
Boost from turbocharger	2



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Cooling System

- **Analysis Of Results**
  - Low coolant clearance
    - Excessive duct restriction
    - Re-circulation



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Cooling System

- **De-Aeration**
  - Possible Causes
    - Poor filling
    - Poor venting
    - Blockages



Cooling System

De-Aeration

- Effects of air in water
  - Local boiling
  - Excessive coolant loss
  - Deterioration of water pump performance
  - Cavitation
  - High metal temperatures
  - Total cooling system failure
  - Engine failure



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Applications Considerations

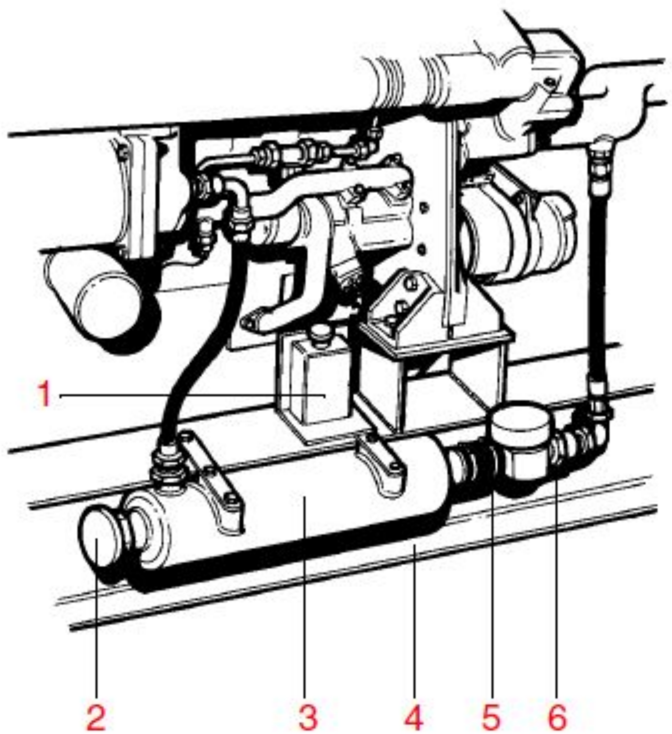
Cold Start



Cold Start

- **Immersion Heaters**
  - In ambient conditions 10°C and below, it is recommended that external Immersion Heaters are fitted – 1 per bank – 4kW rating each

1. Contactor Unit
2. Immersion Heater
3. Water Tank
4. Drain Plug
5. Hose Connection
6. Thermostatic Switch





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Installation Considerations

Fuel System



Fuel System

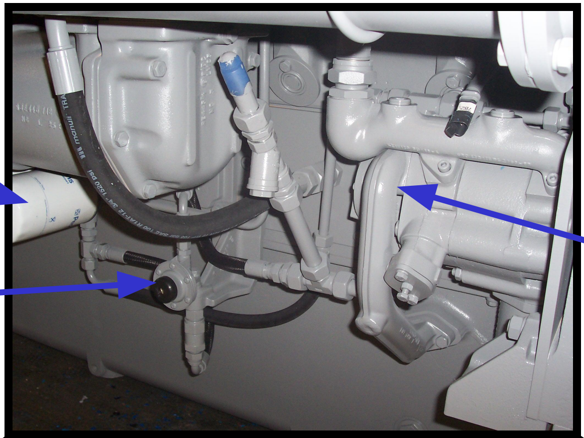
- **The purpose of the fuel system is to ensure:**
  - An ample supply of clean fuel
  - There is no water or air in the fuel system
  - The fuel is at the correct pressure



Fuel System

- ## Fuel Filtration

- Disposable spin-on canister type, with a self venting valve. Full flow type



- Formulated and treated medium used to combine superior fuel filtration and water separation

- Filtration to 10 microns

- Hand priming pump part of fuel lift pump

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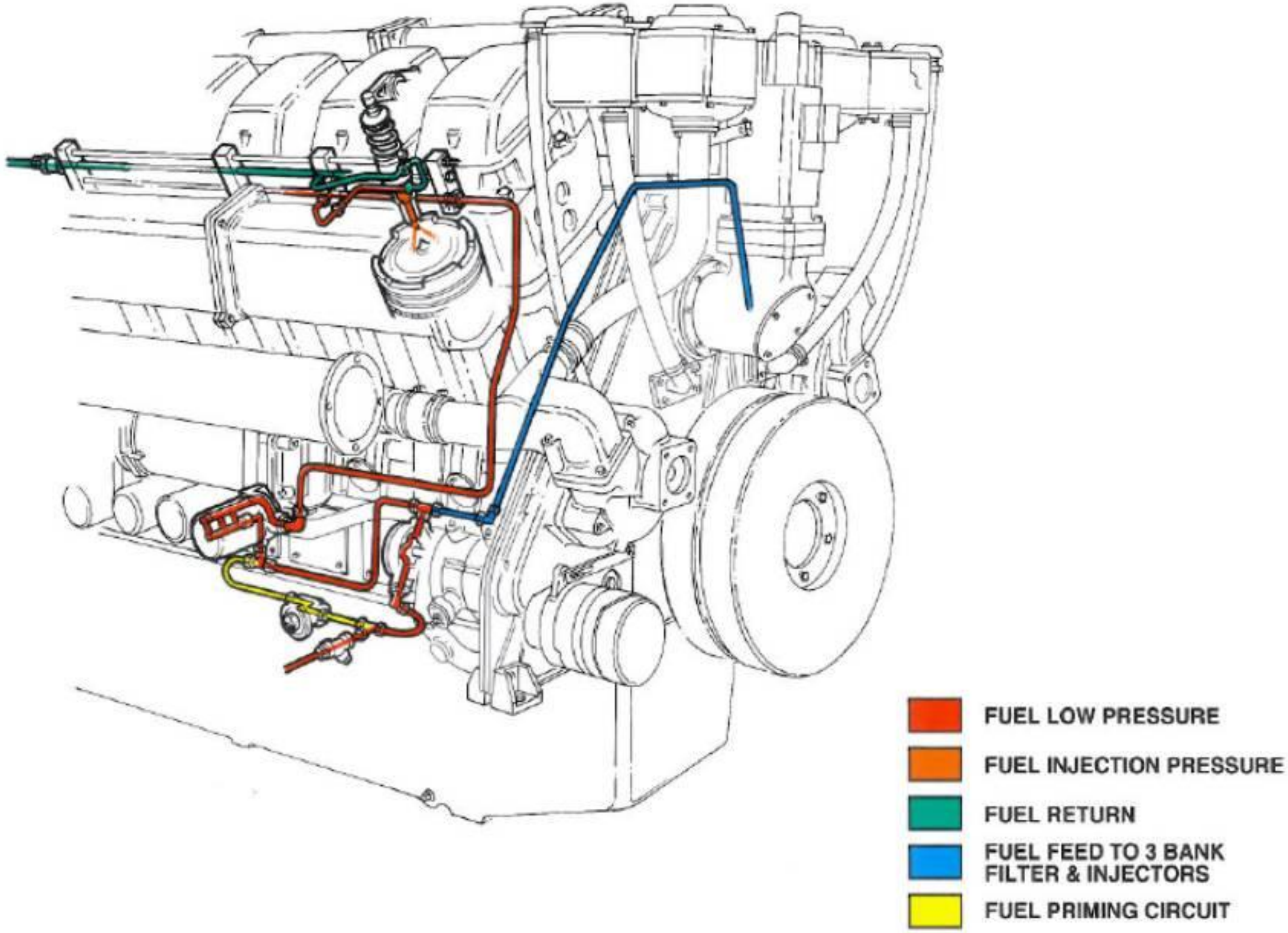
Fuel System


FUEL LOW PRESSURE
FUEL INJECTION PRESSURE
FUEL RETURN
FUEL FEED TO 3 BANK FILTER & INJECTORS
FUEL PRIMING CIRCUIT

Fuel System

- **Fuel Temperature**
  - Effect engine performance and emissions if fuel inlet temperature is too high
  - Fuel inlet temperature should not exceed 58^{o}C
  - Minimum fuel tank size to be 18,000 Litres, if smaller a fuel cooler will have to be incorporated in the system
  - 18,000 Litres will allow 8 hours continuous running at Prime Power Rating



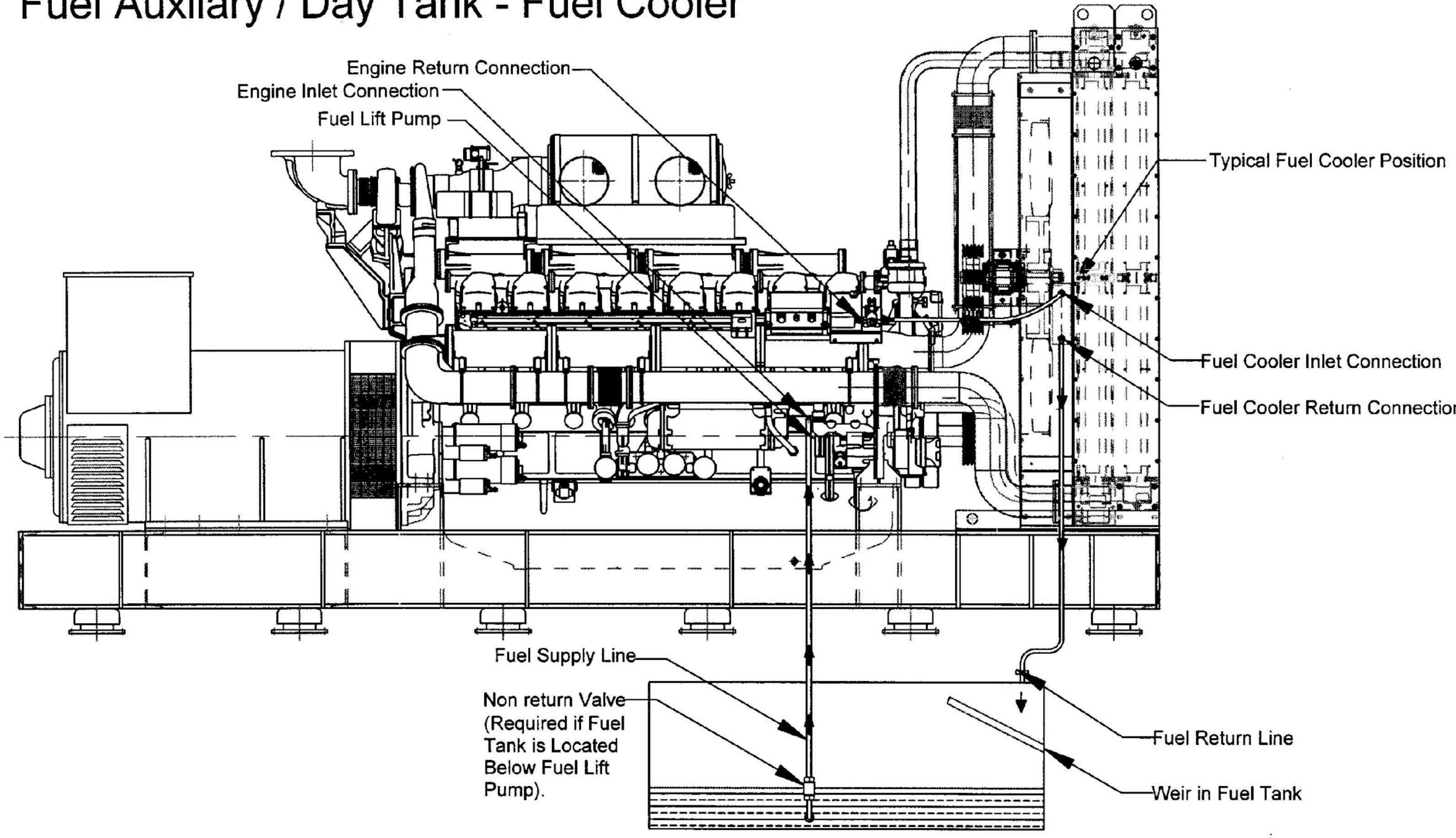
Fuel System

- **Fuel Cooler**
  - If a fuel cooler is required it should be sized to dissipate 12.5kWt min. at 1500rpm Standby
  - Fuel coolers are an delete option and can be selected on the OCD. They will be supplied assembled to the radiator on ElectropaK's, and loose for Electrounit's



Fuel System

Fuel Auxilary / Day Tank - Fuel Cooler





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Fuel System

- **Fuel Auxiliary or 'Day Tanks'**
  - Total suction head must not exceed 2.5meters
  - Day tanks provide a settling reservoir for water and sediment
  - Fuel level in the day tanks must not exceed 1.5meters above the level of the fuel injectors, or an isolating solenoid valve must be installed on the fuel feed, and arranged to open on cranking, with delayed closure on shut down to prevent fuel starvation

Engine Label regarding Height



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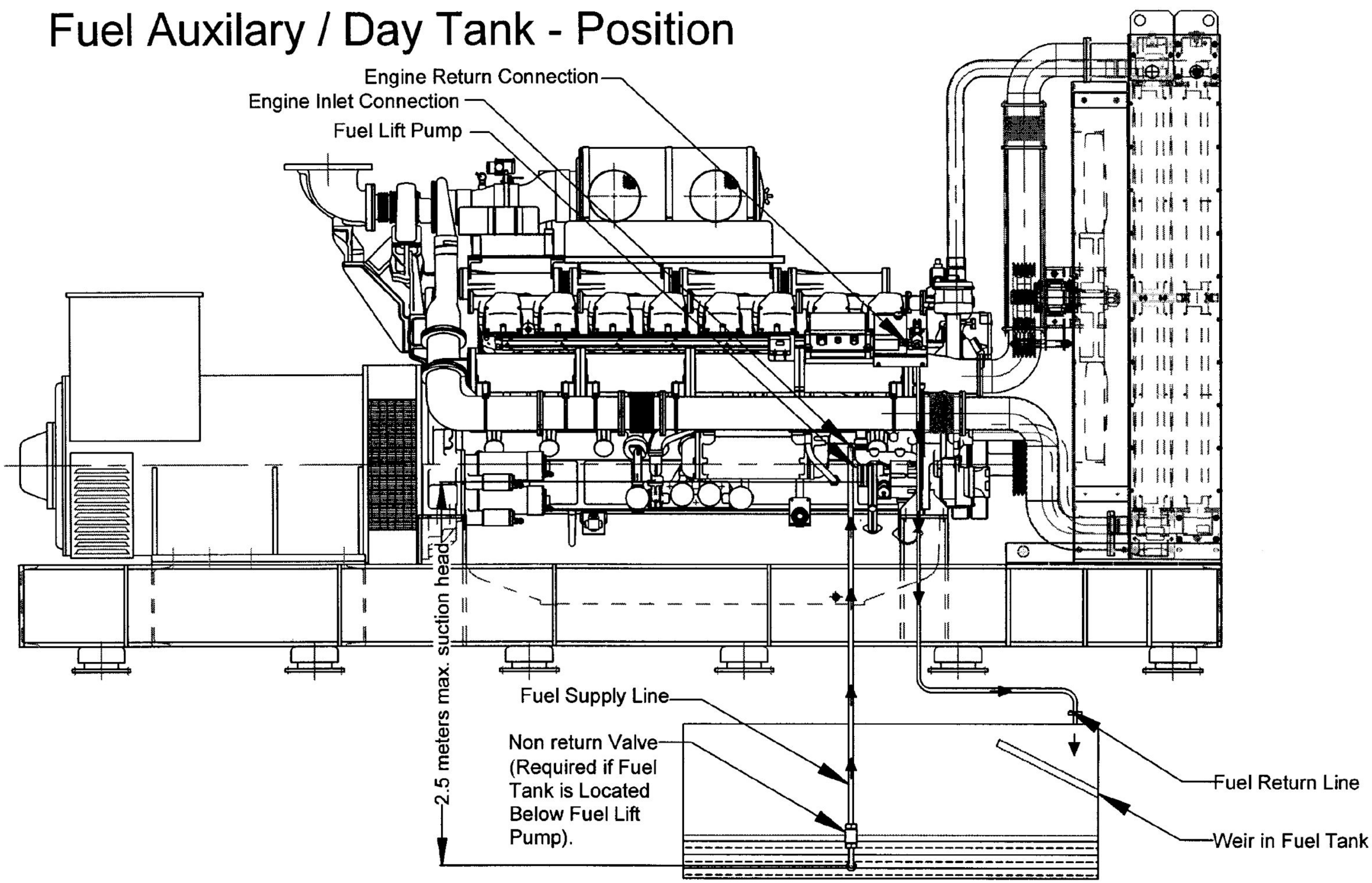
Fuel System



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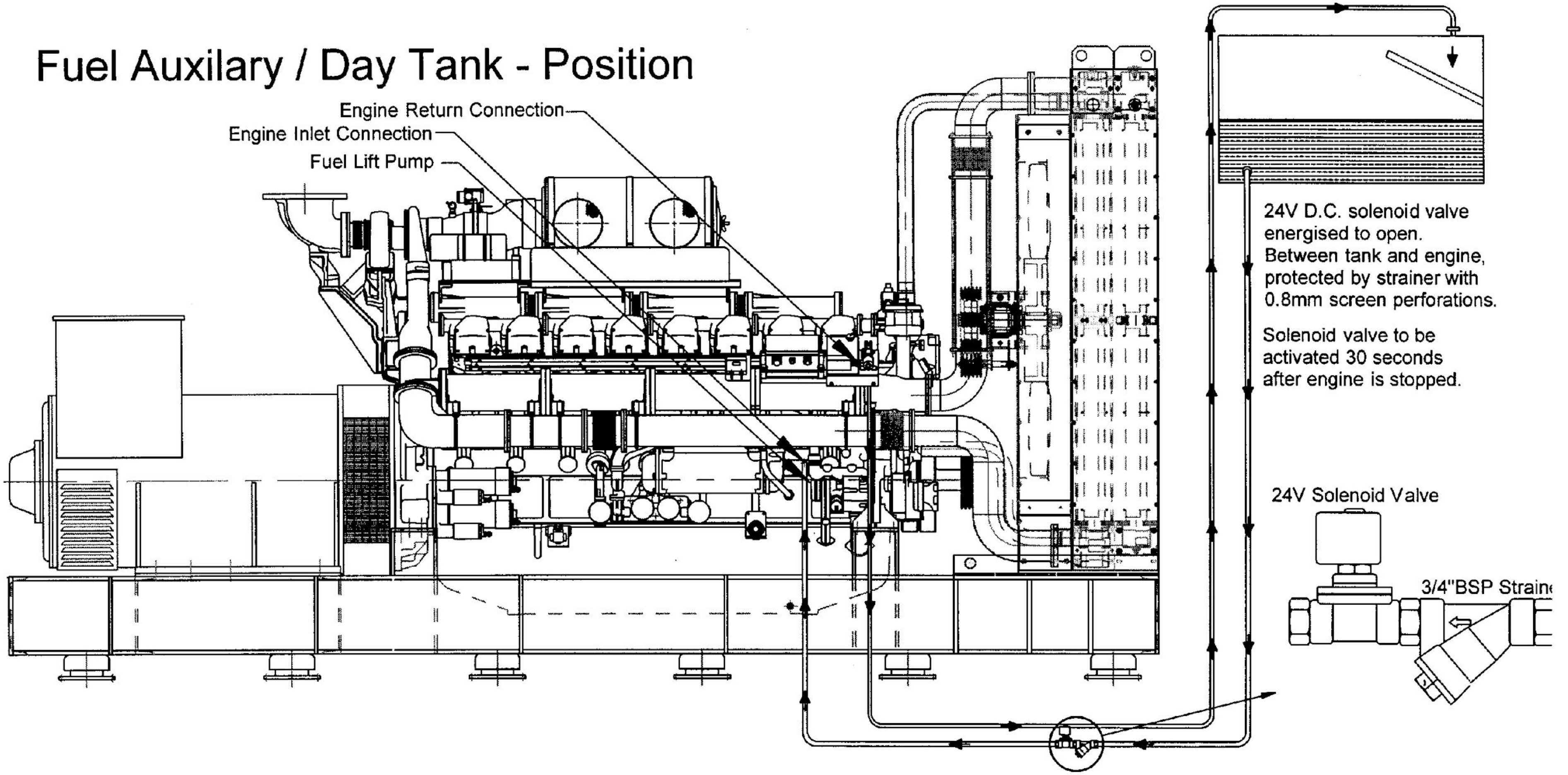
Fuel System

Fuel Auxilary / Day Tank - Position



Fuel System

- **Fuel Auxiliary or ‘Day Tanks’**
  - Weirs must be incorporated in the day tank to ensure fuel to the engine is not full of entrained air
  - Fuel can become aerated due to the day tank running out or low on fuel
  - The consequences of aerated fuel are, poor starting, low power, high exhaust temperatures and cavitation erosion within the injector units



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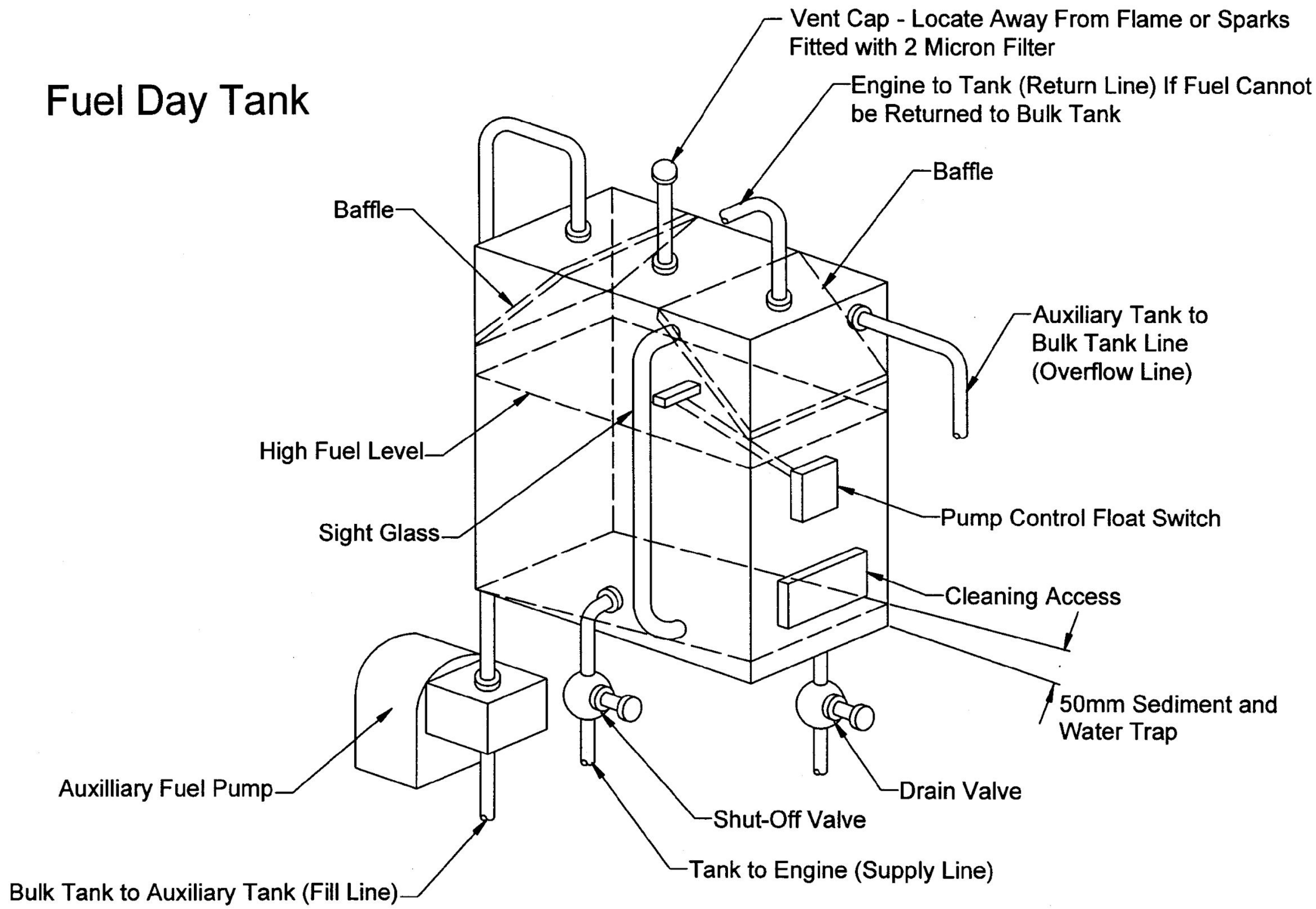
Fuel System



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Fuel System

Fuel Tank

- The fuel intake pipe must be above the bottom of the tank
- There should be no gauze fitted on the fuel feed pipe in the tank
- A serviceable coarse filter may be fitted to the tank filler
- A suitable air vent should be provided to allow free entry of air as fuel is used. Vent should be fitted with a 2 micron filter
- The words ‘DIESEL FUEL ONLY’ is printed on the filler cap
- The position of the feed pipe should not be more than 2.5meters below the lift pump inlet port2



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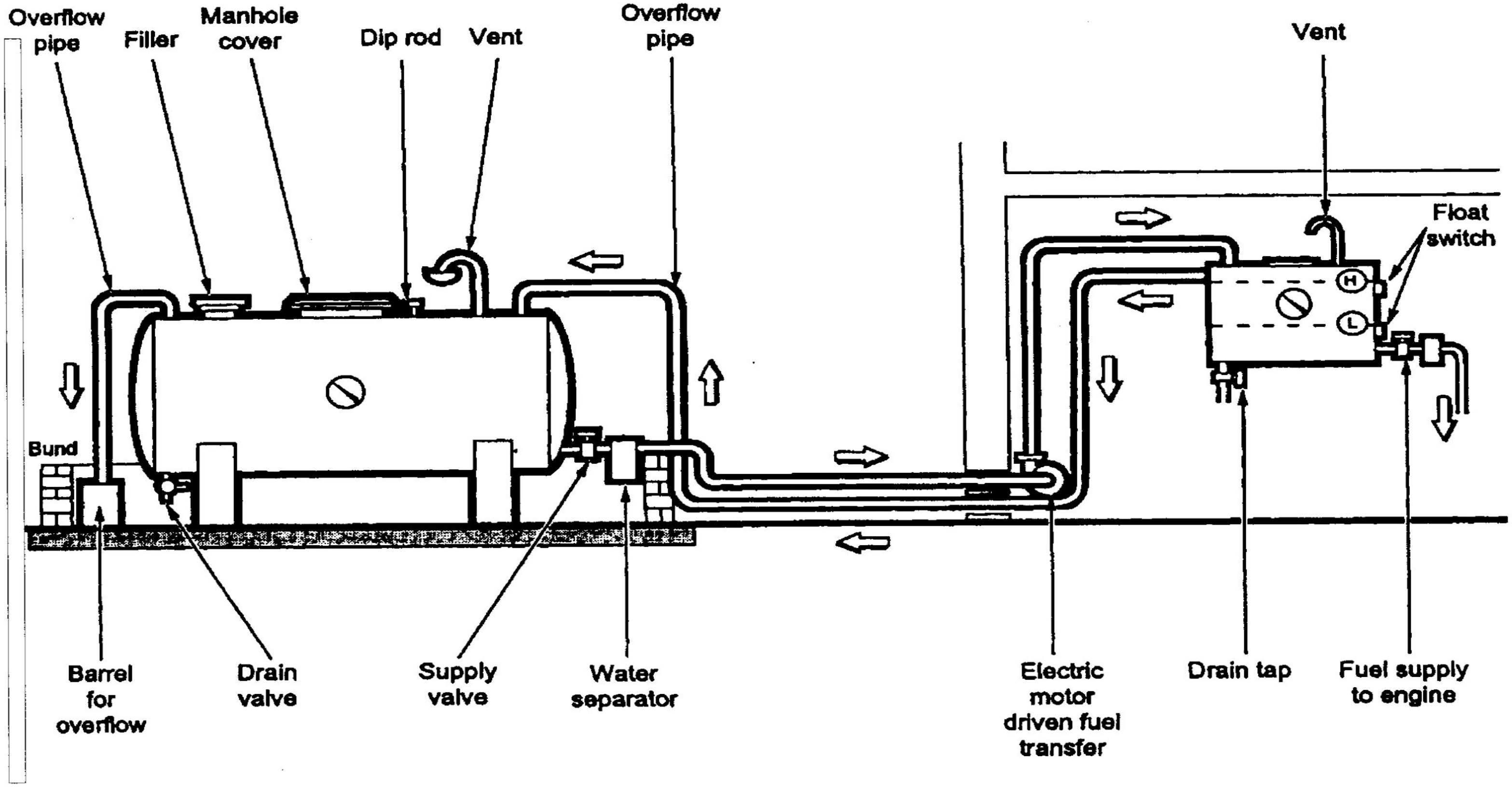
Fuel System

- **Bulk and Day Tank System**





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Fuel System

- **Low Pressure Fuel Pipes**
  - Material - Good quality seamless copper pipe, steel or black iron pipe. Galvanized pipe, fittings or tanks must not be used
  - Flexible pipe for use with fuel oil is acceptable but should be reinforced with metal braid
  - Size - The ID of the low pressure feed and return pipes should be a minimum of 22mm and return pipe should be a minimum of 15mm



Fuel System

- **Water Trap and Sedimenter**
  - A water trap and sedimenter should be installed into all applications
  - The water trap and sedimenter should be clearly visible and easily serviceable
  - The water trap should be of sufficient capacity, so as not to restrict fuel flow



Perkins®

Fuel System

- **Engine Piping**
  - The low pressure fuel system between fuel filter and fuel return should not be disturbed with the exception of bleeding
  - If the low pressure fuel system between the unit injectors and fuel filters is to be modified then approval from Perkins Applications Department is required



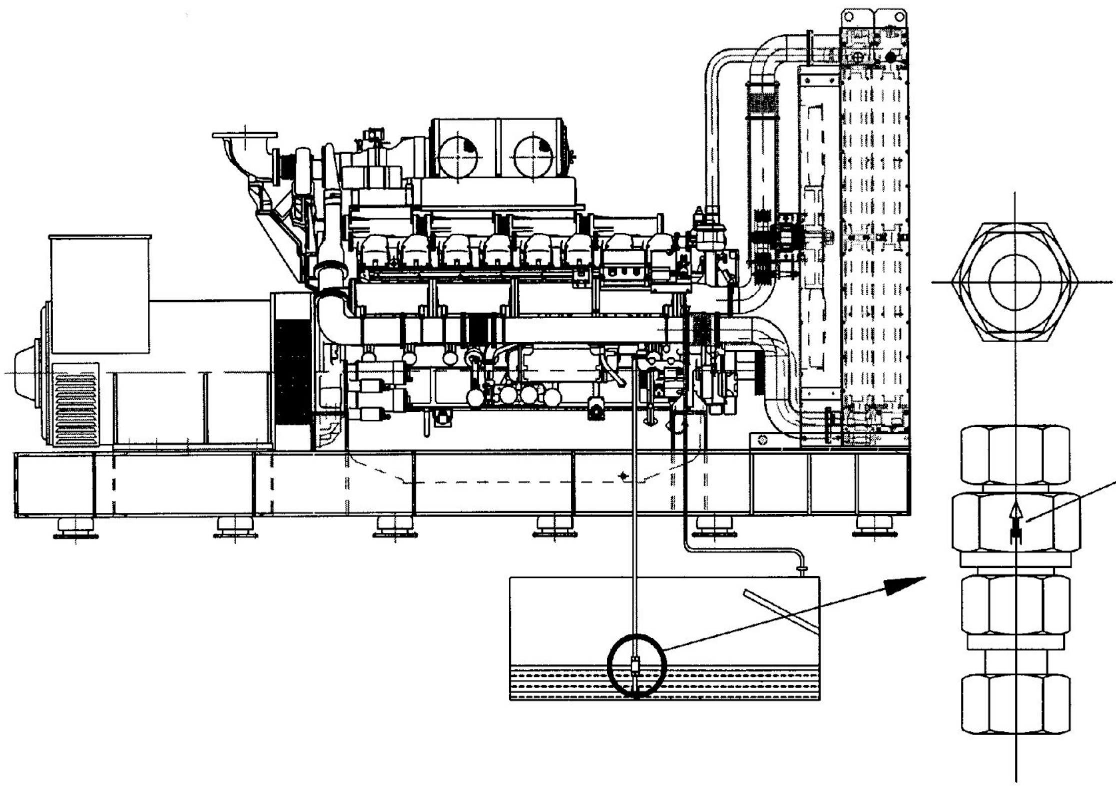
Fuel System

- **Fuel Auxiliary or 'Day Tanks'**
  - For day tanks installed below the engine fuel lift pump, a non return valve must be fitted in the fuel supply line
  - If no valve is fitted fuel can drain back to the tank, then there could be problems with starting



Fuel System

Fuel Auxilary / Day Tank Position - Non Return Valve



Non Return Valve With Viton Seat

Operating : To Lift 5kPa

Perkins Part No. : 860/334

Direction of Flow



Fuel System

- ## Suitable Fuels for 4016TAG'

ACCEPTABLE FUEL SPECIFICATIONS

Good fuel characteristics are essential for the efficient operation of fuel injection equipment and due to this directly affect the operation of the engines to which the equipment is fitted.

Totally Acceptable Fuel Types
N590 Diesel fuel types - Auto / C0 / C1 / C2 / C3 / C4
BS2869 Class A2
ASTM D 975-92 Class 1, 2 and 3 & special grade 3
IS1460: 1995 BS I (A variant engines only)
IS1460: 2005 BS II, BS III & BS IV
(Note : where low sulphur or low aromatic fuels are used it is important that lubricity additives are used & the fuel is acceptable to the lubricity tests described above)

Fuel types that MAY lead to a reduced product life
ASTM D975-91 Class 1-1DA
JP7, MIL T38219 XF63
NATO F63
Refer to USE OF AVIATION FUELS IN DIESEL ENGINES V5 July 2011

Fuel types that WILL lead to reduced product life (Only acceptable if used with additives)
AVTUR FS11, NATO F34, JP8, MIL T83133, DEF STAN 91-87, DERD 2463,
AVCAT FS11, NATO F44, JP5, MIL T5624, DERD 2452, AVTOR,
NATO F35, JET A1, DEF STAN 91-91, DERD 2494
ACAT, NATO F43,
JET A (ASTM D1655)
ASTM D399 Kerosene
Refer to USE OF AVIATION FUELS IN DIESEL ENGINES V5 July 2011

Fuel types NOT ACCEPTABLE with or without additives
AVTAG
AVTAG FS11, NATO F40, JP4, DERD 2545
JET B (ASTM D1655)
BS MA100
JIS K2203 No.2

Bio Fuels – Refer to Recommendations for use of Bio Diesel in Perkins Diesel Engines -June 2011

Bio diesel - R.M.E. fuel can be used in Perkins direct injection diesel engines. However, the following conditions apply:

- The fuel must comply with DIN V 51606 (or other approved national standards as they evolve).
- It can only be used in mixtures of up to 7% to 20% RME in mineral oil diesel fuel. No mixture above 20% is acceptable, as this can result in filter blocking, unless acceptable blend percentages below.
- Fuel storage must be to recommended standards, to avoid the absorption of water, and degradation. In any event, storage should not exceed 12 months. Fuel degradation, if allowed to occur, can result in the corrosion of metallic components, and the premature failure of seals.
- RME is a powerful solvent. Damage may occur if it comes into contact with paintwork.

Perkins cannot be operated on 100% Bio Fuel, the standard mixes are :-

400D/1100D	20%
All other Peterborough	7%
1300	7%
2000	20%
4000	20%

DISCLAIMER (Taken from the Common Position Statement) No legal liability can be accepted for failure attributable to operating products with fuels for which the products were not designed, and no warranties or representations are made as to the possible effects of running these products with such fuels. Non - compliance of the fuel to agreed standards, whether being evident by appearance of the known degradation products of these fuels, or their effects within the fuel injection equipment, will render the FIE manufacturer's guarantee null and void.



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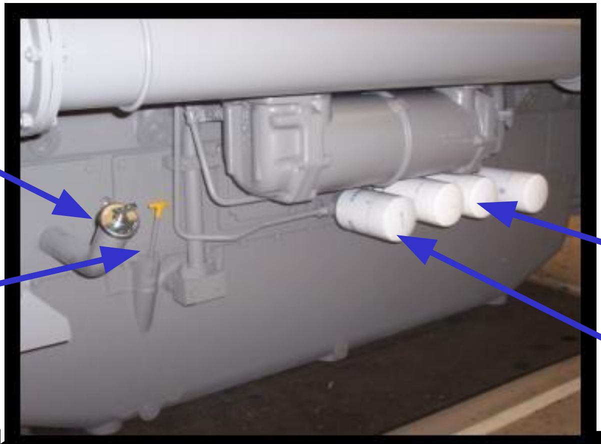
Installation Considerations

Lubricating Oil System



Lubricating Oil System

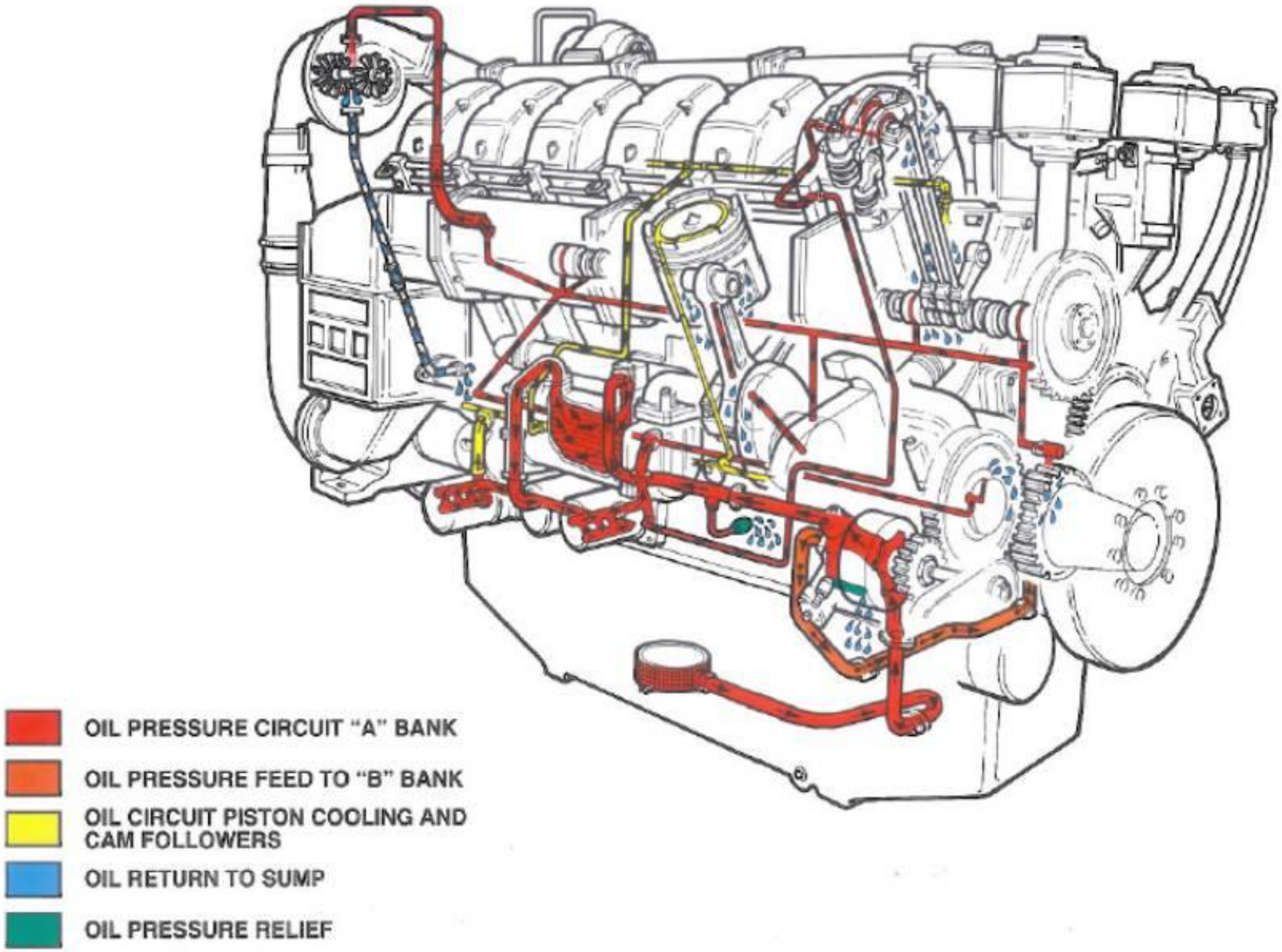
- **Oil Filtration**
- Disposable canister fitted with by-pass, full flow type



- Filtration to 40 microns
- Use only lubricating oils which meet or exceed API CG4
- Oil cooler is an integral part of the engine
- Oil Filler and Dipstick are mounted on B Bank only



Lubricating Oil System



Lubricating Oil System

- **Sump Heaters**
  - There is a possibility of local degrading occurring around the element coil as the oil turns to coke.
  - They have been used but problems were encountered with 'coking'/ burning out of the heaters
  - In terms of cold start, a sump heater only assists with cranking the cold engine, i.e.. by reducing oil viscosity, not directly initial combustion
  - The recommended jacket water immersion heaters aid cold start by warming the whole engine structure including the combustion chambers
  - If sump heating is necessary, space heaters or sump blankets are recommended



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Installation Considerations

Crankcase Ventilation



Crankcase Ventilation

- **Breather**
  - Check breather exit position, the point of exit of the breather should be directed away from the engine air intake and cooling group
  - Fumes would deposit oil on radiator matrix and particles of dust in the airflow would stick, resulting in radiator and fan performance deterioration
  - If possible the pipe work should be less than 5 meters long and should be of equal or greater diameter than 50.8mm
  - Crankcase pressure should not exceed 245Pa at full load



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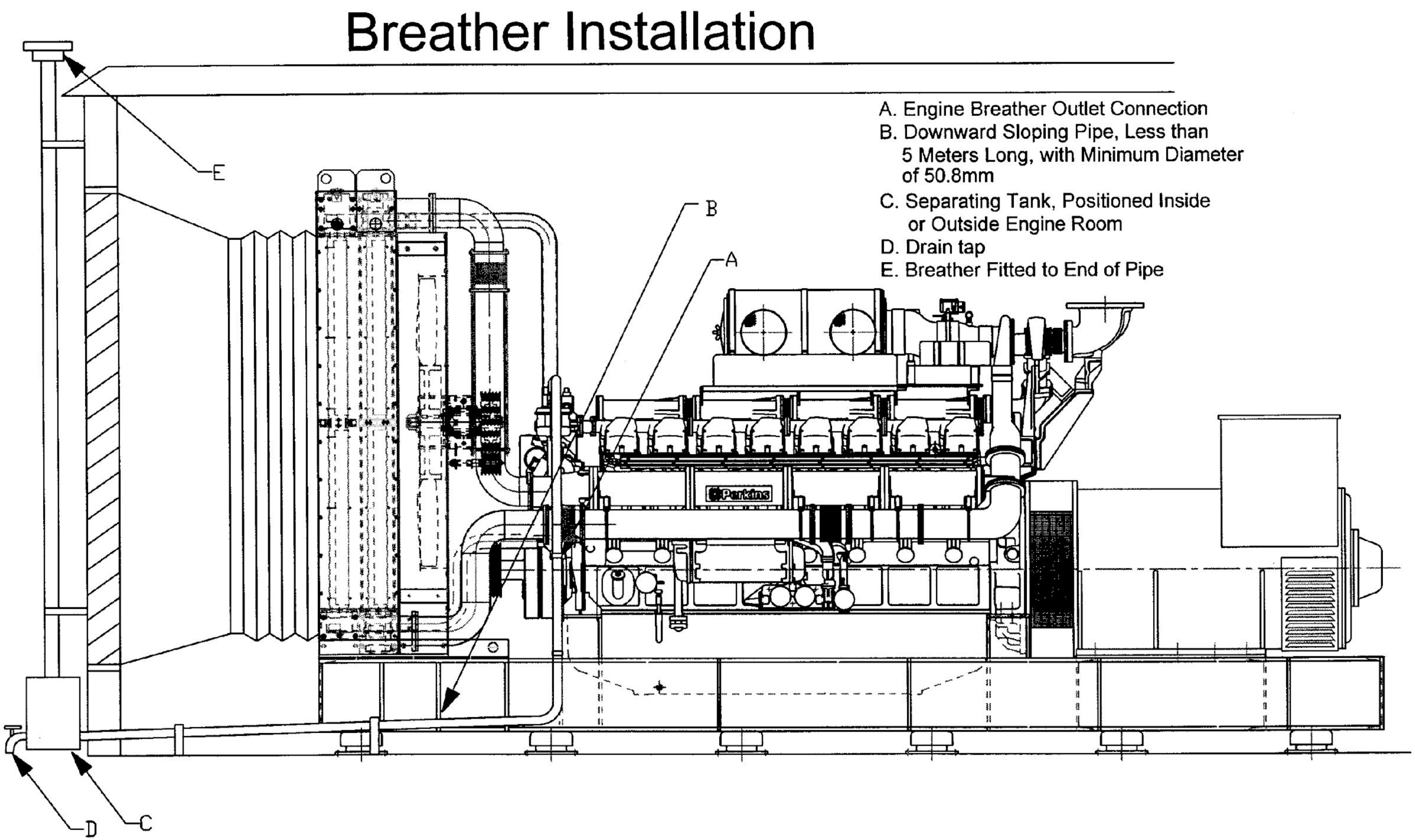
Crankcase Ventilation

- **Breather**
- On Vee Form engines with two breathers these can be piped together in to a single pipe, with a slight slope, led to separating tank
- In multi-engine installations, as with the exhaust system, the breather pipe from each engine must have its own individual run



Crankcase Ventilation



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Installation Considerations

Electrical Systems

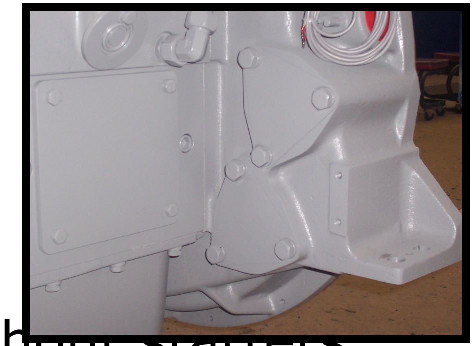


Electrical Systems

- **Starter Motors**
  - Engines can be supplied with a suitable 24 Volt starter motors

Standard Starters A Bank

  - Flywheel housing can accept a second starter, charge-able option on the OCD



  - Engines can be supplied without starters

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Electrical System

- **Alternator**
  - All engines are supplied with a battery charging alternator

  - Alternator output 24 Volt / 55 Amps



Electrical System

- **Batteries**
  - There are three main types of battery in circulation these are :
    - Ni-Cad
    - Alkaline
    - Lead Acid
  - Lead acid being the most common due to its low cost, ease of maintenance and power to weight ratio
  - The main installation considerations :
    - Located away from heat source
    - Protected from the elements, readily accessible for maintenance
    - Located as close to the starter as possible



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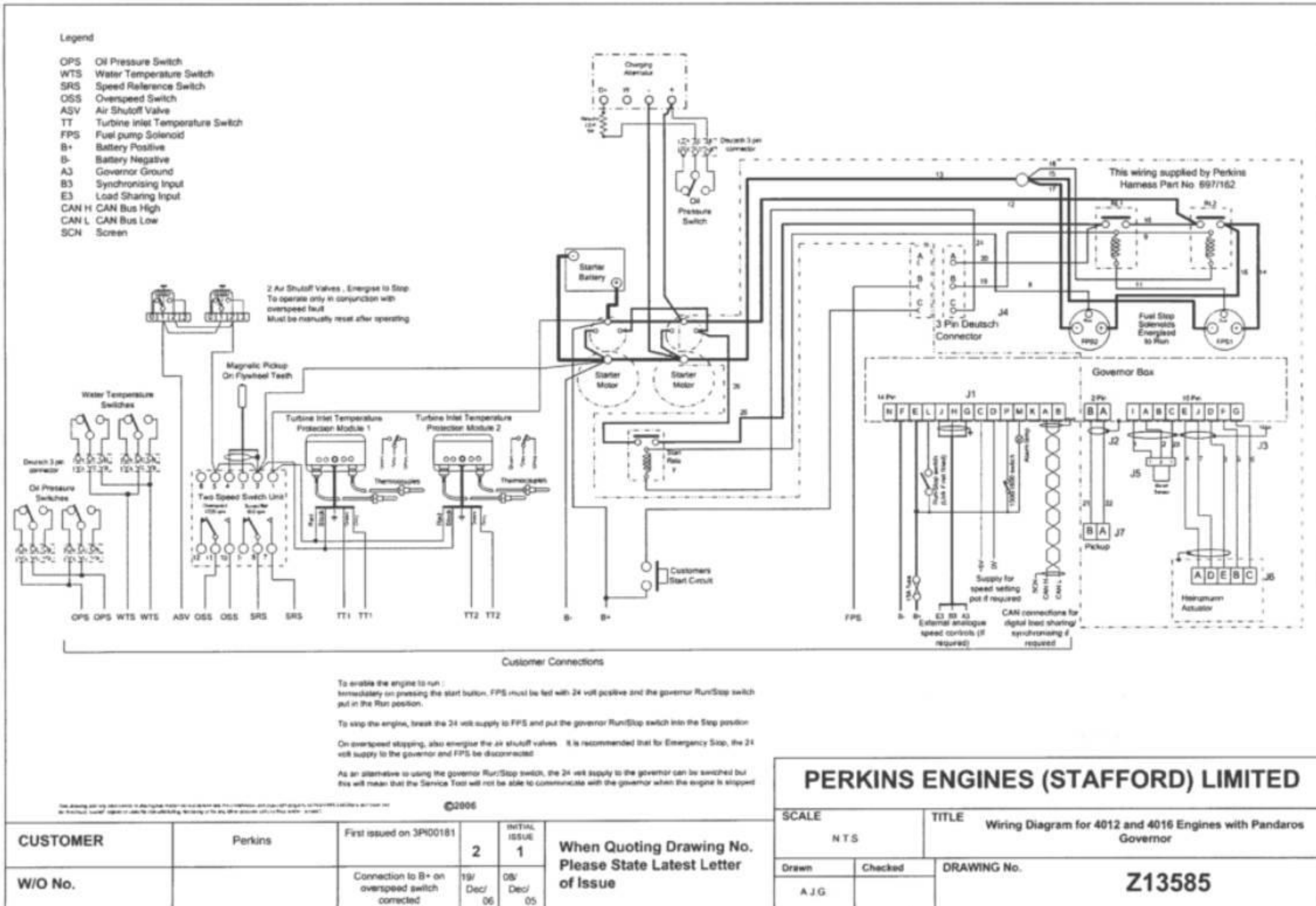
Electrical System

- **Good Wiring Practice**
  - Ensure suitable cables have been used
  - Where possible cables should be secured and wrapped
  - Good quality crimped connections are recommended
  - Ensure good cable routing
  - Make sure cables are kept away from heat sources and have enough flexibility for movement
  - Cable numbering enable trouble free fault finding

Electrical System



Electrical Systems

- **Protection Devices**
  - 4016 are fitted with the following shut-down protection as standard :
    - High Jacket Water Switch (HJW)
    - Low Oil Pressure Switch (LOP)
    - Low Coolant Level Switch (LCL)
    - Turbine Inlet Temperature Switch (TIT)
    - Over Speed (OS) inclusive of :
      - Overspeed Switch
      - Air Shut-off Valves

- It is essential that are protection devices are wired and functioning at the time of commissioning



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Electrical Systems

- **High Jacket Water Switch (HJW)**
  - Set to 101 ^{o}C (Rising) A + B Bank

Electrical Systems

- **Low Oil Pressure Switch (LOP)**
  - Set to 193 kPa (Falling)

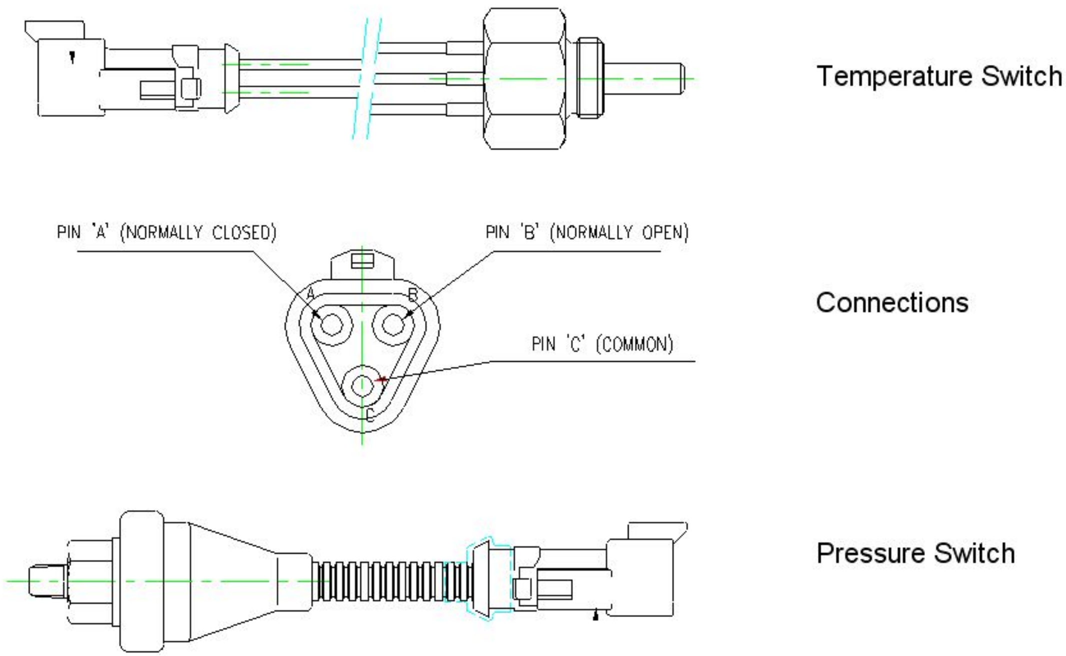
A Bank

B Bank



Electrical Systems

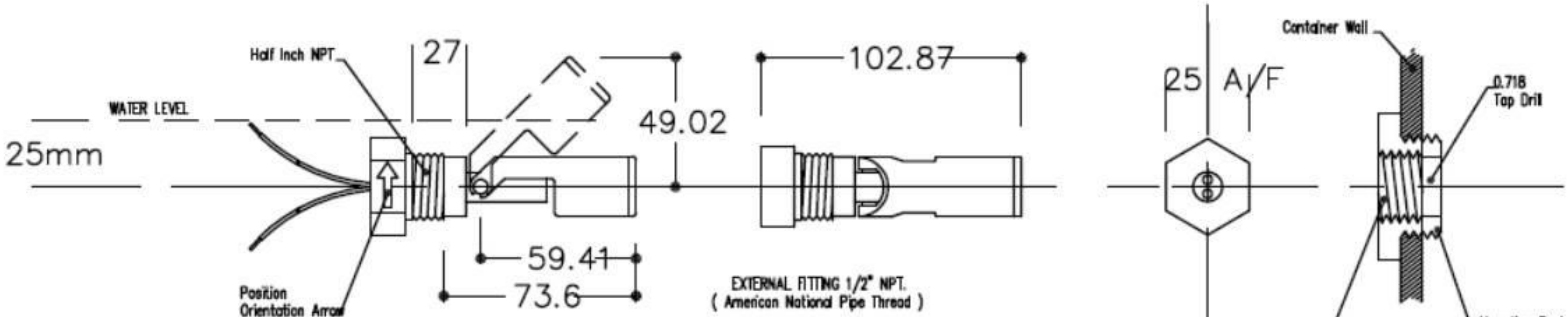
- **HWT and LOP Deutsch Switch Connections**
  - The switches are fitted with a Deutsch DT04-3P 3 pin connector and require a matching DT06-3S connector for wiring. The switches and connections are shown below





Electrical Systems

- **Low Coolant Level Switch (LCL)**
  - Fitted as standard to each cooling group
  - Contacts are normally closed



INSTALLATION AND APPLICATION NOTES

1. The half inch model float assembly is designed to pass through half inch NPT tap drill 0.718 diameter. A number of pipe fittings have a smaller diameter outside the thread area which will restrict entry.
2. Care must be taken to ensure that the product is not damaged due to excessive tightening of the fixing nut or threaded bush. Maximum torque limits are shown below.

MODEL	TORQUE LIMIT	CONTAINER WALL MAXIMUM THICKNESS
External fitting (compression grommet see note 7) (suitable for seal pressure of 70 P.S.I.)	2.0lb ft (2.67 Nm)	0.16ins (4mm)
Internal fitting	3.0lb ft (4 Nm)	0.50ins (12mm)
External fitting (half inch NPT)	5.0lb ft (6,75 Nm)	1.00ins (25mm)



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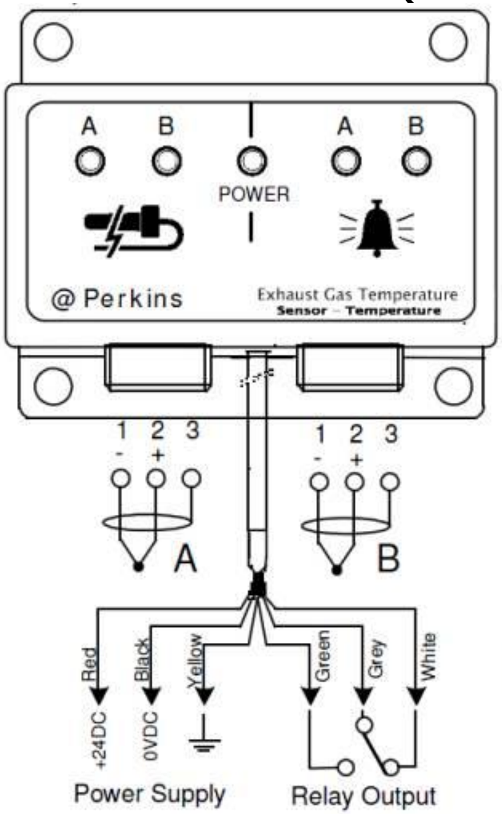
Electrical Systems

- **Turbine Inlet Temperature Switch (TIT)**
  - Set to 735 °C (Rising) A + B Bank



Connector identification

The cable from the unit has 6 cores and the connection details are as follows:

1 - Red wire - 24 volt positive from the battery
2 - Black wire - 24 volt negative from the battery
3. - Yellow wire - ground, connect to engine metalwork
4 - Shutdown relay normally open
5 - Shutdown relay common
6 - Shutdown relay normally closed

Contacts shown with no 24V supply. On power up, contacts will change over

TIT B Bank



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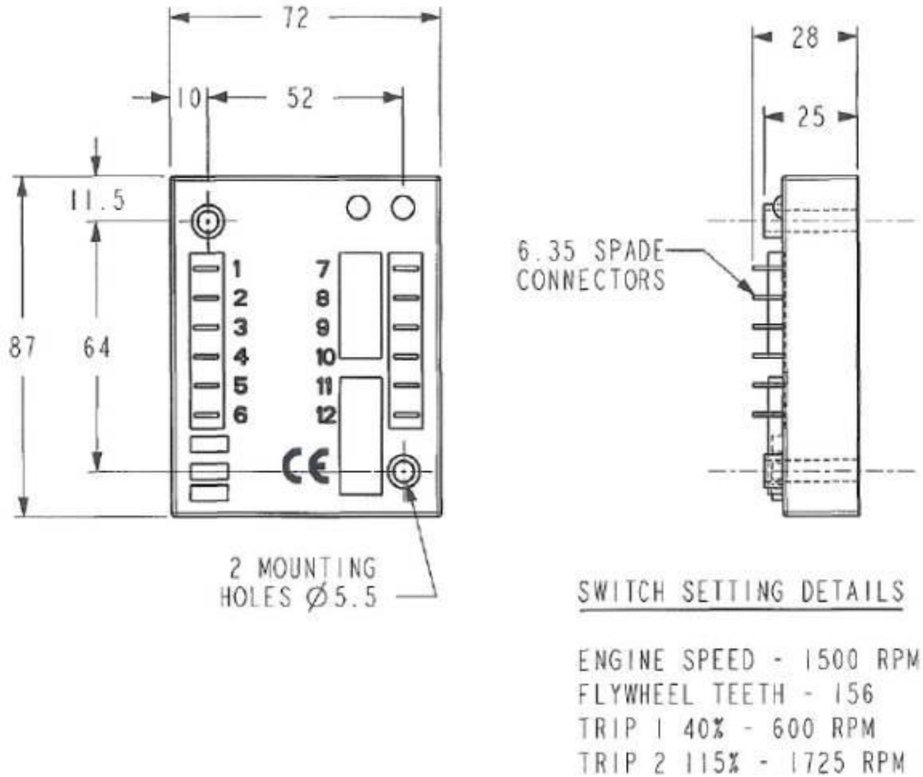
Electrical Systems

- **Overspeed Switch (OS)**
  - Set to in Overspeed Switch : 1725rpm

Supplied Loose



Electrical Systems

- **Overspeed Air Shut-Off Valves (ASOV)**
  - Air Shut-off Valves activated by Overspeed Switch

The ASOV are not to be activated during normal stopping procedures. The ASOV must only be activated in overspeed condition when signal from the OS is received

Electrical Systems

- **Oil Pressure Switch – Battery Charging Alternator Excitation Circuit**
  - The oil pressure switch supplied for the battery charging alternator excitation circuit is fitted into the oil cooler elbow as pictured below on the ‘A’ Bank of the engine

  - When oil pressure sensed alternator becomes excited



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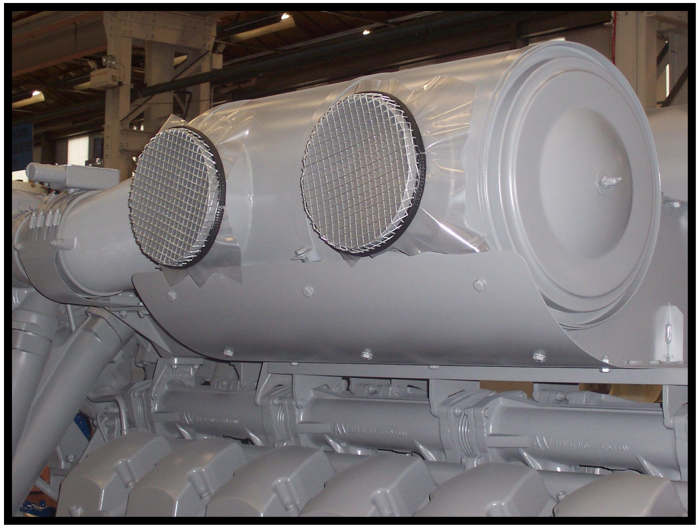
Applications Considerations

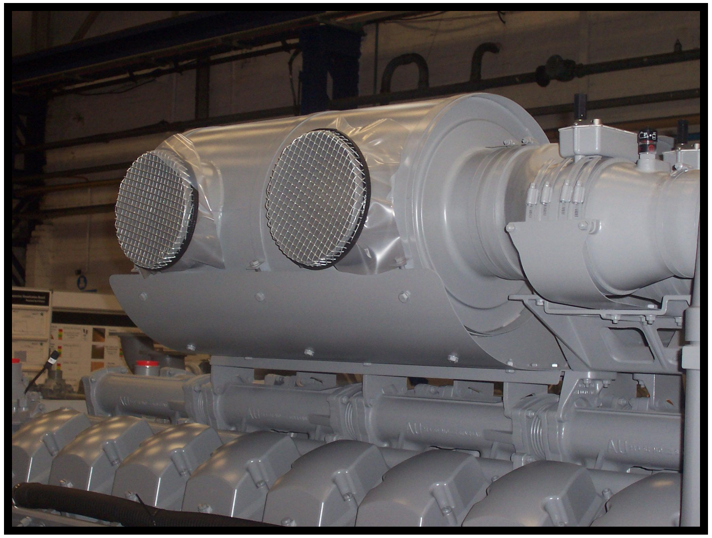
Air Induction System



Air Induction System

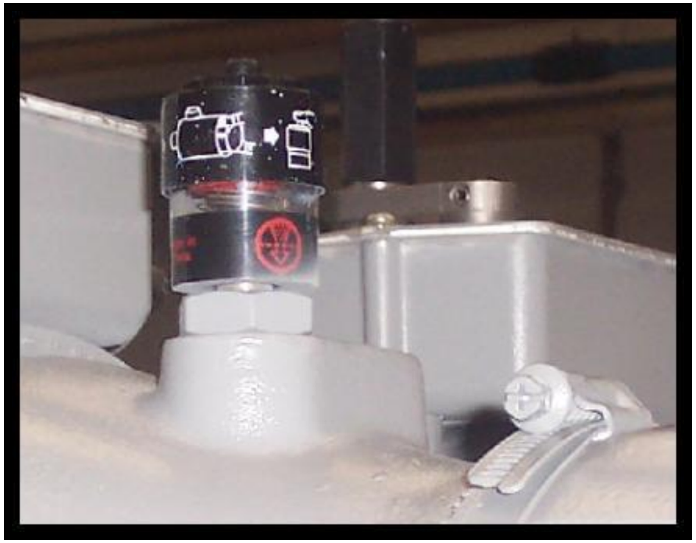
- **Engine Mounted Air Filters**
- Medium Duty paper element type
- Filtration 98% of all particles greater than 10um (micron) in SAE fine test dust





Air Induction System

- **Air Restriction Indicator**
- Fitted as standard to each air filter element
- The indicators are set to 3.7kPa limit



Air Induction System

- **Oil Bath Air Filters**
- Perkins do not recommend the use of oil bath air cleaners
- With turbocharged engines it is difficult to select oil bath air cleaners to operate efficiently over the wide range of air flow 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 98-99%. Hence in even moderate dust conditions, a significant amount of dust will pass through the oil bath cleaner

Air Induction System

Oil Bath Air Filters

- Another potentially disastrous problem is that the oil bath still permits adequate airflow 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. 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



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Installation Considerations

Noise Control



Noise Control

- **Factors Influencing Noise**
  - Radiator fan
  - Induction system
  - Exhaust system
  - Vibration



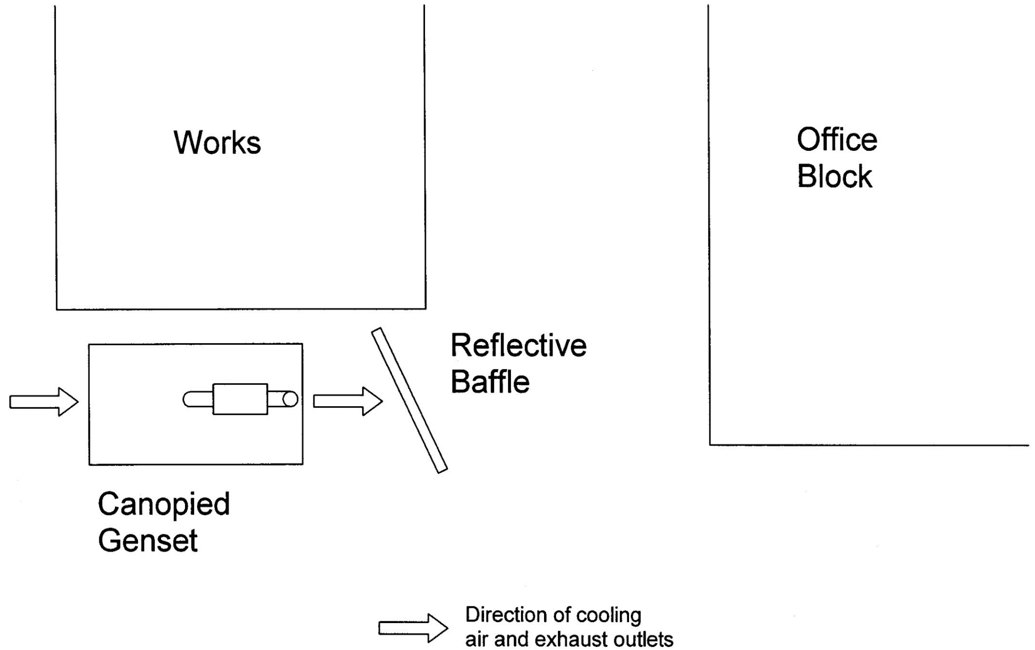
Noise Control

- **Insulation and Absorption**
  - There are many different ways of reducing noise which are individual to each installation, examples :
    - Building construction material used to help reduce the build up of noise within the engine room
    - Attenuation on air inlets and outlets of the engine room
    - Anti vibration mountings under the genset preventing vibration being transmitted to walls
    - Exhaust silencer type and position



Noise Control

- ## Genset Position



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



Noise Control

- **‘Free Field’**
  - Noise escaping from the engine room into a ‘Free Field’ area will reduce by 6dB(A) when the distance is doubled
    - At 1 meter – 70dB(A)
    - At 2 meter – 64dB(A)
    - At 4 meter – 58dB(A)
    - At 8 meter - 52dB(A)



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Noise Control

- **‘Semi-Reverberant Field’**
  - If the area around the engine room include other building or reflective surfaces the area is a ‘Semi-Reverberant Field’, where the noise reduction will be 3dB(A) when the distance is doubled, until clear and in a ‘Free Field’ when 6dB(A) is used
    - At 1 meter – 70dB(A) - Semi-Reverberant Field
    - At 2 meter – 67dB(A) - Semi-Reverberant Field
    - At 4 meter – 64dB(A) - Semi-Reverberant Field
    - At 8 meter - 58dB(A) – Free Field



Installation Considerations

Governing

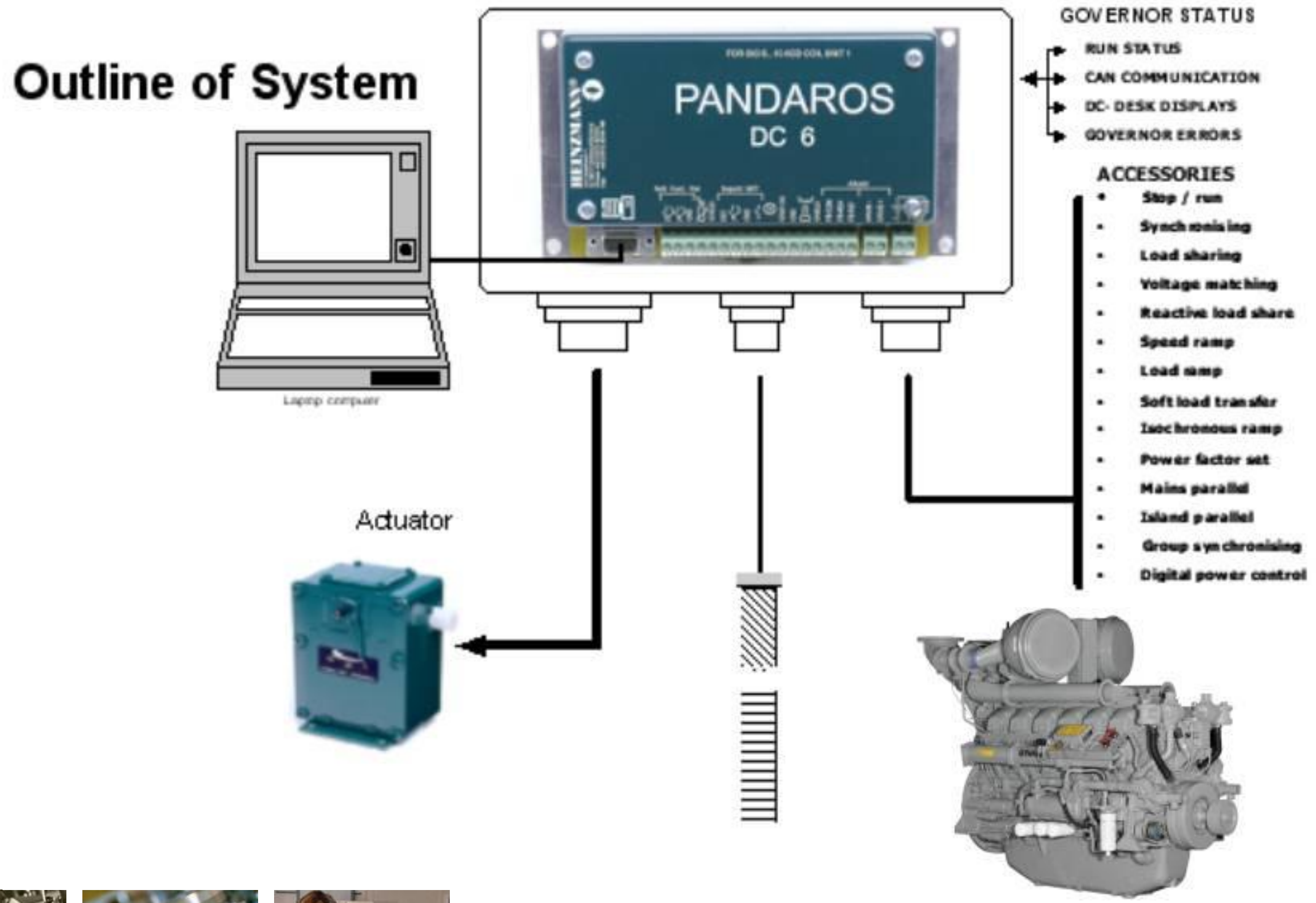


Governing

- 4016 Engines are fitted with Heinzmann E16 series Pandaros Digital governors

Governing

- **System Overview**





Governing

- **Configuration**
- The engine will be configured are shown below:
- **Speed**
- 1500rpm or 1800rpm
- **Droop / Isochronous**
- The default configuration will be isochronous operation. If the engine has been required to run in droop, the desired percentage droop will also have been set
- **Single generator fixed speed**
- The default configuration is for an engine in order to operate in single generator mode. Single generator mode means that the mode is not paralleled with any other generator. This mode has no provision for external speed control. The speed will be fixed at 1500rpm or 1800rpm



Governing

- **Changing the configuration of the governor**
- In order to change the configuration of the engine governor, use the Perkins service tool and the special communication cable. The communication connector is accessible inside the box for the governor. A security dongle is supplied. The dongle must be plugged into the PC parallel port before the software can operate.
- The various parameter settings for the engine modes are detailed later.
- **Note:** After the parameters are changed, it is necessary to store the parameters in governor. Then power down the governor. Power up the governor again before the changes take effect.



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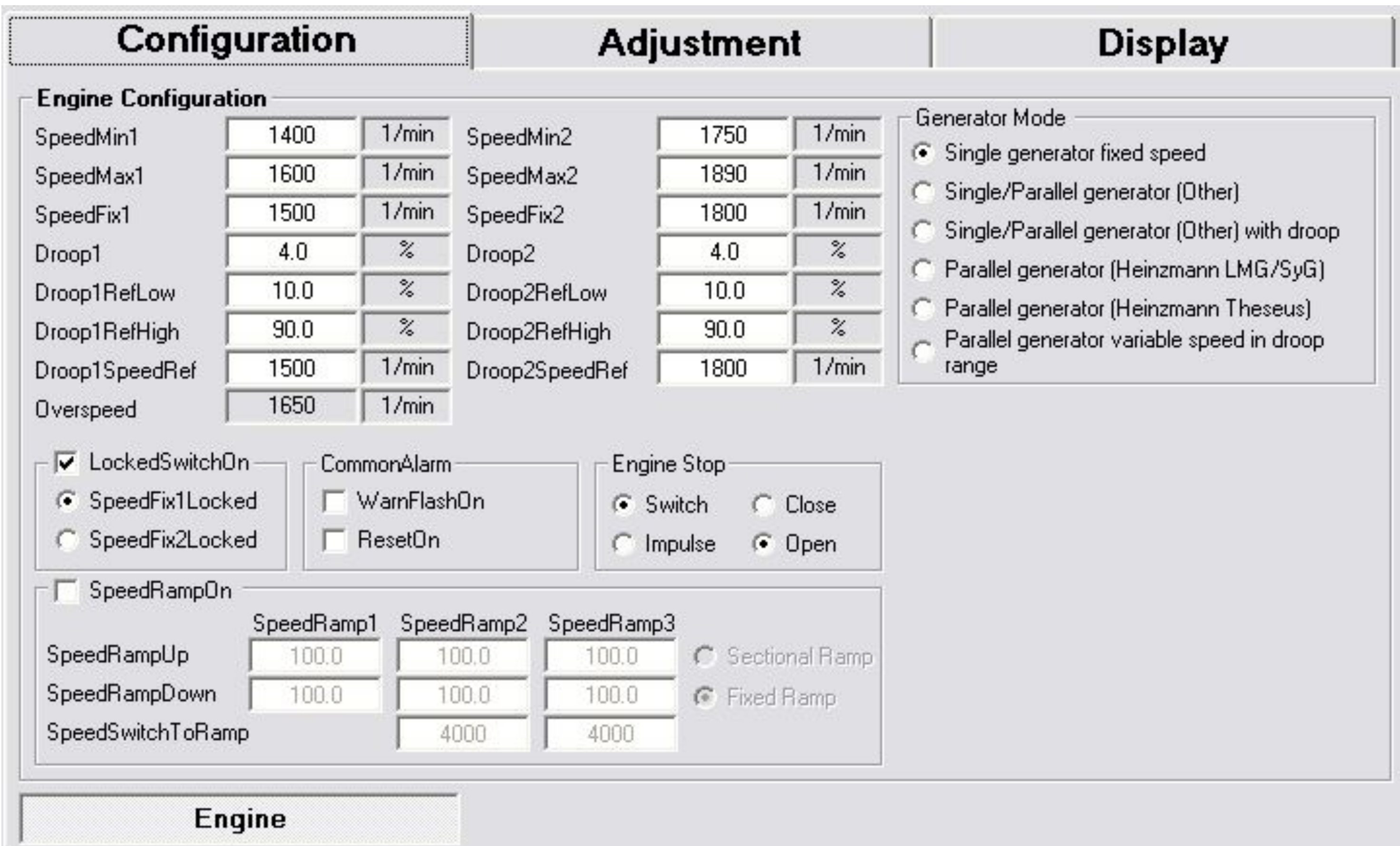
Governing

- **Configuration Screen in Pandaros Packager**





Governing

- **Single generator fixed speed**
- Select the button for Single generator fixed speed on the Generator Mode. The engine will operate in isochronous mode at a fixed speed of 1500 rev/min or 1800 rev/min
- For single speed 1500 rev/min operation, the parameter SpeedFix1 is used to set the engine speed
- For single speed 1800 rev/min operation, the parameter number SpeedFix2 is used to set the engine speed
- If the box LockedSwitchOn is selected, the engine will be single speed. The speed is selected by the SpeedFix1Locked or SpeedFix2Locked buttons.



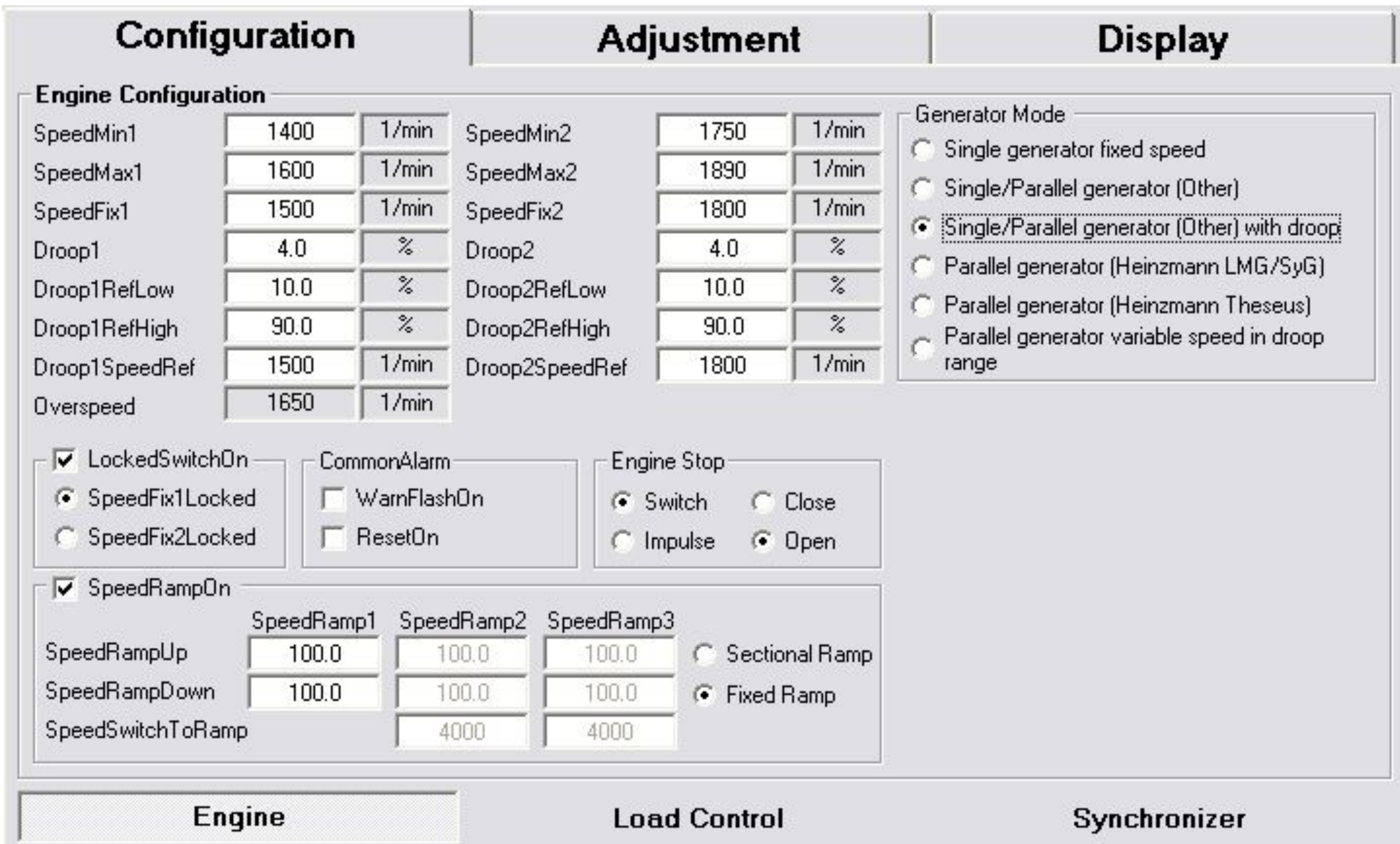
Governing

- **Parallel Generator to Heinzmann LSU/Sync**
- When the Generator Mode - Parallel generator option is selected, the screen will change. The screen will allow the selection of Heinzmann LMG/Syg or other options
- If Heinzmann LMG/Syg is selected, the Load Control and the inputs for the synchronizer are automatically set to the correct values and no other adjustments are required



Governing

- **Parallel Generator Screen**



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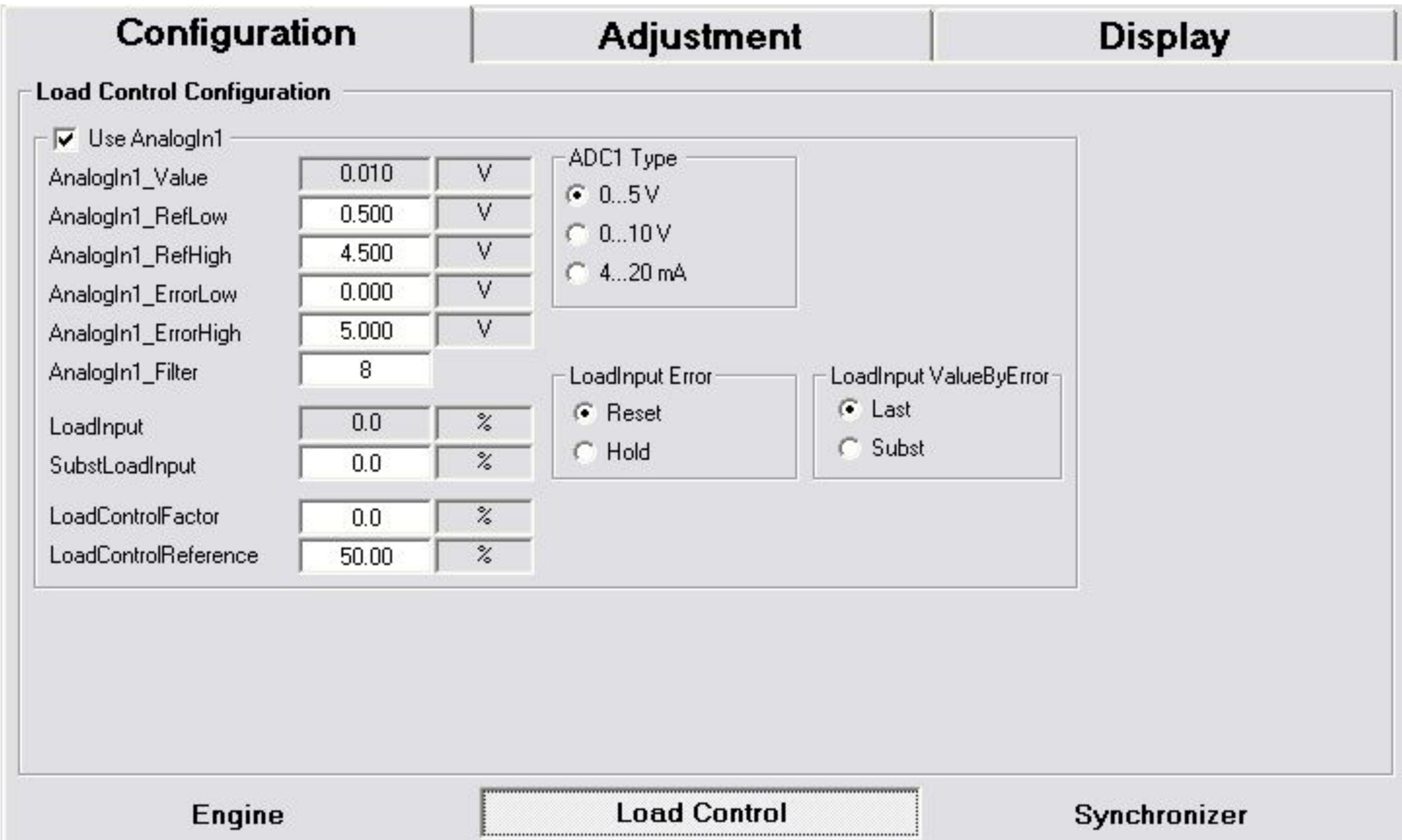
Governing

- **Parallel generator other LSU/Sync**
- There are many possible variations of load sharing and requirements for the input of the synchronizer unit. Some options may only require one input whereas other options may require two inputs.
- For this mode, the Generator Mode must be set to Parallel Operation and the LSU/Sync mode set to Other. The Load Control and the Synchroniser tabs will allow the two analogue inputs to be set for the variable speed option
- The Load Control tab allows the setting of the input parameters of the Analogue 1. The Synchronizer tab allows the setting of the input parameters of the Analogue 2



Governing

- **Load Control Configuration Screen**



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Governing

- **Parallel generator other LSU/Sync**
- **ADC 1_Type -** The parameter enables the selection of the type of input that is required to activate analogue input 2. The settings are listed below
  - 0 to 5 volt input
  - 0 to 10 volt input
  - 4 to 20 mA input
- **AnalogIn1_RefLow -** AnalogIn1_Reflow will set the lowest value that analogue input 1 will allow as an input
- **AnalogIn1_RefHigh -** AnalogIn1_RefHigh will set the largest value that analogue input 1 will accept as a valid input



Governing

- **Parallel generator other LSU/Sync**
- **AnalogIn1_ErrorLow -** AnalogIn1_ErrorLow sets the lowest value at which analogue 1 input signal will give as an error. If AnalogueIn1_RefLo was set at 0.5 volt, AnalogIn1_ErrorLo could be set at 0.3 volt. This enables detection of an open circuit or faulty input signal
- **AnalogIn1_ErrorHigh -** AnalogIn1_ErrorHigh sets the highest value at which analogue 1 input signal will give as an error. If AnalogueIn1_RefHi was set at 4.5 volt, AnalogIn1_ErrorHi could be set at 4.7 volt. This enables detection of a faulty input signal
- **LoadControlFactor and LoadControlReference -** If analogue input 1 is used, the two parameters set the range of the external speed control and the reference % for nominal speed. If 1500 rev/min is the nominal running speed and speed variation of +/- 5% speed variation is required, set LoadControlFactor at 10% and LoadControlReference at 50%



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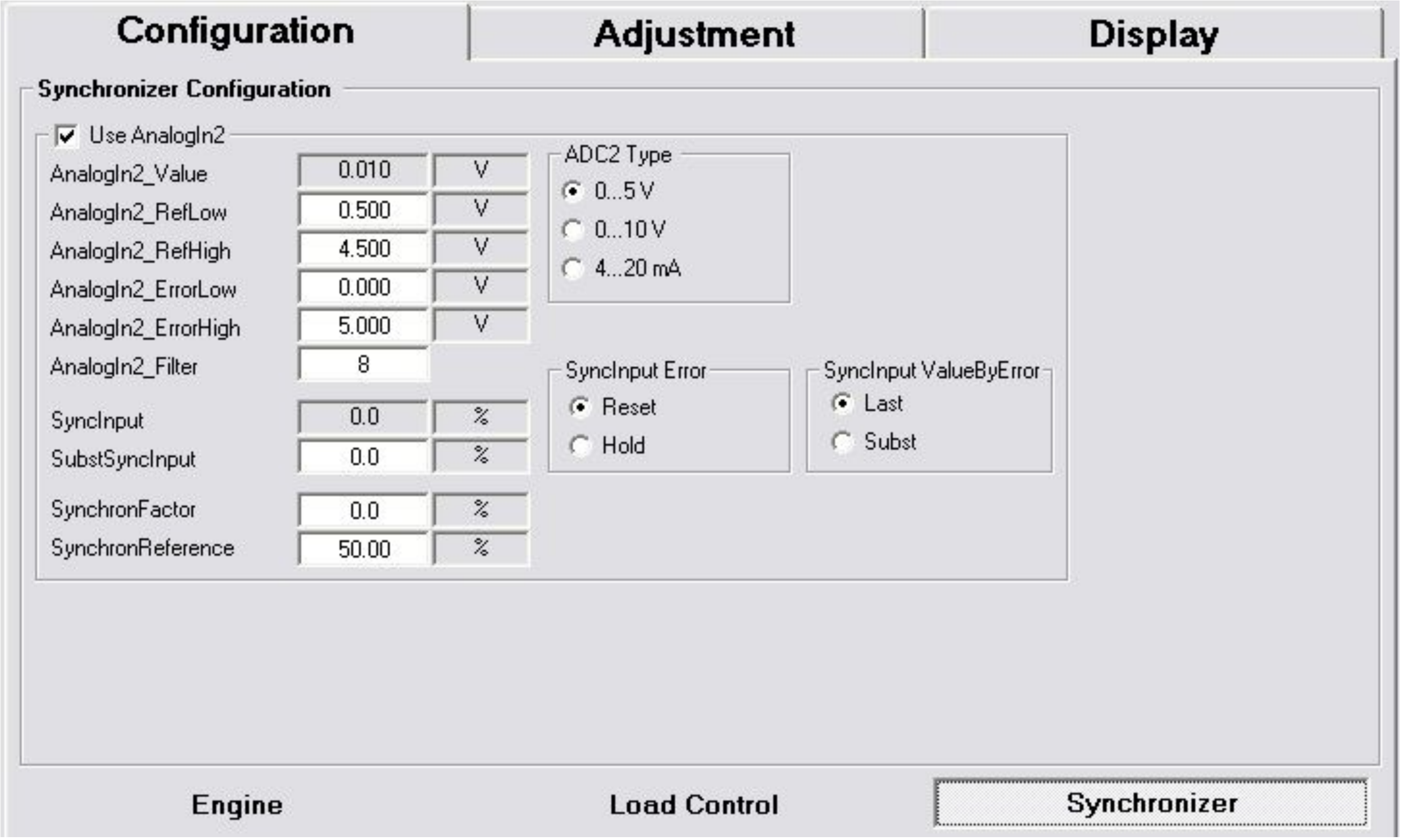
Governing

- **Synchronizer Configuration Screen**





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Governing

- **Parallel generator other LSU/Sync**
- **ADC 2_Type -** The parameter enables the correct selection of input that is required by analogue input 2. The settings are listed below.
  - 0 to 5 volt input
  - 0 to 10 volt input
  - 4 to 20 mA input
- **AnalogIn2_RefLow -** AnalogIn2_RefLow will set the smallest value that analogue input 2 will accept as a valid input
- **AnalogIn2_RefHigh -** AnalogIn2_RefHigh sets the highest value the analoginput will accept as a valid input

Governing

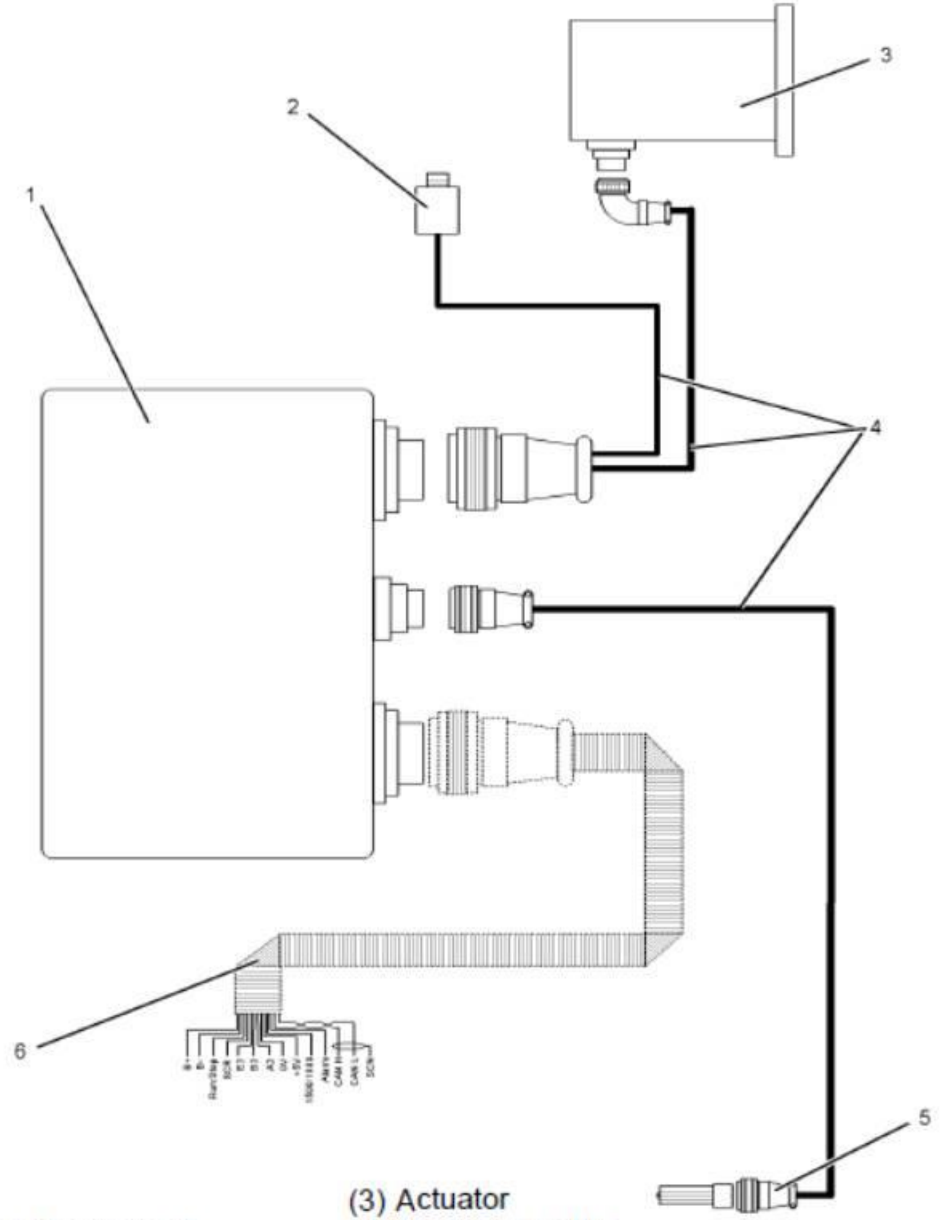
- **Parallel generator other LSU/Sync**
- **AnalogIn2_ErrorLow -** sets the lowest value at which the analogue 2 input signal will give an error. If AnalogueIn2_RefLo was set at 0.5 volt, AnalogIn2_ErrorLo could be set at 0.3 volt. This enables detection of an open circuit or faulty input signal
- **AnalogIn2_ErrorHigh -** sets the highest value at which the analogue 2 input signal will give an error. If AnalogueIn2_RefHi is set at 4.5 volt,
- AnalogIn2_ErrorHi could be set at 4.7 volt. This
- enables detection of a faulty input signal
- **SynchronFactor and SynchronReference -** When analogue input 2 is used, the two parameters set the range of the external speed control. The two parameters will set the reference % for nominal speed. If 1500 rev/min is the nominal running speed and a speed variation of +/- 5% is required, set SynchronFactor at 10% and SynchronReference at 50%



Perkins®

Governing

- **System Wiring**
- The cables (4) between the system components are provided and installed by Perkins.
- The cable (6) which is 4 meters is equipped with a connector. The connector is attached to the control box. The connector is available for external connections to the unit. The cable is an optional extra



Typical example
(1) Control Box
(2) Boost Pressure Sensor (if equipped)
(3) Actuator
(5) Magnetic Pickup



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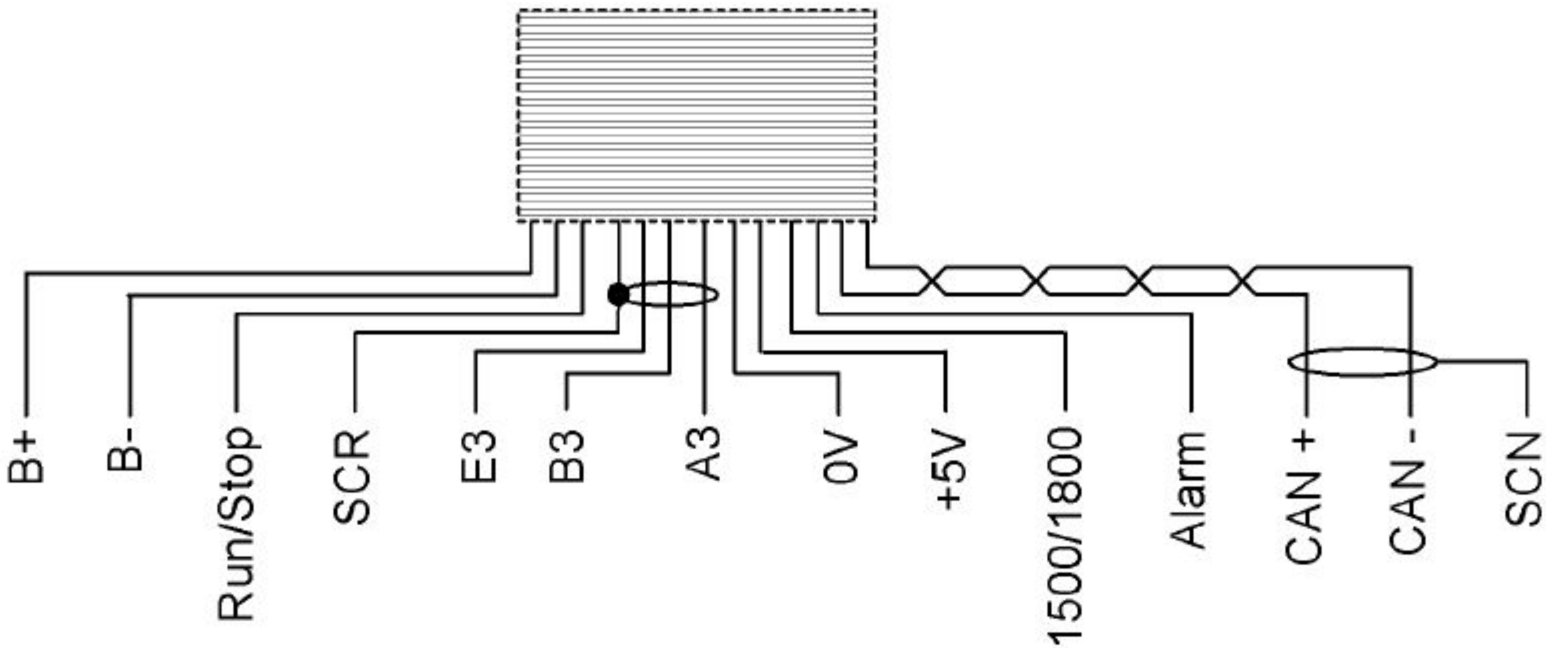
Governing

- **External Connections From Cable**





Governing

External Connections From Cable

- **B+** : A positive 24 VDC supply to the governor from the battery
  - A 15A fuse or a circuit breaker must be installed in the circuit for over-current or short circuit protection
  - **Note:** When an overspeed fault occurs the supply from the battery to the actuator and the stop solenoid should be removed.
- **B-** : negative 24 VDC is supplied from the battery to the governor.
- **Run/Stop Switch** - The switch that is connected from the wire to + 24V will enable the engine to run if the switch is closed. The engine will stop when the switch is open. This is the preferred method of normal stop. If the method of normal stop is not required, connect the wire for the Run/Stop Switch to +24V.



Governing

External Connections From Cable

- **A3** - is common for synchronizer/load sharer input.
- **B3** - is a input for the synchronizer. B3 may be used for a control signal for speed from an analogue synchronizer. B3 can be used for other external speed control that can depend on the configuration. For engines that are fixed speed, no connection is required.
- **E3** - Load sharer input is for a connection to a Heinzmann analogue load sharing unit. For engines of a fixed speed, no connection is required.
- **0V and 5V** - There is a 5V supply for an external speed setting potentiometer for the configuration of a generator with a single variable speed. For engines with a fixed speed, no connection is required.



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Governing

External Connections From Cable

- **Alarm** - This is a digital output in order to indicate a fault on the governor system. Connect a lamp or a relay between this connection and +24V for an indication of the fault condition. It is necessary to use the service tool to establish the reason for the fault indication.

- **SCR** - is the screen of the cable which is connected to the metal work of the connector at the control box for EMC requirements.

- **CAN+ and CANCAN** - bus connections for digital load sharing/synchronizing (if equipped)



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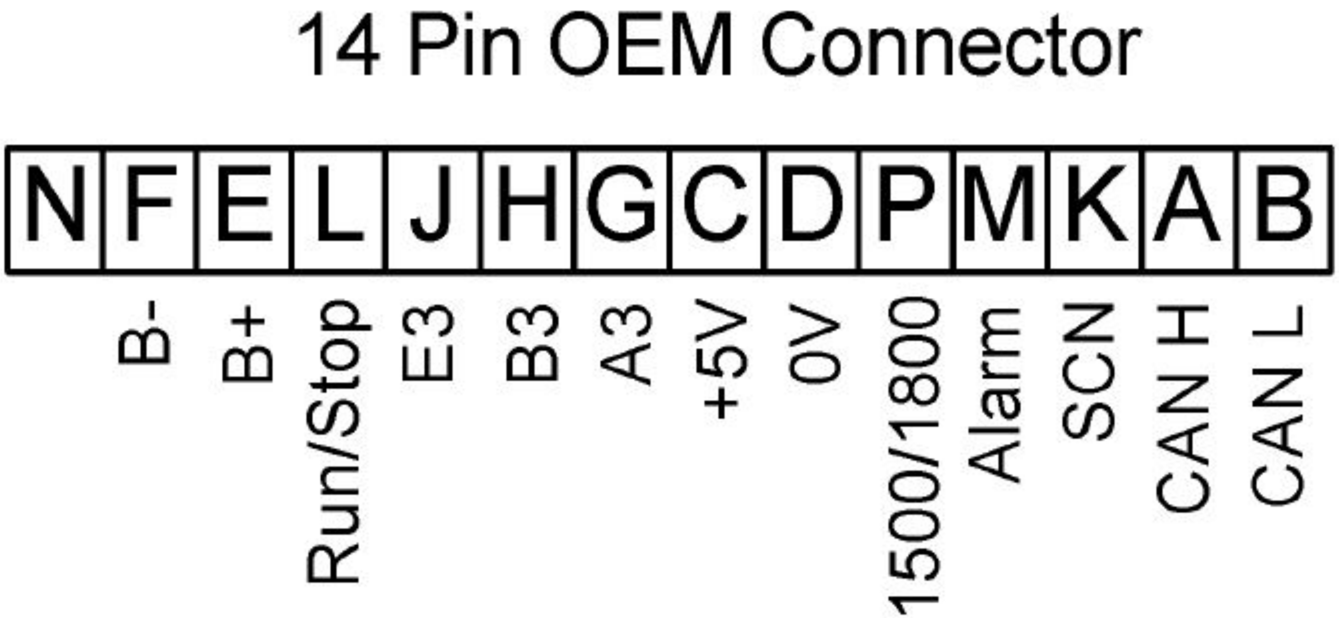
Governing

- **External Connections and the Connector for the Control Box**





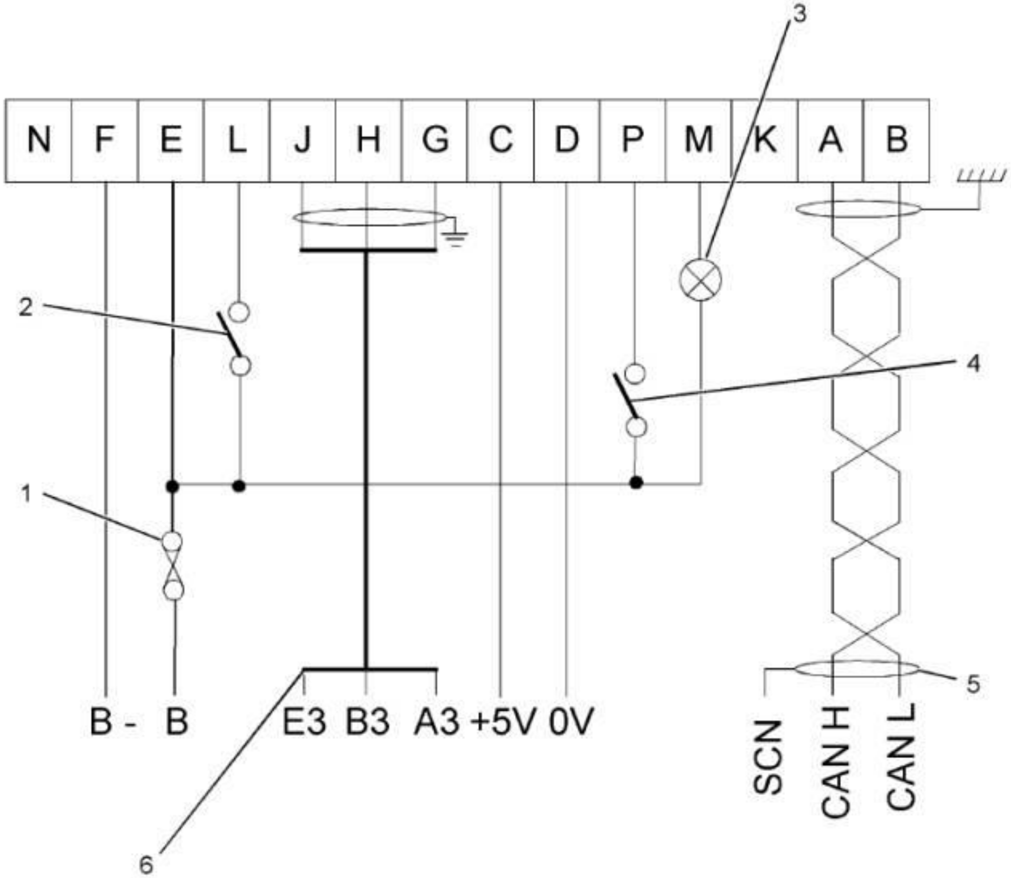
Governing

- **External Connections**

(1) 15A fuse
(2) Run/Stop Switch (if equipped)

(3) Alarm lamp
(4) 1500/1800 switch

(5) CAN bus connections
(6) External analog controls



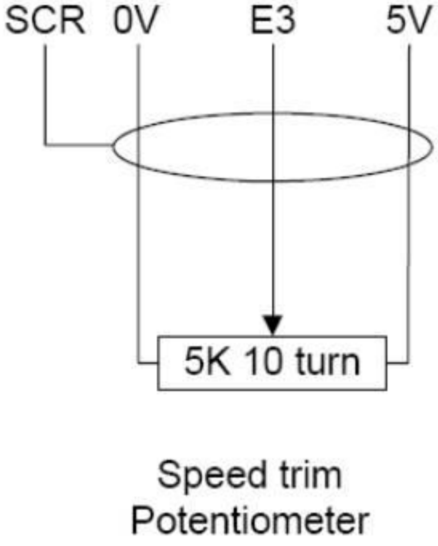
Governing

- **Cable Sizes**
- The cables for the supply for the battery must be 1.5 square mm minimum. The cables may be up to a maximum length of 7 meters. All other cables may be 0.5 square mm minimum



Governing

- **Alternative Connections for Speed Setting Inputs**
- **Single or Parallel Generator Variable Speed**
- Connect 0V and 5V to the potentiometer and the slider of the potentiometer to E3.





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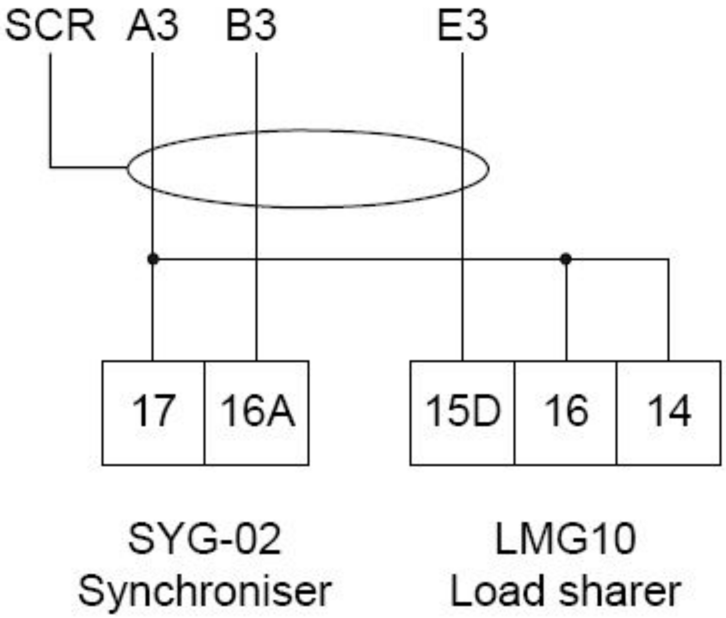
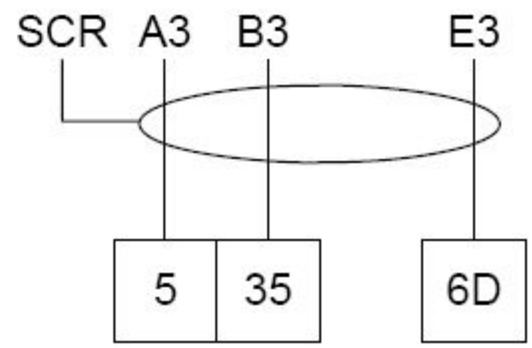
- **Alternative Connections for Speed Setting Inputs**
- **Parallel Generator Heinzmann LSU/Sync**
- Connect A3, B3 and E3 wires



Governing

- **Alternative Connections for Speed Setting Inputs**
- **Parallel Generator (Heinzmann Thesius)**



AT-01 Thesius with jumper set to DIGITAL



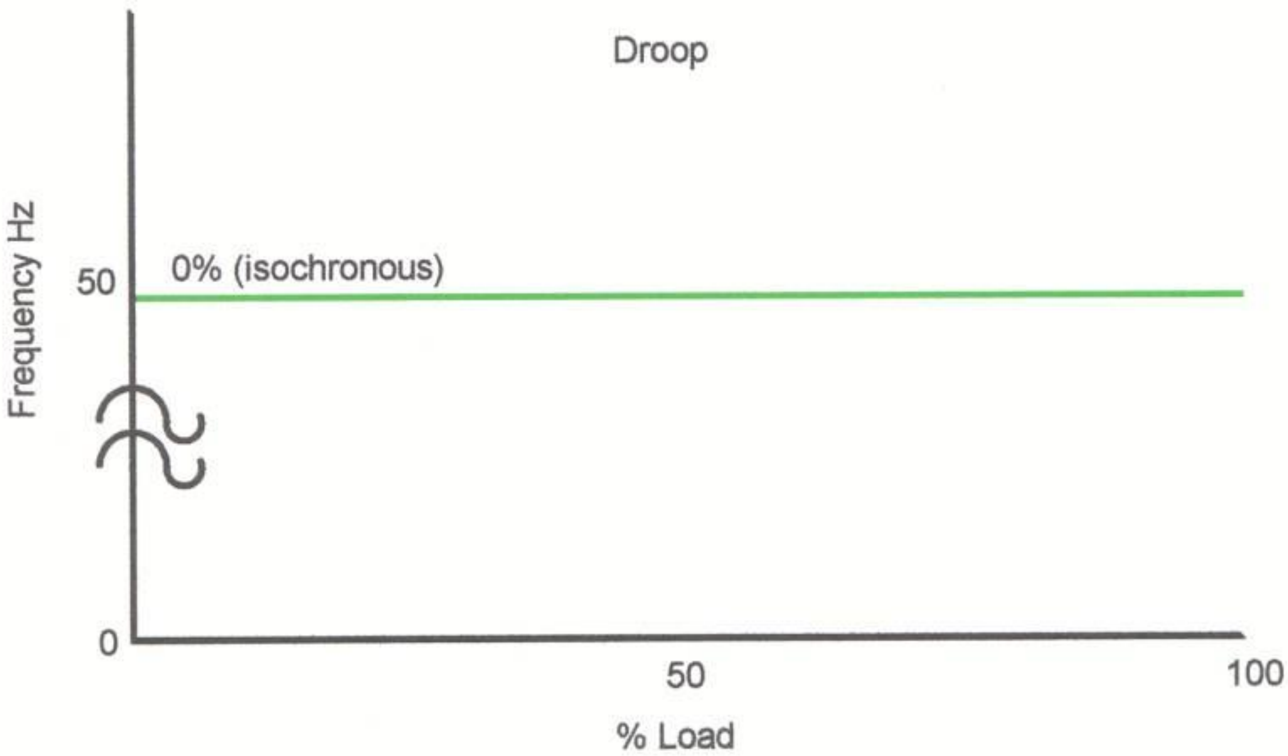
Governing

- **Governor**
  - Performance to ISO 3046 Part 4
  - 4016 to ISO 8528-12 and G2 limits stated in ISO 8528-5
  - Steady state speed stability at constant load +/- 0.25%
  - Droop or isochronous running
  - Default droop setting 4% (if droop required)



Governing

- **Generator Applications**





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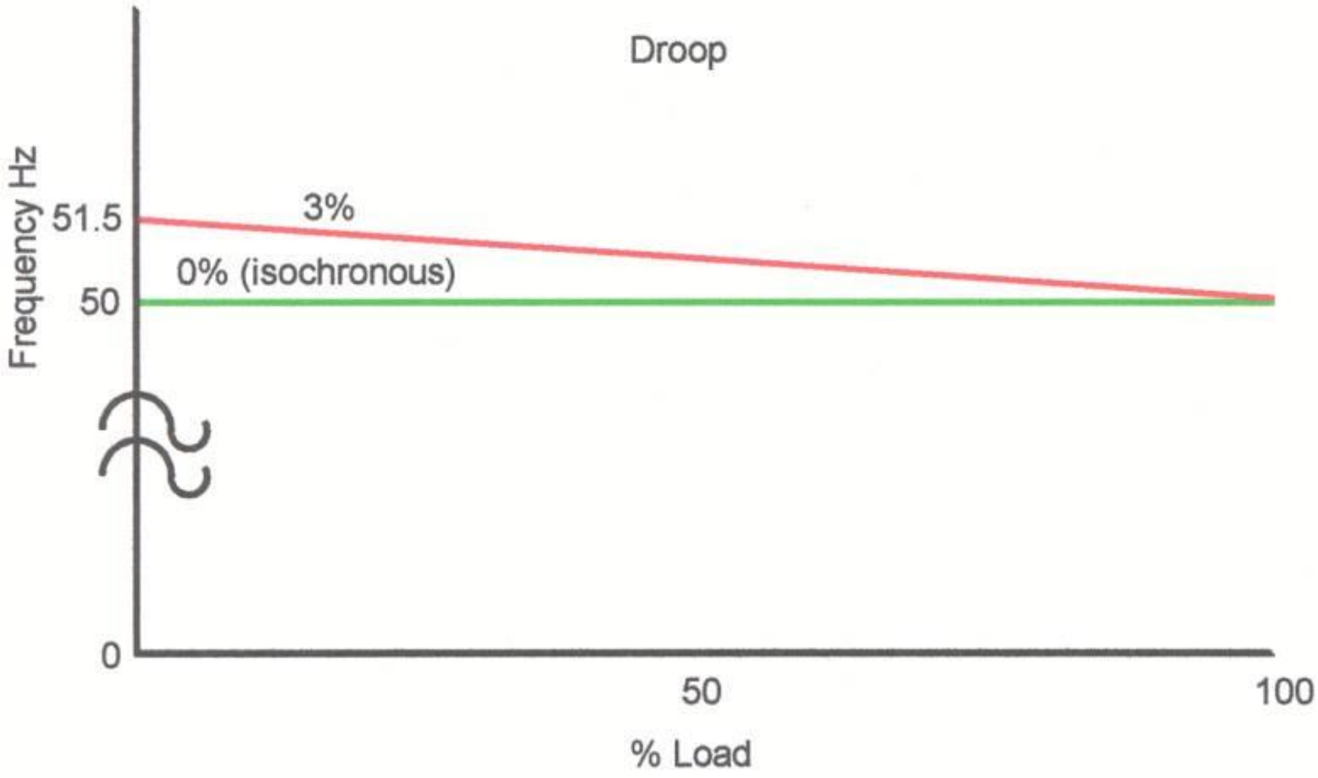
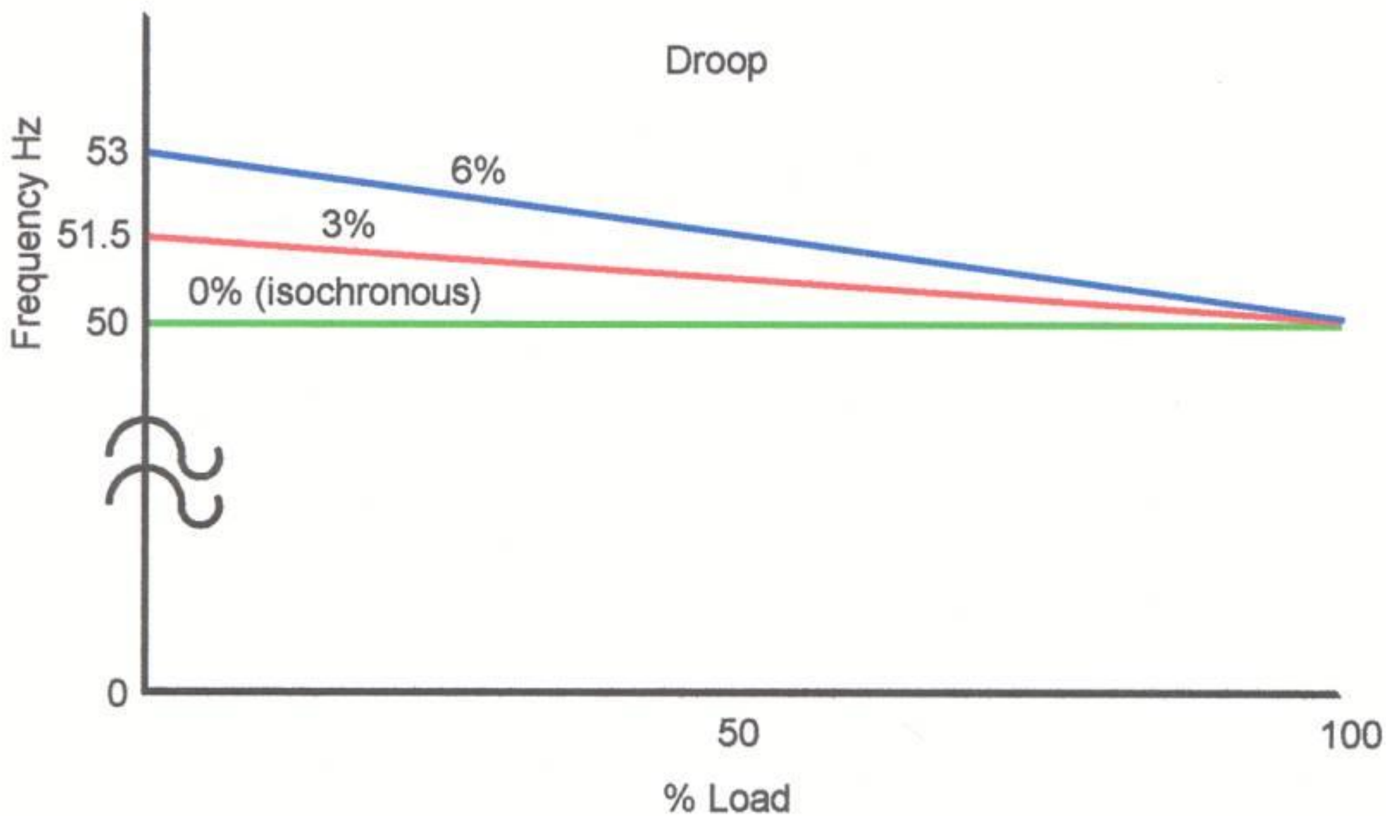
Governing

- **Generator Applications**



Governing

- ## Generator Applications





Installation Considerations

Multiple Gensets Installation



Multiple Genset Installation

- **General – same guidelines as for single unit**
  - Each genset to have it's own independent foundation and exhaust system
  - The exhaust silencer must be supported from the roof, and support brackets should allow for expansion of the piping
  - A length of flexible pipe or bellows should be fitted between the engine outlet and the rigid pipework
  - The exhaust system should be as short as possible, with minimum bends, so to keep the exhaust back pressure within engine allowance
  - Air inlet and outlet openings in the engine room walls should be provide to give free flow area
  - Ducting should be fitted between the radiator and the opening in the engine room wall
  - The length of ducting should be kept to a minimum to prevent excess back pressure
  - The daily fuel tank should be positioned as near to the engine as possible



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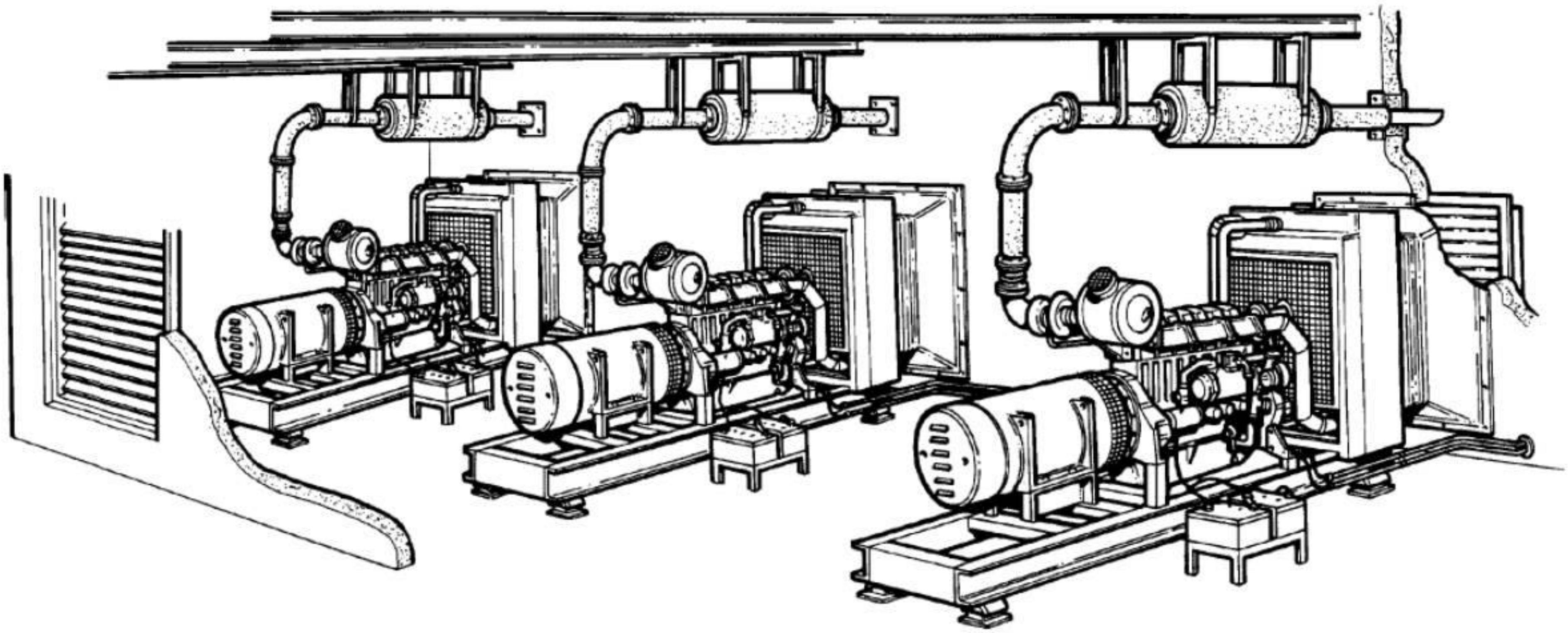
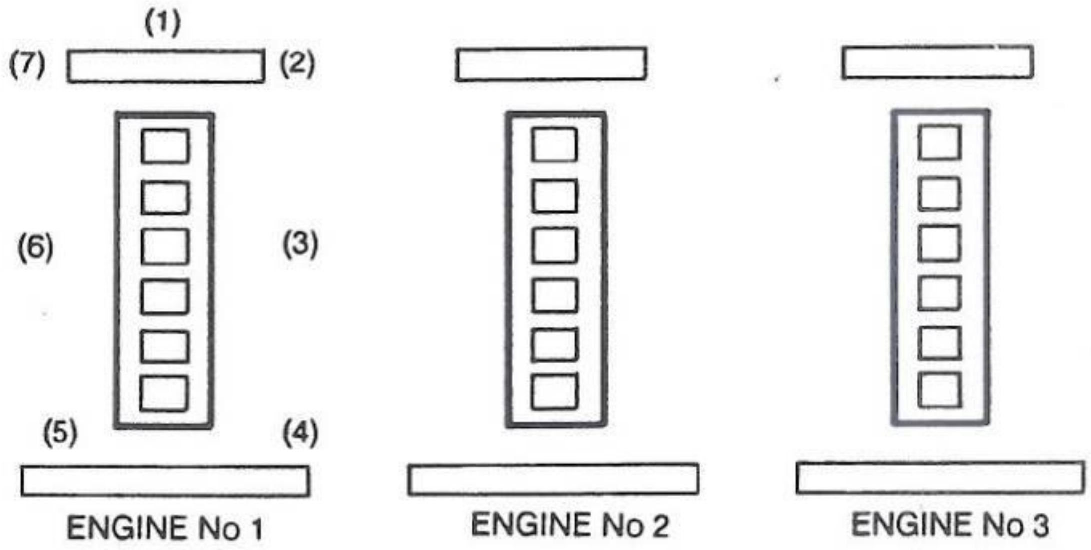
Multiple Genset Installation



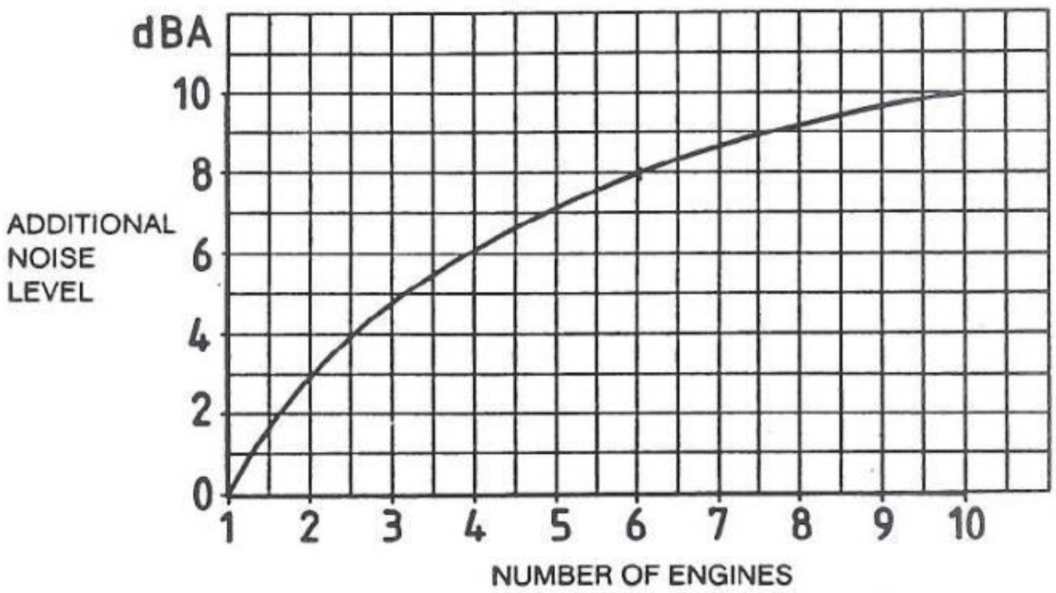
Noise Control

- **Multiple Engine Noise Level**
  - In multiple genset installation using the same engine the maximum noise level will increase above that of a single genset
  - Noise levels can be found on TDS for single engine



Noise Control

- **Multiple Engine Noise Level**
  - Using a single engine at a starting datum the additional noise for other engines operating can be added



- A 4016TAG2A Position 3 - 111dB(A) from TDS
- Total 3 engines running total 111 + 4.8 = 115.8dB(A)

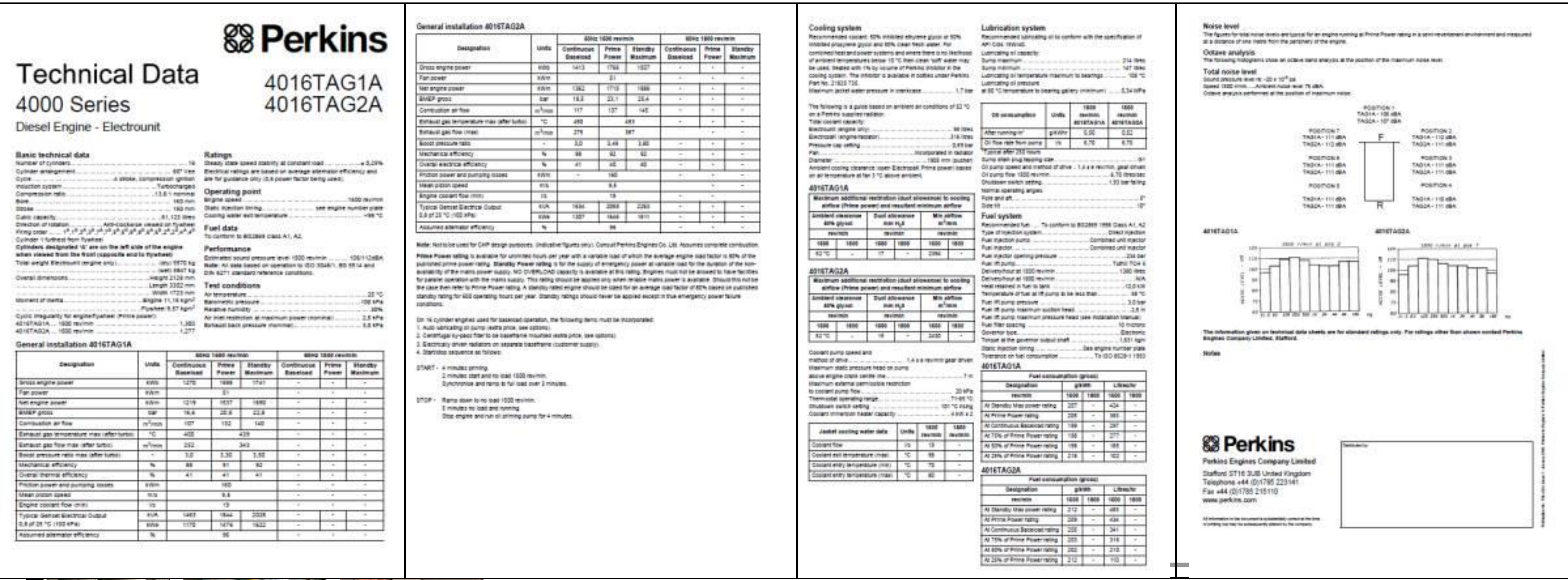
Installation Considerations

Data Available To Support Installations



Technical Data Sheet

- **Technical Data Sheet (TDS)**
  - A full set of TDS are available from Perkins Applications Department and on the secured net : www.perkins.com for all the 4016 Series



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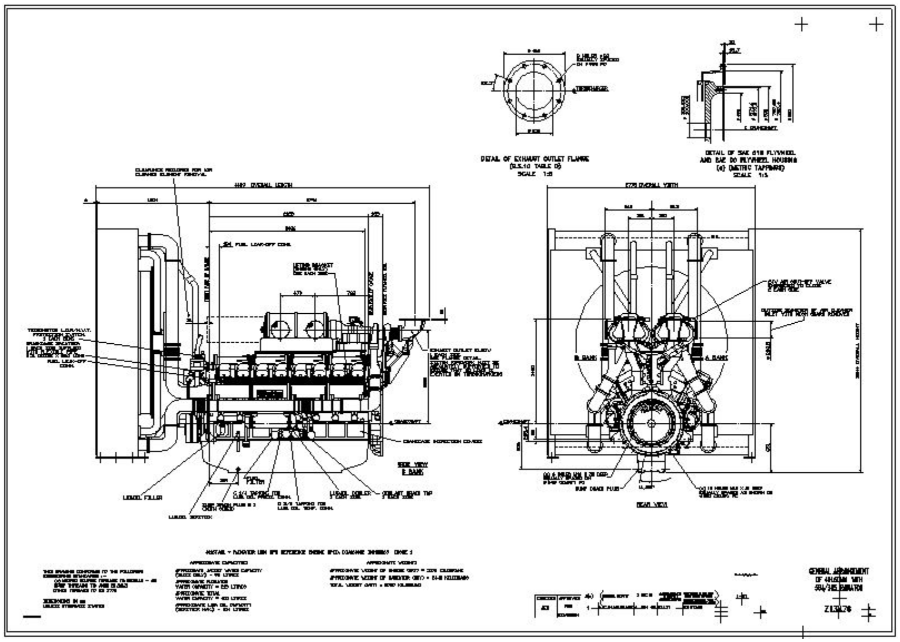
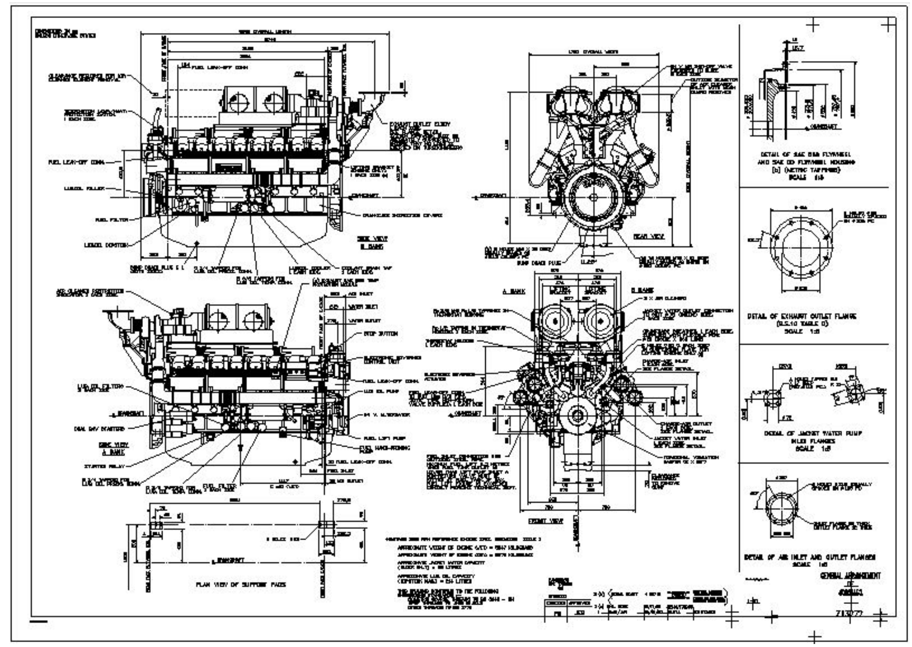
General Arrangement Drawings

- **General Arrangement Drawings (GA drawings)**
  - A full set of GA drawings for Electropaks' and ElectroUnits' are available from Perkins Applications Department and on the secured net : www.perkins.com for all the 4016 Series





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Derate

- **Derate**
  - Derate means reducing the engines maximum power rating at normal temperatures and pressure conditions to allow for adverse effects of site conditions, such as high ambient air temperatures and elevated altitude
  - A full set of derate charts for ambient and altitude are available from Perkins Applications Department and on the secured net : www.perkins.com



Derate

- **Typical 4016 Derate Tables**

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Derate Tables

4000 Series — 4016

Diesel Engines

TWG, TWG2, TAG, TAG1, TAG1A, TAG2, TAG2A, TEG, TEG1 & TEG2

Derating maybe necessary for high air intake temperature and/or elevated altitude. In the case of TWG and TEG engines derating may also be required for high inlet water temperature.
All data is based on a Perkins supplied tropical radiator (not applicable to TEG engines).

4016TWG Standby rating 1343 kWb gross 1500 rev/min

Designation	Ambient temperature to air cleaners (25 °C at 100 m.a.s.l.)			
m.a.s.l.	25	30	40	50
150	1343	1343	1343	1343
500	1343	1343	1343	1297
1000	1343	1343	1303	1236
1500	1304	1284	1234	1174
2000	1234	1213	1166	1112
2500	1163	1143	1097	1050

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Derate Tables

4000 Series 4016

Diesel Engines

TWG, TWG2, TAG, TAG1, TAG1A, TAG2, TAG2A, TEG, TEG1 & TEG2

Derating maybe necessary for high air intake temperature and/or elevated altitude. In the case of TWG and TEG engines derating may also be required for high inlet water temperature.
All data is based on a Perkins supplied tropical radiator (not applicable to TEG engines).

4016TWG Standby rating 1343 kWb gross 1500 rev/min

Designation	Ambient temperature to air cleaners (25 °C at 100 m.a.s.l.)			
m.a.s.l.	25	30	40	50
150	1343	1343	1343	1343
500	1343	1343	1343	1297
1000	1343	1343	1303	1236
1500	1304	1284	1234	1174
2000	1234	1213	1166	1112
2500	1163	1143	1097	1050

4016TWG Prime rating 1224 kWb gross 1500 rev/min

Designation	Ambient temperature to air cleaners (25 °C at 100 m.a.s.l.)			
m.a.s.l.	25	30	40	50
150	1224	1224	1224	1224
500	1224	1224	1224	1162
1000	1224	1224	1187	1126
1500	1189	1170	1125	1070
2000	1125	1105	1062	1013
2500	1060	1042	1000	957

4016TWG Baseload rating 979 kWb gross 1500 rev/min

Designation	Ambient temperature to air cleaners (25 °C at 100 m.a.s.l.)			
m.a.s.l.	25	30	40	50
150	979	979	979	979
500	979	979	979	946
1000	979	979	950	901
1500	951	936	900	856
2000	900	884	850	811
2500	848	833	800	766

4016TAG2 Standby rating 1937 kWb gross 1500 rev/min

Designation	Ambient temperature to air cleaners (25 °C at 100 m.a.s.l.)			
m.a.s.l.	25	30	40	50
150	1937	1918	1873	1782
500	1894	1856	1799	1712
1000	1805	1765	1701	1617
1500	1716	1676	1606	1519
2000	1629	1584	1507	1420
2500	1536	1495	1408	1321

4016TAG2 Prime rating 1766 kWb gross 1500 rev/min

Designation	Ambient temperature to air cleaners (25 °C at 100 m.a.s.l.)			
m.a.s.l.	25	30	40	50
150	1766	1748	1708	1625
500	1727	1692	1641	1561
1000	1646	1609	1551	1475
1500	1565	1528	1464	1385
2000	1485	1445	1374	1294
2500	1402	1363	1284	1204

Perkins
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www.perkins.com

Torsional Vibration Analysis

- **Torsional Vibration Analysis (TVA)**
  - A list of completed TVA's are available from Perkins Applications Department

ENGINE range	Engine model	Speed rpm	Power kWb	Flywheel fitted	Dampers fitted	Alternator Manufacturer	Alternator Model	Alt. Brgs	Coupling Maker	Coupling Model	C'plg Elem.	Date analysed	Res.	Comments
4016	TAG1A	1500	1741	SEV250E/1	2x20"	AVK	DIG120H/4	1	-	-	-	20-Oct-03	OK	Satisfactory as proposed
4016	TWG2	1500	1397	SEV250E/1	2x20"	Hitachi	-	1	-	-	-	20010427	OK	Satisfactory as proposed
4016	TAG2A	1500	1937	SEV250E/1	2x20"	Leroy Somer	LSA 50.2 M60	2	Reich	MMO-2000	75	20030505	OK	Satisfactory as proposed
4016	TAG1	1500	1667	SEV250E/1	2x20"	Leroy Somer	LSA 51.2 L70	1	-	-	-	19991108	OK	Satisfactory as proposed
4016	TAG2	1500	1833	SEV250E/1	2x20"	Leroy Somer	LSA 51.2 L70	1	-	-	-	19991108	OK	Satisfactory as proposed
4016	TWG2	1500	1560	SEV250E/1	2x20"	Leroy Somer	LSA 51.2 M60	1	-	-	-	19991105	OK	Satisfactory as proposed
4016	TAG1	1500	1600	SEV250E/1	2x20"	Leroy Somer	LSA 51.2 M60	1	-	-	-	19991105	OK	Satisfactory as proposed
4016	TAG2	1500	1708	SEV250E/1	2x20"	Leroy Somer	LSA 51.2 M60	1	-	-	-	20010206	OK	Satisfactory using Lloyds Tn at continuous rating
4016	TAG1A	1500	1741	SEV250E/1	2x20"	Leroy Somer	LSA 52.2 L65	1	-	-	-	10-Sep-03	OK	Satisfactory as proposed
4016	TAG	1500	1649	SEV250E/1	2x20"	Leroy Somer	LSA 52.2 L65	2	Reich	MMO-2000-SP	75	07-Jan-04	OK	Satisfactory as proposed
4016	TAG2	1500	1708	SEV250E/1	2x20"	Leroy Somer	LSA51.2 VL85	1	-	-	-	20010326	OK	Satisfactory as proposed
4016	TAG2A	1500	1943	SEV250E/1	2x20"	Leroy Somer	LSA51.2L70	1	-	-	-	20011105	OK	Continuous duty - max. ambient temp. at damper 48 deg C.
4016	TAG	1500	1649	SEV250E/1	2x20"	Leroy Somer	LSA51S4	1	-	-	-	19990401	OK	Satisfactory as proposed
4016	TAG	1500	1649	SEV250E/1	2x20"	Leroy Somer	LSA53L65	2	Reich	MMO-2000-SP	SP(75)	18-Aug-04	OK	Satisfactory as proposed
4016	TAG1A	1500	1741	SEV250E/1	2x20"	Leroy Somer	LSA53L7	2	Reich	MMO-2000-SP	SP(75)	18-Aug-04	OK	Satisfactory as proposed
4016	TAG2	1500	1879	SEV250G/1	2x20"	Leroy Somer	LSA53UL7	2	Reich	MMO2000	75	19980604	OK	Satisfactory as proposed
4016	TAG2	1500	1768	SEV250E/1	2x20"	Leroy Somer	LSA53VL75	2	Reich	AC10-F2-18	SN(75)	19990821	OK	Satisfactory as proposed
4016	TAG2	1500	1937	SEV250G/1	2x20"	Leroy Somer	LSA53XL85	2	Reich	AC11-F2-21	SN(75)	19981127	OK	Satisfactory - single bearing option rejected - alternator mass 2327kg
4016	TAG2A	1500	1937	SEV250E/1	2x20"	Newage	HC734H	1	-	-	-	20001002	OK	Satisfactory as proposed to 52degC at 1773kW gross, check 1937kW
4016	TAG2	1500	1937	SEV250E/1	2x20"	Newage	HC734H	1	-	-	-	20000616	OK	Satisfactory as proposed
4016	TAG2A	1500	1937	SEV250E/1	2x20"	Newage	HC734H	1	-	-	-	20030207	OK	Check belts against vibration report 2003_53202_PGSUTT_TR_33
4016	TAG2A	1500	1943	SEV250G/1	2x20"	Newage	LVSI 824D	2	Reynolds	HTB 20000	Si60	20010612	OK	Satisfactory as proposed
4016	TAG2	1500	1879	SEV250G/1	2x20"	Newage	LVSI814D	2	Reich	AC11-F2-21	NN	19980612	OK	Alternative coupling to E278461 - P/52113/463
4016	TAG2	1500	1890	SEV250E/1	2x20"	Newage	LVSI824E	2	Reich	AC10.F2	SN(75)	20000731	OK	Suitable for O.C.C.O.
4016	TAG2	1500	1879	SEV250G/1	2x20"	Newage	LVSI8D	2	Holset	DCB835.5	70	19980512	OK	1 bearing alt. too heavy, also 5.5RB-SM70, D425-70 & 844.5-SM70 failed
4016	TAG	1500	1746	SEV250E/1	2x20"	Newage AVK	DIG 120 k/4	2	Reich	MMO-2000	75	20021610	OK	Satisfactory as proposed
4016	TAG	1500	1652	SEV250E/1	2x20"	Newage AVK	HVSI 824C	2	Reich	MMO-2000	75	20022409	OK	Satisfactory as proposed
4016	TAG2A	1500	1937	SEV250E/1	2x20"	NEWAGE	P7D	1	-	-	-	18-Jan-05	OK	Satisfactory as proposed
4016	TAG2A	1500	1937	SEV250E/1	2x20"	NEWAGE	P7E	1	-	-	-	18-Jan-05	OK	Satisfactory as proposed
4016	TAG2A	1500	1937	SEV250E/1	2x20"	NEWAGE	P7F	1	-	-	-	18-Jan-05	CHECK	Check due to high front end vibratory amplitude on 1.5 order of 0.51over the 0.50 limit.
4016	TAG2A	1500	1937	SEV250E/1	2x20"	NEWAGE	P7G	1	-	-	-	18-Jan-05	CHECK	Check due to high front end vibratory amplitude on 1.5 order of 0.52 over the 0.50 limit.
4016	TEG2	1500	1550	SEV250G/1	2x20"	Niigata	KA-680042	2	Centaflex	8000SDE	70	19980227	OK	Also checked with Centaflex D425 & Holset 5.5RB - both failed
4016	***TEG2***	***1500***	***1627***	***SEV250E/***	***2x20"***	***Toyo Denk***	***36020002***	***1***	***-***	***-***	***-***	***20020705***	***NO***	***Alternator exceeds recommended flywheel additional load limit***
4016	***TEG2***	***1500***	***1627***	***SEV250E/***	***2x20"***	***Toyo Denk***	***36020902***	***2***	***-***	***-***	***-***	***20020720***	***NO***	***1.5 ORDER VIB AMP EXCEEDS 0.5 LIMIT- S/BY 37 C CONT 47 C***
4016	TEG2	1500	1627	SEV250E/1	2x20"	Toyo Denki	36020902	2	Reynolds	HTB12000	Si70	20020730	OK	Satisfactory as proposed
4016	TAG2	1500	1879	SEV250G/1	2x20"	Van Kaick	DSG99L1/4	2	Reich	AC11-F2-21	NN	19981007	OK	Satisfactory as proposed



Cooling Data Requirements

- ## Cooling Data Requirements
  - A full set of cooling data requirements data for 4016 Series ElectroUnits' are available from Perkins Applications Department
  - This is when the Perkins cooling group is not required, due to installation constraints

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Tropical Cooling Requirements (<55°C air onto fan)
4016TAG2A @ 1500 RPM 1937 kWb Gross
Spill Timing 16° (Standard)

When engines are supplied as an Electrounit the customer must confirm their radiator performance meets or exceeds the following:

Ambient temperature to air filters	25 °C
Ambient temperature to fan (air on)	33 °C
Jacket water temperature out nominal	85 °C
Jacket water temperature out maximum	98 °C
Water flow	1140 l/min
Pressure drop	8 kPa
Heat rejection	721 KWt
Boost temperature to charge cooler	236 °C
Boost temperature from charge cooler	43 °C
Charge cooler thermal effectiveness	0.96
Boost pressure to charge cooler	272 kPa
Boost pressure from charge cooler	260 kPa
Maximum pressure drop	12 kPa
Air consumption	2.86 kg/s
Heat rejection	610 KWt

N.B. A fouling margin and duct allowance must be built in to suit the application. Provision for condensate drain to be made.

Nominal maximum air onto fan		55 °C
Header tank pressure relief		69 kPa
Fan power consumption	up to	51 KWm
Fuel cooler heat rejection		12 KWt
Maximum temperature at fuel lift pump		58 °C

A radiator installed on the engine which cannot achieve this level of performance will impact on the engine performance / durability.

A site assessment for installation vibration and cooling effectiveness would be required for final approval.



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Any Questions ?