

# Technical Data

## 4000 Series

### Gas Engine

## 4006-23TRS1 4006-23TRS2

#### Basic technical data

Number of cylinders ..... 6  
 Cylinder arrangement ..... Vertical, In line  
 Cycle ..... 4 stroke, spark ignition  
 Induction system ..... turbocharged  
 Compression ratio ..... 12:1 nominal  
 Bore ..... 160 mm (6.3 in)  
 Stroke ..... 190 mm (7.5 in)  
 Cubic capacity ..... 22,921 litres  
 Direction of rotation ..... anti-clockwise viewed on flywheel  
 Firing order ..... 1, 5, 3, 6, 2, 4  
 Cylinder 1 ..... furthest from flywheel  
 Total weight of electro unit (engine only)  
 - estimated total weight (dry) ..... 2420 kg (5335.2 lb)  
 - estimated total weight (wet) ..... 2652 kg (5846.7 lb)

#### Overall dimensions

mm (in)	Height	Length	Width
<b>Cogeneration unit</b>			
Natural gas	1671 (65.8)	2242 (88.3)	1400 (55.1)
Bio gas	1787 (70.4)	2242 (88.3)	1418 (55.8)
<b>Electro unit</b>			
Natural gas	1671 (65.8)	2242 (88.3)	1633 (64.3)
Bio gas	1787 (70.4)	2242 (88.3)	1633 (64.3)

#### Moment of inertia (GD<sup>2</sup>)

- engine ..... 4,12 kgm<sup>2</sup>  
 - flywheel ..... 5,92 kgm<sup>2</sup>  
 Cyclic irregularity for engine/flywheel (prime power):  
 4006-23TRS1 - 322 kW @ 1500 rev/min ..... 1:97  
 4006-23TRS2 - 393 kW @ 1500 rev/min ..... 1:110

#### General installation

Designation	Units	Continuous baseload rating			
		Cogeneration unit		Electro unit	
		1500 rev/min			
		TRS1	TRS2	TRS1	TRS2
Gross engine power	kW (bhp)	322 (431.8)	393 (527.0)	322 (431.8)	393 (527.0)
Brake mean effective pressure	kPa (lbf/in <sup>2</sup> )	11,24 (1.63)	13,70 (1.99)	11,24 (1.63)	13,70 (1.99)
Combustion air flow	m <sup>3</sup> /min (ft <sup>3</sup> /min)	25,0 (882.9)	29,9 (1055.9)	25,3 (893.5)	30,2 (1066.5)
Exhaust gas temperature (max) after turbo	°C (°F)	495 (923)	485 (905)	495 (923)	485 (905)
Exhaust gas flow (max)	m <sup>3</sup> /min (ft <sup>3</sup> /min)	65,20 (2302.5)	76,90 (2715.7)	66,00 (2330.8)	78,25 (2763.4)
Boost pressure ratio	-	2,20	2,49	2,20	2,49
Overall electrical efficiency	%	37,44	38,35	36,95	37,85
Mean piston speed	m/s (ft/s)	9,5 (31.2)		9,5 (31.2)	
Charge coolant flow	l/sec (UK gal/sec)	6,7 (1.5)		6,7 (1.5)	
Nominal excess air factor (Lambda)	λ	1,69		1,69	
Typical gross Gen Set electrical output (25 °C, 100 kPa, cos φ 1)	kWe	307	375	307	375
Assumed alternator efficiency	%	95,4		95,4	

**Continuous baseload rating:** Power available for continuous full load operation. No overload available.

#### Ratings

This is defined in ISO3046 / 1 (BS5514 / 1 - 1982)  
 Electrical ratings are based on stated alternator efficiency and are for guidance only. For Load Acceptance figures, please refer to Stafford Applications Engineering Department.

#### Operating point

Engine speed ..... 1500 rev/min  
 Ignition timing ..... 28° BTDC  
 Mixture cooler water temperature ..... 45 °C  
 Cooling water exit temperature ..... < 96 °C  
 Exhaust emission ..... according to TA-Luft (NOx)

#### Fuel data

Lower calorific value ..... 34,710 kJ/Sm<sup>3</sup> (45.671 kJ/kg)  
 Density ..... 0,76 kg/Sm<sup>3</sup>  
 Stoich air requirement ..... 16 kJ/kg  
 Minimum methane number before derate ..... 75

#### Performance

Steady state speed stability at constant load ..... ± 0,25%  
**Note:** All data based on operation to ISO 3046/1, BS 5514 and DIN 6271 standard reference conditions

#### Test conditions

-air temperature ..... 25 °C (77 °F)  
 -barometric pressure ..... 100 kPa (29.5 in hg)  
 -relative humidity ..... 30%

## Energy balance

### 4006-23TRS1 / 4006-23TRS2 - Cogeneration unit

Designation @ 1500 rev/min	Units	TRS1		TRS2	
		Continuous baseload rating	%	Continuous baseload rating	%
Energy in fuel	kW	820	100	978	100
Energy in power output (Net)	kW	322	39,25	393	40,2
Energy in exhaust	kW	263	32,1	311	31,8
Energy to coolant and oil	kW	152	18,5	162	16,6
Energy to charge cooler	kW	38	4,6	57	5,8
Sum of useable heat	kW	433	52,8	461	47,1
Sum of useable energy	kW	754	92,05	854	87,3
Energy to radiation	kW	45	5,4	55	5,6

### 4006-23TRS1 / 4006-23TRS2 - Electro unit

Designation @ 1500 rev/min	Units	TRS1		TRS2	
		Continuous baseload rating	%	Continuous baseload rating	%
Energy in fuel	kW	831	100	990	100
Energy in power output (Net)	kW	322	38,7	393	39,7
Energy in exhaust	kW	266	32,0	314	31,7
Energy to coolant and oil	kW	154	18,5	164	16,6
Energy to charge cooler	kW	39	4,7	58	5,9
Sum of useable heat	kW	459	55,2	536	54,1
Sum of useable energy	kW	781	94,0	929	93,8
Energy to radiation	kW	50	6,0	61	6,2

Not to be used for CHP design purposes (indicative figures only). Consult Perkins Engines Company Limited. Assumes complete combustion.

## Cooling system

Recommended coolant: 50% inhibited ethylene glycol or 50% inhibited propylene glycol and 50% clean fresh water. For combined heat and power systems and where there is no likelihood of ambient temperature below 10 °C, then clean 'soft' water may be used, treated with 1% by volume of Perkins inhibitor in the cooling system. The inhibitor is available in 1 litre bottles from Perkins. Total coolant capacity (engine only) ... 36 litres Maximum jacket water pressure in crankcase ... 1 bar (plus static pressure head)

Jacket cooling water data	Units	1500 rev/min
Coolant flow	m³/h	36
Coolant exit temperature (max)	°C	96
Coolant entry temperature (max)	°C	88

Charge cooling water data	Units	1500 rev/min
Coolant flow	m³/h	24
Coolant entry temperature	°C	45

Charge cooler ... Fin and tube on engine

Shutdown switch setting... coolant 96 °C rising  
Coolant immersion heater capacity... 4 kW 1 off

## Lubrication system

Recommended lubricating oil: lubricating oil requirements vary with fuel used. Full specifications including oil sampling and recommendations and condemnation limits appear on the fuel, coolant and lubricating oil recommendation sheet for the 4000 Series Gas Engines.

### Lubricating oil capacity

Total system ... 122,7 litres  
Sump maximum ... 113,4 litres  
Sump minimum ... 90,7 litres

### Lubricating oil temperature

Maximum to bearings... 105 °C  
Lubricating oil pressure at 85 °C temperature to bearings... 0,34 MPa

Designation	TRS1	TRS2
Oil consumption (continuous rating)	1500 rev/min	
After RUNNING-IN <sup>(1)</sup>	g/kWhr	0,14
Oil flow rate from oil pump	l/s	3,7

1. Typical 250 hours  
Sump drain plug tapping size... GA1  
Oil pump... Gear driven  
Shutdown switch setting... oil 1,93 bar falling

### Normal operating angles:

-front and rear... 5°  
-side tilt... 22,5°

## Fuel system

Recommended fuel: Natural Gas LHV at 34 MJ/m³ (930 Btu/cu.ft). Other fuels may be used, for example landfill or digester gas. Ratings will vary from those shown.

Where fuels other than Natural Gas are being considered it is imperative that a full gas analysis (including details of any solid or liquid components) be obtained. Reference should be made to Perkins Engines Company Limited to determine suitability. Gas supplies must be filtered to the same standard as the engine intake air (i.e. Maximum particle size not to exceed 50 microns). Gas supply pressure ... 1,5 kPa to 5 kPa at full rated flow Carburettor type ... Deltec with zero pressure regulator Installation of gas supply and shut off valves to be in accordance with local regulations.

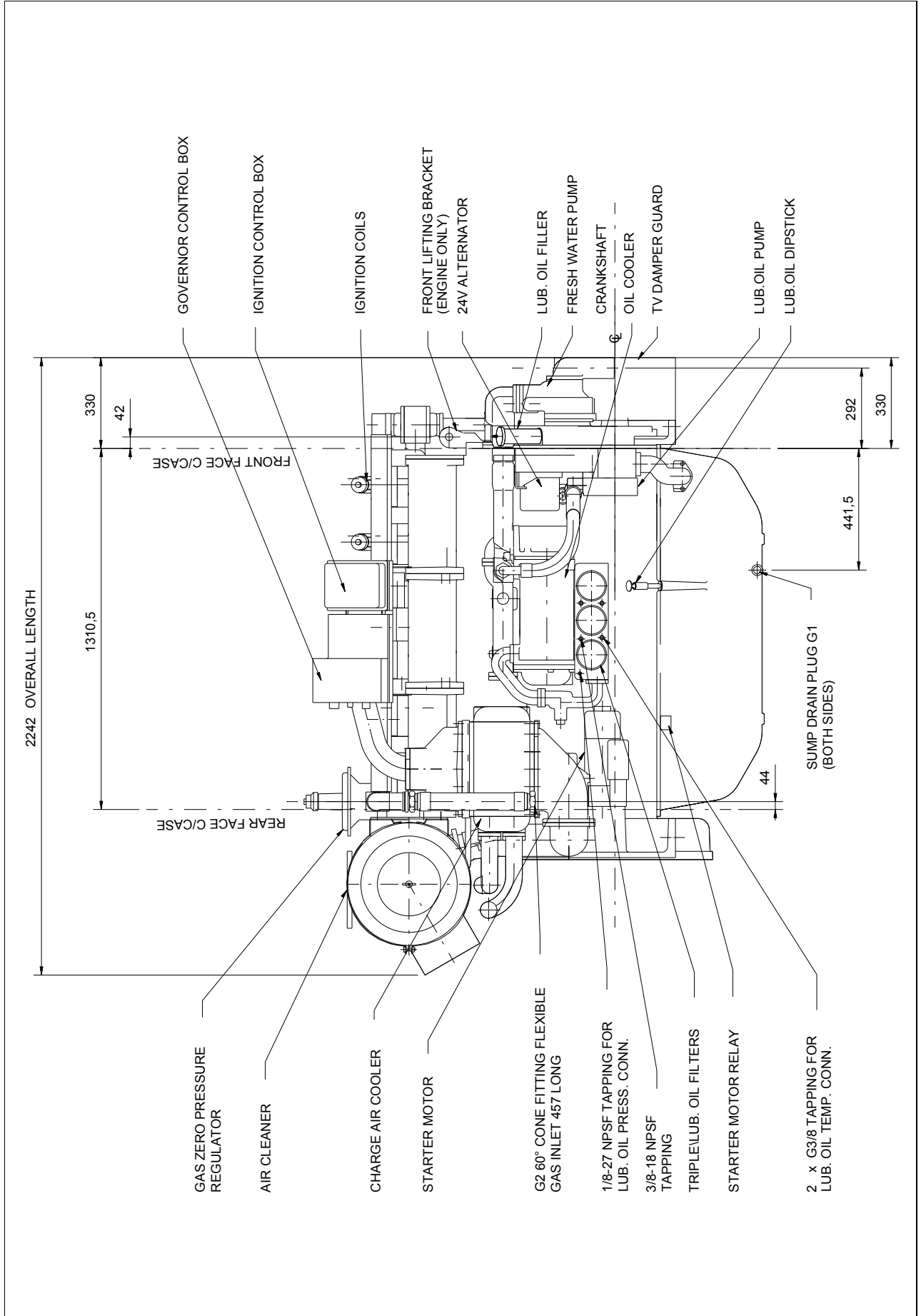
Designation	Cogeneration unit		Electro unit	
	TRS1	TRS2	TRS1	TRS2
Fuel consumption gross @ 1500 rev/min	kJ / kW	kJ / kW	kJ / kW	kJ / kW
At CONTINUOUS Baseload rating	2,55	2,49	2,58	2,52
At 75% of Prime Power rating	2,63	2,57	2,66	2,60
At 50% of Prime Power rating	2,84	2,73	2,87	2,76
At 25% of Prime Power rating	3,88	3,35	3,91	3,38

Fuel: Natural Gas - LHV = 34,71 MJ/m³

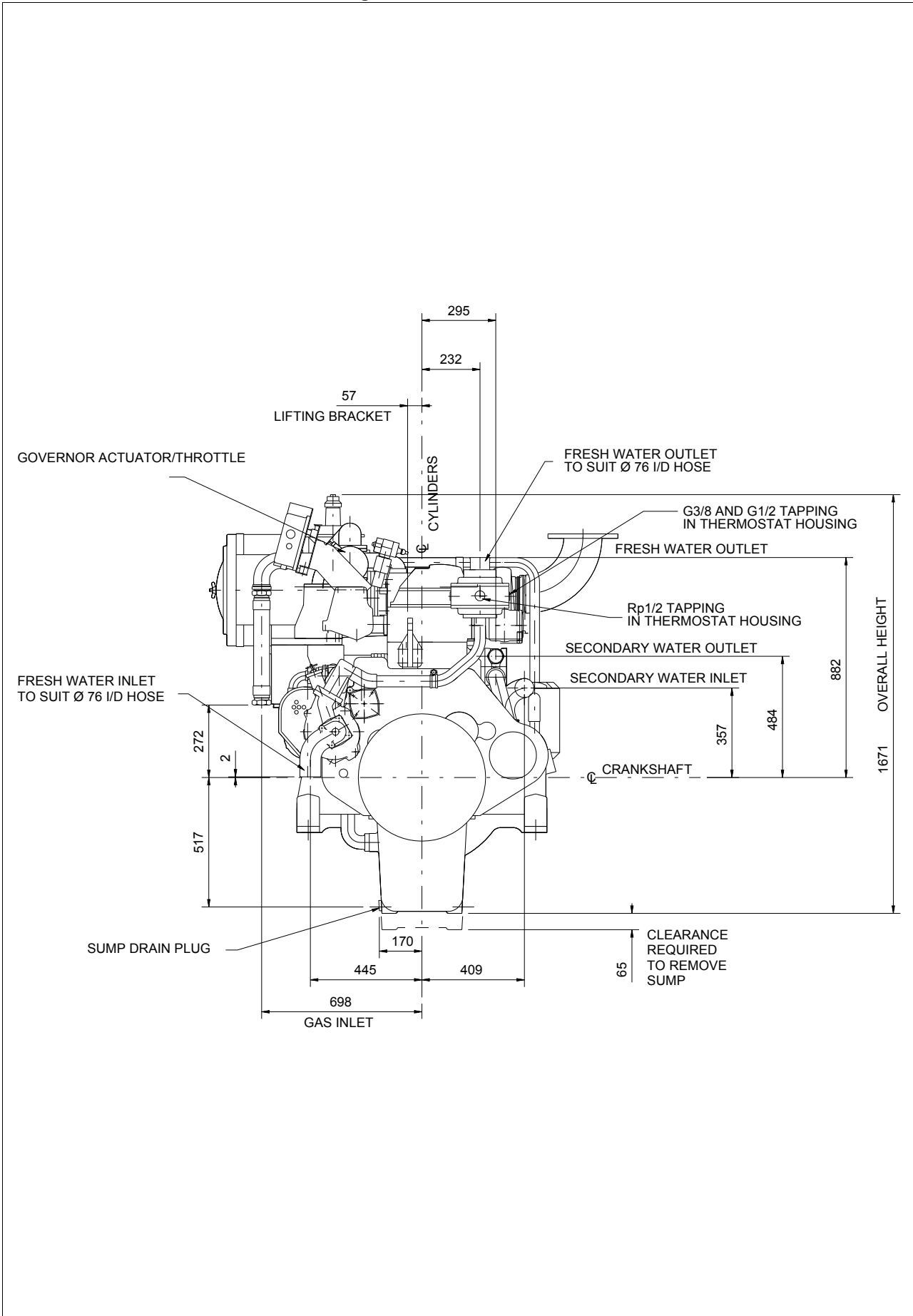
Tolerance on fuel consumption

Designation	Units	Cogeneration unit		Electro unit	
		TRS1	TRS2	TRS1	TRS2
Mass flow data		1500 rev/min			
Fuel	Kg/h	64,4	76,8	65,2	77,7
Volume flow data (100 kPa)					
Fuel (15 °C)	Sm³/hr	84,7	101,0	85,8	102,2

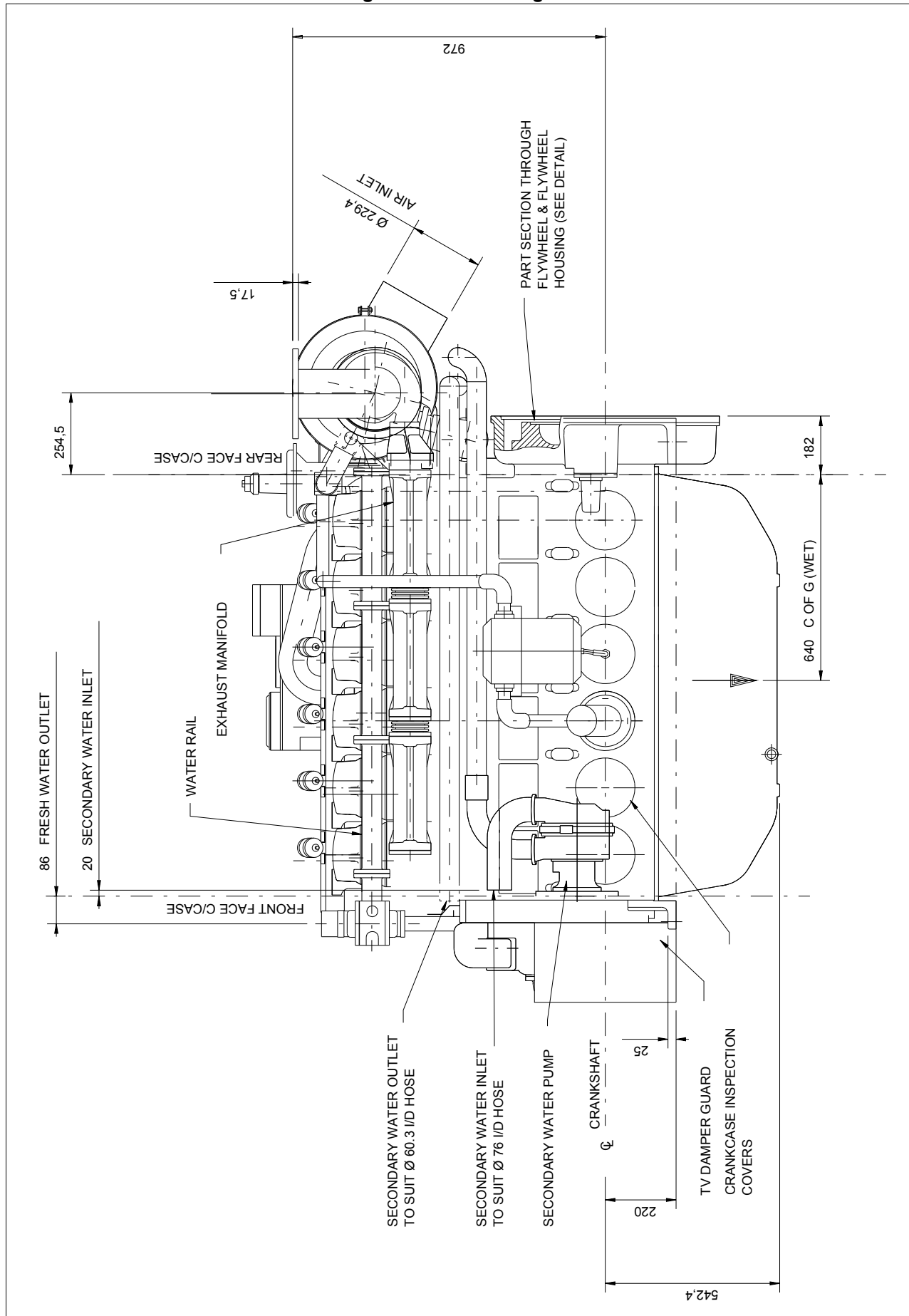
**4006-23TRS1 and 4006-23TRS2 Natural gas electro unit - left side view**



4006-23TRS1 and 4006-23TRS2 Natural gas electro unit - front view

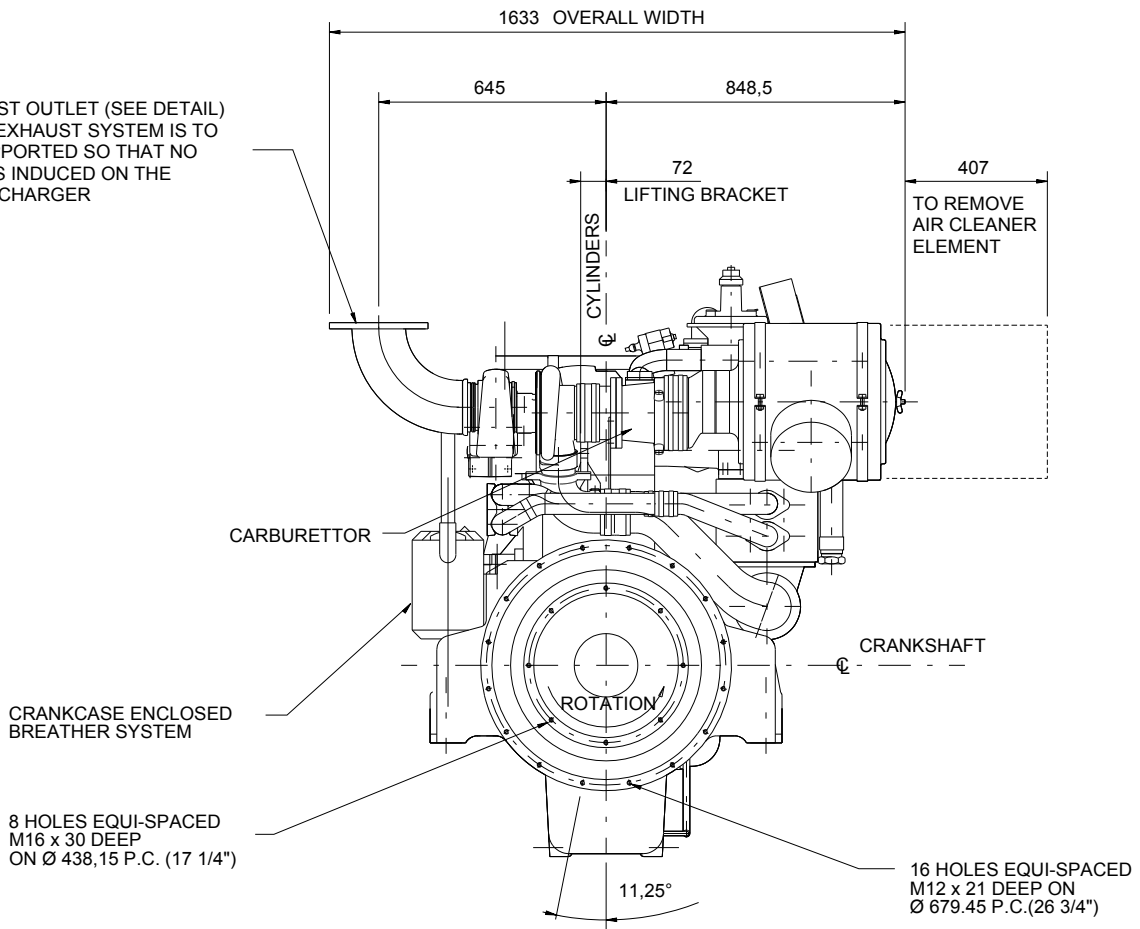


4006-23TRS1 and 4006-23TRS2 Natural gas electro unit - right side view

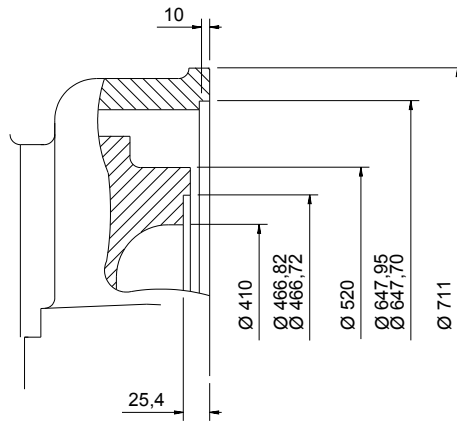


**4006-23TRS1 and 4006-23TRS2 Natural gas electro unit - rear view**

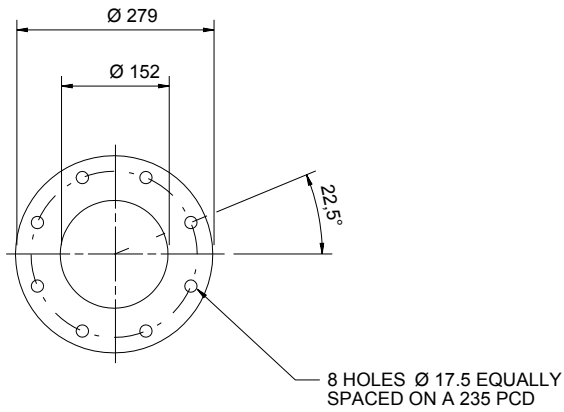
EXHAUST OUTLET (SEE DETAIL)  
NOTE: EXHAUST SYSTEM IS TO  
BE SUPPORTED SO THAT NO  
LOAD IS INDUCED ON THE  
TURBOCHARGER



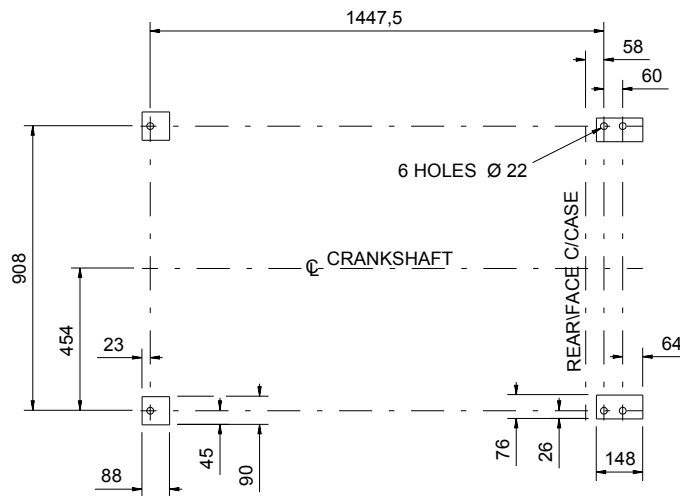
**4006-23TRS1 and 4006-23TRS2 Natural gas electro unit - SAE Flywheel, Exhaust Outlet and Support Pads**



**DETAIL OF SAE 514 FLYWHEEL  
AND SAE O FLYWHEEL HOUSING  
(METRIC TAPPINGS)  
SCALE 1:5**

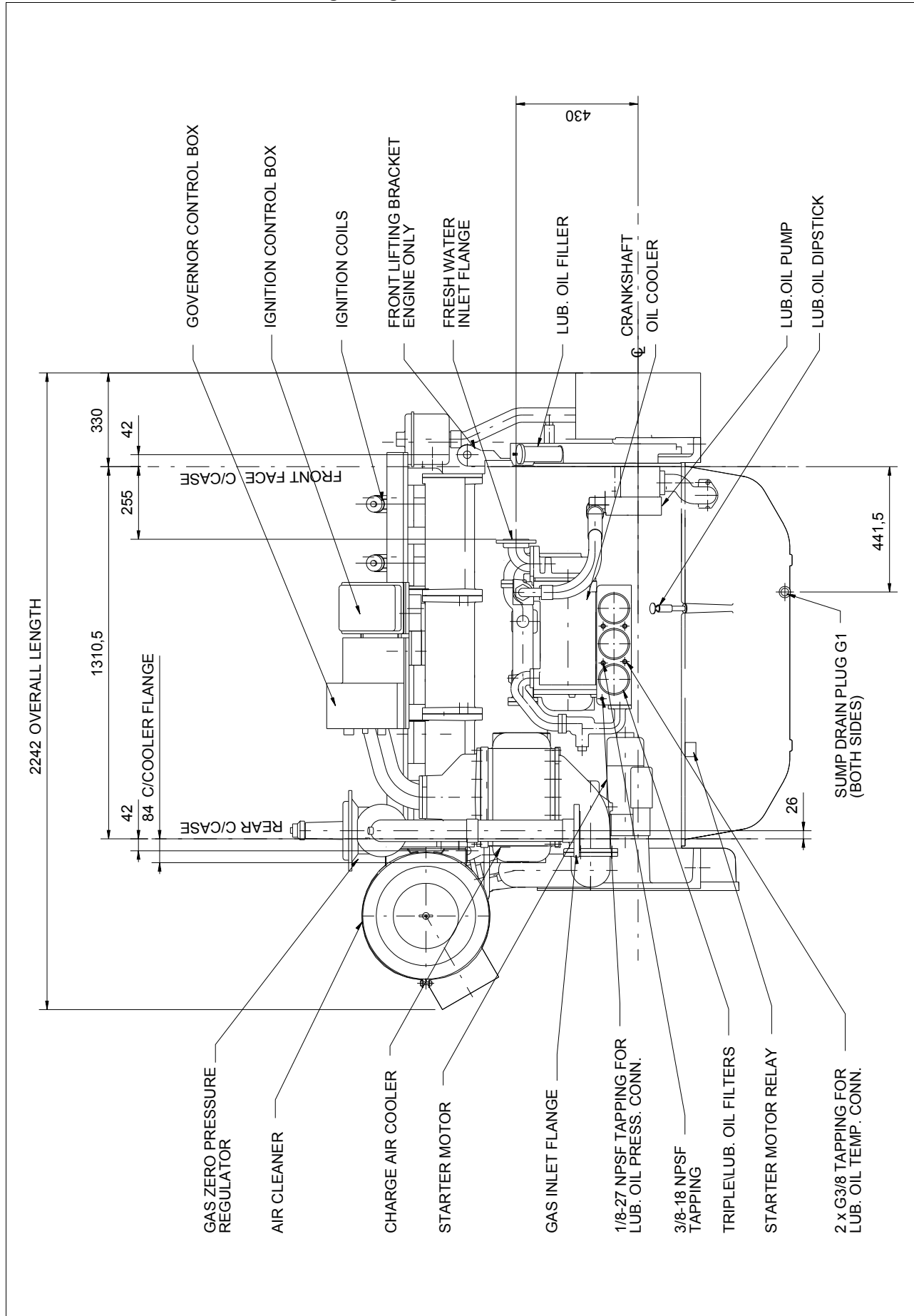


**DETAIL OF EXHAUST OUTLET  
BS10 TABLE 'D'  
SCALE 1:2**



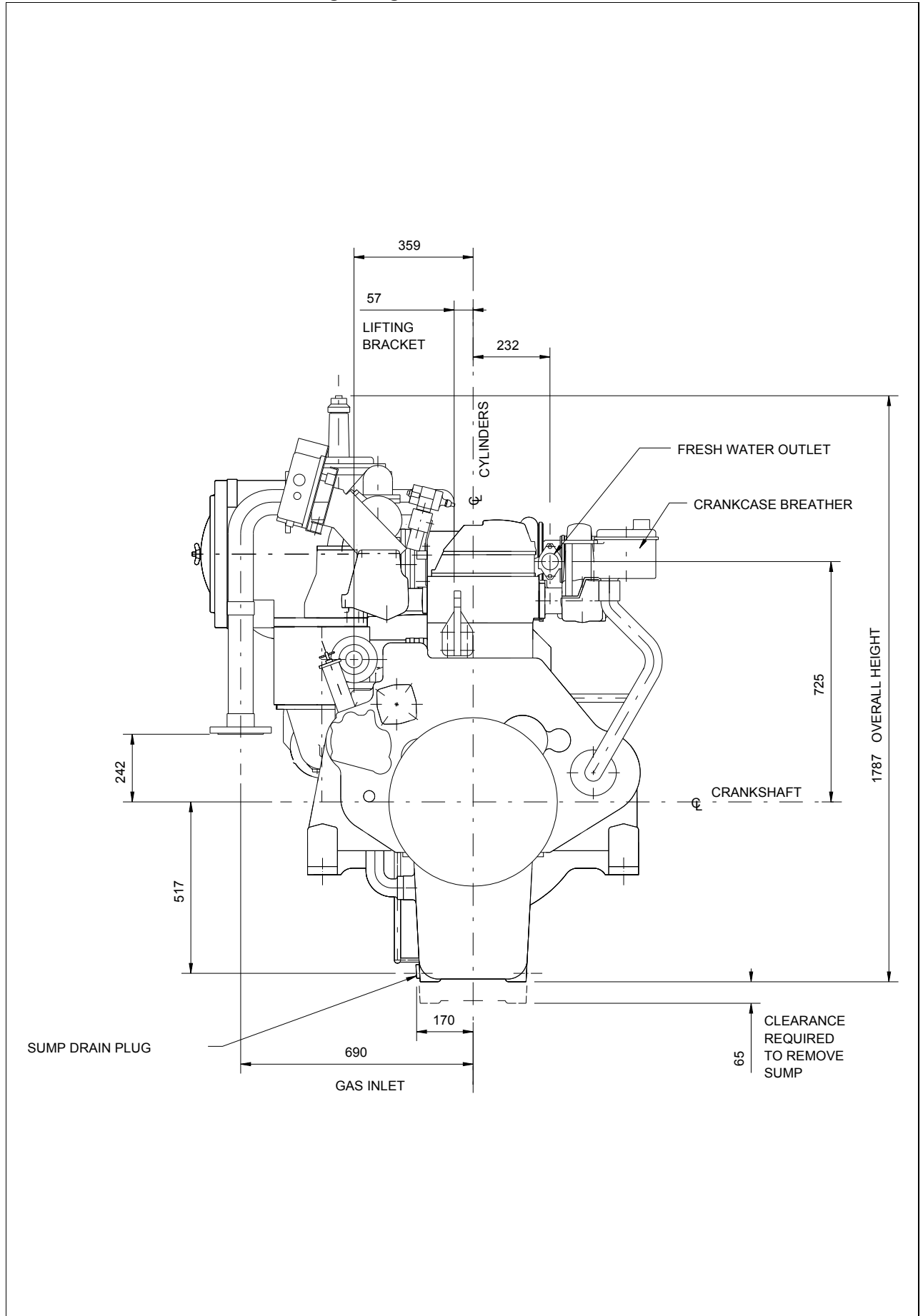
**PLAN VIEW OF SUPPORT PADS**

4006-23TRS1 and 4006-23TRS2 Bio gas cogeneration unit - left side view

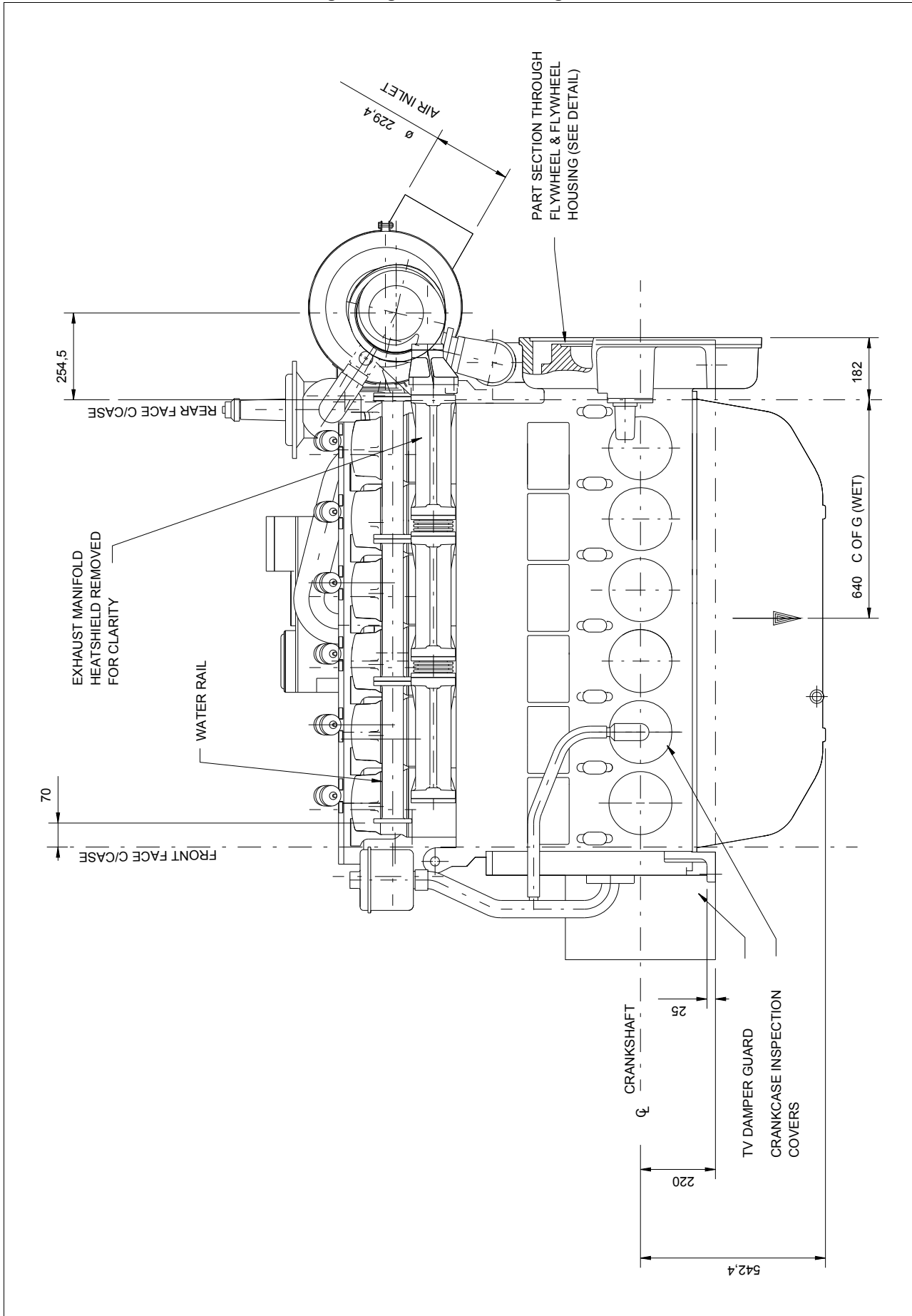




4006-23TRS1 and 4006-23TRS2 Bio gas cogeneration unit - front view

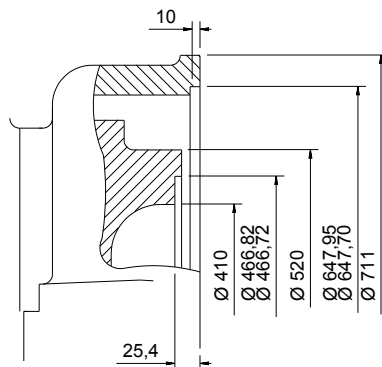


# 4006-23TRS1 and 4006-23TRS2 Bio gas cogeneration unit - right side view

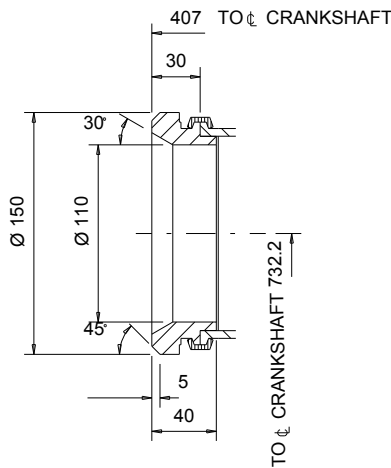




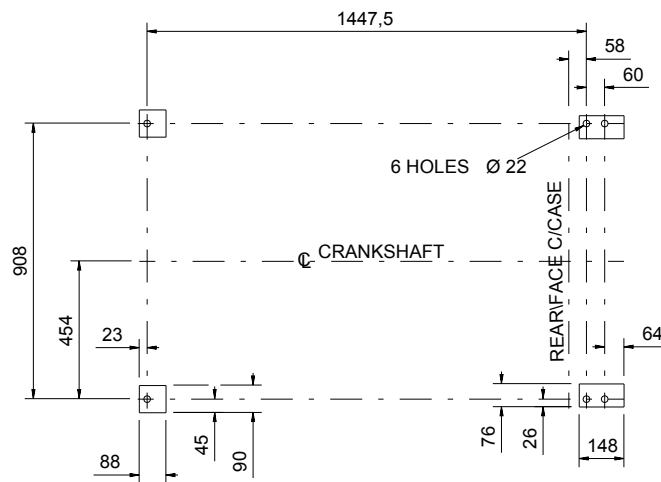
**4006-23TRS1 and 4006-23TRS2 Bio gas cogeneration unit - SAE Flywheel, Exhaust Outlet and Support Pads**



**DETAIL OF SAE 514 FLYWHEEL  
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(METRIC TAPPINGS)  
SCALE 1:5**

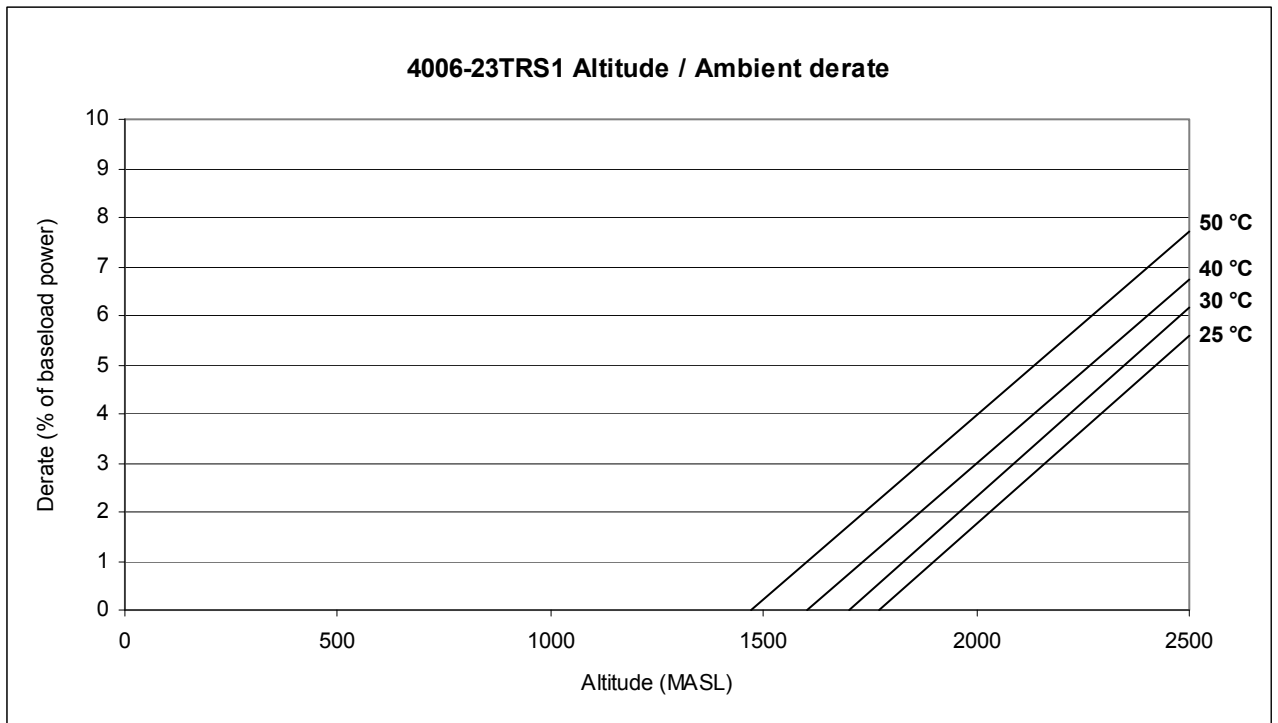
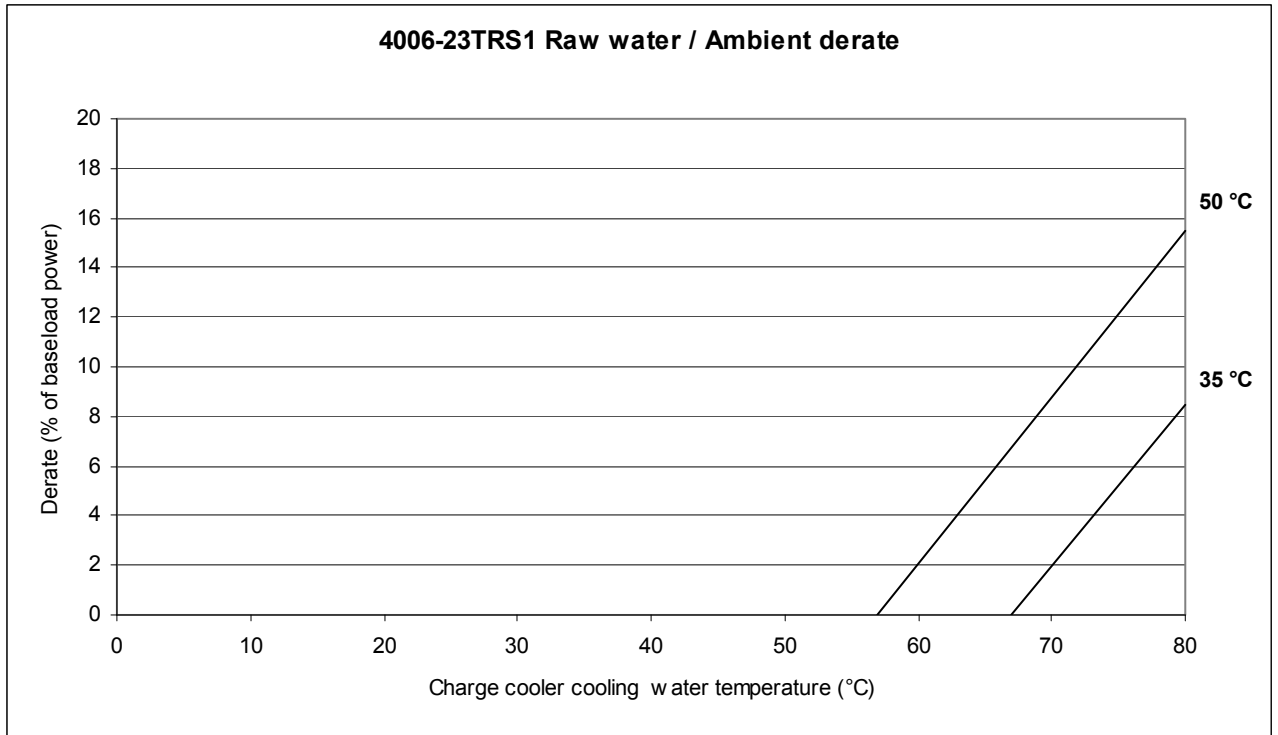


**DETAIL OF EXHAUST OUTLET  
SCALE 1:2**

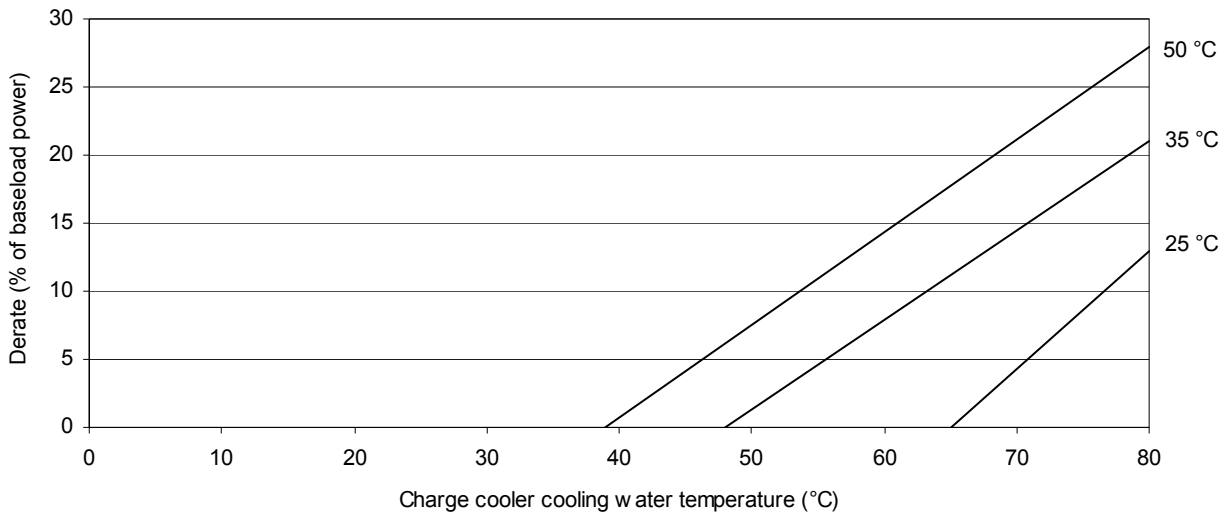


**PLAN VIEW OF SUPPORT PADS**

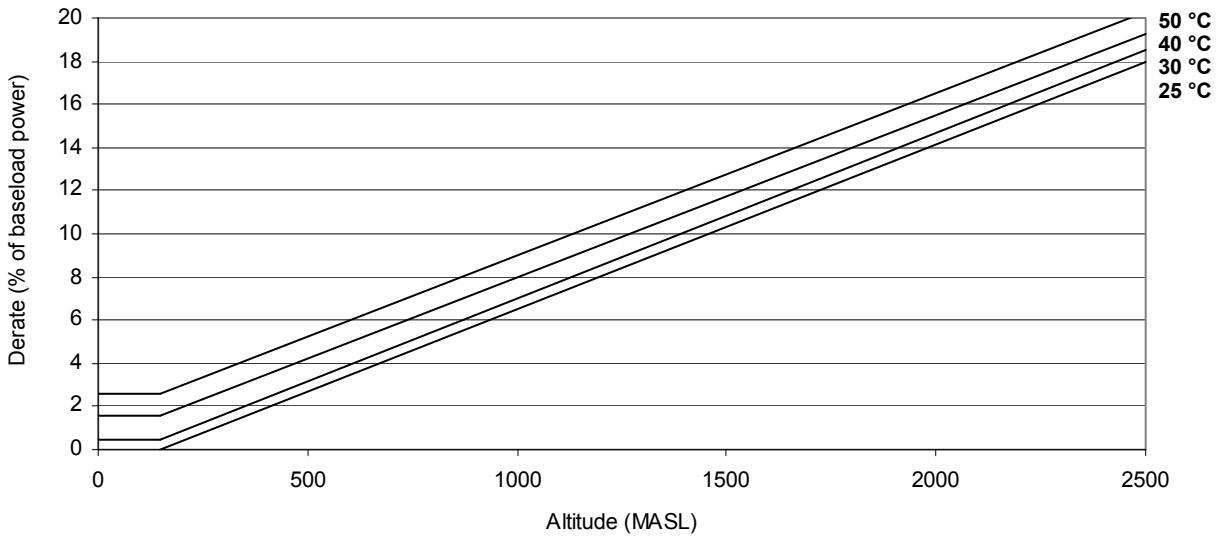
## Derate tables



4006-23TRS2 Raw water / Ambient derate



4006-23TRS2 Altitude / Ambient derate



## Induction system

Maximum air intake restriction of engine:

Clean filter .....	127 mm H <sub>2</sub> O
Dirty filter .....	380 mm H <sub>2</sub> O
Air filter type .....	1 off dry type

## Exhaust emissions data

Ambient temperature of 25 °C

Emissions at continuous baseload rating.

If the engine is to operate in ambient conditions other than test conditions then suitable adjustments may be necessary for any change in inlet air temperature or barometric pressure.

Designation		TRS1	TRS2
		1500 rev/min	
Oxygen (O <sup>2</sup> )	%	8,93	9,00
*Oxides of Nitrogen (NOx)	mg/Nm <sup>3</sup>	477	493
*Hydrocarbons (HC)	mg/Nm <sup>3</sup>	3	3
*Carbon Monoxide (CO)	mg/Nm <sup>3</sup>	735	750

Designation		Cogeneration unit		Electronit	
		TRS1	TRS2	TRS1	TRS2
<b>Mass flow data</b>		1500 rev/min			
Combustion air (25 °C)	kg/h	1742	2087	1769	2108
<b>Volume flow data</b>					
Combustion air (25 °C)	m <sup>3</sup> /h	1501	1793	1572	1813

## Exhaust system

Designation		TRS1	TRS2
Maximum back pressure for total system	Units	1500 rev/min	
	mm H <sub>2</sub> O	400	400

Exhaust outlet flange size .....

For recommended pipe sizes see the Installation Manual.

Designation		Cogeneration unit		Electronit	
		TRS1	TRS2	TRS1	TRS2
<b>Volume flow data (100 kPa)</b>		1500 rev/min			
Exhaust gas (at turbo exit temperature)	m <sup>3</sup> /h	3912	4615	3964	4695

Designation		TRS1	TRS2
<b>Exhaust data</b>		1500 rev/min	
Exhaust temperature	°C	498	485
Oxygen content in exhaust gas	%	8,93	9,00
Lambda	λ	1,69	1,69

## Starting requirements

Temperature range		
Down to 0 °C (32 °F)	Oil:	Refer to Perkins Engines Company Limited
	Starter:	1 x 24 volts
	Battery:	2 x 12V Total Ah 232
	Inrush current to starter:	1000 amps
	Cranking current:	600 amps
	Starter cable size:	70 mm <sup>2</sup>
Maximum length:	6 m	

### Notes:

- Engines **not** equipped with additional A:F ratio control will require immersion heaters to be fitted when ambient temperatures are below 15 °C
- Engines fitted with additional A:F ratio control will start unaided down to 0 °C
- The battery capacity is defined by the 20 hour rate.
- The starting ability of an engine with immersion heater will be improved by about 10 °C and the start aid specification can be modified accordingly. The oil specification should be for the minimum ambient temperature as the oil will not be warmed by the immersion heater.
- Breakaway current is dependant on battery capacity available. Cables should be capable of handling the transient current which may be up to double the steady cranking current.

## Electrical system

Type .....

Insulated return

Starter motor .....

24 volts

Starter motor power .....

7,5 kW

Number of teeth on flywheel.....

190

Number of teeth on starter motor .....

12

Minimum cranking speed .....

120 rev/min

Pull in current of starter motor solenoid.....

26,8 amps at 24 volts

Hold in current of starter motor solenoid .....

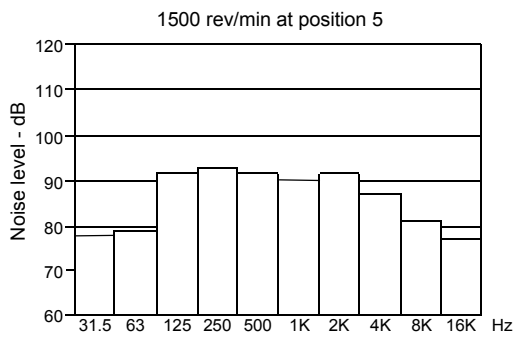
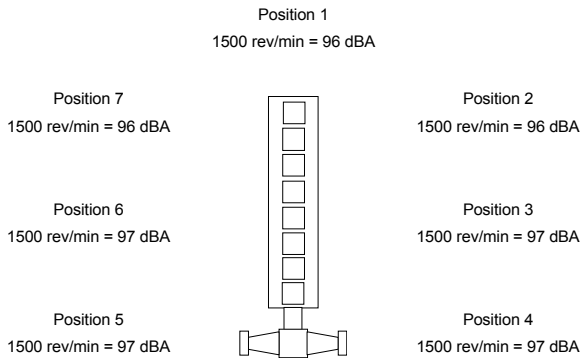
9 amps at 24 volts

### Ignition system

Primary system ..... Altronic Disn 800  
 Primary voltage ..... 24 volts  
 Polarity ..... Negative earth  
 Spark plug gap ..... 0,25 mm  
 Ignition timing ..... 28° BTDC

### Noise levels

The figures for total noise levels are typical for an engine running at the continuous baseload power rating in a semi-reverberant environment and measured at a distance of one metre from the periphery of the engine (sound pressure level re:  $-20 \times 10^{-6}$  pa).  
 Speed ..... 1500 rev/min  
 Ambient noise level ..... 70 dBA



### Engine mounting

Maximum additional load applied to flywheel due to all rotating components ..... 650 kg

The information given on this Technical Data Sheet are for guidance only.

For ratings other than those shown, please contact Perkins Engines Company Limited.



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