

# Technical Data

## 4000 Series

# 4016-61TRS1

# 4016-61TRS2

### Gas Engine

### 1500 rev/min

#### Basic technical data

Number of cylinders .. 16  
 Cylinder arrangement ... 60° Vee  
 Cycle ... 4 stroke  
 Induction system ... turbocharged, air to water charge cooled  
 Combustion system ... spark ignition  
 Compression ratio ... 12:1  
 Bore ... 160 mm  
 Stroke ... 190 mm  
 Cubic capacity ... 61.123 litres  
 Direction of rotation ... anti-clockwise viewed on flywheel  
 Firing order ... 1A, 1B, 3A, 3B, 7A, 7B, 5A, 5B,  
 ... 8A, 8B, 6A, 6B, 2A, 2B, 4A, 4B  
 Cylinder 1 ... furthest from flywheel

#### Ratings

This is defined in ISO3046/1, BS5514 and DIN 6271  
 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 ... 26° BTDC  
 Inlet manifold mixture temperature ... 45 °C  
 Cooling water exit temperature ... < 96°C  
 Exhaust emission ... according to TA-Luft (NOx)

#### Fuel data

Lower calorific value ... 34710 kJ/Sm<sup>3</sup>  
 Density ... 0,76 kg/Sm<sup>3</sup>  
 Stoich air requirement ... 16 kg/kg  
 Minimum methane number before derate ... 75

#### Overall weight (all engines) and dimensions

| Model                    | Height mm | Length mm | Width mm | Weight (dry) kg | Weight (wet) kg |
|--------------------------|-----------|-----------|----------|-----------------|-----------------|
| <b>Cogeneration unit</b> |           |           |          |                 |                 |
| Bio gas                  | 1979      | 2949      | 1660     | 5820            | 6158            |
| Natural gas              | 1969      | 2949      | 1737     | 5820            | 6158            |
| <b>Electro unit</b>      |           |           |          |                 |                 |
| Natural gas              | 1969      | 3192      | 1737     | 5820            | 6158            |

#### Performance

Steady state speed stability at constant load ... ± 0,75%  
**Note:** All data based on operation to ISO 3046/1, BS 5514 and DIN 6271 standard reference conditions.

Governing type ... Digital speed governor

#### Centre of Gravity (all engines)

Forward of rear face of cylinder block ... tba  
 Above crankshaft centre line ... tba

#### Test conditions

-air temperature ... 25 °C  
 -barometric pressure ... 100 kPa  
 -relative humidity ... 30%

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

-engine ... 8,65 kgm<sup>2</sup>  
 -flywheel ... 9,57 kgm<sup>2</sup>  
 Cyclic irregularity for engine/flywheel ... 1:312

#### General installation

| Designation   | Units               | Continuous baseload rating |      |              |      |
|---|---------------------|----------------------------|------|--------------|------|
|   |                     | Cogeneration unit          |      | Electro unit |      |
|   |                     | TRS1                       | TRS2 | TRS1         | TRS2 |
| Gross engine power  | kW                  | 912                        | 1042 | 912          | 1042 |
| Brake mean effective pressure   | kPa                 | 1193                       | 1364 | 1193         | 1364 |
| Combustion air flow   | m <sup>3</sup> /min | 68,3                       | 78,8 | 69,1         | 79,7 |
| Exhaust gas temperature (max) before turbo                              | °C                  | 594                        | 600  | 594          | 600  |
| Exhaust gas temperature (max) after turbo                               | °C                  | 482                        | 468  | 482          | 468  |
| Exhaust gas flow (max)  | m <sup>3</sup> /min | 178                        | 205  | 180          | 207  |
| Exhaust gas mass flow   | kg/s                | 1,4                        | 1,6  | 1,4          | 1,6  |
| Boost pressure ratio  | -                   | 2,5                        | 2,8  | 2,5          | 2,8  |
| Overall electrical efficiency   | %                   | 38,4                       | 38,6 | 37,6         | 37,8 |
| Charge coolant flow   | l/sec               | 350                        |      |              |      |
| Nominal excess air factor (Lambda)                                      | λ                   | 1,7                        |      |              |      |
| Typical gross Genset 25 °C (100 kPa)<br>Electrical output (unity 1.0pf) | kWe                 | 875                        | 1000 | 875          | 1000 |
| Assumed alternator efficiency   | %                   | 96                         |      |              |      |

**Baseload rating:** Unlimited hours usage with an average load factor of 100% of the published baseload power rating.

## Energy balance

### 4016-61TRS1&2- Cogeneration unit

| Designation                              | Units | Continuous Baseload rating |      |       |      |
|--|-------|----------------------------|------|-------|------|
|  |       | TRS1                       |      | TRS2  |      |
|  |       | Value                      | %    | Value | %    |
| Energy in fuel                           | kWt   | 2288                       | 100  | 2584  | 100  |
| Energy in power output (Net)             | kWb   | 912                        | 39,8 | 1042  | 40,3 |
| Energy in exhaust (25°C)                 | kWt   | 661                        | 28,9 | 803   | 31,1 |
| Energy to exhaust (120°C)                | kWt   | 539                        | 23,6 | 646   | 25,0 |
| Energy to coolant and oil                | kWt   | 487                        | 21,3 | 445   | 17,2 |
| Energy to charge cooler                  | kWt   | 134                        | 5,9  | 180   | 7,0  |
| Energy to radiation (exhaust temp. 25°C) | kWt   | 95                         | 4,1  | 114   | 4,4  |

### 4016-61TRS1&2 - ElectroUnit

| Designation                              | Units | Continuous Baseload rating |      |       |      |
|--|-------|----------------------------|------|-------|------|
|  |       | TRS1                       |      | TRS2  |      |
|  |       | Value                      | %    | Value | %    |
| Energy in fuel                           | kWt   | 2334                       | 100  | 2630  | 100  |
| Energy in power output (Net)             | kWb   | 912                        | 39,1 | 1042  | 39,6 |
| Energy in exhaust (25°C)                 | kWt   | 661                        | 28,3 | 803   | 30,5 |
| Energy to exhaust (120°C)                | kWt   | 539                        | 23,1 | 646   | 24,6 |
| Energy to coolant and oil                | kWt   | 501                        | 21,5 | 459   | 17,5 |
| Energy to charge cooler                  | kWt   | 148                        | 6,4  | 194   | 7,4  |
| Energy to radiation (exhaust temp. 25°C) | kWt   | 113                        | 4,8  | 132   | 5,0  |

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) ... 95 litres Maximum jacket water pressure in crankcase ... 100 kPa (plus static pressure head)

### Jacket cooling water data

Total coolant flow ... 950 l/min  
Coolant exit temperature (max) ... 96 °C  
Coolant entry temperature (max) ... 81 °C

### Charge cooling water data

Coolant flow ... 600 l/min  
Coolant entry temperature ... 36 °C  
Coolant exit temperature ... 40 °C  
Charge cooler ... fin and tube on engine x2  
Shutdown switch setting ... 193 kPa falling  
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 capacity ... 286 litres  
Sump maximum ... 257 litres  
Sump minimum ... 147 litres

### Lubricating oil temperature

Oil temperature in rail (continuous operation) ... 88 °C  
Lubricating oil pressure at rated speed ... 470 kPa  
Lubricating oil flow at 1500 rev/min ... 402 l/min  
Sump drain plug tapping size ... GA1  
Oil pump ... gear driven  
Shutdown switch setting ... 193 kPa falling  
Oil filter screen spacing ... 20 microns  
Oil consumption after running in ... 0,25 g/kWhr

### Normal operating angles:

-front and rear ... 5°  
-side tilt ... 10°

## Ignition system

Type ... electronic ignition system  
Primary voltage ... 24V  
Polarity ... Negative earth  
Spark plug type ... Pre-chamber

## Fuel system

Recommended fuel: Natural Gas LHV at 34 MJ/m<sup>3</sup> (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 you must obtain a full gas analysis including details of any solid or liquid components. Refer results 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).

Minimum gas supply pressure ... 5 kPa  
Maximum gas supply pressure ... 25 kPa  
Fuel system type ... Electronic AFR control system  
Installation of gas supply and shut off valves to be in accordance with local regulations.

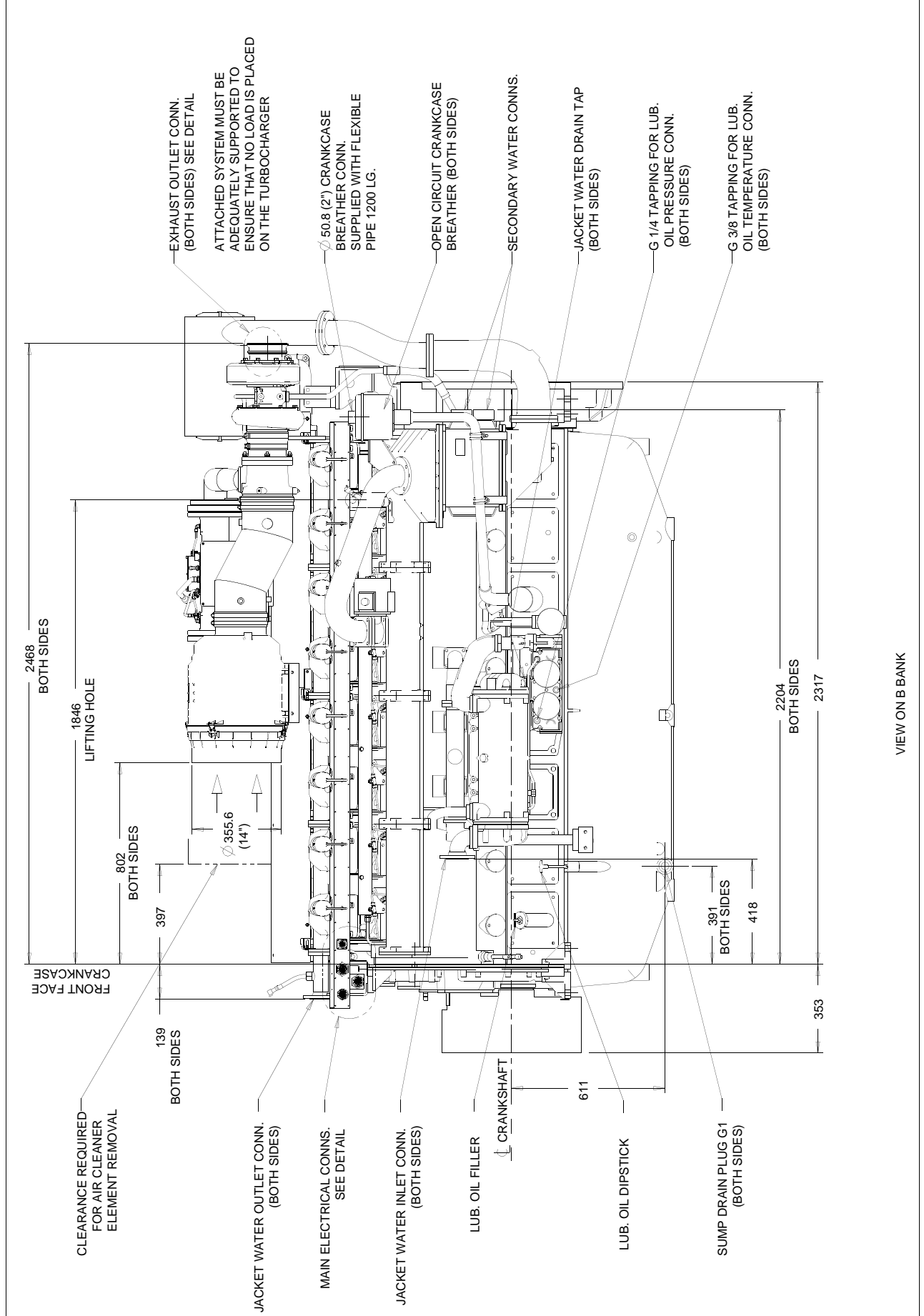
| Designation                        | Cogeneration unit |                  | ElectroUnit      |                  |
|------------------------------------|-------------------|------------------|------------------|------------------|
|                                    | TRS1              | TRS2             | TRS1             | TRS2             |
| <b>Fuel consumption gross</b>      | <b>kJ / kWts</b>  | <b>kJ / kWts</b> | <b>kJ / kWts</b> | <b>kJ / kWts</b> |
| 100% Continuous baseload rating    | 2,51              | 2,48             | 2,56             | 2,53             |
| 75% of Continuous base load rating | 2,60              | 2,58             | 2,63             | 2,60             |
| 50% of Continuous baseload rating  | 2,68              | 2,66             | 2,70             | 2,68             |
| 25% of Continuous base rating      | 2,75              | 2,74             | 2,77             | 2,76             |

Fuel: Natural Gas - LHV = 34,71 MJ/m<sup>3</sup>

Tolerance on Fuel consumption

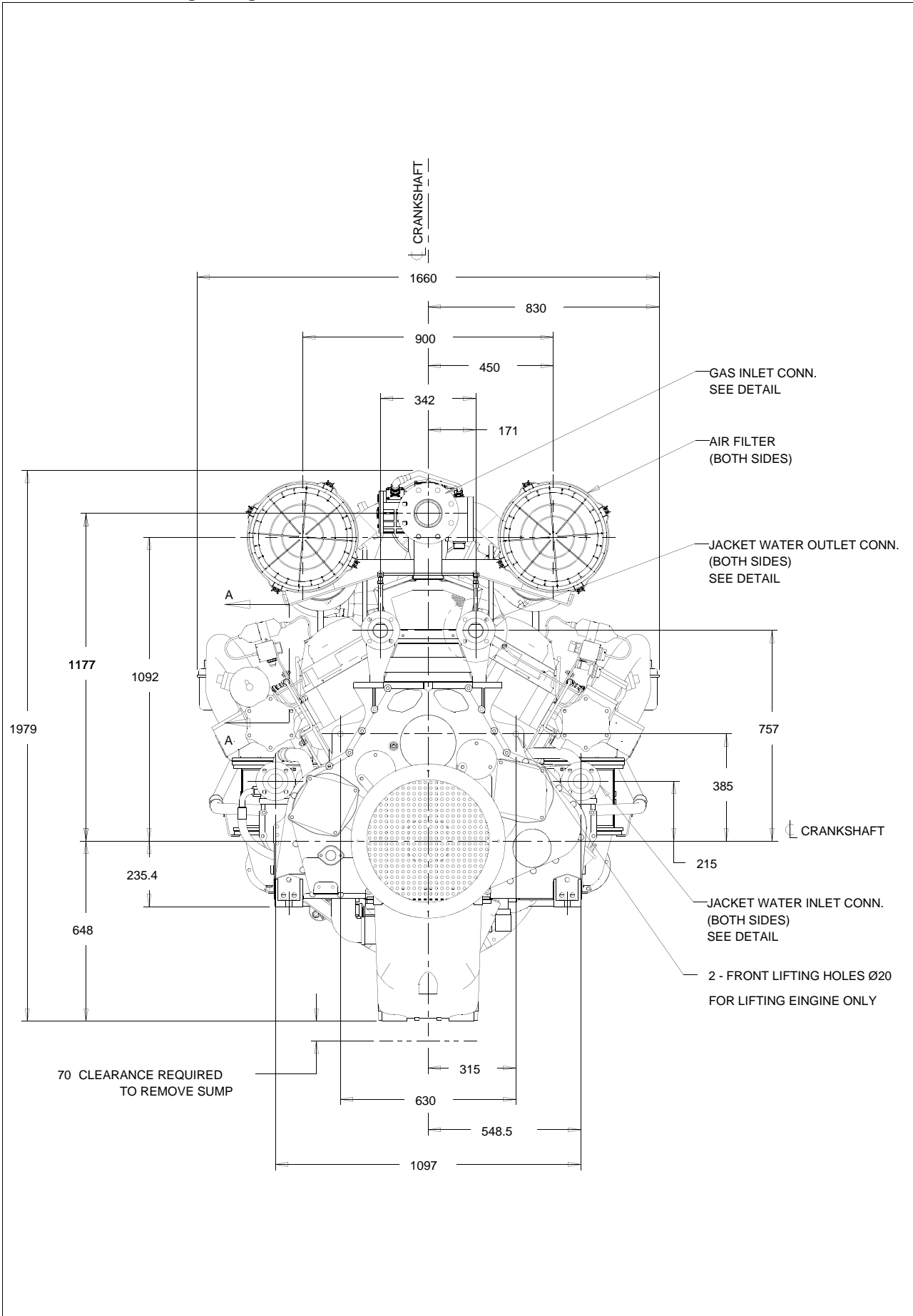
| Designation             |                    | Cogeneration unit |      | ElectroUnit |      |
|-------------------------|--------------------|-------------------|------|-------------|------|
| Mass flow data          | Units              | TRS1              | TRS2 | TRS1        | TRS2 |
| Fuel                    | Kg/h               | 180               | 203  | 183         | 207  |
| <b>Volume flow data</b> |                    |                   |      |             |      |
| Fuel (15 °C)            | m <sup>3</sup> /hr | 237               | 268  | 241         | 273  |

4016-61TRS1&2 Bio gas cogeneration unit - Left view

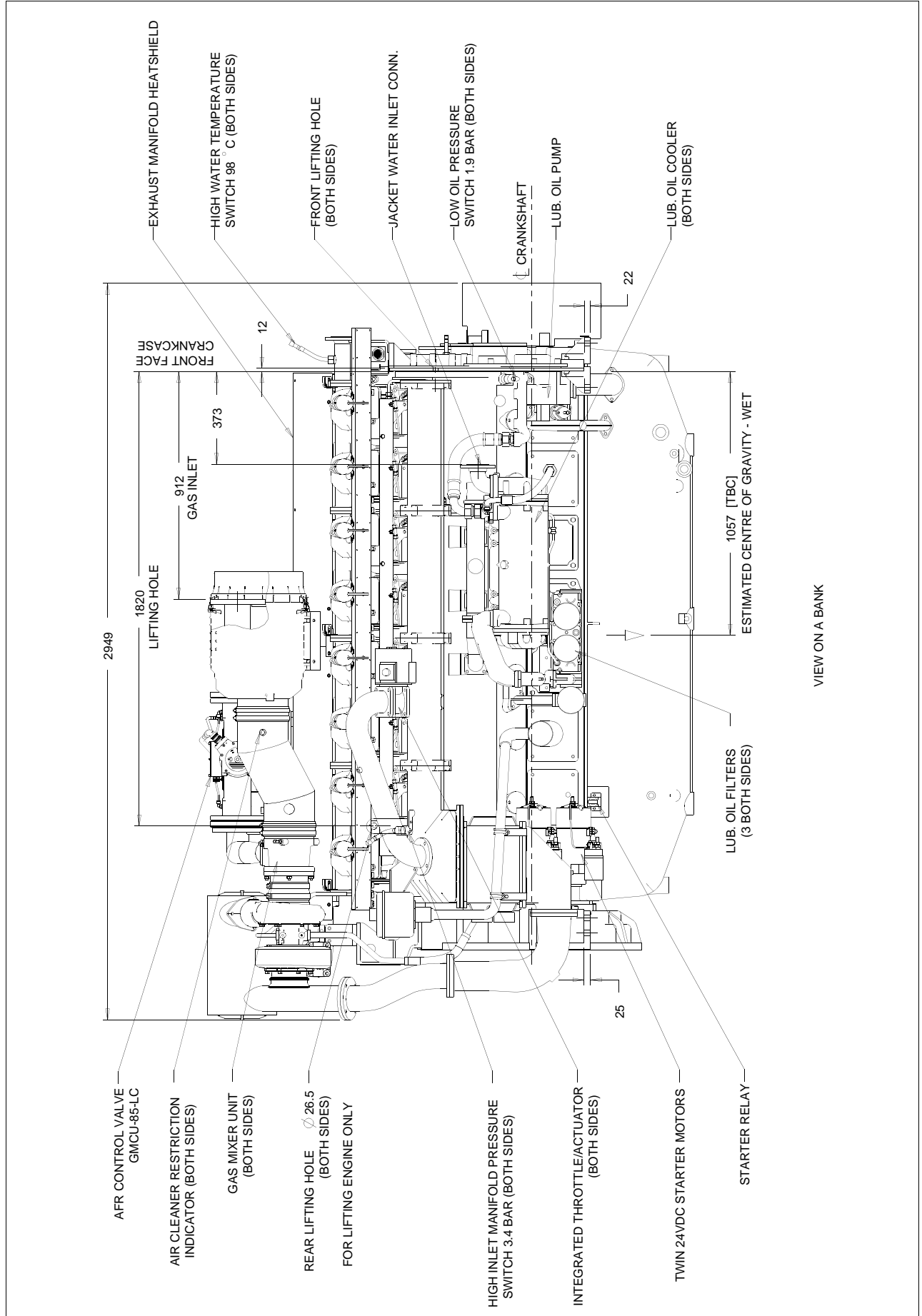


VIEW ON B BANK

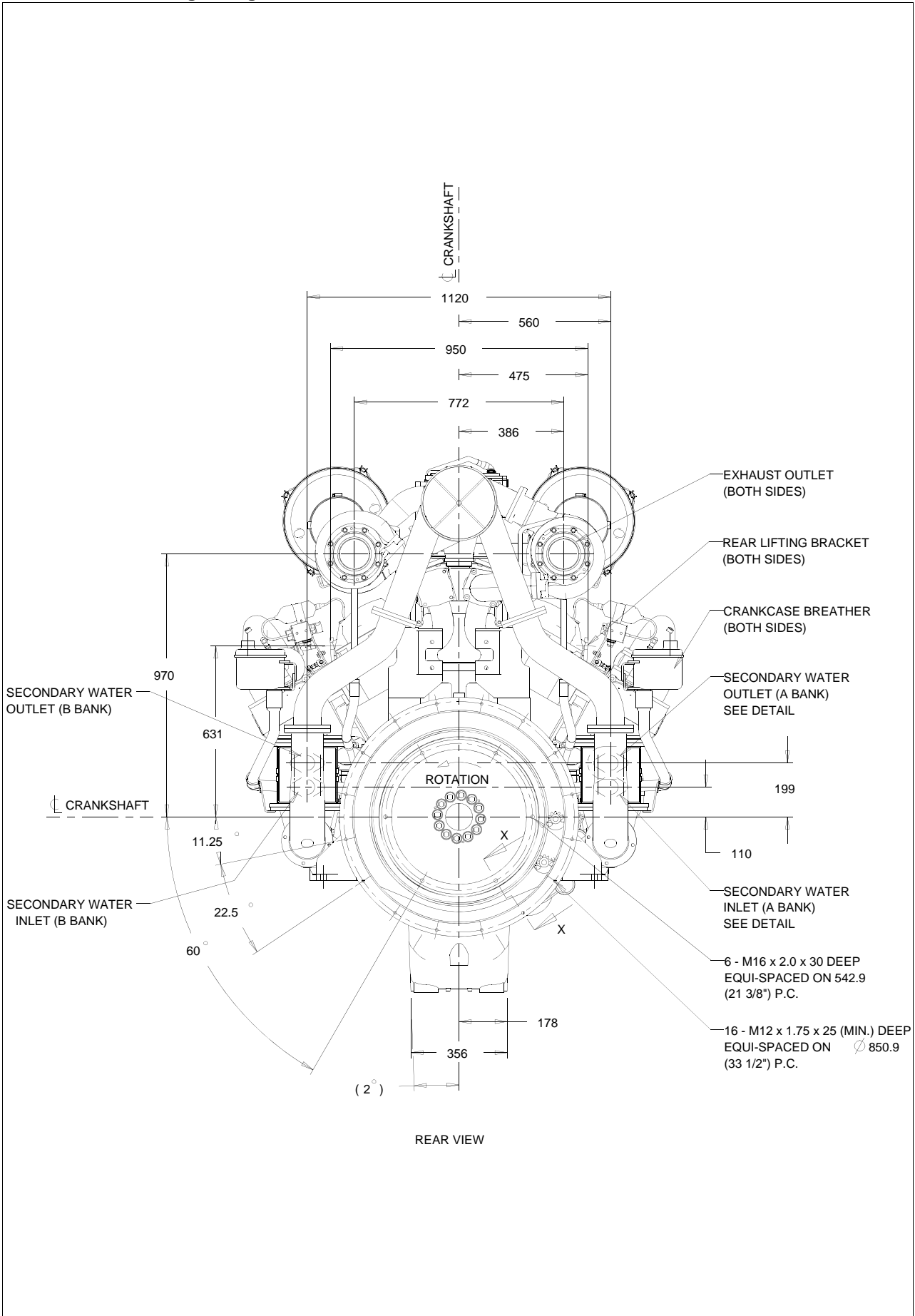
**4016-61TRS1&2 Bio gas cogeneration unit - Front view**



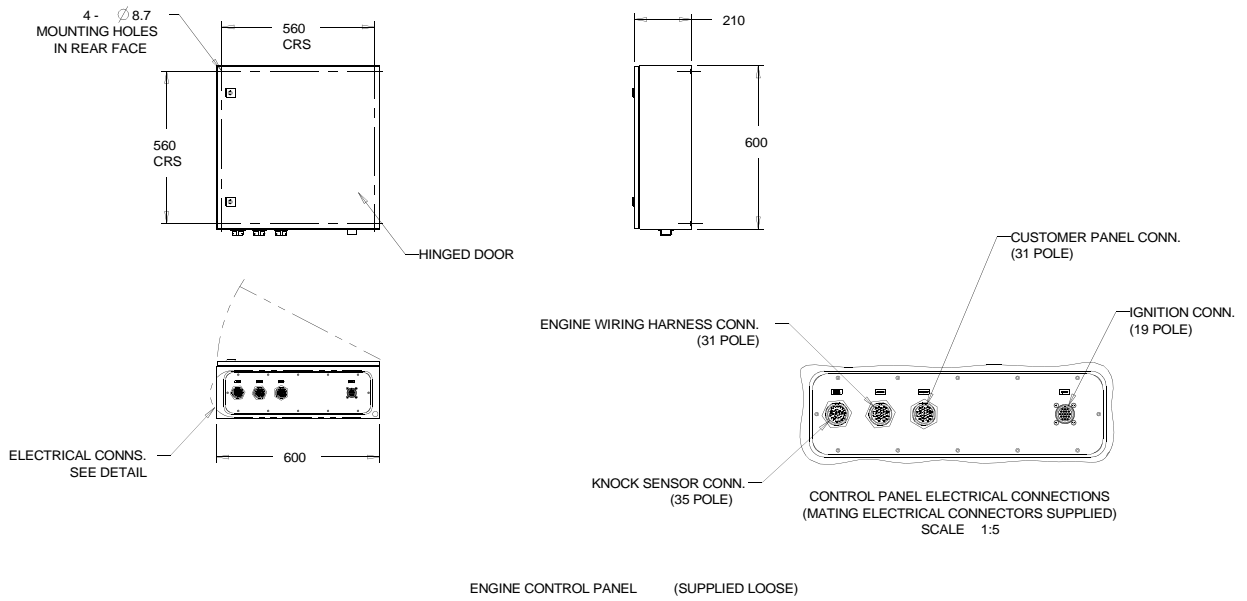
4016-61TRS1&2 Bio gas cogeneration unit - Right view



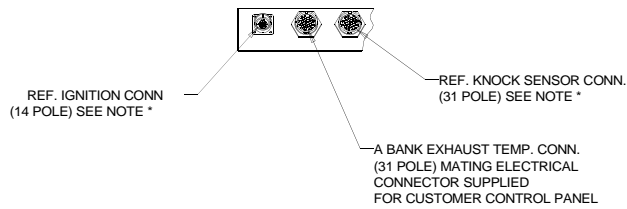
**4016-61TRS1&2 Bio gas cogeneration unit - Rear view**



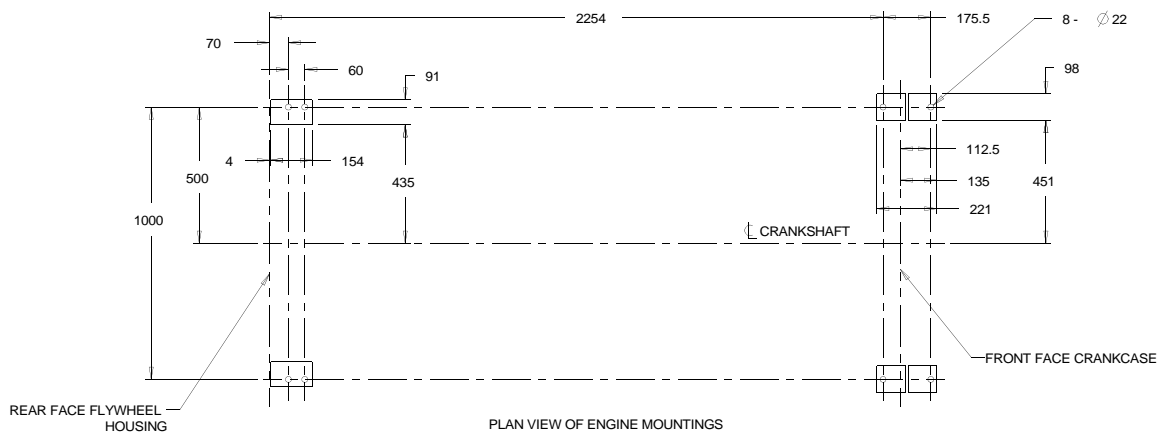
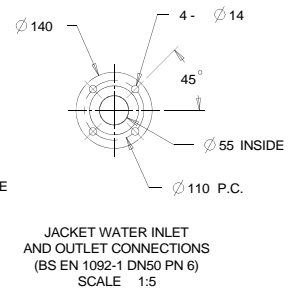
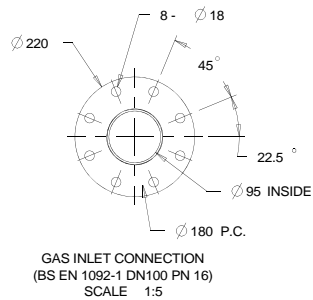
# 4016-61TRS1&2 Bio gas cogeneration unit - Electrical connections, Exhaust Outlet and Support Pads



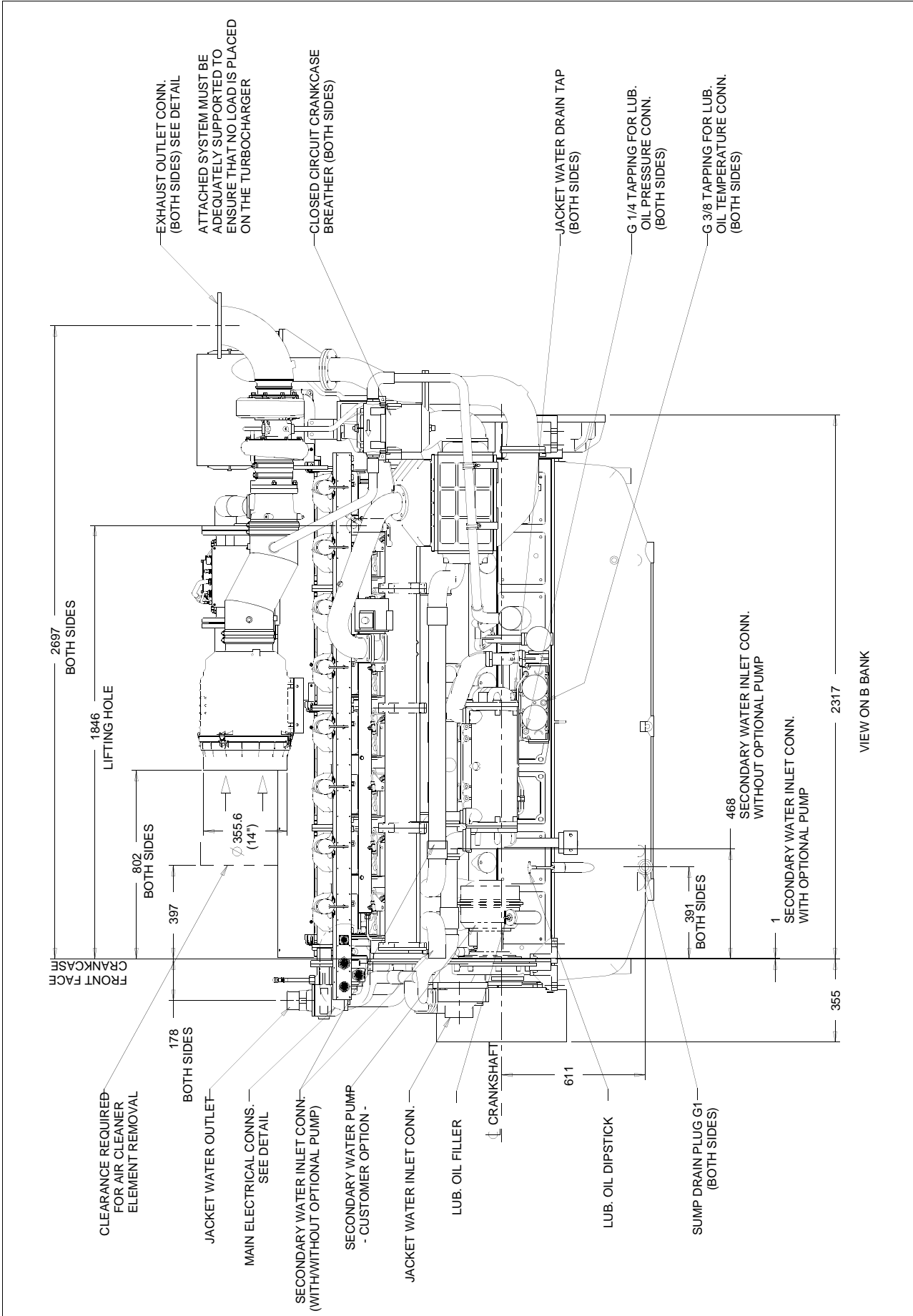
NOTE \*  
IGNITION AND KNOCK SENSOR CONNECTIONS ARE FOR INTEGRATED HARNESS (SUPPLIED FITTED) FROM B BANK WIRING RAIL



VIEW A-A  
SHOWING ELECTRICAL CONNECTIONS ON A BANK WIRING RAIL  
SCALE 1:5

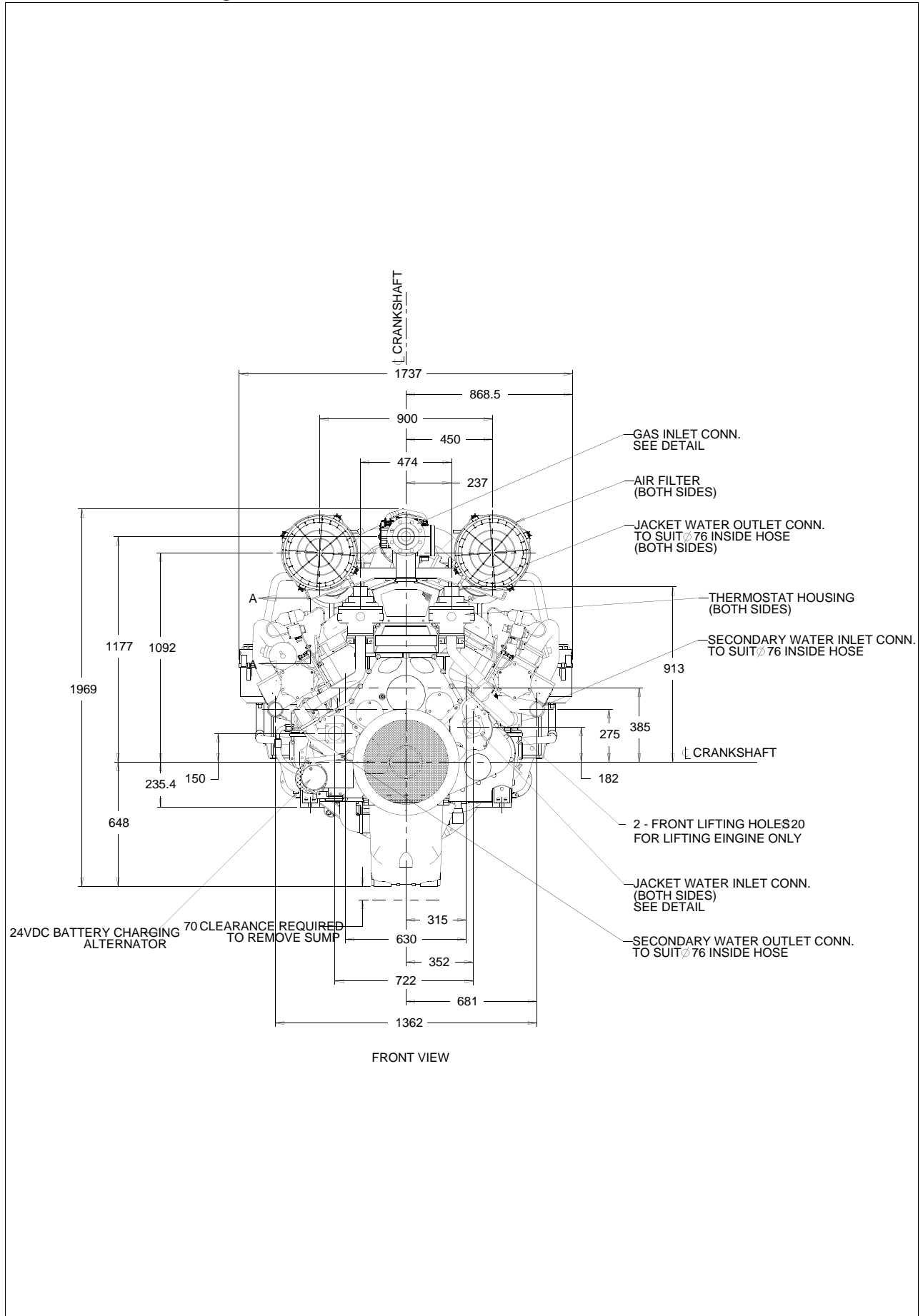


4016-61TRS1&2 Natural gas electro unit - Left view

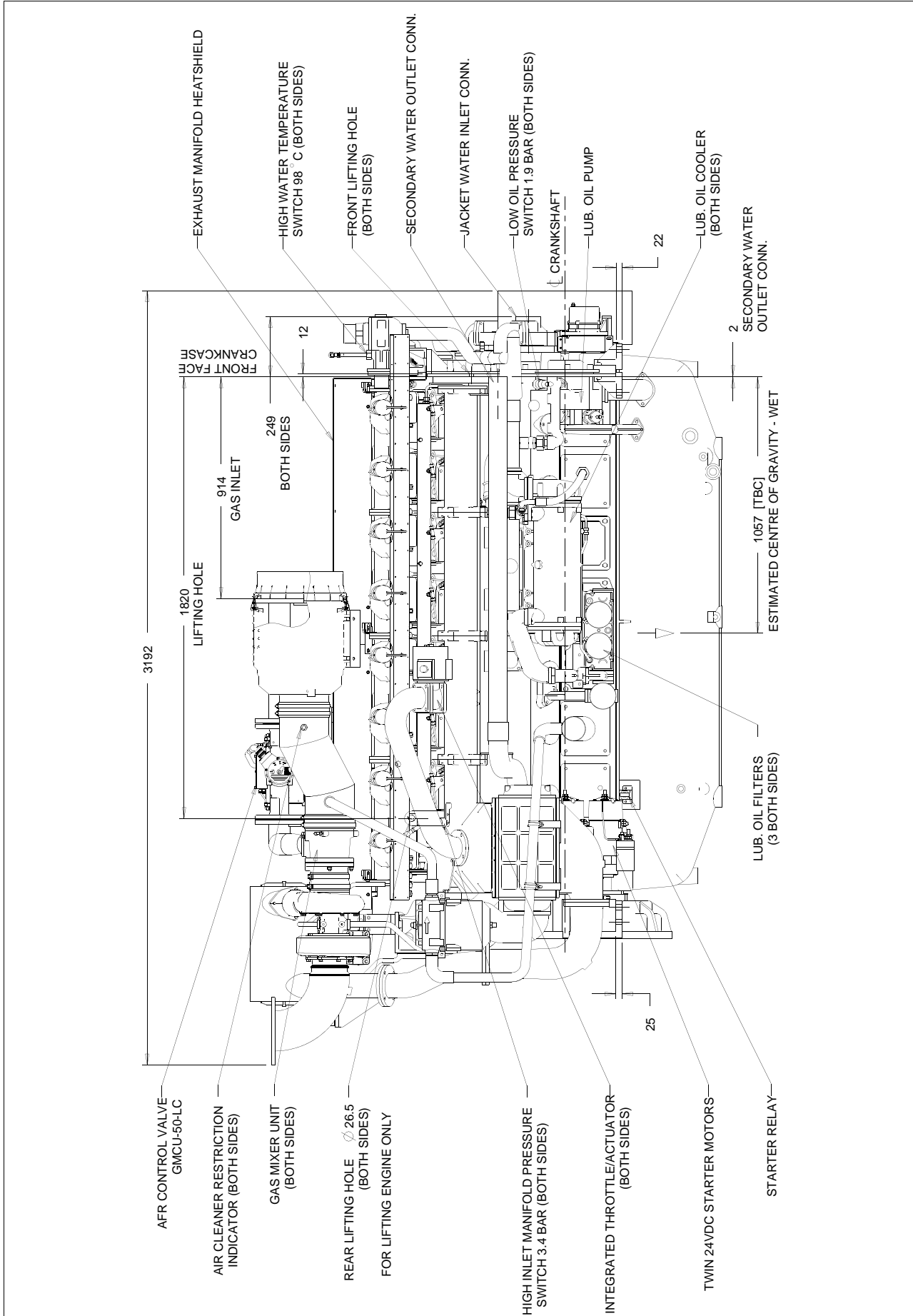




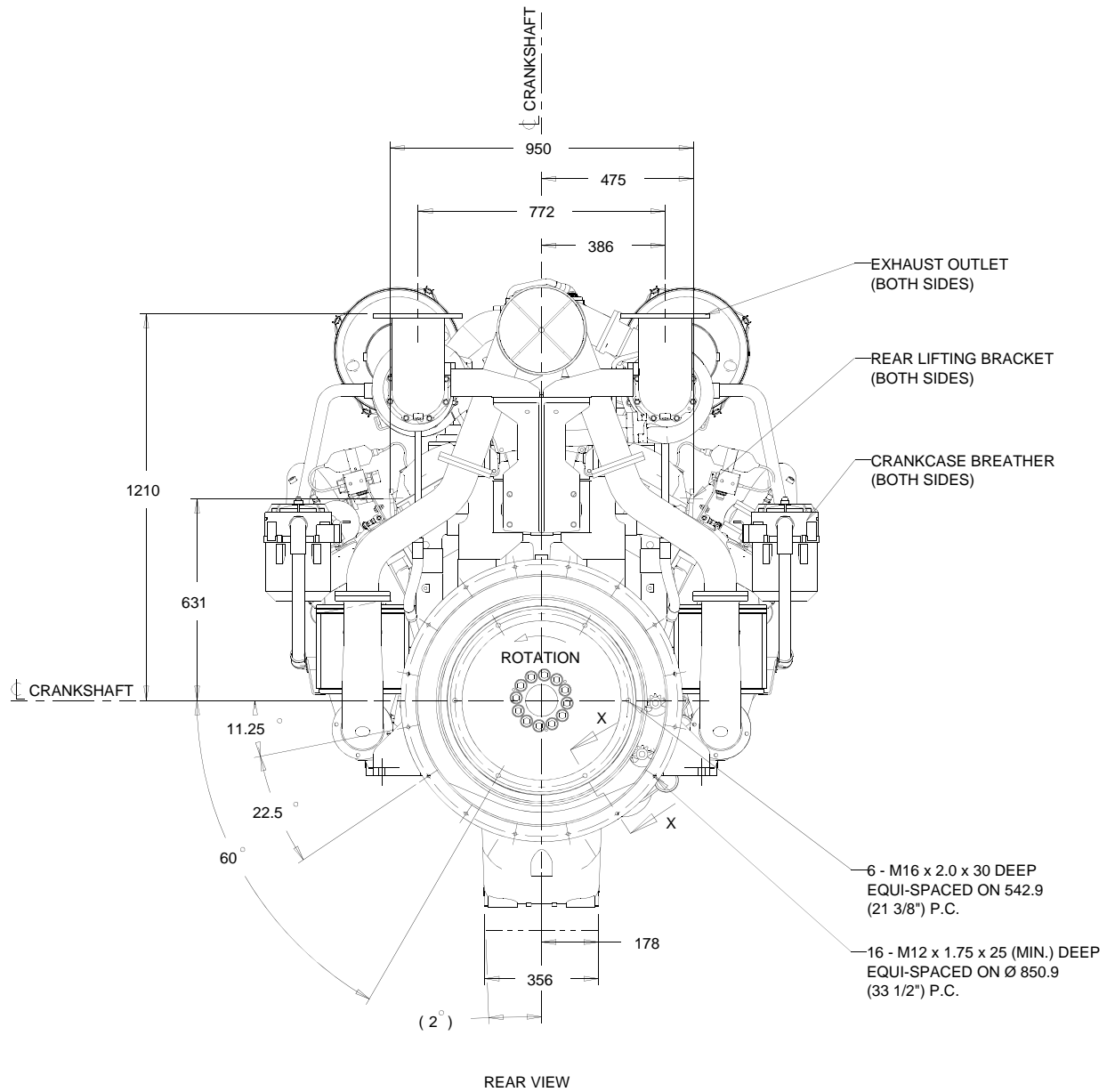
**4016-61TRS1&2 Natural gas electro unit - Front view**



4016-61TRS1&2 Natural gas electro unit - Right view

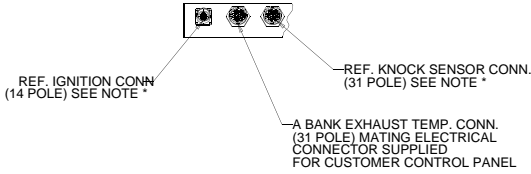


4016-61TRS1&2 Natural gas electro unit - Rear view

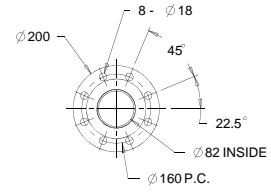


# 4016-61TRS1&2 Natural gas electro unit - SAE Flywheel, Exhaust Outlet and Support Pads

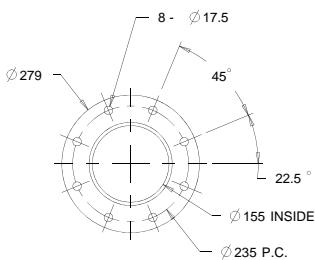
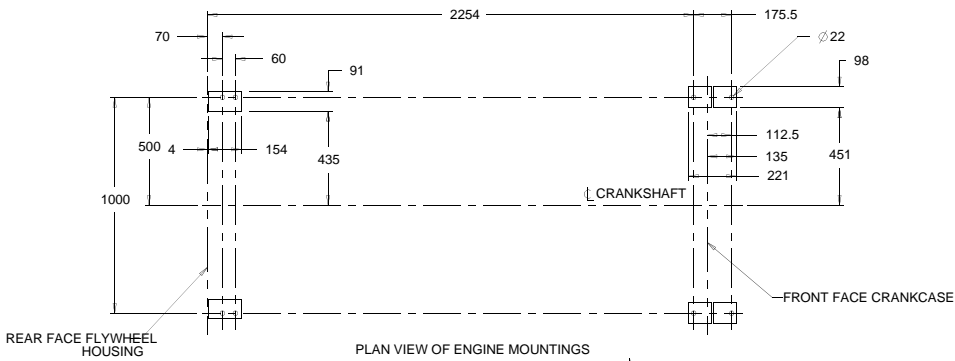
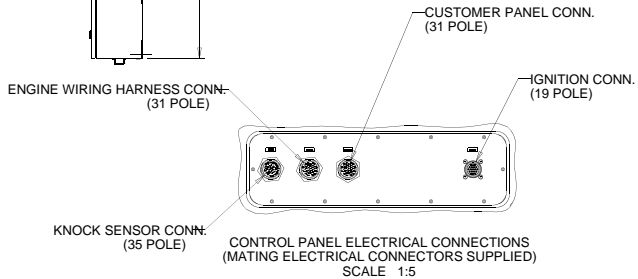
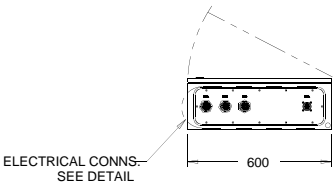
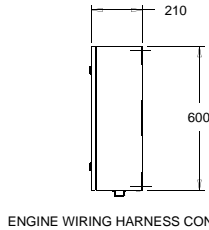
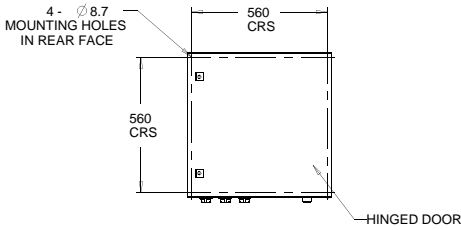
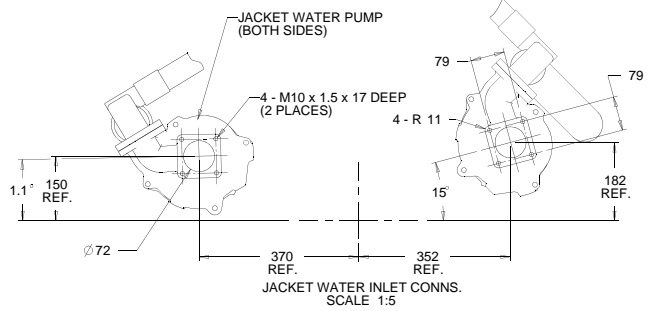
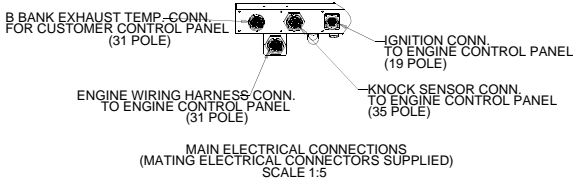
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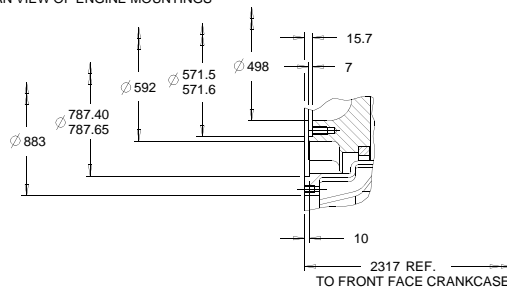
SECTION A-A  
SCALE 1:5



GAS INLET CONNECTION  
(BS EN 1092-1 DN80 PN 16)  
SCALE 1:5

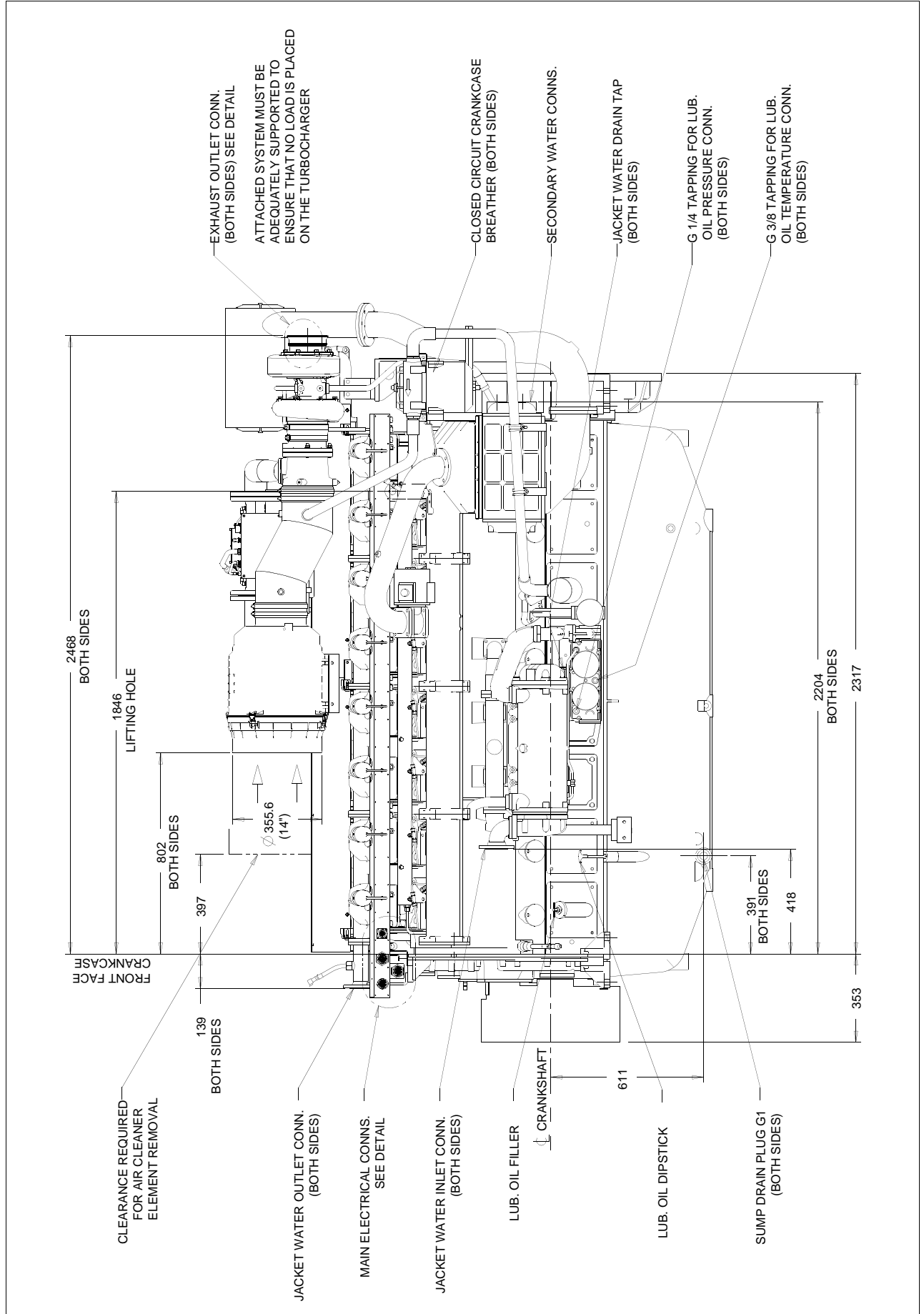


EXHAUST OUTLET CONNECTION  
(6" BS 10 TABLE D)  
SCALE 1:5

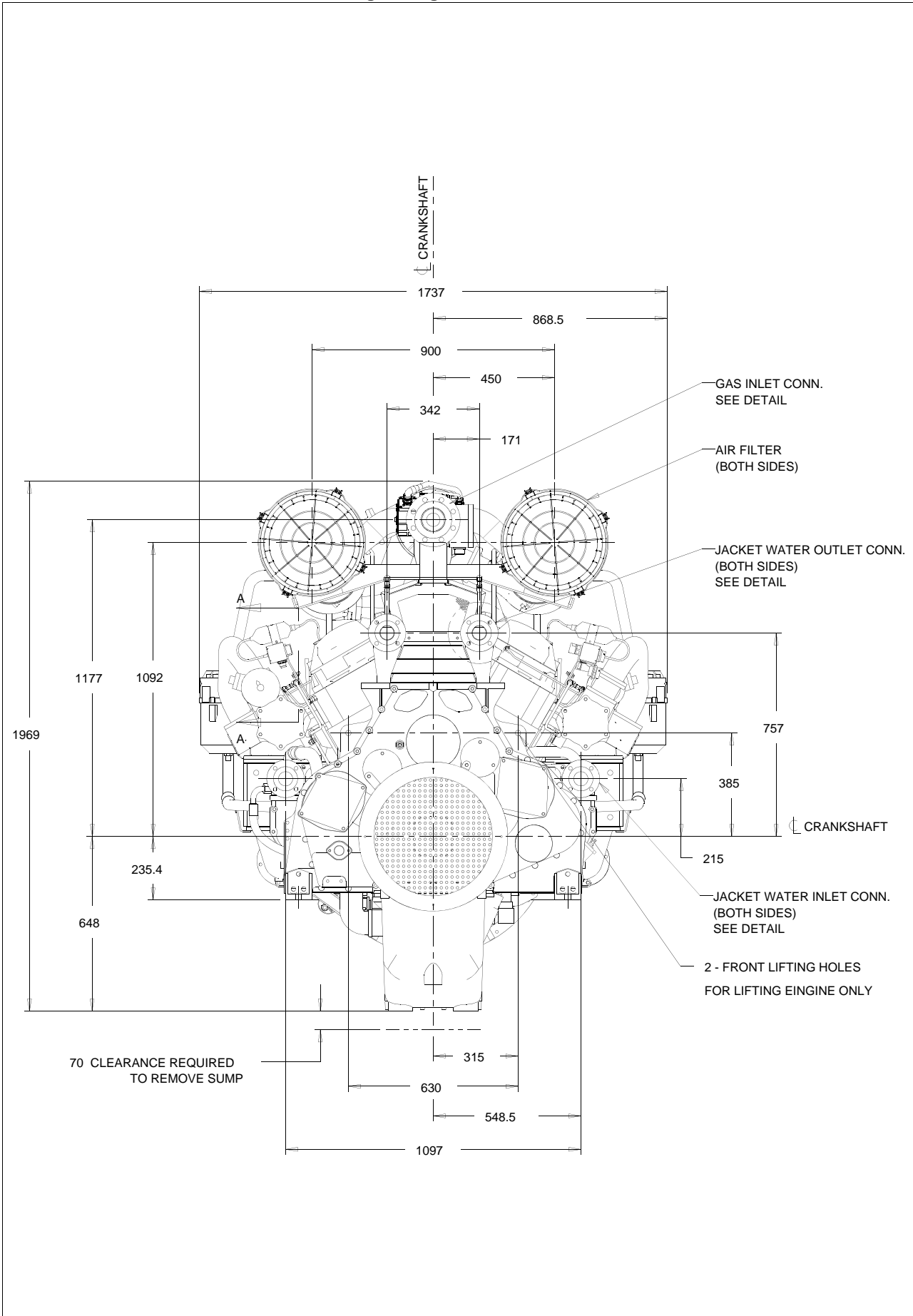


SECTION X-X  
SAE J620 SIZE 18 FLYWHEEL  
SAE J617 No. 00 FLYWHEEL HOUSING  
METRIC TAPPINGS  
SCALE 1:5

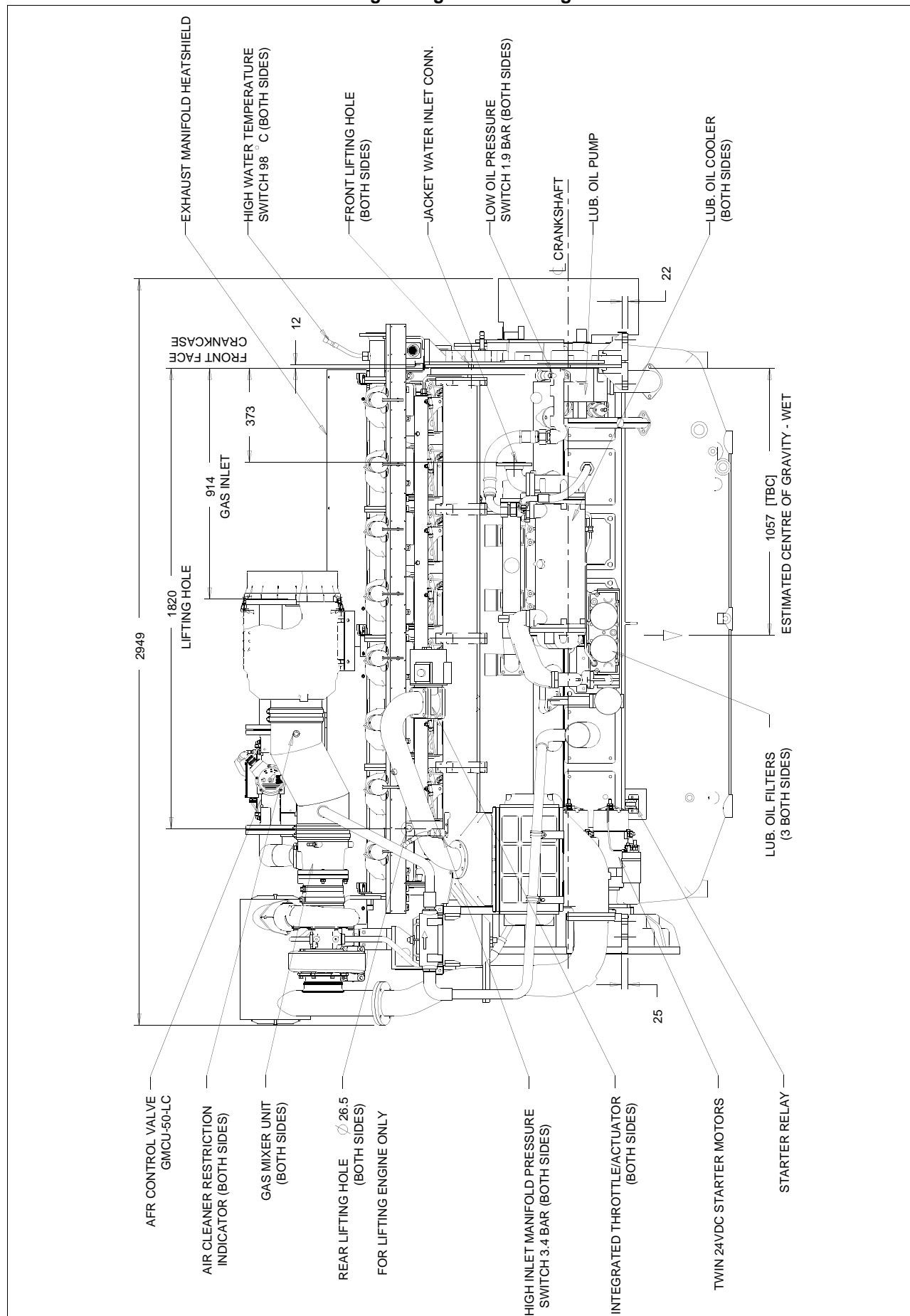
4016-61TRS1&2 Natural gas co-generation unit - Left view



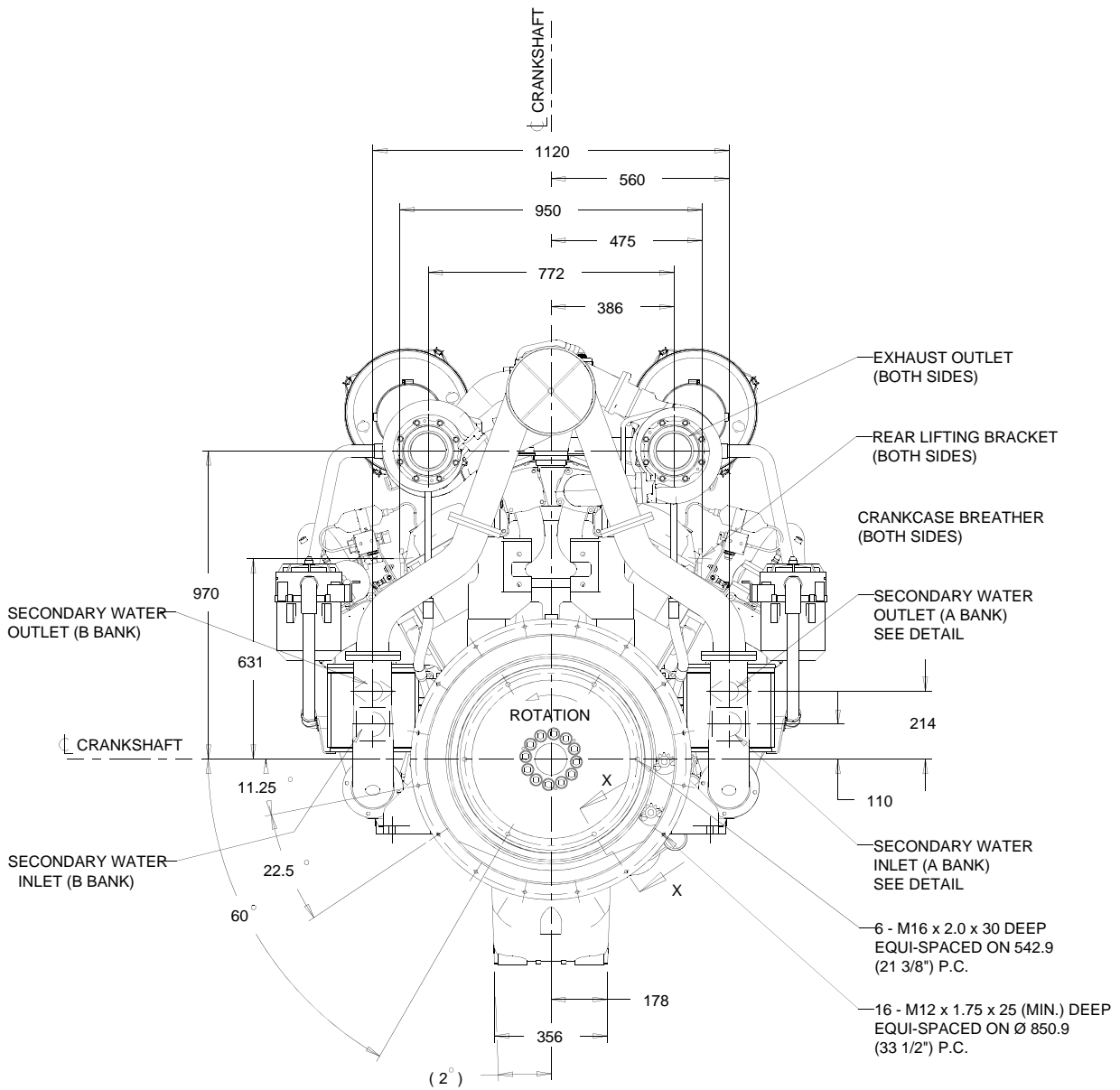
4016-61TRS1&2 4016-61TRS1&2 Natural gas co-generation - Front view



4016-61TRS1&2 4016-61TRS1&2 Natural gas co-generation - Right view

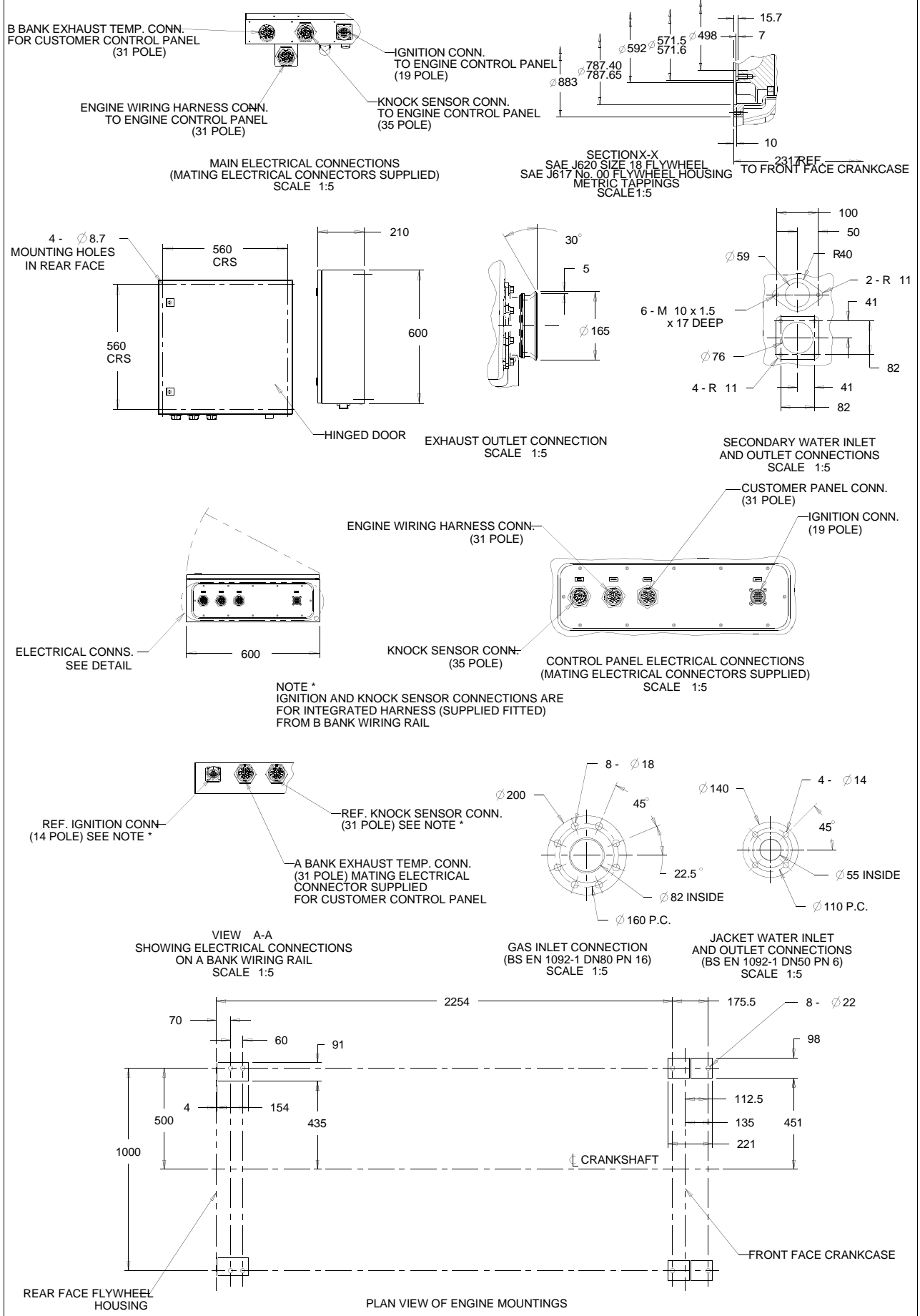


4016-61TRS1&2 Natural gas co-generation - Rear view





# 4016-61TRS1&2 Natural gas co-generation - SAE Flywheel, Exhaust Outlet and Support Pads



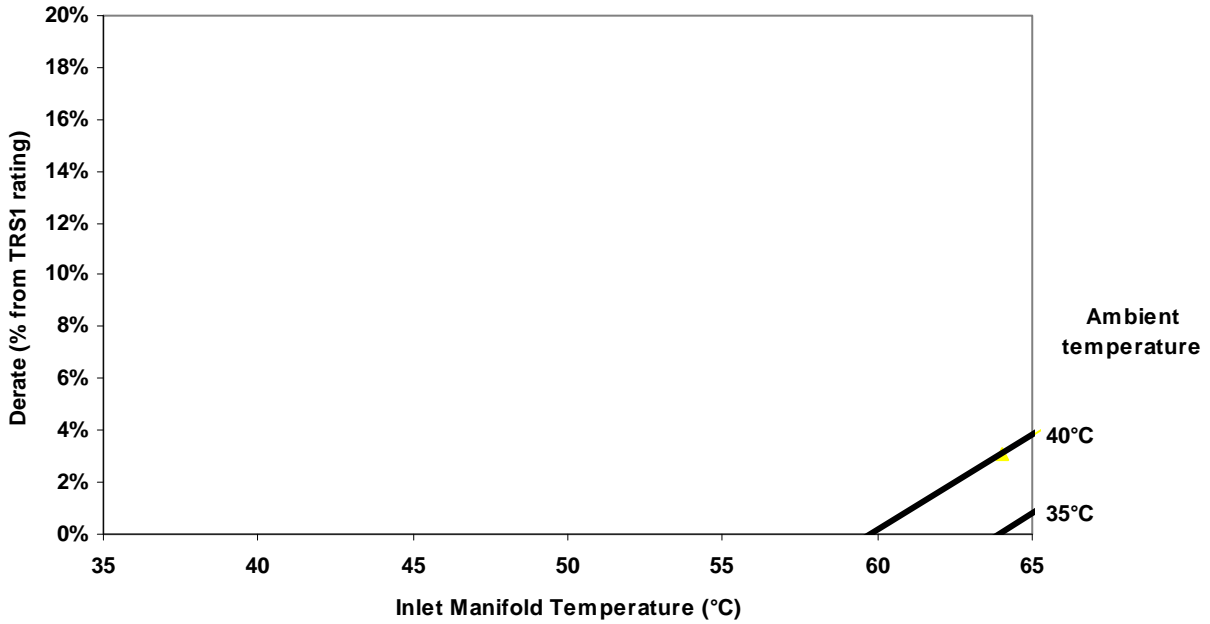
## Derate tables

**Note:** Standard conditions for the following derate charts are:

50 °C inlet manifold temperature; 120 m altitude; TA Luft NOx emissions (500 Nm<sup>2</sup>)

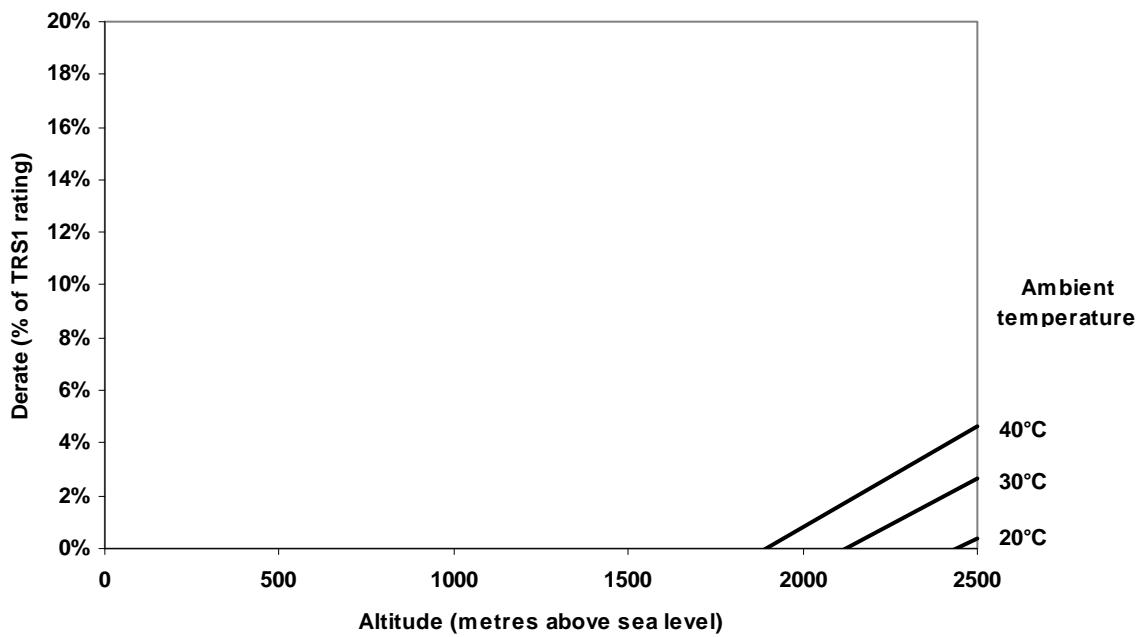
### Ambient/inlet manifold temperature, TRS1

Ambient and Inlet Manifold Temperature Derate - 4016-61TRS1



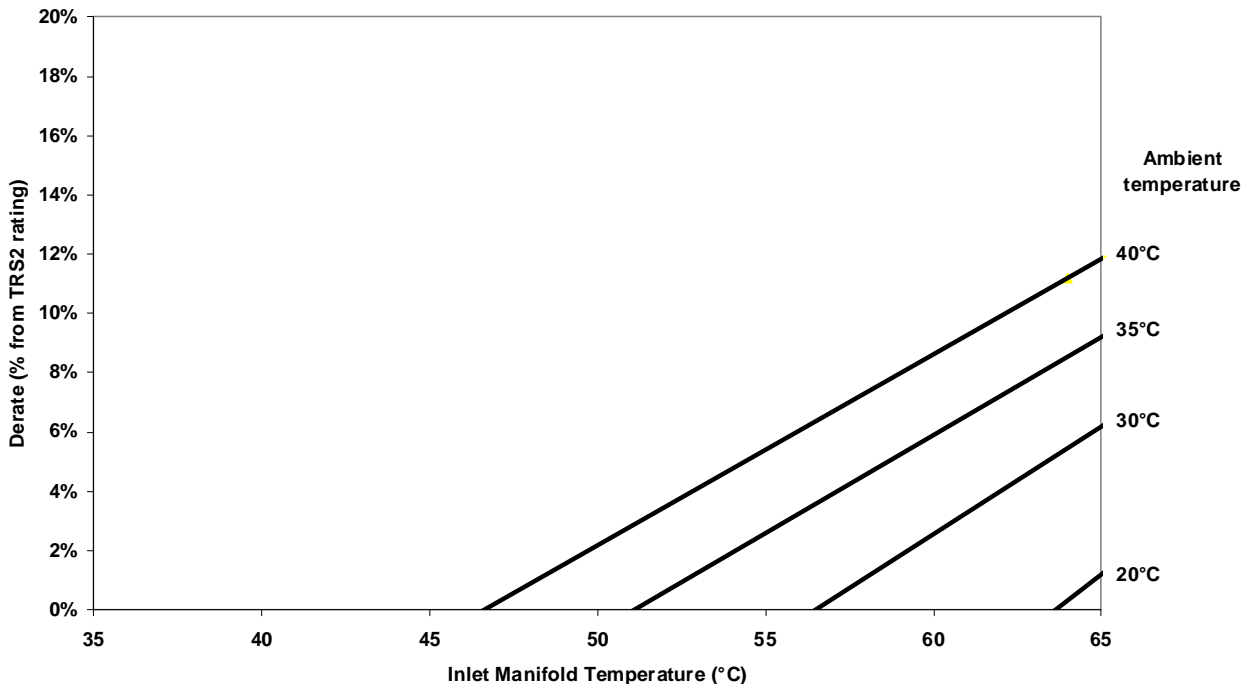
### Ambient / Altitude, TRS1

Ambient and Altitude Derate - 4016-61TRS1



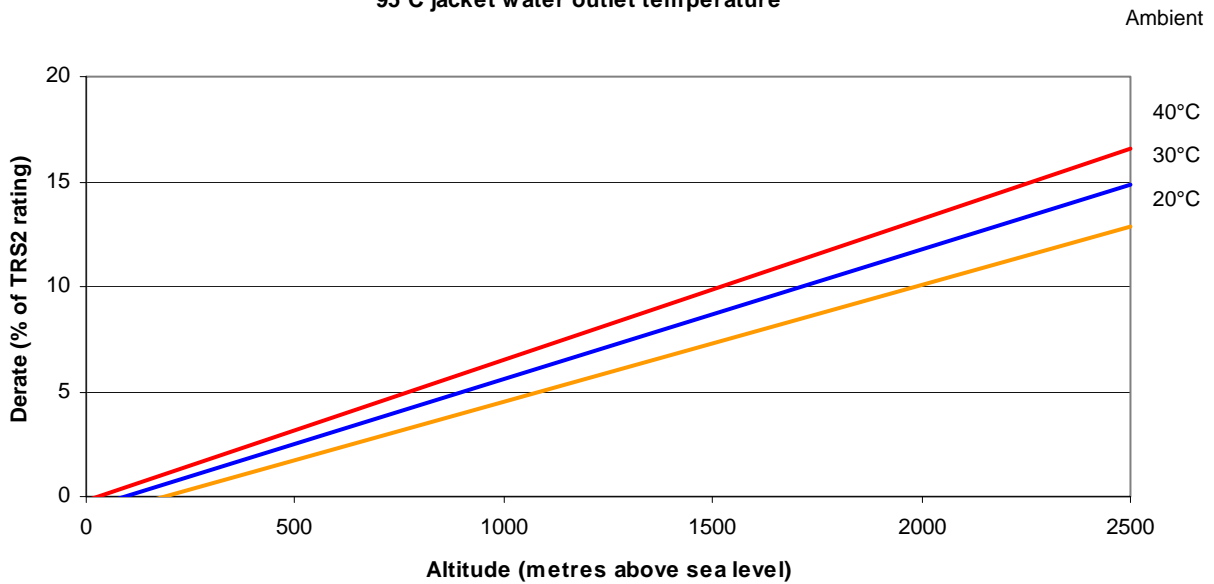
### Ambient / Inlet manifold temperature, TRS2

Ambient and Inlet Manifold Temperature Derate - 4016-61TRS2



### Ambient/altitude, TRS2

Derate Chart - Ambient and Altitude  
 45°C inlet manifold temperature  
 95°C jacket water outlet temperature



## 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 . . . . . 2 of 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 |
|---------------------------------------|--------------------|------|------|
| Oxygen (O <sub>2</sub> )              | %                  | 9,2  | 9,4  |
| Oxides of Nitrogen (NO <sub>x</sub> ) | mg/Nm <sup>3</sup> | 460  | 480  |
| Hydrocarbons (THC)                    | mg/Nm <sup>3</sup> | 1502 | 1410 |
| Carbon Monoxide (CO)                  | mg/Nm <sup>3</sup> | 860  | 870  |
| Lambda                                |                    | 1,7  | 1,7  |

| Designation             |                   | Cogeneration unit |      | Gas unit |      |
|-------------------------|-------------------|-------------------|------|----------|------|
|                         |                   | TRS1              | TRS2 | TRS1     | TRS2 |
| <b>Mass flow data</b>   |                   |                   |      |          |      |
| Combustion air (25 °C)  | kg/h              | 4852              | 5598 | 4909     | 5662 |
| <b>Volume flow data</b> |                   |                   |      |          |      |
| Combustion air (25 °C)  | m <sup>3</sup> /h | 4098              | 4728 | 4146     | 4782 |

## Exhaust system

| Designation                            | Units               | TRS1 | TRS2 |
|--|---------------------|------|------|
| Maximum back pressure for total system | mm H <sub>2</sub> O | 600  | 400  |

Exhaust outlet flange size . . . . . 2 x 152 mm

For recommended pipe sizes see the Installation Manual.

| Designation                                  | Units             | Cogeneration unit |       | Electro unit |       |
|--|-------------------|-------------------|-------|--------------|-------|
|  |                   | TRS1              | TRS2  | TRS1         | TRS2  |
| <b>Exhaust gas volume flow (100 kPa)</b>     |                   |                   |       |              |       |
| Exhaust gas flow (at turbo exit temperature) | m <sup>3</sup> /h | 10816             | 12395 | 11053        | 12632 |
| Exhaust gas mass flow                        | kg/h              | 4932              | 5652  | 5040         | 5760  |

## Electrical system

Type .. insulated return  
Alternator voltage .. 24V with integral regulator  
Alternator output ... 32A at stabilised output 28 A at 20°C ambient  
Starter motor voltage .. 24V  
Starter motor power .. 16,4kW  
Number of teeth on flywheel .. 156  
Number of teeth on starter motor .. 12  
Minimum cranking speed .. 120 rev/min  
Starter motor solenoid pull-in current ... 26,8A at 24V  
Starter motor solenoid hold-in current... 9A at 24V

## Engine mountings

Maximum static bending moment at rear face of block. ... 1356 kg  
Maximum permissible overhung load on flywheel. .... 850 kg

## Starting requirements temperature down to 0°C

Oil: .. See page 2, Lubrication system  
Starter: .. 2 x 24 Volts  
Battery: .. 4 x 12V total Ah 143  
In-rush current to starter: .. 1000 amps  
Cranking current: .. 600 amps  
Starter cable size: .. 120 mm<sup>2</sup>  
Maximum length: .. 6 m

- The battery capacity is defined by the 20 hour rate
- The starting ability of an engine with an immersion heater will be improved by approx. 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.

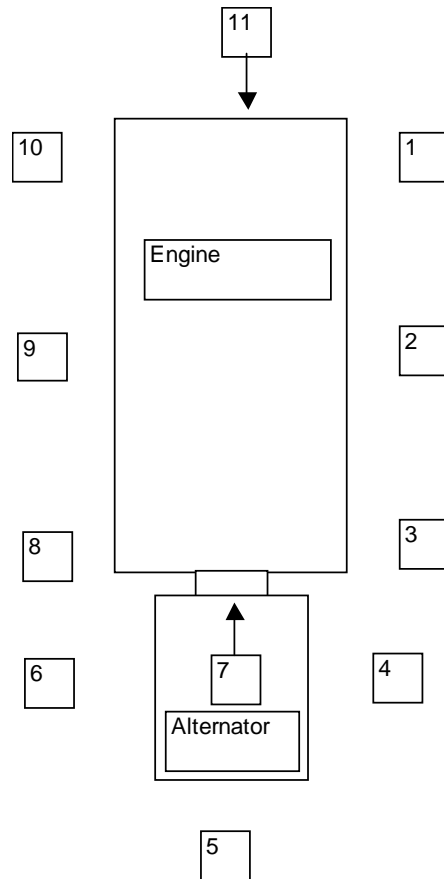
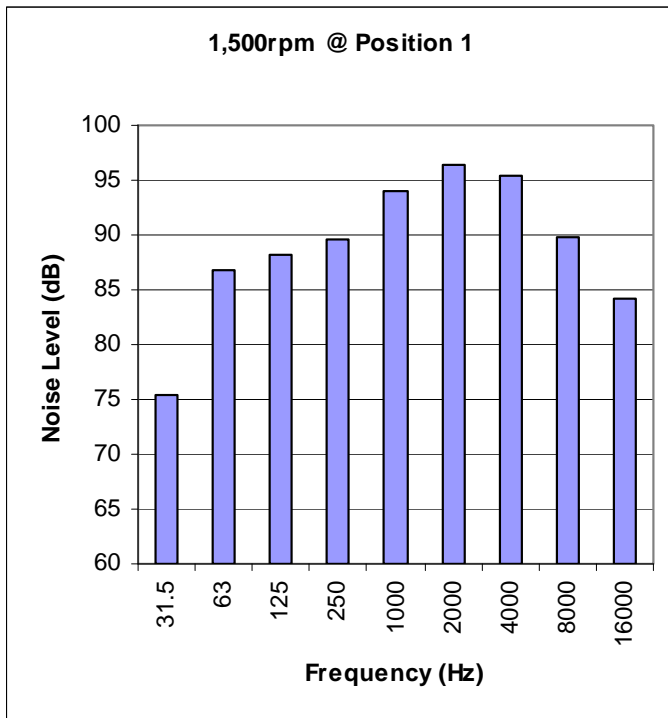
**Noise Data**

**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).

Ambient noise level .....78 dBA

| Position | Noise Level (dBA) |
|----------|-------------------|
| 1        | 106.4             |
| 2        | 105.4             |
| 3        | 103.4             |
| 4        | 102.1             |
| 5        | 99.8              |
| 6        | 102.8             |
| 7        | 105.6             |
| 8        | 104.3             |
| 9        | 104.6             |
| 10       | 105.0             |
| 11       | 103.5             |



The information given on this Technical Data Sheet is for guidance only. For ratings other than those shown, please contact Perkins Engines Company Limited.



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