All data provided in this document is non-binding. This data serves informational purposes only and is especially not guaranteed in any way. Depending on the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions. If this document is delivered in another language than English and doubts arise concerning the translation, the English text shall prevail. Copyright © MAN Diesel & Turbo • Subject to modification in the interest of technical progress. D2366513 Printed in Germany GKM-AUG • BB
Reliable
Innovative
Dynamic
Open
# Contents

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MAN Diesel & Turbo can look back on more than 250 years of industrial history with the roots of the company, and indeed of the entire MAN Group, stretching back to 1758 and the St. Anthony ironworks that laid the foundation for the development of the coal and steel industry in the Ruhr region. While focus initially remained on ore mining and iron production in the German Ruhr region, mechanical engineering became the dominant branch of business in Augsburg and Nuremberg.

In Augsburg, on 10 August 1893, Rudolf Diesel’s prime model, a single 10-foot (3.0 m) iron cylinder with a flywheel at its base, ran on its own power for the first time. Diesel and MAN engineers spent four more years making improvements and, in 1897, presented another model with a tested efficiency of 26%, in contrast to the 10% efficiency of the steam engine.

Today, MAN Diesel & Turbo SE, based in Augsburg, is the world’s leading supplier of large-bore diesel engines and turbomachinery for marine and stationary applications. It designs two-stroke and four-stroke engines with power outputs ranging from 47 kW to 87 kW. MAN Diesel & Turbo also designs and manufactures gas turbines, steam turbines and compressors up to 50 MW. The product range is rounded off by turbochargers, propellers, gas engines and chemical reactors. MAN Diesel & Turbo’s range of goods includes complete marine propulsion systems, turbomachinery units for the oil & gas as well as the process industries and complete power plant solutions. World-wide after-sales service is provided by MAN PrimeServ.

The company employs around 15,000 staff at more than 100 international sites, primarily in Germany, Denmark, France, Switzerland, the Czech Republic, India and China. MAN Diesel & Turbo is a company in the Power Engineering business area of MAN SE.
Generating Success
The economic solution

Power generation employing large reciprocating engines is an increasingly popular solution in a world of rapidly expanding demand for electrical power. With our advanced technology and extensive experience in power plant planning and construction globally, MAN Diesel & Turbo is a reliable partner for all categories of electricity producers and all scopes of supply:

- From single engines and generating sets to complete made-to-measure power plants with EPC (Engineering – Procurement – Construction) scope, acting as main contractor/consortium leader
- From major national utilities to operators of municipal or industrial co-generation plants and independent power producers (IPPs), operating power purchase agreements (PPAs).

Power plants from MAN Diesel & Turbo offer:

- Highest fuel efficiency
- Low maintenance, high reliability
- Excellent power quality and security
- Operational flexibility, from base load to standby
- Rapid construction from earthworks to first kWh
- Wide fuel flexibility
- Wide scope for thermal energy recovery
- Insensitivity to “hot and high” locations
- Modular concept for flexible capacity expansion

Quality and reliability = availability

Precise manufacturing and thorough testing guarantee the reliability and operational safety of the diesel and gas engines at the heart of MAN Diesel & Turbo power plants. Robustness, reliability, ease of operation and maintenance are the preconditions for availabilities above 8,000 hours per year.
The 18V48/60TS diesel engine

The idea is simple: just place two of MAN’s most efficient turbochargers upstream from the engine, one after the other. The result: the engine gets twice the charge air pressure, while the turbocharger efficiency is increased significantly.

The excess combustion air from the turbochargers provides greater operational flexibility. The high charge air pressure can be used for enhanced Miller cycling, delivering significant fuel savings and further reducing NOx emissions. With this engine, MAN Diesel and Turbo obtains: a flexible continuous power output rating, from 18,900 kWh\textsubscript{mech} to 21,600 kWh\textsubscript{mech}, specific fuel oil consumption down to 171.5 g/kWh\textsubscript{mech} * (at 18,900 kWh\textsubscript{mech} rating) and very low NO\textsubscript{x} emissions of 20% below the World Bank 2008 requirement (at a power rating of 21,600 kWh\textsubscript{mech}).

* LCV=42,700 kJ/kg, +5% tolerance, without attached pumps
The 20V35/44G gas engine

A reliable supply of electricity is essential for worldwide economic growth. MAN Diesel & Turbo helps to provide this crucial resource with its new high-efficient 20V35/44G spark ignited gas engine with 10.6 MW at mechanical engine efficiency of 49.2%. Not only is it ideal for decentralized applications, this versatile engine can also be deployed in large base load power plants requiring electrical output of up to 200 MW and more.

Utilising waste heat from cooling water and exhaust gas, the 20V35/44G gas engine is a high-efficient prime mover for combined heat and power (CHP) applications, producing hot water for district heating, process heat for industrial use or heat to feed an absorption chiller to supply chilled water for air conditioning.

Major benefits of the 20V35/44G:
- High power density, low specific investment cost
- Low fuel costs due to very high efficiency
- By heat utilisation >90% total efficiency
- Short power ramp-up time
- Excellent load response
- Easy maintenance and high availability
EDF La Réunion, France

A consortium with MAN Diesel & Turbo as leader built and commissioned the turnkey power plant on the French island La Réunion located in the Indian Ocean. Identical power plants will be erected in Martinique and Guadeloupe, both in the Caribbean. MAN Diesel & Turbo was in charge for process technology, plant design, mechanical equipment and system erection and commissioning.

The power plant is equipped with twelve 18V48/60 diesel engines operating on heavy fuel oil to supply a net electrical power output of 210 MW.
The facility complies with the highest environmental standards, e.g. operation with an SCR catalyst to reduce NOx emissions by more than 88 per cent. The redundancy of all systems ensures a maximum plant availability. To provide all required water qualities such as demineralized and potable water, a sea water treatment plant was installed as well.

<table>
<thead>
<tr>
<th>Customer:</th>
<th>EDF PEI, Electricité de France</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application:</td>
<td>Peak load power plant</td>
</tr>
<tr>
<td>Location:</td>
<td>La Réunion (Indian Ocean), France</td>
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<tr>
<td>No. and engine type:</td>
<td>12 × 18V48/60</td>
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<tr>
<td>Plant output:</td>
<td>210 MW</td>
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<tr>
<td>Fuel:</td>
<td>HFO</td>
</tr>
<tr>
<td>Commissioning:</td>
<td>October 2013</td>
</tr>
<tr>
<td>MAN’s work scope:</td>
<td>Process technology, Plant design, Mechanical equipment, System commissioning</td>
</tr>
</tbody>
</table>
Alenakiri Power Plant, Gabon

With the inauguration of the 70 MW Alenakiri thermal power station in August 2013, it became one of the highest efficiency power plants in Gabon.

Alenakiri is located at the southern outskirts of the capital Libreville in Gabon’s Northwest coastline in the municipality of Owendo. The power will be utilized by Gabon’s electricity company SEEG and the Gabon Special Economic Zone at Nkok.

The plant is based on four highly efficient MAN 18V51/60DF generating sets.
The MAN 51/60DF provides great flexibility being capable to generate 70 megawatts by operating on diesel fuel or natural gas, which is the primary source of energy. In the event of a gas supply interruption, the MAN 51/60DF seamlessly transitions to operate on liquid fuel without any loss of output to the power station.

**Customer:** Telemenia Ltd  
**Application:** Base load power plant  
**Location:** Alenakiri, Libreville, Gabon  
**No. and engine type:** 4 × 18V51/60DF  
**Plant output:** 70 MW  
**Fuel:** Gas  
**Commissioning:** July 2013  
**MAN’s work scope:** Equipment supply
Power Product Overview

Engineering the Future – since 1758.
MAN Diesel & Turbo
Power Product Overview
Four-stroke medium speed engines

Liquid Fuel
Large liquid fuel engines from MAN Diesel & Turbo (MDT) are the most fuel efficient combustion engines available. With mechanical efficiencies between 45% and 49%, they offer an excellent fuel economy as a firm basis for low emissions. Thus, they are an ideal solution for electricity generation.

By using liquid fuel stored in a tank farm on site, diesel power plants are independent of fixed infrastructures, such as gas pipelines, and less affected by fuel supply fluctuations. In terms of economic considerations, the heavy fuel oil (HFO) commonly used in diesel engine power plants is traditionally cheaper than distillate diesel fuels.
Gas Fuel & DF

Gas is an increasingly popular option for power generation. One reason is the growing availability via gas grids or LNG transport by ships. Another is its value for money, as gas is generally much cheaper than HFO. A key advantage of gas power plants is their flexibility: they can be activated rapidly, making them an excellent source of peak base load power. Additionally, gas has a very low environmental impact. Low emissions and high efficiency in energy productions play a key role in investment decisions.

The DF Engine offers users the possibility of switching smoothly and seamlessly from gas to liquid fuel operation (and vice versa).
Two-stroke low speed diesel engines for stationary application have been installed at various sites since 1929. Technical data for the MC-S programme was initiated in 1984. Two-stroke low speed diesel engines are available for both 50 Hz and 60 Hz applications. The engines can serve as power generation units or mechanical drives for mills, pumps, etc. and are known for their fuel flexibility and robustness. Please see the chapter ‘Two-Stroke Licence Business’.
MAN Diesel & Turbo covers the specific needs in the power generation industry with its comprehensive range of modularized, but also custom made equipment including industrial gas turbines from 6-13 MW and steam turbines from 1 to 160 MW.

Our steam turbines serve combined heat and power (CHP), waste-to-energy (WtE), diesel combined cycle (DCC)*, concentrated solar power (CSP), biomass and pulp & paper applications.

MAN Diesel & Turbo gas turbines are suitable for combined cycle, cogeneration (process steam, district heating, cooling), base load, peak shaving and emergency.

* for more details concerning DCC, please see in chapter “Power Plant Solutions”
MAN Diesel & Turbo offers various turbine models and sizes such as condensing type turbines, backpressure turbines and admission/extraction turbines.

**Special purpose steam turbines for power generation (2–160 MW)**

<table>
<thead>
<tr>
<th>Power range</th>
<th>Max. steam inlet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>2–160 MW 130 bar (1,885 psi), 540°C (1,004°F)</td>
</tr>
<tr>
<td>Low pressure turbines</td>
<td>5–90 MW 1-20 bar (max. 290 psi), saturated steam</td>
</tr>
</tbody>
</table>

**MARC® steam turbines for power generation (2–40 MW, non API)**

<table>
<thead>
<tr>
<th>Power range</th>
<th>Max. steam inlet</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARC® 1</td>
<td>1,5–4,5 MW 65 bar (870 psi), 450°C (842°F)</td>
</tr>
<tr>
<td>MARC® 2</td>
<td>4–10 MW 90 bar (1,305 psi), 520°C (968°F)</td>
</tr>
<tr>
<td>MARC® 4</td>
<td>10–20 MW 120 bar (1,740 psi), 520°C (968°F)</td>
</tr>
<tr>
<td>MARC® 6</td>
<td>15–40 MW 120 bar (1,740 psi), 530°C (968°F)</td>
</tr>
</tbody>
</table>
**THM Model**

<table>
<thead>
<tr>
<th></th>
<th>1304–10 N</th>
<th>1304–12 N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Generator Drive (at generator terminals)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Output</td>
<td>kWe</td>
<td>10,080</td>
</tr>
<tr>
<td>Efficiency</td>
<td>%</td>
<td>29,2</td>
</tr>
<tr>
<td>Heat Rate</td>
<td>kJ / kWh</td>
<td>12,380</td>
</tr>
<tr>
<td><strong>Exhaust Gas Data</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exhaust gas temperature °C / °F</td>
<td>490 / 914</td>
<td>515 / 959</td>
</tr>
<tr>
<td>Exhaust gas flow kg/s / lb/s</td>
<td>46.5 / 103</td>
<td>49.1 / 108</td>
</tr>
<tr>
<td><strong>Emissions (ref. to 15% O₂ dry)</strong>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOx</td>
<td>mg/Nm³</td>
<td>50</td>
</tr>
<tr>
<td>CO</td>
<td>mg/Nm³</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

*for gas turbines equipped with DLE Combustion System

The gas turbine portfolio is comprised of the mature THM Gas Turbine family in the 9-13 MW range as well as a newly developed gas turbine MGT6100 with power outputs of up to 7 MW.
## MGT6100 Generator Drive

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Power Output</td>
<td>6.53 MW</td>
</tr>
<tr>
<td>Efficiency</td>
<td>32.0%</td>
</tr>
<tr>
<td>Heat Rate</td>
<td>11,250 kJ/kWh</td>
</tr>
<tr>
<td>Exhaust gas flow</td>
<td>28.0 kg/s</td>
</tr>
<tr>
<td>Exhaust gas temperature</td>
<td>465 °C</td>
</tr>
<tr>
<td>Fuel flow</td>
<td>1,530 kg/h (LHV = 48 MJ/kg)</td>
</tr>
<tr>
<td>Heat input</td>
<td>20.4 MJ/s</td>
</tr>
</tbody>
</table>

### Emissions (ref. to 15% O₂ dry)

<table>
<thead>
<tr>
<th>Emission</th>
<th>mg/Nm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>30</td>
</tr>
<tr>
<td>CO</td>
<td>&lt;15</td>
</tr>
</tbody>
</table>

Load Range % 50-100

Above data valid under ISO conditions
MAN Diesel & Turbo offers the complete range of engine-based power plant equipment. The customer can choose from our wide array of products based on specific needs: from single GenSets with or without mechanical and electrical auxiliaries to full EPC power plants ready for operation.

**GenSet scope includes:**
- Engine
- Generator
- Base frame
- Connecting components

**Mechanical & electrical equipment** includes in addition to the GenSet’s mechanical and electrical components:
- Fuel supply and treatment systems
- Lube oil system
- Cooling system
- Exhaust gas system
- Control system, MV switchgear system, LV system
- and, if requested, step-up transformer and HV substation

**EPC**, the complete power plant ready for operation, includes all components and services until completion of the power plant, such as:
- Civil works, buildings, steel constructions
- Ducts, pipes, cables
- Tank farm
- Erection and assembling works, pipe fitting and cabling

Independent of scope, the customer can always rely on MAN Diesel & Turbo’s proven and experienced team in Business Unit Power Plants to perform all tasks, including, engineering, site management, supervision and commissioning.
Power Plant Solutions

Engineering the Future – since 1758.

MAN Diesel & Turbo
MAN four-stroke diesel engines are designed to provide optimum fuel flexibility. The engines are the ideal source of power, whether you want to build a gas power plant, an oil power plant, or even a green power plant, burning liquid biofuels.

**Liquid fuels:** Diesel, HFO, liquid biofuel and crude oil  
**Gaseous fuels:** Natural gas

For further information regarding the possibility of using these fuels according to particular specifications, please contact MAN Diesel and Turbo.

**Ambient conditions according to ISO 3046-1:2002**  
The stated consumption figures refer to the following reference conditions according to ISO 3046-1:

- Ambient air pressure: 1,000 mbar  
- Ambient air temperature: 25°C (77°F)  
- Charge air temperature: According to engine type, corresponding to 25°C cooling water temperature before charge air cooler

The SFOC figures for engines in liquid fuel operation are based on a lower calorific value of the fuel of 42,700 kJ/kg.

**Engine and GenSet power**  
The engine and GenSet power is stated in kW. Ratings are given according to ISO 3046-1:2002. Figures for gas engines refer to natural gas with a methane number ≥ 70 unless otherwise stated. Electric power calculations are based on a normal alternator efficiency according to IEC 60034 in the corresponding power range and a power factor of 0.9. Maximum output varies according to the site conditions.
Peak load
Peak load applications are defined as stationary plants which are only used a few hours a day to compensate peak demands of electrical power.

Heat rate
The figures are given for 100% load and without engine driven pumps. Attached pumps will require additional fuel consumption. The tolerance for guarantee is +5%. Please note that the additions to fuel consumption must be considered before the tolerance for guarantee is taken into account. Basis for reference conditions, see section: “Ambient conditions according to ISO 3046-1:2002”.

Conversions to different heat rates and efficiency units:
- from kJ/kWh to BTU/KWh → with factor 0.9478
- from kJ/kWh to g/KWh → with factor 1/LHV (acc. to ISO 3046-1:2002 LHV: 42.7 MJ/kg)
- from kJ/kWh to efficiency in % → with factor [(1/3600)-1 *100]

Lube oil consumption
Figures for specific lube oil consumption are specified with a tolerance of 20%.

Compliance with emission guidelines and legislation
The relevant emission guidelines, for which the listed performances are valid, are presented with the relevant performance date table for each engine. Unless otherwise stated, the relevant emissions apply to World Bank 2007/2008 for liquid fuel power plants and to World Bank 2007/2008 or German TA-Luft for gas fuel power plants.

Dimensions and masses
The masses stated correspond to the complete unit (including alternator). The total weight varies depending on the alternator make. All masses given are without lube oil and cooling water filling. Dimensions and weights given are for guidance only and are subject to change without notice. The length of the GenSet unit depends on the alternator make.

Please contact MAN Diesel & Turbo if:
- higher requirements for emissions levels, such as the EU-Directive, are in effect
- special requirements of the plant for heat recovery exist
- special requirements on media temperatures of the engine exist
Power Plant Solutions
HFO/diesel fuel power plants

MAN engines are capable of running on the widest range of liquid fuels. The engines for HFO and diesel fuel power plants have an extraordinary robust design that makes them highly reliable.

Benefits:

- **Efficiency:** high-efficient combustion engines available – with mechanical efficiencies between 45% and 49%
- **Low emissions,** fulfillment of worldwide environmental regulations; below World Bank limits
- **High reliability**
- **Ease of maintenance:** longest safe interval between major overhauls and minimal daily maintenance
- **High operational flexibility,** from standby to base load
- **Reliable power supply under all conditions** – insensitivity to hot and high-altitude locations
- **Power range from 1,045 up to 21,103 kWe/unit**
- **Power plants with an output of more than 300 MWe**
- **Modular concept for flexible capacity extension**
- **Long lifetime**
Liquid Fuel Specifications

Diesel fuel oil
Diesel fuel oil (DFO) – based on ISO F DMB. (ISO 8217-2010). The usability of DFO depends on its conformity with the key properties listed below:

Density at 15°C ................................................................. < 900 kg/m³
Kinematic viscosity at 40°C .............................................. 2.0 ... 11 mm²/s
Pour point, winter quality .................................................. < 0 °C
Pour point, summer quality .............................................. < 6 °C
Flash point (Pensky Martens) ........................................... > 60 °C
Total sediment fraction .................................................. < 0.10% wt.
Water content ................................................................. < 0.3% vol.
Sulphur content .............................................................. < 2.0% wt.
Ash content ................................................................. < 0.01% wt.
Coke residue (MCR) .......................................................... < 0.3% wt.
Cetane number or cetane index ....................................... > 35
Hydrogen sulphide ........................................................ < 2 mg/kg
Total acid number ........................................................ < 0.5 mg KOH/g
Oxidation stability ....................................................... < 25 g/m³
Lubricity (wear scar diameter) ....................................... < 520 µm
Heavy fuel oil

The HFO specified in the following chapters represent the worst-case fuel on which diesel engines can operate satisfactorily.

Fuel system related characteristic values

The fuel system is designed to operate on the basis of the following fuel oil specifications based on ISO 8217-2010:

- Viscosity (at 50°C) .......................................................... max. 700 mm²/s
- Density (at 15°C) ............................................................... max. 1010 kg/m³
- Sulphur content ............................................................. max. 4.5%-wt.
- Ash content ................................................................. max. 0.015%-wt.
- Flash point ................................................................. min. 60 °C
- Pour point ................................................................. max. 30 °C
- Coke residue (Conradson) ............................................... max. 20% wt.
- Vanadium ................................................................. max. 450 mg/kg
- Water ................................................................. max. 0.5% vol.
- Sediment (potential) .......................................................... max. 0.1% wt.
- Aluminium and silicon (total) .............................................. max. 60 mg/kg
- Total acid number ........................................................ max. 2.5 mg KOH/g
- Hydrogen sulphide ........................................................ max. 2 mg/kg
- Asphaltene content .................................................. max. 2/3 of coke residue % wt (Conradson)
- Sodium ................................................................. sodium < 1/3 vanadium, sodium < 100 mg/kg
- CCAI number ........................................................... max. 870

The current fuel oil characteristics are not sufficient for estimating the combustion properties of the fuel oil. This means that service results depend on oil properties that cannot be known beforehand. This especially applies to the tendency of the oil to form deposits in the combustion chamber, gas passages and turbines. It may, therefore, be necessary to rule out some oils that cause difficulties.

The fuel must be free of admixtures not based on mineral oil, e.g. coal oil or vegetable oils, free of tar oil and lubricating oil, and any chemical waste, solvents and polymers.

Treated heavy fuel oil at engine inlet

- Inorganic foreign particles .................................................. < 5 μm and < 20 mg/kg
- Aluminium + silicon content ............................................ < 15 mg/kg
- Water ................................................................. < 0.2% vol.
Power Plant Solutions
HFO/diesel fuel power plants

- MAN 18V48/60TS
- MAN 48/60
- MAN 32/44CR
### MAN 18V48/60TS

**Bore 480 mm, Stroke 600 mm**

<table>
<thead>
<tr>
<th>Operation mode</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<tbody>
<tr>
<td>Engine speed</td>
<td>rpm</td>
<td>500/514</td>
<td>500/514</td>
<td>500/514</td>
</tr>
<tr>
<td>Frequency</td>
<td>Hz</td>
<td>50/60</td>
<td>50/60</td>
<td>50/60</td>
</tr>
<tr>
<td>Electr. GenSet power</td>
<td>kW</td>
<td>18,465</td>
<td>19,345</td>
<td>20,224</td>
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</table>

**Electr. GenSet heat rate at 100% load**

<table>
<thead>
<tr>
<th>World Bank 2007/2008</th>
<th>kW/h</th>
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</thead>
<tbody>
<tr>
<td>kJ/kWh</td>
<td></td>
</tr>
<tr>
<td>7,497</td>
<td></td>
</tr>
<tr>
<td>7,539</td>
<td></td>
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<tr>
<td>7,627</td>
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<td>7,757</td>
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**Lube oil consumption**

<table>
<thead>
<tr>
<th>kg/h</th>
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<tbody>
<tr>
<td>9.5</td>
</tr>
<tr>
<td>9.9</td>
</tr>
<tr>
<td>10.4</td>
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<td>10.8</td>
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*Nominal generator efficiency 97.7%*

**GenSet dimensions**

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<tr>
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<table>
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<table>
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<table>
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**Dry mass**

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<tbody>
<tr>
<td>407</td>
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---

30  Power Plant Solutions
## MAN 48/60

### Bore 480 mm, Stroke 600 mm

<table>
<thead>
<tr>
<th></th>
<th>12V</th>
<th>18V</th>
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<tbody>
<tr>
<td><strong>Engine speed</strong></td>
<td>rpm</td>
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<tr>
<td><strong>Frequency</strong></td>
<td>Hz</td>
<td>50/60</td>
</tr>
<tr>
<td><strong>Electr. GenSet power</strong></td>
<td>kW</td>
<td>12,310</td>
</tr>
</tbody>
</table>

### Electr. GenSet heat rate at 100% load

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>World Bank</strong></td>
<td>kJ/kWh</td>
<td></td>
</tr>
<tr>
<td><strong>1998</strong></td>
<td>7,605</td>
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</tr>
<tr>
<td><strong>2007/2008</strong></td>
<td>7,779</td>
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### Lube oil consumption

<table>
<thead>
<tr>
<th></th>
<th>12V</th>
<th>18V</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>kg/h</strong></td>
<td>6.3</td>
<td>9.5</td>
</tr>
</tbody>
</table>

Nominal generator efficiency L-type: 97.3%, V-type: 97.7%

Engine also available in two-stage turbocharging, please see 48/60TS

### GenSet dimensions

<table>
<thead>
<tr>
<th></th>
<th>12V</th>
<th>18V</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong></td>
<td>mm</td>
<td>9,835</td>
</tr>
<tr>
<td><strong>B</strong></td>
<td>mm</td>
<td>4,950</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>mm</td>
<td>14,785</td>
</tr>
<tr>
<td><strong>W</strong></td>
<td>mm</td>
<td>4,700</td>
</tr>
<tr>
<td><strong>H</strong></td>
<td>mm</td>
<td>6,250</td>
</tr>
<tr>
<td><strong>Dry mass</strong></td>
<td>t</td>
<td>273</td>
</tr>
</tbody>
</table>
MAN 32/44CR

Bore 320 mm, Stroke 440 mm

<table>
<thead>
<tr>
<th></th>
<th>12V</th>
<th>20V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine speed</td>
<td>rpm</td>
<td>750/720</td>
</tr>
<tr>
<td>Frequency</td>
<td>Hz</td>
<td>50/60</td>
</tr>
<tr>
<td>Electr. genset power</td>
<td>kW</td>
<td>7,020</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/6,786</td>
</tr>
</tbody>
</table>

Electr. GenSet heat rate at 100% load

| World Bank 2007/2008    | kJ/kWh    | 7,839     | 7,839     |
| (1,460mg NO_x@15%0^2)   |           |           |

For World Bank 1998 please contact MAN Diesel & Turbo.

Lube oil consumption     kg/h     3.6       6.0

Nominal generator efficiency L-type: 97.0% V-type: 97.5%

GenSet dimensions (valid only for V-type)

<table>
<thead>
<tr>
<th></th>
<th>mm</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7,055</td>
<td>9,575</td>
</tr>
<tr>
<td>B</td>
<td>4,376</td>
<td>4,376</td>
</tr>
<tr>
<td>C</td>
<td>11,431</td>
<td>13,951</td>
</tr>
<tr>
<td>W</td>
<td>4,200</td>
<td>4,260</td>
</tr>
<tr>
<td>H</td>
<td>5,000</td>
<td>5,200</td>
</tr>
<tr>
<td>Dry mass</td>
<td>t</td>
<td>117</td>
</tr>
</tbody>
</table>
The growing availability of gaseous fuel has made it increasingly popular for power generation. Gas is a very clean fuel with low emissions, a small CO₂ footprint, making it thus suitable to build gas power plants even within urban areas.

The best performance for this type of power plant is obtained on base load and peak load applications.

**Benefits**

- Operational flexibility: can be activated very rapidly and offers best performances
- High cost efficiency, environmentally friendly and clean: high efficiency and low emissions, e.g. low CO₂ emissions, low NOₓ emissions, almost no SOₓ emissions, almost no particle emissions
- Operation and maintenance costs are lower than those burning liquid fossil fuels
- Retrofits: for several engine types, a conversion from operation with liquid fuel to operation with natural gas can be provided
- Fuel flexibility: our dual fuel power plants run on gas, diesel or HFO. If one fuel becomes difficult to obtain or gets too expensive, you can simply switch to another source of fuel
- Reliable output: dual fuel engines can be changed over from gas to liquid fuel operation at full load without any output and speed fluctuations
- High and stable ratings in hot and high locations.
## Gas Fuel Specifications

### Natural gas

<table>
<thead>
<tr>
<th></th>
<th>Min.</th>
<th>Unit</th>
<th>35/44DF</th>
<th>35/44G</th>
<th>51/60DF 51/60G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calorific value (LHV)</td>
<td></td>
<td>kJ/Nm³</td>
<td>32,400</td>
<td>28,000</td>
<td></td>
</tr>
<tr>
<td>Methane number</td>
<td>-</td>
<td>-</td>
<td></td>
<td>≥ 80</td>
<td></td>
</tr>
<tr>
<td>Hydrogen sulphide content (H₂S)</td>
<td></td>
<td>mg/Nm³</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Total sulphur content</td>
<td></td>
<td>mg/Nm³</td>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Particle concentration</td>
<td>Max.</td>
<td>mg/Nm³</td>
<td></td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Particle size</td>
<td></td>
<td>µm</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Total fluoride content</td>
<td></td>
<td>mg/Nm³</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Total chlorine content</td>
<td></td>
<td>mg/Nm³</td>
<td></td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Nm³ corresponds to one cubic meter of gas at 0 °C and 101.32 kPa.

### MN [-] Graph

- Biogas [23/133]
- Natural gas H [36/92]
- Natural gas L [32/88]
- Methane [36/100]
- Ethane C₂H₆ [65/44]
- Ethene C₂H₄ [60/15]
- Propane C₃H₈ [93/34]
- Propene C₃H₆ [88/19]
- Butane C₄H₁₀ [124/10]

Rated Power

Efficiency Reduction and possibly Power Derating

No operation

Nm³ corresponds to one cubic meter of gas at 0 °C and 101.32 kPa.
MAN 51/60DF
BLUEFIRE ENABLES GREATER FLEXIBILITY

www.man-bluefire.com

Discover the power of MAN’s gas technology

Engineering the Future – since 1758.
MAN Diesel & Turbo
Power Plant Solutions
Gas fuel/DF engines

- MAN 51/60G
- MAN 51/60DF
- MAN V35/44G
- MAN L35/44DF
## MAN 51/60G

**Bore 510 mm, Stroke 600 mm**

<table>
<thead>
<tr>
<th></th>
<th>18V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine speed</td>
<td>rpm</td>
</tr>
<tr>
<td>Frequency</td>
<td>Hz</td>
</tr>
<tr>
<td>Electr. GenSet power</td>
<td>kW</td>
</tr>
</tbody>
</table>

**Electr. GenSet heat rate at 100% load**

<table>
<thead>
<tr>
<th></th>
<th>kJ/kWh</th>
<th>7,468</th>
<th>7,468</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical optimised, TA-Luft</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas combined cycle, TA-Luft</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Lube oil consumption**

|                  | kg/h  | 9.5   | 9.5   |

*Nominal generator efficiency 97.7%, Methane no. ≥ 80*

**GenSet dimensions**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Unit</th>
<th>Value 1</th>
<th>Value 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>mm</td>
<td>13,148</td>
<td>13,148</td>
</tr>
<tr>
<td>B</td>
<td>mm</td>
<td>5,410</td>
<td>5,410</td>
</tr>
<tr>
<td>C</td>
<td>mm</td>
<td>18,558</td>
<td>18,558</td>
</tr>
<tr>
<td>W</td>
<td>mm</td>
<td>4,700</td>
<td>4,700</td>
</tr>
<tr>
<td>H</td>
<td>mm</td>
<td>6,530</td>
<td>6,530</td>
</tr>
<tr>
<td>Dry mass</td>
<td>t</td>
<td>373</td>
<td>373</td>
</tr>
</tbody>
</table>

---

**Diagram of MAN 51/60G engine**

---

38 Power Plant Solutions
## MAN 51/60DF

<table>
<thead>
<tr>
<th>Bore 510 mm, Stroke 600 mm</th>
<th>9L</th>
<th>12V</th>
<th>14V</th>
<th>18V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine speed (rpm)</td>
<td>500</td>
<td>500</td>
<td>514</td>
<td>500</td>
</tr>
<tr>
<td>Frequency (Hz)</td>
<td>50</td>
<td>50</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>Electr. GenSet power (kW)</td>
<td>8,757</td>
<td>11,724</td>
<td>11,724</td>
<td>13,678</td>
</tr>
</tbody>
</table>

### Electr. GenSet heat rate at 100% load

<table>
<thead>
<tr>
<th></th>
<th>9L</th>
<th>12V</th>
<th>14V</th>
<th>18V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid fuel (WB2007/2008) (kJ/kWh)</td>
<td>7,877</td>
<td>7,877</td>
<td>7,965</td>
<td>7,877</td>
</tr>
<tr>
<td>Gas fuel (WB2007/2008) (kJ/kWh)</td>
<td>7,767</td>
<td>7,634</td>
<td>7,553</td>
<td>7,634</td>
</tr>
<tr>
<td>Gas fuel (TA-Luft) (kJ/hWh)</td>
<td>7,798</td>
<td>7,663</td>
<td>7,713</td>
<td>7,663</td>
</tr>
</tbody>
</table>

### Lube oil consumption (kg/h)

- 4.8
- 7.2

Nominal generator efficiency L-type: 97.3% V-type: 97.7%

Liquid fuel: HFO or diesel fuel
Gas fuel: Incl. pilot fuel. methane no. ≥ 80

There is a variant of the 51/60DF engine. This variant is designed for power plants running initially on liquid fuel before gas is available. It is optimized for liquid fuel operation which leads to a reduction in SFOC compared to the 51/60DF.

This version is not able to run on gas prior to upgrade. But it is however completely prepared for gas operation and can be easily upgraded in a short time period to the full 51/60DF version.

### GenSet dimensions

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>W</th>
<th>H</th>
<th>Dry mass (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>t</td>
</tr>
<tr>
<td>10,545</td>
<td>4,805</td>
<td>15,350</td>
<td>2,970</td>
<td>6,030</td>
<td>225</td>
</tr>
<tr>
<td>9,835</td>
<td>4,950</td>
<td>14,785</td>
<td>4,700</td>
<td>6,530</td>
<td>276</td>
</tr>
<tr>
<td>10,835</td>
<td>5,150</td>
<td>15,985</td>
<td>4,700</td>
<td>6,530</td>
<td>318</td>
</tr>
<tr>
<td>13,148</td>
<td>5,410</td>
<td>18,558</td>
<td>4,700</td>
<td>6,530</td>
<td>381</td>
</tr>
</tbody>
</table>
# MAN V35/44G

**Bore** 350 mm, **Stroke** 440 mm

<table>
<thead>
<tr>
<th>Engine speed</th>
<th>rpm</th>
<th>750</th>
<th>720</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Hz</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>Electr. GenSet power</td>
<td>kW</td>
<td>10,335</td>
<td>9,945</td>
</tr>
</tbody>
</table>

**Electr. GenSet heat rate at 100% load**

<table>
<thead>
<tr>
<th>SC (TA-Luft)</th>
<th>kJ/kWh</th>
<th>7,510</th>
<th>7,510</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHP (TA-Luft)</td>
<td>kJ/kWh</td>
<td>7,722</td>
<td>7,722</td>
</tr>
</tbody>
</table>

**Lube oil consumption**

| kg/h | 3.7 | 3.7 |

*Nominal generator efficiency 97.5%, methane no. ≥ 70*

**GenSet dimensions**

<table>
<thead>
<tr>
<th>A</th>
<th>mm</th>
<th>9,680</th>
<th>9,680</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>mm</td>
<td>4,295</td>
<td>4,295</td>
</tr>
<tr>
<td>C</td>
<td>mm</td>
<td>13,975</td>
<td>13,975</td>
</tr>
<tr>
<td>W</td>
<td>mm</td>
<td>3,845</td>
<td>3,845</td>
</tr>
<tr>
<td>H</td>
<td>mm</td>
<td>4,540</td>
<td>4,540</td>
</tr>
<tr>
<td>Dry mass</td>
<td>t</td>
<td>145</td>
<td>145</td>
</tr>
</tbody>
</table>
## MAN L35/44DF

### Bore 350 mm, Stroke 440 mm

<table>
<thead>
<tr>
<th></th>
<th>6L</th>
<th>9L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine speed</td>
<td>rpm</td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>Hz</td>
<td></td>
</tr>
<tr>
<td>Electr. GenSet power</td>
<td>kW</td>
<td></td>
</tr>
<tr>
<td></td>
<td>750</td>
<td>750</td>
</tr>
<tr>
<td></td>
<td>720</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3,085</td>
<td>4,627</td>
</tr>
<tr>
<td></td>
<td>4,452</td>
<td></td>
</tr>
</tbody>
</table>

### Electr. GenSet heat rate at 100% load

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>kJ/kWh</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid fuel (WB2007/2008)</td>
<td></td>
<td>8,056</td>
</tr>
<tr>
<td>Gas fuel (WB2007/2008)</td>
<td></td>
<td>7,763</td>
</tr>
</tbody>
</table>

### Lube oil consumption

<table>
<thead>
<tr>
<th></th>
<th>kg/h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>2.3</td>
</tr>
</tbody>
</table>

**Nominal generator efficiency L-type: 97.0%**

**Liquid fuel: Diesel fuel**

**Gas fuel: Incl. pilot fuel, methane no. ≥ 80**

### GenSet dimensions

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>W</th>
<th>H</th>
<th>Dry mass*</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td></td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6,390</td>
<td>3,350</td>
<td>9,740</td>
<td>2,903</td>
<td>4,688</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>8,075</td>
<td>4,010</td>
<td>12,035</td>
<td>3,109</td>
<td>4,894</td>
<td>92</td>
</tr>
</tbody>
</table>

* depending on alternator applied
There is no better partner for green power than MAN Diesel & Turbo. Green energy can be generated from vegetable oils and fat, or even from used cooking oil and tallow in a MAN Diesel & Turbo medium speed or low speed engine. This is documented by a long list of satisfied green power customers.

Benefits

- Clean: environmentally friendly, small carbon footprint if coming from sustainable sources
- Sustainable: with MAN biofuel engines, a very small carbon footprint can be achieved, especially if certified biofuels are used
- Fuel flexibility: MDT engines can run on liquid and gaseous fuels, a wide array of liquid biofuels, such as animal fat, palm oil, frying fat and many more → customers can run the plant on an alternative source of fuel, for example if one fuel becomes difficult to obtain or gets too expensive, it is possible to switch from liquid to gaseous fuel or vice versa
- High efficiency: MDT engines achieve high performances, even on difficult fuels
- Huge power range from 1 to 20 MW per unit
- With CHP, an overall efficiency of almost 90%

Selected references

- Fritzens, Austria, 1 × 5L16/24
- Electrawinds, Belgium, 1 × 18V48/60
**Bio Fuel Specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Requirement</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density/15 °C</td>
<td>900 – 930 kg/m³</td>
<td>DIN EN ISO 3675, EN ISO 12185</td>
</tr>
<tr>
<td>Flash point</td>
<td>&gt; 60 °C</td>
<td>DIN EN 22719</td>
</tr>
<tr>
<td>Lower calorific value</td>
<td>&gt; 35 MJ/kg (typical: 37 MJ/kg*)</td>
<td>DIN 51900-3</td>
</tr>
<tr>
<td>Viscosity/50 °C</td>
<td>&lt; 40 (corresponds to viscosity/40 °C &lt; 60 cSt)</td>
<td>DIN EN ISO 3104</td>
</tr>
<tr>
<td>Cetane number</td>
<td>&gt; 40</td>
<td>FIA</td>
</tr>
<tr>
<td>Coke residue</td>
<td>&lt; 0.4 %</td>
<td>DIN EN ISO 10370</td>
</tr>
<tr>
<td>Sediment content</td>
<td>&lt; 200 ppm</td>
<td>DIN EN 12662</td>
</tr>
<tr>
<td>Oxidation stability (110 °C)</td>
<td>&gt; 5 h</td>
<td>ISO 6886</td>
</tr>
<tr>
<td>Phosphorus content</td>
<td>&lt; 15 ppm</td>
<td>ASTM D3231</td>
</tr>
<tr>
<td>Na + K content</td>
<td>&lt; 15 ppm</td>
<td>DIN 51797-3</td>
</tr>
<tr>
<td>Ash content</td>
<td>&lt; 0.01 %</td>
<td>DIN EN ISO 6245</td>
</tr>
<tr>
<td>Iodine Number</td>
<td>&lt; 125 g/100g</td>
<td>DIN EN 14111</td>
</tr>
<tr>
<td>Water content</td>
<td>&lt; 0.5 %</td>
<td>EN ISO 12537</td>
</tr>
<tr>
<td>TAN (total acid number)</td>
<td>&lt; 5 mgKOH/g (TAN 5 mgKOH/g ~ 2.5 % FFA)</td>
<td>DIN EN ISO 660</td>
</tr>
<tr>
<td>Cold Filter Plugging Point</td>
<td>&lt; 10 °C below lowest temperature in fuel system</td>
<td>EN 116</td>
</tr>
</tbody>
</table>

**Bio Fuel Engines Technical Data**

<table>
<thead>
<tr>
<th>Speed r/min</th>
<th>Power output [kW el.]</th>
</tr>
</thead>
<tbody>
<tr>
<td>L+V48/60</td>
<td>500 – 515</td>
</tr>
<tr>
<td>L+V32/40</td>
<td>720 – 750</td>
</tr>
<tr>
<td>L+V28/32S</td>
<td>720 – 750</td>
</tr>
<tr>
<td>L27/38S</td>
<td>720 – 750</td>
</tr>
<tr>
<td>L23/30S</td>
<td>720 – 750</td>
</tr>
<tr>
<td>L21/31S</td>
<td>900 – 1,000</td>
</tr>
<tr>
<td>L16/24S</td>
<td>1,000 – 1,200</td>
</tr>
</tbody>
</table>
In order to fulfil the requirements of high efficiency and environmental regulations for power production, MAN Diesel & Turbo has developed a combined cycle process for stationary power plants utilising the exhaust gas of diesel engines for the production of live steam.

The steam is expanded in a MARC steam turbine which produces electrical energy according to the Clausius-Rankine-cycle. This additional electrical energy is produced without any higher consumption of fuel, which is the most important advantage of the Diesel Combined Cycle (DCC).

MAN Diesel & Turbo is the only company building large engines and steam turbines within the same company. This ensures an optimum power plant efficiency and the customer gets both key components from one supplier.

References
- Atlas Power, Pakistan, 11 × 18V48/60 + 1 steam turbine
- Hubco Power, Pakistan, 11 × 18V48/60 + 1 steam turbine
- Thika, Kenya, 5 × 18V48/60 + 1 steam turbine
- Jiyeh, Lebanon, 4 × 18V48/60 + 1 steam turbine
- Zouk, Lebanon, 10 × 18V48/60 + 1 steam turbine
Heat balance of a DCC process

Example for a DCC power plant (any other engine configuration is possible)

<table>
<thead>
<tr>
<th>No. and engine type</th>
<th>8 x 18V48/60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single cycle net plant output</td>
<td>143,965 kW</td>
</tr>
<tr>
<td>Single cycle net efficiency</td>
<td>44.8%</td>
</tr>
<tr>
<td>Steam turbine genset power</td>
<td>12,050 kW</td>
</tr>
<tr>
<td>DCC net plant output</td>
<td>155,865 kW</td>
</tr>
<tr>
<td>DCC net plant efficiency</td>
<td>48.4%</td>
</tr>
</tbody>
</table>

Water cooled condenser
Reference Project

Customer: Atlas Power
Application: Base load power plant, Diesel Combined Cycle
Location: Lahore, Pakistan
No. and engine type: 11 \times 18V48/60 + 1 \cdot steam turbine
Plant output: 225 MW
Fuel: HFO
Commissioning: December 2009
Operation & Maintenance: O&M contract for 10 years
When electricity is generated in gas or diesel engine-based power plants, waste heat at different temperature levels is produced. MAN Diesel & Turbo offers different technologies to convert this waste heat into a useful energy form.

Combined Heat and Power (CHP) is the simultaneous generation of electricity and useful heat from a single fuel source close to its point of use. Combined Cooling, Heat and Power (CCHP) refers to the concurrent generation of electricity, heat and cooling. Both technologies – CHP and CCHP – are well-established, highly-efficient, cost-effective and environmentally-friendly solutions making an important contribution to the global energy demand.

MAN Diesel & Turbo’s engine-based CHP and CCHP plants are designed to meet the overall thermal demand of the end consumer and can be used for a wide range of thermal applications – whether at industrial, city-wide or at individual building levels.

The heat extracted from the engine’s exhaust gases can be utilised for steam generation required in the textile, food, paper and chemical industries. By including an exhaust gas or hot water driven absorption chiller, chilled water can be produced to run central air conditioning systems in hospitals, hotels and office blocks. The heat extracted from the engine lube oil, the engine jacket water and the charge air cooling circuits can be utilised for hot water generation, e.g. used in a district heating network for heating purposes.

**Benefits**

- Lower energy costs through more efficient utilisation of primary energy
- Improved environmental quality through reduced emissions of pollutants
- Recovered waste heat for a wide range of sustainable thermal applications
- Operational flexibility acc. to changes for heat and electricity demand.
Hot water generation for different applications

Energy flow diagram for hot water applications*

* Based on 20V35/44G ISO 3046 conditions and efficiencies valid for:
  Return line temperature 60°C
  Supply line temperature 125°C
17.7 MW rated 18V48/60 type engine
## Power Plant Solutions

### CHP reference electrawinds

<table>
<thead>
<tr>
<th>Customer:</th>
<th>Electrawinds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outputs:</td>
<td>17.7 MW electrical</td>
</tr>
<tr>
<td></td>
<td>14.0 MW thermal</td>
</tr>
<tr>
<td>Overall efficiency</td>
<td>85%</td>
</tr>
<tr>
<td>GenSet</td>
<td>18V48/60</td>
</tr>
<tr>
<td>Fuel</td>
<td>Organic waste oils and fats</td>
</tr>
<tr>
<td>Fuel conditioning</td>
<td>Heating, 3-stage fine filtration</td>
</tr>
<tr>
<td>Recovered heat utilisation</td>
<td>Fuel conditioning</td>
</tr>
<tr>
<td></td>
<td>Space heating</td>
</tr>
<tr>
<td></td>
<td>Heat for local swimming pool</td>
</tr>
</tbody>
</table>
The environmental policy of many countries worldwide generally calls for a higher share of renewable energy sources in their power generation concepts to reduce emissions and the high share of fossils in the electricity generation mix. MAN Diesel & Turbo combines both types of energy in hybrid power plants. Renewable energy sources are combined with liquid fuel or gas fuel engines, obtaining a continuous power output.

**Benefits:**

- Maximization of independency and flexibility
- Keeping fuel costs and CO₂ emissions down
- Lowest possible life cycle costs and environmental footprint
- Very short start-up time of the MDT engines → constant and reliable power supply
- Highly reliable backup – very little maintenance of the engines, even with the fluctuating requirements of a hybrid plant
- By use of biofuels, 100% CO₂-neutral wind diesel hybrid system is possible.

References
- WEB Bonaire, Netherlands Antilles, 5 · 9L27/38 in cooperation with 11 MW wind power

3D Model of WEB Bonaire, Island of Bonaire
Power Plant Solutions

Power barge

For coastal regions or large river sites, floating power stations are an ideal solution for meeting power supply needs on a fast track basis. MAN Diesel & Turbo power barges are offered with all of our diesel and gas engine types from the 32-bore series to the 51- series.

Power barges offer the possibility of supplying electrical power to all locations accessible by water: in coastal areas, in harbours, on rivers, lakes and other waterways.
Benefits
- Simple and straightforward location of the power station where power is required
- Support rapid infrastructure development in remote regions
- Short building times: 70 MW power station can be installed in less than 12 months
- Reduced reliance on poor or non-existent local capacities
- Unaffected by landslides and earthquakes
- Independence from local infrastructure
- Minimum operator investment risk and advantage in financing thanks to the mobility, versatility and adaptability of this type of plant

Examples/References
- Margaritha II in Nicaragua, 4 × 18V48/60
- Esperanza in Guatemala, 7 × 18V48/60
- Karadeniz Powerships, supply of engines and equipment for Karadeniz: Doğan Bey: 3 × 14V48/60 and 6 × 18V51/60DF
  Rauf Bey: 9 × 18V51/60DF
  Kaya Bey: 9 × 18V51/60DF, under construction
Diesel engines are the key components of the generating sets for the safety of a nuclear plant. The MAN Diesel & Turbo PC2 and PA6 diesel engines have been certified for nuclear application in countries such as China, France, India, Japan, Korea, USA.

The PC2.6 B N and the PA6 B N have been awarded the nuclear qualification only after stringent testing according to the IEEE 387, RCC-E and KTA standards, involving 100 (or 300) consecutive hot and cold starts. Both the PC2 engine and the PA6 engine can operate under seismic conditions. The nuclear power GenSet business is centralized in MAN Diesel & Turbo France, which has been granted the ISO 9001:2000 certification by the BVQI and the ISO 14001:2004 certification by LRQA as well.
### PC2.6 B N engine

#### MCR (maximum continuous rating)

<table>
<thead>
<tr>
<th>Engine type</th>
<th>Cyl. No.</th>
<th>kWm</th>
<th>kWe</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 V PC2.6 B N</td>
<td>12</td>
<td>8,640</td>
<td>8,380</td>
</tr>
<tr>
<td>14 V PC2.6 B N</td>
<td>14</td>
<td>10,500</td>
<td>10,185</td>
</tr>
<tr>
<td>16 V PC2.6 B N</td>
<td>16</td>
<td>12,000</td>
<td>11,640</td>
</tr>
<tr>
<td>18 V PC2.6 B N</td>
<td>18</td>
<td>13,500</td>
<td>13,095</td>
</tr>
<tr>
<td>20 V PC2.6 B N</td>
<td>20</td>
<td>15,000</td>
<td>14,550</td>
</tr>
</tbody>
</table>

#### Consumption 100% load

- **Heat rate**: 7,771 kJ/kWhm
- **GenSet**: 8,012 kJ/kWhm
- **Specific lube oil consumption**: 0.3 – 0.6 kg/cyl.h

### MAN PC2.6 B N

<table>
<thead>
<tr>
<th>Engine type</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>Dry mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 V PC2.6 B N</td>
<td>5,960</td>
<td>7,850</td>
<td>3,900</td>
<td>3,715</td>
<td>3,950</td>
<td>11,890</td>
<td>210</td>
</tr>
<tr>
<td>14 V PC2.6 B N</td>
<td>6,700</td>
<td>8,590</td>
<td>3,900</td>
<td>3,715</td>
<td>3,950</td>
<td>12,630</td>
<td>245</td>
</tr>
<tr>
<td>16 V PC2.6 B N</td>
<td>7,440</td>
<td>9,550</td>
<td>4,000</td>
<td>4,075</td>
<td>3,950</td>
<td>13,590</td>
<td>280</td>
</tr>
<tr>
<td>18 V PC2.6 B N</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>20 V PC2.6 B N</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Skid mounted, generator included, valid only for 12, 14 and 16 cylinders*

*Nominal generator efficiencies: 97%*

*Available on request*
### MAN PA6 B N

<table>
<thead>
<tr>
<th>Engine type</th>
<th>60 Hz at 900 rpm (kWm/kWe)</th>
<th>50 Hz at 1,000 rpm (kWm/kWe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 V PA6 B N</td>
<td>4,200/4,074</td>
<td>4,440/4,307</td>
</tr>
<tr>
<td>16 V PA6 B N</td>
<td>5,600/5,432</td>
<td>5,920/5,742</td>
</tr>
<tr>
<td>18 V PA6 B N</td>
<td>6,300/6,111</td>
<td>6,660/6,460</td>
</tr>
<tr>
<td>20 V PA6 B N</td>
<td>7,000/6,790</td>
<td>7,400/7,178</td>
</tr>
</tbody>
</table>

#### Consumption 100% load

<table>
<thead>
<tr>
<th></th>
<th>60 Hz at 900 rpm (kWm/kWe)</th>
<th>50 Hz at 1,000 rpm (kWm/kWe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat rate</td>
<td>8,412 / 8,672</td>
<td>8,497 / 8,760</td>
</tr>
<tr>
<td>Specific lube oil consumption</td>
<td>0.11 – 0.22 kg/cyl.h</td>
<td>0.10 – 0.21 kg/cyl.h</td>
</tr>
</tbody>
</table>

#### Dimensions

<table>
<thead>
<tr>
<th>Engine type</th>
<th>A (mm)</th>
<th>B (mm)</th>
<th>C (mm)</th>
<th>D (mm)</th>
<th>E (mm)</th>
<th>Wt t</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 V PA6 B N</td>
<td>4,510</td>
<td>4,600</td>
<td>6,840</td>
<td>3,935</td>
<td>2,800</td>
<td>65</td>
</tr>
<tr>
<td>16 V PA6 B N</td>
<td>5,430</td>
<td>4,800</td>
<td>7,760</td>
<td>3,935</td>
<td>2,800</td>
<td>78</td>
</tr>
<tr>
<td>18 V PA6 B N</td>
<td>5,800</td>
<td>4,933</td>
<td>8,220</td>
<td>3,935</td>
<td>2,800</td>
<td>86</td>
</tr>
<tr>
<td>20 V PA6 B N</td>
<td>6,350</td>
<td>5,000</td>
<td>8,680</td>
<td>3,935</td>
<td>2,800</td>
<td>95</td>
</tr>
</tbody>
</table>

Nominal generator efficiencies: 97%. All dimensions and masses are approximate and subject to change without prior notice.
Small Bore GenSets

Engineering the Future – since 1758.

MAN Diesel & Turbo
# Small Bore GenSets

<table>
<thead>
<tr>
<th>Speed rpm</th>
<th>Engine type</th>
<th>Electric power range kW</th>
<th>Speed range rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>720-750</td>
<td>V28/32S</td>
<td>3,456 – 4,061</td>
<td>720 – 750</td>
</tr>
<tr>
<td>720-750</td>
<td>L28/32S</td>
<td>1,000 – 1,880</td>
<td>720 – 750</td>
</tr>
<tr>
<td>720-750</td>
<td>L28/32S-DF</td>
<td>950 – 1,710</td>
<td>720 – 750</td>
</tr>
<tr>
<td>720-750-900</td>
<td>L27/38S</td>
<td>1,440 – 2,851</td>
<td>720 – 750</td>
</tr>
<tr>
<td>900-1,000</td>
<td>L23/30S</td>
<td>809 – 1,330</td>
<td>720 – 750 – 900</td>
</tr>
<tr>
<td>1,000-1,200</td>
<td>L21/31S</td>
<td>1,045 – 1,881</td>
<td>900 – 1,000</td>
</tr>
<tr>
<td>1,000-1,200</td>
<td>L16/24S</td>
<td>428 – 941</td>
<td>1,000 – 1,200</td>
</tr>
<tr>
<td></td>
<td>9L28/32S-DF</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Dual fuel**
- **Type of application**
- **Stroke in cm**
- **Bore in cm**
- **L or V version**
- **Number of cylinders**
Small Bore GenSets

Engine programme
These well-established engine types are used in various applications all around the world. Based on long-term experience, the engines are subject to continuous development to improve power, emissions, fuel consumption and reliability, making them the ‘work horse’ in your power house.

Full fuel flexibility
MAN small bore diesel engines are designed to offer optimum in fuel flexibility. The engines are the ideal source of power whether you want to build a ‘green power plant’ burning liquid bio fuels or you need power from crude oil. Please contact MAN Diesel & Turbo for further information.

Liquid fuels: diesel, HFO, liquid bio fuel and crude oil

GenSet power
The GenSet power is stated in kW on alternator. Ratings are given according to ISO 3046-1:2002.

The electrical power quoted is based on a normal alternator efficiency in the corresponding power range and a power factor of 0.8. The maximum output varies according to the site conditions.

Emission control
All small bore engines in this booklet comply with the World Bank 1998 & 2007/2008 guidelines for power plants < 300 MWth thermal fuel input. All small bore four-stroke engines comply with the latest World Bank guidelines.

Engines with even lower NOx values are available on request. MAN Diesel & Turbo is prepared to deliver NOx as well as SOx and particle reduction systems.
Heat Rate
The figures are given for 100% load and without engine driven pumps. Attached pumps will require additional fuel consumption. The tolerance for guarantee is +5%. Please note that the additions to fuel consumption must be considered before the tolerance for guarantee is taken into account. Basis for reference conditions, see section: “Ambient conditions according to ISO 3046-1:2002”

Conversion between heat rate and specific fuel oil consumption (SFOC) is found by applying the following formular:

\[
\text{SFOC (g/kWh)} = \frac{\text{Heat Rate} \times 1000}{\text{LHV}}
\]

The SFOC figures for engines in diesel operation are based on a lower calorific value of the fuel of 42,700 kJ/kg.

Ambient conditions according to ISO 3046-1:2002
The stated consumption figures refer to the following reference conditions according to ISO 3046-1:

- Ambient air pressure 100 kPa (1,000 mbar)
- Ambient air temperature 298 K (25°C)
- Charge air temperature According to engine type, corresponding to 25°C cooling water temperature before charge air cooler.

Specific lube oil consumption (SLOC)
The specific lube oil consumption is specified with a tolerance of 20%.

Masses and dimensions
The masses stated correspond to the complete unit (including alternator). The total weight varies depending on the alternator make. All masses listed are without lube oil and cooling water. Dimensions and weights are listed for guidance only and are subject to change without notice. The length of the GenSet unit depends on the alternator make.
Small power plant development – partner concept

MAN Diesel & Turbo has more than 17 years of experience in building small power plants with our worldwide partners. A small power plant usually means a plant with single or multiple units of approximately 1-4 MW/unit. The basic idea of the concept is to keep overall costs as low as possible by working with a high degree of standardisation and using as much local equipment and manpower as possible.

“Low costs for us – low costs for you”

The partner concept is basically a concept where we work with local or international partners, who then build power plants based on our Gen-Sets and our basic documentation and engineering. The remaining plant equipment and civil works are then delivered either by the partner or the customer, as the case may be.

MAN Diesel & Turbo has a great interest in maintaining the relevant standard and quality of all plants equipped with our GenSets.

For this reason, we provide partners and customers with our standard documentation, enabling the builder to complete the plant and the user to operate the plant successfully.

Ambatovy power plant with 9 × 7L27/38 is located on Madagascar
Small power plant development – the containerised solution

MAN Diesel & Turbo has developed a container concept based on the 9L21/31S GenSet. This is a unique concept where the power plant is composed of six GenSet containers and the containerised mechanical and electrical plant equipment. The entire plant has been designed with emphasis on reducing the civil work and site installation, and thereby the overall time needed on site. This power plant is able to operate on the same fuel as a conventional power plant up to a fuel viscosity of 700 cSt. A version operating on bio fuel is also available.

Although the plant is optimised with 6 containerised GenSets, the plant can be delivered with 1-8 GenSet containers depending on the customers need. Additionally, the GenSet containers can be delivered with varying cylinder numbers from 5 to 9 cylinders. This flexibility provides the customer with all the required combinations. If more power is required, the selected combination can be multiplied to meet this requirement.
**Containerised Power Plant (CPP) – 11 MW**

The CPP design concept for the engine-unit container and the auxiliary container have evolved from MAN Diesel & Turbo’s long experience of operating GenSets with diesel oil, HFO, bio fuel and crude oil. All auxiliary systems are based on well-proven setups and all auxiliary suppliers are recognised names within the energy sector involving the operation of GenSets using liquid fuels.

1. Engine container (9L21/31S)
2. HFO auxiliary container
3. Air auxiliary container
4. Electrical container (LV)
5. Electrical container (MV)
6. Fuel storage tanks

*Overview of HFO-burning containerised power plant (CPP). Typical CPP scope: 6 engine-unit containers, 2 mechanical aux. containers, 1 electrical aux. container, 1 control room container.*
Engine-Unit Container with MAN L21/31S GenSet

1. Engine (9L21/31S)
2. Generator
3. Exhaust gas silencer
4. Radiator cooler
5. Enclosure (container)
6. Lube oil separator
7. Air vessel for starting air
8. Fans for container ventilation (inlet)
9. Silencer for container ventilation (outlet)
10. Charge air filter
11. Air venting tank for HT water circuit
12. Pressure expansion tank

* Total weight of engine-unit container with 9L21/31S GenSet is 55 tons. GenSet output 1.81 MWe @ISO conditions.
### MAN V28/32S

**Bore 280 mm, Stroke 320 mm**

<table>
<thead>
<tr>
<th></th>
<th>16V</th>
<th>18V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine speed</td>
<td>750</td>
<td>720</td>
</tr>
<tr>
<td>Frequency</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>Electr. GenSet power</td>
<td>3,610</td>
<td>3,456</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>16V</th>
<th>18V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine speed</td>
<td>750</td>
<td>720</td>
</tr>
<tr>
<td>Frequency</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>Electr. GenSet power</td>
<td>3,610</td>
<td>3,456</td>
</tr>
</tbody>
</table>

**Electr. GenSet Heat Rate at 100% load**

<table>
<thead>
<tr>
<th></th>
<th>16V</th>
<th>18V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid fuel (WB2007/2008) kJ/kWh</td>
<td>8,420</td>
<td>8,411</td>
</tr>
</tbody>
</table>

**Lube Oil Consumption kg/h**

<table>
<thead>
<tr>
<th></th>
<th>16V</th>
<th>18V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.5-3.0</td>
<td>1.6-3.4</td>
</tr>
</tbody>
</table>

*Nominal generator efficiency 96%*

**GenSet dimensions**

<table>
<thead>
<tr>
<th></th>
<th>16V</th>
<th>18V</th>
</tr>
</thead>
<tbody>
<tr>
<td>A mm</td>
<td>6,116</td>
<td>6,626</td>
</tr>
<tr>
<td>B mm</td>
<td>3,822</td>
<td>4,081</td>
</tr>
<tr>
<td>C mm</td>
<td>9,938</td>
<td>10,707</td>
</tr>
<tr>
<td>W mm</td>
<td>2,470</td>
<td>2,470</td>
</tr>
<tr>
<td>H mm</td>
<td>3,574</td>
<td>3,574</td>
</tr>
<tr>
<td>Dry mass t</td>
<td>62.2</td>
<td>70.8</td>
</tr>
</tbody>
</table>

---

*Small Bore GenSets 67*
### MAN L28/32S

**Bore 280 mm, Stroke 320 mm**

<table>
<thead>
<tr>
<th>Engine speed</th>
<th>rpm</th>
<th>5L</th>
<th>6L</th>
<th>7L</th>
<th>8L</th>
<th>9L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Hz</td>
<td>50</td>
<td>60</td>
<td>50</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>Electr. GenSet power</td>
<td>kW</td>
<td>1,045</td>
<td>1,000</td>
<td>1,255</td>
<td>1,200</td>
<td>1,465</td>
</tr>
</tbody>
</table>

**Electr. GenSet Heat Rate at 100% load**

Liquid fuel (WB2007/2008)  
kJ/kWh  
8,549 8,518 8,549 8,518 8,549 8,518 8,549 8,518 8,549 8,518

**Lube Oil Consumption**  
kg/h  
0.7-1.1 0.8-1.3 0.9-1.5 1.0-1.8 1.2-2.0

*Nominal generator efficiency 95%*

**GenSet dimensions**

<table>
<thead>
<tr>
<th>A</th>
<th>mm</th>
<th>4,279</th>
<th>4,759</th>
<th>5,499</th>
<th>5,979</th>
<th>6,199</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>mm</td>
<td>2,400</td>
<td>2,510</td>
<td>2,680</td>
<td>2,770</td>
<td>2,690</td>
</tr>
<tr>
<td>C</td>
<td>mm</td>
<td>6,679</td>
<td>7,269</td>
<td>8,179</td>
<td>8,749</td>
<td>8,889</td>
</tr>
<tr>
<td>W</td>
<td>mm</td>
<td>2,370</td>
<td>2,370</td>
<td>2,390</td>
<td>2,419</td>
<td>2,489</td>
</tr>
<tr>
<td>H</td>
<td>mm</td>
<td>3,184</td>
<td>3,184</td>
<td>3,374</td>
<td>3,374</td>
<td>3,534</td>
</tr>
<tr>
<td>Dry mass</td>
<td>t</td>
<td>32.6</td>
<td>36.3</td>
<td>39.4</td>
<td>40.7</td>
<td>47.1</td>
</tr>
</tbody>
</table>

---

[Diagram showing dimensions A, B, C, W, H]
**MAN L28/32S-DF**

**Bore 280 mm, Stroke 320 mm**

<table>
<thead>
<tr>
<th>Engine speed</th>
<th>rpm</th>
<th>5L</th>
<th>6L</th>
<th>7L</th>
<th>8L</th>
<th>9L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Hz</td>
<td>50</td>
<td>60</td>
<td>50</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>Electr. GenSet power</td>
<td>kW</td>
<td>950</td>
<td>950</td>
<td>1,140</td>
<td>1,140</td>
<td>1,330</td>
</tr>
</tbody>
</table>

**Electr. GenSet heat rate at 100% load**

| Liquid fuel (WB2007/2008) kJ/kWh | 9,314 | 9,265 | 9,314 | 9,265 | 9,314 | 9,265 | 9,314 | 9,265 | 9,314 | 9,265 |

**Lube oil consumption** kg/h

| 0.6-1.0 | 0.7-1.2 | 0.8-1.4 | 1.0-1.6 | 1.0-1.8 |

Nominal generator efficiency 95%

**GenSet dimensions**

<table>
<thead>
<tr>
<th>A</th>
<th>mm</th>
<th>4,321</th>
<th>4,801</th>
<th>5,281</th>
<th>5,761</th>
<th>6,241</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>mm</td>
<td>2,400</td>
<td>2,510</td>
<td>2,680</td>
<td>2,770</td>
<td>2,690</td>
</tr>
<tr>
<td>C</td>
<td>mm</td>
<td>6,721</td>
<td>7,311</td>
<td>7,961</td>
<td>8,531</td>
<td>8,931</td>
</tr>
<tr>
<td>W</td>
<td>mm</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>H</td>
<td>mm</td>
<td>2,835</td>
<td>3,009</td>
<td>3,009</td>
<td>3,009</td>
<td>3,009</td>
</tr>
<tr>
<td>Dry mass</td>
<td>t</td>
<td>32.6</td>
<td>36.3</td>
<td>39.4</td>
<td>40.7</td>
<td>47.1</td>
</tr>
</tbody>
</table>

Gas / fuel ratio:

* at load: 30-90% 90 / 10
* at full load 80 / 20

Gas methane number ≥ 80
### MAN L27/38S

**Bore 270 mm, Stroke 380 mm**

<table>
<thead>
<tr>
<th></th>
<th>5L</th>
<th>6L</th>
<th>7L</th>
<th>8L</th>
<th>9L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine speed</td>
<td>rpm</td>
<td>750</td>
<td>720</td>
<td>750</td>
<td>720</td>
</tr>
<tr>
<td>Frequency</td>
<td>Hz</td>
<td>50</td>
<td>60</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>Electr. GenSet power</td>
<td>kW</td>
<td>1,536</td>
<td>1,440</td>
<td>1,900</td>
<td>1,900</td>
</tr>
</tbody>
</table>

**Electr. GenSet Heat Rate at 100% load**

<table>
<thead>
<tr>
<th>Liquid fuel (WB2007/2008)</th>
<th>kJ/kWh</th>
<th>8,140</th>
<th>8,095</th>
<th>8,140</th>
<th>8,095</th>
<th>8,140</th>
<th>8,095</th>
<th>8,140</th>
<th>8,095</th>
</tr>
</thead>
</table>

**Lube Oil Consumption**

<table>
<thead>
<tr>
<th>kg/h</th>
<th>0.7-1.3</th>
<th>0.8-1.6</th>
<th>0.9-1.8</th>
<th>1.1-2.1</th>
<th>1.2-2.4</th>
</tr>
</thead>
</table>

*Nominal generator efficiency 96%*

**GenSet dimensions**

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>W</th>
<th>H</th>
<th>Dry mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>4,346</td>
<td>2,486</td>
<td>6,832</td>
<td>2,293</td>
<td>3,712</td>
<td>40.0</td>
</tr>
<tr>
<td>mm</td>
<td>4,791</td>
<td>2,766</td>
<td>7,557</td>
<td>2,293</td>
<td>3,712</td>
<td>44.5</td>
</tr>
<tr>
<td>mm</td>
<td>5,236</td>
<td>2,766</td>
<td>8,002</td>
<td>2,420</td>
<td>3,899</td>
<td>50.4</td>
</tr>
<tr>
<td>mm</td>
<td>5,681</td>
<td>2,986</td>
<td>8,667</td>
<td>2,420</td>
<td>3,899</td>
<td>58.2</td>
</tr>
<tr>
<td>mm</td>
<td>6,126</td>
<td>2,986</td>
<td>9,112</td>
<td>2,420</td>
<td>3,899</td>
<td>64.7</td>
</tr>
</tbody>
</table>

**Nominal generator efficiency 96%**
### MAN L23/30S

**Bore 160 mm, Stroke 240 mm**

<table>
<thead>
<tr>
<th>Engine speed</th>
<th>rpm</th>
<th>5L</th>
<th>6L</th>
<th>7L</th>
<th>8L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Hz</td>
<td>60</td>
<td>50</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>Electr. GenSet power</td>
<td>kW</td>
<td>618/675 641/703 809 844 944 984 1,079 1,125</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Electr. GenSet Heat Rate at 100% load**

| Liquid fuel (WB2007/2008) | kJ/kWh | 8,585 8,630 8,585 8,630 8,585 8,630 8,585 8,630 |

**Bore 160 mm, Stroke 240 mm**

<table>
<thead>
<tr>
<th>Engine speed</th>
<th>rpm</th>
<th>5L</th>
<th>6L</th>
<th>7L</th>
<th>8L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Hz</td>
<td>-</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Electr. GenSet power</td>
<td>kW</td>
<td>-</td>
<td>998 1,164 1,330</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Electr. GenSet Heat Rate at 100% load**

| Liquid fuel (WB2007/2008) | kJ/kWh | 8,675 8,675 8,675 |

**Lube oil consumption**

| kg/h | 0.4-0.7 0.5-1.0 0.6-1.2 0.7-1.4 |

**Nominal generator efficiency 95%**

**GenSet dimensions**

<table>
<thead>
<tr>
<th>Cyl. No.</th>
<th>5</th>
<th>6</th>
<th>6</th>
<th>7</th>
<th>7</th>
<th>8</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>r/min</td>
<td>720/750 720/750 900 720/750 900 720/750 900</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A mm</td>
<td>3,369 3,738 3,738 4,109 4,109 4,475 4,475</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B mm</td>
<td>2,155 2,265 2,265 2,395 2,395 2,480 2,340</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C mm</td>
<td>5,524 6,004 6,004 6,504 6,504 6,959 6,815</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W mm</td>
<td>1,690 1,690 1,768 1,715 1,888 1,715 1,888</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H mm</td>
<td>2,402 2,402 2,466 2,466 2,466 2,466 2,466</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry mass</td>
<td>t</td>
<td>17.0 18.5 19.8 20.0 21.4 21.9 22.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
MAN L21/31S

**Bore 210 mm, Stroke 310 mm**

<table>
<thead>
<tr>
<th>Engine speed</th>
<th>5L</th>
<th>6L</th>
<th>7L</th>
<th>8L</th>
<th>9L</th>
</tr>
</thead>
<tbody>
<tr>
<td>rpm</td>
<td>1,000</td>
<td>900</td>
<td>1,000</td>
<td>900</td>
<td>1,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Hz</th>
<th>50</th>
<th>60</th>
<th>50</th>
<th>60</th>
<th>50</th>
<th>60</th>
<th>50</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electr. GenSet power</td>
<td>kW</td>
<td>1,045</td>
<td>1,045</td>
<td>1,254</td>
<td>1,254</td>
<td>1,463</td>
<td>1,463</td>
<td>1,672</td>
<td>1,672</td>
</tr>
</tbody>
</table>

**Electr. GenSet Heat Rate at 100% load**

<table>
<thead>
<tr>
<th>Liquid fuel (WB2007/2008)</th>
<th>kJ/kWh</th>
<th>8,405</th>
<th>8,360</th>
<th>8,405</th>
<th>8,360</th>
<th>8,405</th>
<th>8,360</th>
<th>8,405</th>
<th>8,360</th>
</tr>
</thead>
</table>

**Lube Oil Consumption**

<table>
<thead>
<tr>
<th>kg/h</th>
<th>0.4-0.9</th>
<th>0.5-1.1</th>
<th>0.6-1.2</th>
<th>0.7-1.4</th>
<th>0.8-1.6</th>
</tr>
</thead>
</table>

*Nominal generator efficiency 95%*

**GenSet dimensions**

<table>
<thead>
<tr>
<th>A</th>
<th>mm</th>
<th>3,959</th>
<th>4,314</th>
<th>4,669</th>
<th>5,024</th>
<th>5,379</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>mm</td>
<td>1,870</td>
<td>2,000</td>
<td>1,970</td>
<td>2,250</td>
<td>2,400</td>
</tr>
<tr>
<td>C</td>
<td>mm</td>
<td>5,829</td>
<td>6,314</td>
<td>6,639</td>
<td>7,274</td>
<td>7,779</td>
</tr>
<tr>
<td>W</td>
<td>mm</td>
<td>1,750</td>
<td>1,750</td>
<td>1,750</td>
<td>1,750</td>
<td>1,750</td>
</tr>
<tr>
<td>H</td>
<td>mm</td>
<td>3,183</td>
<td>3,183</td>
<td>3,289</td>
<td>3,289</td>
<td>3,289</td>
</tr>
</tbody>
</table>

Dry mass | t | 21.5 | 23.7 | 25.9 | 28.5 | 30.9 |

---

72 Small Bore GenSets
**MAN L16/24S**

Bore 160 mm, Stroke 240 mm

<table>
<thead>
<tr>
<th>Engine speed</th>
<th>5L</th>
<th>6L</th>
<th>7L</th>
<th>8L</th>
<th>9L</th>
</tr>
</thead>
<tbody>
<tr>
<td>rpm</td>
<td>1,000</td>
<td>1,200</td>
<td>1,000</td>
<td>1,200</td>
<td>1,000</td>
</tr>
</tbody>
</table>

| Frequency | Hz | 50 | 60 | 50 | 60 | 50 | 60 | 50 | 60 |

| Electr. GenSet power | kW | 428 | 475 | 542 | 627 | 732 | 722 | 836 | 812 | 941 |

**Electr. GenSet heat rate at 100% load**

Liquid fuel (WB2007/2008) kJ/kWh

| kW | 428 | 475 | 542 | 627 | 632 | 732 | 722 | 836 | 812 | 941 |

**Lube oil consumption**

| kW | 0.2-0.4 | 0.2-0.5 | 0.3-0.6 | 0.3-0.7 | 0.3-0.8 |

*Nominal generator efficiency 96%*

**GenSet dimensions**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>W</th>
<th>H</th>
<th>Dry mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>2,807</td>
<td>3,082</td>
<td>3,557</td>
<td>3,832</td>
<td>4,107</td>
</tr>
<tr>
<td>mm</td>
<td>1,400</td>
<td>1,490</td>
<td>1,585</td>
<td>1,680</td>
<td>1,680</td>
</tr>
<tr>
<td>mm</td>
<td>4,207</td>
<td>4,572</td>
<td>5,142</td>
<td>5,512</td>
<td>5,787</td>
</tr>
<tr>
<td>mm</td>
<td>1,464</td>
<td>1,464</td>
<td>1,478</td>
<td>1,478</td>
<td>1,478</td>
</tr>
<tr>
<td>mm</td>
<td>2,337</td>
<td>2,337</td>
<td>2,415/2,337</td>
<td>2,415</td>
<td>2,415</td>
</tr>
<tr>
<td>t</td>
<td>9.5</td>
<td>10.5</td>
<td>11.4</td>
<td>12.4</td>
<td>13.1</td>
</tr>
</tbody>
</table>

**Dry mass**

- 9.5 t
- 10.5 t
- 11.4 t
- 12.4 t
- 13.1 t
MAN Diesel & Turbo Engines

MAN Diesels & Turbo designs MAN B&W two-stroke low speed diesel engines and MAN four-stroke small bore GenSets for stationary application.

The design is based on continuous development to meet the customers’ requirements in the following focus areas:

- Highest fuel efficiency
- Low maintenance costs
- High reliability
- Operational flexibility – from base load to standby
- Wide fuel flexibility
- Wide scope for thermal energy recovery
- Insensitivity to high ambient temperatures and high-altitude locations
- Modular concept for flexible capacity expansion

The MAN Diesel & Turbo engines of our design are characterised by robustness, reliability, simple operation and easy maintenance, which are preconditions for achieving an availability of more than 8,000 hours per year.

The engines of our design are sold and built by licensees (engine builders) located world wide.
Definitions

MAN B&W two-stroke low speed diesel engines are designed to provide optimum fuel flexibility and are an ideal source of power, whether operating on gas, liquid fuel or liquid biofuel.

Liquid fuels: HFO, diesel, crude biofuel and crude oil.
Gaseous fuels: Natural gas and LNG.
Liquid gas fuels: LPG, DME, methanol and ethanol.

Engine and GenSet power

The engine and generator power are stated in kW. Ratings are given according to ISO 3046-1:2002. The electrical power has been calculated based on a standard generator efficiency according to IEC 60034 in the corresponding power range and at a power factor of 0.9. This is for guidance only as it is to be confirmed by the selected generator maker.

Nominal rating (MCR)

The engine ratings quoted remain valid up to tropical conditions:

- Blower inlet temperature 45ºC
- Blower inlet pressure 1,000 mbar
- Charge air coolant temperature 32ºC

For more demanding ambient conditions, please contact MAN Diesel & Turbo, Copenhagen or the engine builder.

Engine application

The engine ratings and speeds shown are based on generator drive application. For other drives, such as mechanical drive of mills, pumps, compressors, etc., please contact MAN Diesel & Turbo, Copenhagen, or the engine builder. The diesel generating set ratings and heat rates shown depend on the actual generator make and are for guidance only.
Site specified rating

$L_1 \geq \text{site specified rating} \geq L_2$

The engine may be operated without restriction at any load up to site specified rating. Operating at overload rating, i.e. 110% of the site specified rating, is permissible for one hour every 12 consecutive hours.

Engine heat rate

The figures specified in the table refer to mechanical output and to ISO 3046/1-2002 ambient conditions:

- Blower inlet temperature 25°C
- Blower inlet pressure 1,000 mbar
- Charge air coolant temperature 25°C

For other ambient conditions, please contact MAN Diesel & Turbo, Copenhagen, or the engine builder.

Fuel oil consumption guarantee – MC-S engines

The MCR engine heat rate guaranteed by MAN Diesel & Turbo is subject to a tolerance of ±5% at ISO 3046/1-2002 ambient conditions. For other ambient conditions and for engines with emission control, TCS and/or BCST, please contact MAN Diesel & Turbo, Copenhagen, or the engine builder.

Turbocharger selection

Two-stroke low speed engines can be delivered with MAN Diesel & Turbo, ABB Turbo Systems Ltd., or Mitsubishi Heavy Industries, Ltd., turbochargers as standard.
Engine design

MC-S design
The MAN B&W two-stroke low speed diesel engines are provided with mechanically driven camshaft, which controls the fuel oil pumps and exhaust valves. These engines operate on liquid fuels only.

ME-S design
The electronic control of the MAN B&W two-stroke low speed diesel engines includes the combustion process, i.e. fuel injection timing, actuation of exhaust valves, starting valves and cylinder lubrication. The extent of electronic control depends on the fuel quality, engine bore size and design principles at the time of the order. These engines operate on liquid fuels only.

ME-GI-S design
Engines operating on dual fuel, i.e. gaseous fuel oil with high flash point and pilot oil, will be designated ME-GI-S. The engines operate on any highcalorific gas, which can be compressed to 300 bar at 45°C entering the engine as single phase.

ME-LGI-S design
Engines operating on dual fuel, i.e. liquid gas fuels with low flash point and pilot oil, will be designated ME-LGI-S.
Heavy fuel oil engines

The engine data stated are valid using marine diesel oil or heavy fuel oil according to the guiding specification (maximum values at inlet to centrifuging plant):

- Density at 15°C kg/m$^3$ 991*
- Kinematic viscosity at 100°C cSt 55
- Kinematic viscosity at 50°C cSt 700
- Flash point °C min. 60
- Pour point °C 30
- Carbon residue % (m/m) 22
- Ash % (m/m) 0.15
- Total sediment after ageing % (m/m) 0.10
- Water % (v/v) 1.0
- Sulphur % (m/m) 5.0
- Vanadium mg/kg 600
- Aluminium/silicon mg/kg 60

Equal to ISO 8217/CIMAC-H55

* 1010 provided automatic modern clarifiers are installed.
Biofuel engines

The engine data stated are valid using liquid biofuel according to the guiding specification (maximum values at inlet to centrifuging plant):

- Density at 15ºC kg/m³ 1,010
- Kinematic viscosity at 10ºC cSt 55
- Flash point ºC ≥60
- Carbon residue % (m/m) 22
- Ash % (m/m) 0.15
- Water % (m/m) 1.0
- Sulphur* % (m/m) 5.0
- Vanadium ppm (m/m) 600
- Aluminium + Silicon mg/kg 80
- Sodium plus potassium ppm (m/m) 200
- Calcium ppm (m/m) 200
- Lead ppm (m/m) 10
- TAN (Total Acid Number) mg KOH/g <25
- SAN (Strong Acid Number) mg KOH/g 0

* Iodine, phosphorus and sulphur content according to agreement with emission controls maker.

For other fuel qualities, please contact MAN Diesel & Turbo, Copenhagen, or the engine builder.
Dual fuel engines

All engine types from 35 to 98-bore mentioned in the power plants programme are available as dual fuel engines under the designation ME-GI-S or ME-LGI-S.

*Automatic switchover between gas and pilot oil or fuel injection at 10% load

Technical data

Power, speed and gross efficiency of the ME-S, ME-GI-S and ME-LGI-S type engines are the same as for the corresponding MC-S engines. Please contact MAN Diesel & Turbo in Copenhagen or the engine builder for technical engine data for your specific project, including project specific emission requirements.
Two-stroke low speed diesel engine of MAN B&W design in combined cycle

Part load behaviour

<table>
<thead>
<tr>
<th>Efficiency %</th>
<th>Load %</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>50</td>
</tr>
<tr>
<td>54</td>
<td>60</td>
</tr>
<tr>
<td>53</td>
<td>70</td>
</tr>
<tr>
<td>52</td>
<td>80</td>
</tr>
<tr>
<td>51</td>
<td>90</td>
</tr>
<tr>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

- Combined cycle with TCS
- Single cycle with TCS
- Single cycle
Engine emissions
The engine data are valid for emission uncontrolled engines. For information on emission control, please contact MAN Diesel & Turbo, Copenhagen, or the engine builder.

Turbo compound system (TCS)
The turbo compound system, subject to the use of high-efficiency turbochargers, can be applied on the K98, K90, K80 and K60MC-S type engines as well as K90 and K80MC-S9. The use of a TCS system allows a reduction of up to 4% of the combined heat rate, depending on the site ambient conditions.

For detailed information, please contact MAN Diesel & Turbo, Copenhagen, or the engine builder.

MAN TCS unit for exhaust gas energy recovery
Utilisation of the energy sources of the diesel engine

MAN B&W two-stroke low speed stationary diesel engines can be optimised to the following fields of energy productions:

- District heating/cooling
- Freshwater

The following energy sources of the diesel engine can be utilised for district heating/cooling or freshwater production:

- Heat from scavenge air cooling
- Heat from jacket cooling
- Heat from lube oil cooling

For further technical information about this topic, please contact MAN Diesel & Turbo, Copenhagen, or the engine builder.

Extent of delivery

The final and binding extent of delivery of MAN B&W two-stroke diesel engines is to be supplied by our licensees, the engine builders, who are to be contacted in order to plan the execution of the actual project.

In order to facilitate negotiations between the end-user, contractor and engine maker, a guiding ‘Extent of Delivery’ (EoD), ref. publication no 2030-0001-06ppr Sep 2012, is available in which recommendations for MAN Diesel & Turbo’s basic and optional executions for the engine proper are specified. The publication is subject to modification in the interest of the technical progress without notice.

Please note that the licensees may select a different extent of delivery as their standard.
Engine type designation

7 K 80 M E -GI -S 9

- **Mark number**
- **Design**
  - S Stationary
- **Fuel injection concept**
  - GI Gas injection high flash point gas fuel
  - LGI Gas injection for low flash point gas fuel
- **Concept**
  - E Electronically controlled
  - C Camshaft controlled
- **Engine programme series**
- **Diameter of piston in cm**
- **Stroke/bore ratio**
  - L Long stroke
  - K Short stroke
- **Number of cylinders**
Power Product Overview
MAN B&W low speed engines

- MAN B&W K98MC-S
- MAN B&W K90MC-S9
- MAN B&W K90MC-S
- MAN B&W K80MC-S9
- MAN B&W K80MC-S
- MAN B&W K60MC-S
- MAN B&W K50MC-S
- MAN B&W L35MC-S
**MAN B&W K98MC-S**

### Site Rating

- **L₁**: Power optimised
- **L₂**: Fuel economy optimised

### Bore 980 mm, Stroke: 2,400 mm

### Power and Heat Rate

<table>
<thead>
<tr>
<th>Speed</th>
<th>r/min</th>
<th>103.4</th>
<th>102.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Hz</td>
<td>50</td>
<td>60</td>
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<table>
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<tbody>
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<td>kWₑ</td>
<td>kWₘₙ</td>
<td>kWₑ</td>
<td>kWₘₙ</td>
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<td>44,265</td>
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<td>48,690</td>
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<td>53,120</td>
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<td>61,970</td>
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### Heat Rate at MCR

<table>
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<tbody>
<tr>
<td>7,387</td>
<td>7,387</td>
</tr>
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</table>

### Lubricating and Cylinder Oil Consumption

- **Lubricating oil consumption**: 0.3 - 0.7 kg/cyl.h
- **Cylinder oil consumption**: 0.6 - 1.2 g/kWh
MAN B&W K90MC-S9

Site Rating

L₁ : Power optimised
L₂ : Fuel economy optimised

Speed

Bore 900 mm, Stroke 2,600 mm

Power and Heat Rate

<table>
<thead>
<tr>
<th>Layout points</th>
<th>L₁</th>
<th>L₂</th>
<th>L₁</th>
<th>L₂</th>
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<td>kWₑe</td>
<td>kWₑm</td>
<td>kWₑe</td>
<td>kWₑm</td>
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<tr>
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<td>35,570</td>
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<td>49,430</td>
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Heat Rate at MCR

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<th>kWₑm</th>
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<td>7,003</td>
</tr>
<tr>
<td>7,314</td>
<td>7,183</td>
</tr>
</tbody>
</table>

With TCS

Up to 4% heat rate reduction is obtainable depending on actual site ambient conditions.

Lubricating and Cylinder Oil Consumption

| Lubricating oil consumption | 0.3 - 0.6 kg/cyl.h |
| Cylinder oil consumption   | 0.6 - 1.2 g/kWh |
**Site Rating**

- $L_1$: Power optimised
- $L_2$: Fuel economy optimised

**Bore 900 mm, Stroke: 2,300 mm**

**Power and Heat Rate**

<table>
<thead>
<tr>
<th>Speed r/min</th>
<th>107.1</th>
<th>109.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Hz</td>
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<td>$kW_m$</td>
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<tr>
<td>7 K90MC-S</td>
<td>31,080</td>
<td>30,300</td>
<td>24,850</td>
<td>24,230</td>
</tr>
<tr>
<td>8 K90MC-S</td>
<td>35,520</td>
<td>34,630</td>
<td>26,800</td>
<td>26,130</td>
</tr>
<tr>
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<td>44,400</td>
<td>43,290</td>
<td>35,500</td>
<td>34,610</td>
</tr>
<tr>
<td>11 K90MC-S</td>
<td>48,840</td>
<td>47,620</td>
<td>39,050</td>
<td>38,075</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Speed r/min</th>
<th>103.4</th>
<th>102.9</th>
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</thead>
<tbody>
<tr>
<td>12 K90MC-S</td>
<td>51,480</td>
<td>50,193</td>
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</tbody>
</table>

**Heat Rate at MCR**

- **7-12 cyl:**
  - $kJ/kWh_m$: 7,344  7,088  7,344  7,088
  - $kJ/kWh_e$: 7,532  7,270  7,532  7,270

**With TCS**

Up to 4% heat rate reduction is obtainable depending on actual site ambient conditions.

**Lubricating and Cylinder Oil Consumption**

- Lubricating oil consumption: 0.3 - 0.6 kg/cyl.h
- Cylinder oil consumption: 0.6 - 1.2 g/kWh
**MAN B&W K80MC-S9**

**Site Rating**

- **L₁ : Power optimised**
- **L₂ : Fuel economy optimised**

**Bore 800 mm, Stroke 2,600 mm**

**Power and Heat Rate**

<table>
<thead>
<tr>
<th>Speed r/min</th>
<th>103.4</th>
<th>102.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Hz</td>
<td>50</td>
<td>60</td>
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</table>

<table>
<thead>
<tr>
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<th>L₂</th>
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<td>kWₑ</td>
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<td>kWₑ</td>
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<td>38,610</td>
</tr>
<tr>
<td>12 K80MC-S9</td>
<td>48,120</td>
<td>46,920</td>
<td>43,200</td>
<td>42,120</td>
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</tbody>
</table>

**Heat Rate at MCR**

<table>
<thead>
<tr>
<th>kJ/kWhₑ</th>
<th>7,314</th>
<th>7,183</th>
<th>7,314</th>
<th>7,183</th>
</tr>
</thead>
<tbody>
<tr>
<td>kJ/kWhₑ</td>
<td>7,131</td>
<td>7,003</td>
<td>7,131</td>
<td>7,003</td>
</tr>
</tbody>
</table>

**With TCS**

Up to 4% heat rate reduction is obtainable depending on actual site ambient conditions.

**Lubricating and Cylinder Oil Consumption**

- **Lubricating oil consumption**: 0.3 - 0.5 kg/cyl.h
- **Cylinder oil consumption**: 0.6 - 1.2 g/kWh
**MAN B&W K80MC-S**

**Site Rating**

- **L₁**: Power optimised
- **L₂**: Fuel economy optimised

**Bore 800 mm, Stroke 2,300 mm**

**Power and Heat Rate**

<table>
<thead>
<tr>
<th>Speed r/min</th>
<th>107.1</th>
<th>109.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Hz</td>
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<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>L₂</th>
<th>L₁</th>
<th>L₂</th>
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<td>kWe</td>
<td>kWm</td>
<td>kWe</td>
<td>kWm</td>
<td>kWe</td>
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<td>9 K80MC-S</td>
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<td>32,875</td>
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**Heat Rate at MCR**

<table>
<thead>
<tr>
<th>kJ/kWhm</th>
<th>7,344</th>
<th>7,088</th>
<th>7,344</th>
<th>7,088</th>
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</thead>
<tbody>
<tr>
<td>kJ/kWe</td>
<td>7,532</td>
<td>7,270</td>
<td>7,532</td>
<td>7,270</td>
</tr>
</tbody>
</table>

**With TCS**

Up to 4% heat rate reduction is obtainable depending on actual site ambient conditions.

**Lubricating and Cylinder Oil Consumption**

<table>
<thead>
<tr>
<th>Lubricating oil consumption</th>
<th>0.3 - 0.5 kg/cyl.h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder oil consumption</td>
<td>0.6 - 1.2 g/kWh</td>
</tr>
</tbody>
</table>
MAN B&W K60MC-S

Site Rating

L₁ : Power optimised
L₂ : Fuel economy optimised

Bore 600 mm, Stroke 1,740 mm

Power and Heat Rate

<table>
<thead>
<tr>
<th>Speed r/min</th>
<th>150</th>
<th>150</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>Layout points</td>
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<td>L₂</td>
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<tr>
<td>kWₘm</td>
<td>kWₑ</td>
<td>kWₘm</td>
</tr>
<tr>
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<td>17,375</td>
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<td>19,800</td>
<td>19,305</td>
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<tr>
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<td>21,235</td>
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Heat Rate at MCR

<table>
<thead>
<tr>
<th>kWₘm</th>
<th>kWₑ</th>
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<tbody>
<tr>
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<td>7,046</td>
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<tr>
<td>7,174</td>
<td>7,046</td>
</tr>
</tbody>
</table>

With TCS

Up to 4% heat rate reduction is obtainable depending on actual site ambient conditions.

Lubricating and Cylinder Oil Consumption

| Lubricating oil consumption | 0.2 - 0.3 kg/cyl.h |
| Cylinder oil consumption   | 0.6 - 1.2 g/kWh   |
MAN B&W K50MC-S

Site Rating

L₁: Power optimised
L₂: Fuel economy optimised

Bore 500 mm, Stroke 1,370 mm

Power and Heat Rate

<table>
<thead>
<tr>
<th>Speed r/min</th>
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<tr>
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<tr>
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<td>19,880</td>
<td>19,385</td>
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</table>

Heat Rate at MCR

kJ/kWhₑ: 7,430 7,174 7,430 7,174
kJ/kWhₑ: 7,621 7,358 7,621 7,358

Lubricating and Cylinder Oil Consumption

| Lubricating oil consumption | 0.17 - 0.21 kg/cyl.h |
| Cylinder oil consumption  | 0.6 - 1.2 g/kWh |
MAN B&W L35MC-S

Site Rating

- $L_1$: Power optimised
- $L_2$: Fuel economy optimised

Bore 350 mm, Stroke 1,050 mm

Power and Heat Rate

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<th>L2</th>
<th>L1</th>
<th>L2</th>
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<td>kW_e</td>
<td>kW_m</td>
<td>kW_e</td>
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<td>4,055</td>
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<td>5,850</td>
<td>5,705</td>
<td>4,680</td>
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<td>6,340</td>
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<td>5,070</td>
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<td>5,575</td>
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Heat Rate at MCR

<table>
<thead>
<tr>
<th></th>
<th>kW/m</th>
<th>kW/h</th>
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</thead>
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<tr>
<td>7 L35MC-S</td>
<td>7,387</td>
<td>7,131</td>
</tr>
<tr>
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Lubricating and Cylinder Oil Consumption

<table>
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<tr>
<th>Consumption Type</th>
<th>Range</th>
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<tbody>
<tr>
<td>Lubricating oil consumption</td>
<td>0.08 - 0.13 kg/cyl/h</td>
</tr>
<tr>
<td>Cylinder oil consumption</td>
<td>0.6 - 1.2 g/kWh</td>
</tr>
</tbody>
</table>
Turbochargers

Engineering the Future – since 1758.
MAN Diesel & Turbo
Power Product Overview

Turbochargers

MAN Diesel & Turbo is the world’s leading designer and manufacturer of large exhaust gas turbochargers for low and medium speed diesel and gas engines.

As an integral part of a leading developer and builder of two and four-stroke, low and medium speed engines, the MAN Diesel & Turbo Business Unit Turbocharger has a deep understanding of the core technologies of large engines and their interaction with the turbocharger.

The integral development and design of engine and turbocharger results in world and market leading turbocharger technology.

Features and benefits of TCA, TCR, NA, NR

- Uncooled gas casings
- In-board plain bearing arrangement
- Lubrication by engine lube oil system
- High efficiency
- High availability, reliability, durability
- Easy maintenance and servicing
- Long lifetime of components
- Long intervals between overhauls
- A one stop service for engine and turbocharger
- Knowledgeable partners in more than 150 service stations worldwide

Applications for marine and stationary

- Propulsion units
- Generating sets
- Diesel and dual fuel engines
- Gas engines
- HFO engines
Special

- Tailormade solutions
- Power turbines (PTG)
- Turbo compound systems (TCS–PTG) with power turbine and generator
- Variable turbine area (VTA)

2 × TCR22 turbochargers with VTA on 20V32/44CR engine
Steam Turbines for Power Plants

Engineering the Future – since 1758.
MAN Diesel & Turbo
Bioenergy is renewable energy made available from biological sources. Biomass is any organic material which has stored sunlight in form of chemical energy such as wood, straw, manure, sugarcane or many other by-products from a variety of agricultural processes. Bioenergy contributes to reduce atmospheric methane and carbon emissions as well as fossil fuel consumption and strengthen energy security due to its steady availability.

MAN Diesel & Turbo offers for bioenergy plants a highly comprehensive range of steam turbines (2 - 40 MW) with proven performance and high availability. In industrial biomass plants the efficiency of combined heat and power plays an important role. MAN Diesel & Turbo is well prepared to optimize the complete water/steam-cycle in close cooperation with its customers.

<table>
<thead>
<tr>
<th>Order year</th>
<th>Country of Installation</th>
<th>Customer</th>
<th>MDT equipment</th>
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<tr>
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<td>Romania</td>
<td>Fritz Egger GmbH &amp; Co.</td>
<td>Steam turbine-generator set MARC-4 C11</td>
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<tr>
<td>2011</td>
<td>Finland</td>
<td>Fortum Power and Heat Oy</td>
<td>Steam turbine-generator set MARC 6-H04</td>
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<tr>
<td>2010</td>
<td>France</td>
<td>Dalkia France</td>
<td>Steam turbine-generator set MARC-2 C11</td>
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<td>2010</td>
<td>Latvia</td>
<td>MW Biopower Oy</td>
<td>Steam turbine-generator set MARC-2 H01</td>
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</table>
Steam Turbines for Power Plants

Concentrated solar power (CSP)

The requirement to produce CO\(_2\) neutral electricity by using renewable energy sources has created various innovative solutions. One of these solutions is Concentrated solar power (CSP), established especially in sun-rich countries.

In CSP power plants mirrors reflect the solar radiation to a receiver. Different technologies exist for the extraction of this energy. Sunlight is converted via mirrors and receivers into heating directly vaporizing water into steam or increasing the temperature of thermo oil or molten salt. By way of water fed heat exchangers steam is produced and expanded in a steam turbine driving a generator.

In CSP power plants efficiency plays a major role due to high overall investment costs and renewable energies feed-in legislation. MAN Diesel & Turbo is well prepared to optimize the complete water/steam-cycle in close cooperation with its customers. Depending on the plant concept re-heat (two casings) or single casing steam turbines both with up to 8 bleeds for pre-heating purposes can be supplied. MAN Diesel & Turbo offers more than 10 steam turbines for solar power generation with a power output range of 4 up to 125 MW.

Selected CSP References

<table>
<thead>
<tr>
<th>Order year</th>
<th>Country of Installation</th>
<th>Customer</th>
<th>MDT equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>Les Borges Blanques, Spain</td>
<td>UTE Termosolar Borges</td>
<td>Steam turbine-generator MARC 6-R05 (water-cooled condenser)</td>
</tr>
<tr>
<td>2011</td>
<td>Viellena, Spain</td>
<td>UTE Termosolar</td>
<td>Steam turbine-generator set (reheat)</td>
</tr>
<tr>
<td>2010</td>
<td>Palma del Rio, Spain</td>
<td>UTE Termosolar</td>
<td>Steam turbine-generator set (reheat)</td>
</tr>
<tr>
<td>2009</td>
<td>Kanchanaburi, Thailand</td>
<td>Thai Solar Energy</td>
<td>Steam turbine-generator MARC 2-C04 (water-cooled condenser)</td>
</tr>
<tr>
<td>2008</td>
<td>Alcudia de Guadix, Spain Solar Millenium AG</td>
<td></td>
<td>Steam turbine-generator set (reheat)</td>
</tr>
<tr>
<td>2008</td>
<td>Shams, UAE</td>
<td>PJSC</td>
<td>Steam turbine-generator set</td>
</tr>
</tbody>
</table>
Steam Turbines for Power Plants
Pulp & paper

The pulp & paper industry is mainly situated in North America, Scandina-
via, East Asia and South America. It uses wood as raw material to pro-
duce pulp, paper and other cellulose-based products.

Steam turbines that are utilized in the pulp & paper industry have an im-
portant function in the plant process. Thanks to the highly comprehensive
range of efficient and custom-made steam turbines, MAN Diesel & Turbo
is well prepared for our customer demands. We offer controlled and un-
controlled extractions and are able to provide all relevant equipment for
the steam turbine generator set (i.e. generator and condenser).

In 2009 MAN Diesel & Turbo supplied two steam turbines with 98 MWel
and 60 MWel power output to the South American market.

Selected Pulp & Paper References

<table>
<thead>
<tr>
<th>Order year</th>
<th>Country of Installation</th>
<th>Customer / Operator</th>
<th>MDT equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>Santa Fe, Chile</td>
<td>CMPC</td>
<td>Steam turbine-generator set</td>
</tr>
<tr>
<td>2009</td>
<td>Laja, Chile</td>
<td>CMPC</td>
<td>Steam turbine-generator set</td>
</tr>
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</table>
Waste-to-Energy (WtE) refers to treatment and conversion of waste sources into electricity or/and heat. In many WtE plants the objective is waste removal by incineration rather than landfill. The heat generated by this combustion process can be used for power generation resulting in additional profit for the operator. WtE activities in Europe intensified after the 2005 EU Directive prohibiting landfill of non-treated waste.

Depending on the customer requirements, MAN Diesel & Turbo can include parts of the water-steam-cycle into its scope of supply. This is in addition to the steam turbine generator. Examples of such typical additional deliveries may include heating condensers, air-cooled condensers,
pre-heaters, by-pass stations and some connecting pipe work. A special operational requirement that we encounter in the WtE business is long-term turbine bypass operation. For this requirement turbine blading design can be adapted.

Electrical power generation based on waste incineration is an example of an application for MAN steam turbines. In 2011 MAN Diesel & Turbo delivered the biggest steam turbine generator set for a WtE plant in the U.K. with a power output of 80 MWel.

Selected Waste-to-Energy References

<table>
<thead>
<tr>
<th>Order year</th>
<th>Country of Installation</th>
<th>Customer</th>
<th>MDT equipment</th>
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<tr>
<td>2011</td>
<td>Oxfordshire, U.K.</td>
<td>CNIM</td>
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<td>2010</td>
<td>MHKW Kassel, Germany</td>
<td>Müllheizkraftwerk Kassel GmbH</td>
<td>Steam turbine-generator MARC 6-C11, water-cooled condenser</td>
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<td>2010</td>
<td>Torino, Italy</td>
<td>Unieco Torino</td>
<td>Steam turbine-generator set incl. condenser</td>
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<tr>
<td>2008</td>
<td>South East London, U.K.</td>
<td>vonRoll, Riverside Resource &amp; Recovery</td>
<td>Steam turbine-generator set (controlled extraction to provide energy for district heating)</td>
</tr>
<tr>
<td>2007</td>
<td>WTE Teeside Cleveland, U.K.</td>
<td>SITA Suez</td>
<td>Steam turbine-generator MARC 4-C03</td>
</tr>
<tr>
<td>2003</td>
<td>KVV Torsvik, Sweden</td>
<td>Jönköping Energie AB</td>
<td>Steam turbine-generator MARC 4-H02, HP + LP pre-heaters, bypass station, summer cooler, piping</td>
</tr>
</tbody>
</table>
In recent years, local and global regulations covering exhaust gas emissions from internal combustion engines have become increasingly stringent. These regulations mainly focus on NO\textsubscript{x}, HC, SO\textsubscript{x}, particle and sound emissions and their surveillance. MAN Diesel and Turbo has developed the power plant technology to ensure full compliance.
Catalytic after-treatment of the exhaust gas breaks down harmful NO$_x$ into harmless nitrogen and water. A reducing agent is injected into the exhaust gas flow upstream from a catalytic reactor. Together with the catalyst, this agent causes the breakdown of the NO$_x$. With SCR, the engine can operate at partial and full load and maximum efficiency. With this technology a NO$_x$ reduction ratio of up to 97% is achievable.

MAN Diesel & Turbo developed a standardized portfolio of SCR systems together with leading catalyst developers and producers, based on the experience of several successful projects.
Where excellent thermal efficiency is required and/or emission limits for carbon monoxide, hydrocarbons or formaldehyde are given in combination with low sulfur fuels (gas or liquid), oxidation catalysts are the key to success.

Based on the individual requirements, MAN will select the best catalyst for your application based on function and price oxidization from a series of different coated catalysts. A monitoring system will indicate when the catalyst has to be cleaned or replaced.

Oxidation catalysts can be easily combined with SCR systems, if necessary.

The main reactions in oxidation catalyst systems are:

<table>
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<th>Substance</th>
<th>Reaction Formula</th>
</tr>
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<tr>
<td>Carbon Monoxide</td>
<td>CO + ½ O₂ → CO₂</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>C_mH_n + (m + n/4) O₂ → m CO₂ + n/2 H₂O</td>
</tr>
<tr>
<td>Aldehydes, Ketones, etc.</td>
<td>C_mH_nO + (m + n/4 - 0.5) O₂ → m CO₂ + n/2 H₂O</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>H₂ + ½ O₂ → H₂O</td>
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</table>
SO\textsubscript{X} emissions are caused by the sulphur content in the fuel and cannot be influenced by the engine. Any sulphur burned in the combustion process will be emitted as SO\textsubscript{X}. Low-sulphur fuel is usually expensive and not always available, and removing sulphur from the fuel can be costly. The sulphur has to be removed from the exhaust gas by the appropriate technique to fulfill different emission limits.

**Two established methods are available:**
- Conditioned dry scrubbing with hydrated lime powder
- Dry scrubbing with sodium bicarbonate powder

The choice of the suitable desulfurization method depends mainly on the water and absorbent availability.
Due to the ash content and combustion characteristics of the fuel in heavy fuel oil applications, particle emissions will occur. Where it is necessary to reduce these already low particle emissions further, two different systems are possible:

**Electrostatic precipitator (ESP):**
For high exhaust gas temperature applications, electrofiltration, the electrostatic attraction of ionized particles, is the best solution.

**Bag filtration:**
Where low exhaust gas temperatures are given, for example in CHP applications, bag filters are applicable. If necessary, these can be easily combined with a DeSO\textsubscript{X} system.

**Emission monitoring**
To fulfill local regulations regarding proof of exhaust gas emissions and to ensure ideal operation of exhaust gas treatment units MAN Diesel & Turbo will choose the best solution in terms of price and practicality to fulfil your needs. The function and reliability of these systems has been proven in a number of installations.
The specification of the particular requirements for acoustically relevant equipment follows as a result of the acoustical design of a power plant.

The reduction of the sound emissions is achieved by means of appropriate sound attenuation (silencers) and damping (of buildings and equipment) as well as by use of low-emission equipment (radiator coolers, transformers, compressors and pumps).

Factory and site acceptance tests are made to verify the fulfilment of the requirements to specific equipment and the plant as a whole.
Services

Engineering the Future – since 1758.

MAN Diesel & Turbo
PrimeServ is MAN Diesel & Turbo’s highly efficient and customer-oriented aftersales organisation with more than 115 service centres worldwide, offering first-class 24/7 technical support and customer service.

PrimeServ Product & Service Overview
1. Spare Parts
2. Upgrade and Retrofit
3. Service Agreements
4. Additional PrimeServ Solutions
5. PrimeServ Academies

1. Spare Parts
Basis for safe and efficient operation with global availability of original high-quality spare parts from PrimeServ and 24h delivery service for urgent requirements.

2. Upgrade and Retrofit
Broad range of solutions updating engines in service to latest standards, i.e. in order to meet modern emission levels and lowering operation costs not only for MAN engines, but also for third-party engines.
- Fuel conversion retrofits, such as liquid fuel oil to dual fuel, liquid fuel oil to gas or special fuel (e.g. bio fuel)
- Measures improving fuel & lube oil savings and emission reductions, enhancing engine lifetime and reliability (Common Rail, SCR-systems, DeSOx-scrubbers, MDO/MGO upgrades, etc.)
- Updating monitoring and controlling equipment in order to optimise engine safety and performance
- Upgrade from engine single-stage turbocharging to two-stage version
- Upgrade with WHR (Waste Heat Recovery) systems e.g. from standard power plant to DCC (Diesel Combined Cycle), or ORC (Organic Rankine Cycle)
3. Service Agreements

PrimeServ O&M has a wide portfolio of Service Agreements. The basic agreements are flexible so that they can be adapted to meet the specific needs of any project. The portfolio is grouped into two categories:

3.1 Long Term Service Agreements (LTSA)
3.2 Operation and Maintenance Agreements (O&MA)

<table>
<thead>
<tr>
<th>Service Agreements</th>
<th>Agreed Terms &amp; Conditions</th>
<th>Execution of Logistic Works</th>
<th>Higher Availability</th>
<th>Faster Trouble Shooting</th>
<th>Onsite Support</th>
<th>Performance Commitments</th>
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</table>

3.1 Long Term Service Agreements (LTSA)

The LTSA program is a series of long term contractual relationships in which PrimeServ supports the customer with maintenance services and spare parts.
Time and Material Agreement (TMA)

A TMA is a frame agreement, outlining the terms and conditions for any services or supplies ordered by the customer. The customer is responsible for logistics planning and orders spares and service when needed.

Benefits of the TMA
- Pre-agreed terms and conditions
- Reduced order processing times
- Price predictability

Basic Maintenance Agreement (BMA)

With a Basic Maintenance Agreement (BMA) the customer is assigned a designated contract manager who is responsible for the scheduling and logistics of each maintenance, as well as monitoring customer needs and work execution. It is a long term arrangement covering the supply of spare parts and superintendent services at site for specified planned maintenance intervals within a predefined period.

Benefits of the BMA package
- Preferred pricing
- Key account relationship
- Collaborative maintenance planning
- MAN responsibility for spares and service logistics
- Regular meetings on management level

Accelerated Maintenance Agreement (AMA)

In the Accelerated Maintenance Agreement (AMA) downtime for planned maintenance is minimized by using a pit stop style approach to maintenance. Strategic spares are kept in stock at site for rapid exchange during maintenance, reducing the scheduled outage time. After the exchange, the engine is returned to service and the removed spare parts undergo reconditioning and quality inspection before being added to the strategic stock of spares parts.

Additional benefits of the AMA package
- Reduced downtime for planned maintenance
- Preferential pricing on strategic spares packages
- Option for full maintenance crew from MAN
- Strategic stock for reducing unscheduled maintenance outages
Performance Maintenance Agreement (PMA)

The Performance Maintenance Agreement (PMA) covers both planned and unplanned maintenance. The contract is structured so that Prime-Serv O&M and the customer are aligned and incentivized to meet certain pre-defined performance goals. In addition, the scope typically includes online monitoring, periodic on-site support, priority access to spare parts, as well as logistics support to minimize unscheduled events.

Additional benefits of the PMA package
- Availability commitments
- Price predictability for scheduled and unscheduled maintenance
- Priority access to long lead spare parts
- Faster troubleshooting and fault elimination
- Regular data reporting and analysis sharing

3.2 Operation & Maintenance Agreements (O&MA)

The O&MA program is a series of long term contractual relationships in
which PrimeServ O&M plays larger roles in the management and operation of complete power plant facilities on top of the maintenance services.

**O&M Support Agreement (OMSA)**

The Operation & Maintenance Support Agreement (OMSA) is an advisory agreement in which PrimeServ O&M arranges for one or more operation and maintenance specialists to provide guidance to the customer during the mobilization and operations of the power plant.

**Benefits of an OMSA**

- Management and supply of spare parts and service
- Onsite support from experienced professional(s)
- On the job mentoring
- Proven methods and procedures

**O&M Management Agreement (OMMA)**

The Operation & Maintenance Management Agreement (OMMA) embeds
PrimeServ O&M staff into key management positions in the customer’s operation and maintenance organization. During the operations period PrimeServ O&M staff will assume the key positions and authority to manage the customer’s organization in the execution of all administration, operation and maintenance activities.

Benefits of an OMMA
- Management responsibility of the complete facility on a 24/7 basis
- On site mentoring
- Management and supply of all plant spare parts and related services
- Downtime commitments for scheduled maintenance

Full Operation & Maintenance Agreement (FOMA)
The Full Operation & Maintenance Agreement (FOMA) is a holistic solution in which PrimeServ O&M manages, operates and maintains the complete facility on behalf of the customer. The scope typically includes mobilization services prior to the start of commercial operations such as the hiring of the staff, staff and plant outfitting, establishment of a computerized maintenance management systems, and development of standard procedures. From the start of commercial operations PrimeServ O&M is responsible for the management, operations and maintenance of the full power plant facility including daily operations, routine maintenance, major overhauls, feedstock and inventory management.

Benefits of an FOMA
- Responsibility of the entire facility on a 24/7 basis
- Performance commitments
- Proven operation & maintenance practices
- Single point of responsibility
- Local solution, global support

4. Additional PrimeServ Solutions
PrimeServ also has several additional solutions within its portfolio which can be included in any of the Service Agreements or ordered separately.

Performance Assessment (Audit)
Performance Assessment Modules include the evaluations of technical equipment, the organizational structure, staff skills and competency, operations and maintenance practices.
Online Service
The PrimeServ Online Service securely transfers key engine data from any place in the world to the PrimeServ headquarters. Engine experts analyze the data and provide the customer with written recommendations. The experts can also provide engine operators with remote support by accessing real-time engine data.

Computerized Maintenance Management System
A Computerized Maintenance Management System (CMMS) is a software program which helps optimize maintenance planning. Selected modules are setup to organize all data and processes related to maintenance activities including the planning of spare parts requirements and workflows, as well as the simplification of warehouse management and purchasing control.

PrimeServLab
MAN Diesel & Turbo provides analysis for engine fluids and non-metallic materials such as fuel, lubricating oil and cooling water. Testing is conducted in accordance with common standards for operating fluids such as ISO8217 for fuels.

PrimeServClean
MAN Diesel & Turbo offers two cleaning agents designed to be used in dip tanks and turbocharger compressors, with ultrasonic cleaning. It efficiently removes contamination without damaging sensitive components.

PrimeServLube
MAN Diesel & Turbo provides premium lubricating oil recommended for its modern, four-stroke power plant engines. Service includes planning and logistics of all deliveries, as well as, periodic testing of lubricating oil quality.

PrimeServGran
The condition and cleanliness of the turbine of an exhaust gas turbocharger have a decisive influence on the efficiency, the performance of the combustion process and hence on the service data of the engine. By using PrimeServGran the turbine of the exhaust gas turbocharger can be cleaned at operating load and grants optimal operating values.
**PrimeServ Protect**

PrimeServ Protect is a highly effective, eco-friendly and silicone-free solution. It protects metal against corrosion, extending the life of your engine and cutting downtime. The product is delivered in a ready-to-use form, and can be applied easily with a pressurized spray gun or using immersion baths. It offers reliable short and mid-term protection – for individual parts or entire engines.

5. **PrimeServ Academies**

High-quality training opportunity for MAN customers, ensuring the most effective and efficient engine operation and maintenance. Conducted in our professionally equipped hands-on training centres and on-site. Standard as well as customised courses are offered worldwide from our 12 PrimeServ academies.
Services

Power plant projects usually require huge investments and therefore need long term financing. Banks, especially those not in the top 100, may have difficulties obtaining long term (10 years) refinancing on the capital markets. We, as a member of the MAN Group, have relationships with a large number of international first class banks and, together with our national Export Credit Agencies (Euler Hermes Deutschland AG, Coface, EKF), can provide you with long term financing at very attractive rates. Only long term financing makes huge investments possible.

Below you can find a chart explaining the typical structure of such financing.

* The requirement for an additional guarantee depends on the loan amount and the credit standing of the customer.

The local guarantor can be a local bank or the parent company of the customer which has a credit standing acceptable to the banks and ECAs.
Advantages:

- Long term financing up to 10-12 years from the taking over of the plant
- Fixed interest rates possible
- Diversification of the financing basis – access to the international capital markets
- Good corporates, which are accepted by ECAs without additional guarantee, get access to cheap long term funds, which are much more attractive than the ones available on their local market
- Loan amount up to 85% of the contract value plus 100% of the ECA premium
- Interest during construction can be capitalised and included in the financing
- Financing is possible in all major currencies
- MAN has access to banks that are in a position to finance bigger tickets. MAN can in addition form banking consortia that are able to finance very big power plants

Usual conditions:

- ECA coverage is generally linked to equipment sourced from the country of the ECA. However, there are cooperation agreements in place which allow for multi-sourcing under one ECA policy.
- Local content can be included in the financing up to 23% of the contract value
- ECA cover is subject to an acceptable credit check and a satisfactory environmental due diligence
- Repayments in semi-annual instalments, grace period 6 months

Such type of financing can also be granted to IPPs after a detailed feasibility study. The loan term can in such cases be extended to 14 years with some flexibility in the repayment stream if the average loan term does not exceed 14 years. Fixed interest rates are possible, thus eliminating the interest rate change risk.

This type of financing also covers the construction period.

With our worldwide presence and our long lasting relationships with leading international banks, including development banks, we can offer you tailor-made financing solutions for your business.
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<table>
<thead>
<tr>
<th>Region</th>
<th>MAN Diesel &amp; Turbo</th>
<th>Address</th>
<th>Phone</th>
<th>Fax</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia Pacific</td>
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</tbody>
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List of Licensees
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F: MAN Diesel & Turbo Four-stroke licence
FS: MAN Diesel & Turbo Four-stroke SEMT Pielstick licence
P: MAN Diesel & Turbo Propeller licence
TC: MAN Diesel & Turbo Turbocharger licence

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