Attention

1. The diesel engine has undergone release test rigidly on specifications, and the lead seal on fuel injection pump has been set. Do not dismantle the lead seal at will to increase fuel injection, or the engine maker will not bear the responsibility due to it.

2. The operator shall read the instruction manual carefully to be familiar with the construction of the engine, and manipulate it according to the regulations of operation and maintenance.

3. The oil shall be inspected and assayed after the first 50 running hour of new engine; the oil filter shall be cleaned; the torque of cylinder-head nut and connecting rod bolt shall be checked before further running.

4. In the case of new engine or engine having been standstill for a long time, before its starting, it is necessary to open the air escape valve (or power indicator) of cylinder head to blow off the engine in addition to starting of oil priming pump to guard against damage to the engine due to condensation water in exhaust pipe flowing into cylinder.

5. The engine shall run at 500–600 rpm without load to warm up after it is started. Do not increase its speed or load sharply. Do not shut down the engine immediately after running for long time with heavy load. It must be shut down after running in low speed without load for 5-10 minutes.

6. The antifreeze agent shall be used in coolant if the ambient temperature is lower than 0℃. If the ambient temperature is lower than 5℃, starting engine is to be implemented only after its cooling water and oil are preheated.

7. The fuel and oil must be determined according to the specifications. When they are filled into engine, they shall be kept in a clean container, and filtered by a strainer. It is preferred to allow the fuel settle for more than 72 hours.

8. The inspection and maintenance of electrical system shall be taken over by the person with electrical knowledge.

9. Installation and repair shall only be carried out by trained and qualified personnel.

10. The residual fluids must be disposal correctly according to local regulations.

11. The rated speed of the engine has been adjusted and limited. Never attempt to change the speed adjusting device.

12. Some parts, such as the turbo, the intercooler, the pipes and injection pump of heavy diesel
and the exhaust pipes, are hot. All these parts are protected by guards or thermal isolation material. Do not remove these protection till these hot parts are cooled down when repair or maintenance. Restore these protections after repair or maintenance in time.

13. Do not install and use the engines in explosive environment.
EC Declaration of Conformity
Machine Directive 2006/42/EC

Reference No.: BJ50099197 01

This is hereby declared that following designated product complied with the essential health and safety requirements of Council Directive 2006/42/EC on the approximation of the laws of the Member States relating to it.

Designation:

Diesel Engine

Model/Type:
CW6200ZD, XCW6200ZD, XCW6200ZD-1, XCW8200ZD-2, CW8200ZD, CW8200ZD-Z,
XCW8200ZD, XCW8200ZD-1, XCW8200ZD-2, CW12V200ZD, CW12V200ZD-Z,
XCW12V200ZD, XCW12V200ZD-1, CW16V200ZD, CW16V200ZD-6,

Standard:
Annex I of 2006/42/EC
EN 1679-1:1998

This declaration is the responsibility of the Manufacturer:

Weichai Heavy Machinery Co., Ltd. Chongqing Branch
Degan Qianjin Street, 402262, Jiangji, Chongqing, P.R.China

This declaration applies to all specimens manufactured identical to the model submitted for testing / evaluation. Assessment of compliance of the product with the requirements relating to safety standards listed above was performed by TÜV SÜD Group. This DOC is only valid with positive testing result of the relating test report No. BJ50099197 01.

Manufacturer:

Weichai Heavy Machinery Co., Ltd. Chongqing Branch

[Signature]

## Equivalence between GB standards and ISO standards

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>GB standards</th>
<th>ISO standards</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Flash point</td>
<td>GB/T261</td>
<td>ISO2719</td>
<td>Fuel oil</td>
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<tr>
<td>2</td>
<td>Carbon residue [10% V/V distillation bottoms]</td>
<td>GB/T268</td>
<td>ISO6615</td>
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<tr>
<td>3</td>
<td>Ash %</td>
<td>GB/T508</td>
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<td>4</td>
<td>Pour point</td>
<td>GB/T3535</td>
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<td>GB/T17144</td>
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<td>7</td>
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<td>GB/T3536</td>
<td>ISO2592</td>
<td>Lube oil</td>
</tr>
<tr>
<td>8</td>
<td>Foamability</td>
<td>GB/T12579</td>
<td>ISO6247</td>
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</table>
Preface

200 series V-type diesel engines are developed and manufactured by Chongqing Weichai Engine Works based on researching techniques of medium speed engine both at home and abroad, and are awarded the title of “Famous-brand Products in Chongqing”.

The V-type engines feature compact construct, reliable running, good economic index, easy operation, so they are ideal propelling power for passenger ships, transport ships, fishing boats, etc. and also perfect primary power for marine auxiliary sets, land-used generating sets and other power plants.

Possessing techniques of four-stroke, direct injection, water-cooling, pulse system supercharging, intercooling, etc, the 200 series V-type engines have rated power 900kW~1760 kW and rated speed 750r/min~1000r/min.

This manual explains emphatically the construction of 200 series V-type diesel engines, and explains the principle of every system, and gives specification to the operation, maintenance, procedure of service and test, the quality of fuel oil, lubrication oil, and cooling water.

The user shall read this manual sufficiently to acquaint himself with the construction and operation of the diesel engine before starting it, so that the efficacy of the engines can be brought out fully.

The construction and performance of the 200 series engines will be improved with the development of science and technique; thus, the users will not be notified if there is modification in newly developed engine, except a new version is published. Please notice the technical documents delivered with the diesel engine. Therefore, the diesel engine shall be regarded as standard if there is difference between the specification of manual and the actual performance of engine due to the improvement of product.

December, 2013
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<td>Check and start before operation, running and stop</td>
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Cross section of CW16V200ZC diesel engine
Longitudinal section of CW12V200ZC diesel engine
Longitudinal section of CW16V200ZC diesel engine
V type diesel engine installation drawing

Installation Drawing of CW12V200 Engine (Burning LFO)

Installation dimension of engine feet

This drawing applies to engines as below: CW12V200ZC, CW12V200ZC-2, XCW12V200ZC-1, XCW12V200ZC-4
Installation Drawing of CW200 HFO Engine (V-TYPE)

Installation dimension of engine feet:

This drawing applies to engines as below: CW12V200ZC, CW12V200ZC-2, XCW12V200ZC-1, XCW12V200ZC-4, CW16V200ZC, CW16V200ZC-6
Installation Drawing of CW16V200 Diesel Engine (Burning LFO)

This drawing applies to engines as below: CW16V200ZC, CW16V200ZC-6
Performance diagram of diesel engine

Load-bearing performance diagram of CW12V2000ZD diesel engine

Propulsion performance diagram of CW12V2000ZC diesel engine
Load-bearing performance diagram of XCMV200ZD-1 diesel engine

Propulsion performance diagram of XCMV200ZC-1 diesel engine
Load-bearing performance diagram of CW16V200ZD diesel engine

Propulsion performance diagram of CW16V200ZC diesel engine
## Chapter 1 Technical performance of V-type diesel engine

### 1. Main technical parameter of main models

#### Model 1000r/min

<table>
<thead>
<tr>
<th>S/N</th>
<th>Items</th>
<th>Model *①</th>
<th>12V</th>
<th>16V</th>
<th>12V</th>
<th>16V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CW12V200ZC</td>
<td>XWC12V200ZC</td>
<td>XWC12V200ZC</td>
<td>CW16V200ZC</td>
<td>CW16V200ZC-6</td>
</tr>
<tr>
<td>1</td>
<td>Rated power kW *②</td>
<td>1200</td>
<td>1392</td>
<td>1440</td>
<td>1760</td>
<td>1600</td>
</tr>
<tr>
<td>2</td>
<td>Rated speed r/min</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Quantity of cylinder</td>
<td>12</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Type</td>
<td>4-stroke, water cooling, V-type, direct injection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Bore / stroke mm</td>
<td>200/270</td>
<td>200/270</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Total displacement L</td>
<td>101.784</td>
<td>135.68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Mean piston speed m/s</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Compression ratio</td>
<td>13.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Max. explosion pressure MPa</td>
<td>≤11.5</td>
<td>≤12.5</td>
<td>≤12.5</td>
<td>≤12</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Air intake type</td>
<td>Supercharging intercooling</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>11</td>
<td>Mean effective pressure MPa</td>
<td>1.415</td>
<td>1.642</td>
<td>1.698</td>
<td>1.56</td>
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<tr>
<td>12</td>
<td>Valve clearance mm (cold state) mm</td>
<td>Inlet valve: 0.5, exhaust valve: 0.7</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Valve timing</td>
<td>Inlet valve opens: 50° before TDC; Inlet valve closes: 20° after BDC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exhaust valve opens: 60° before BDC; Exhaust valve closes: 50° after TDC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Included angle between two banks</td>
<td>45°</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Starting method</td>
<td>Started by air</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>17</td>
<td>Wet oil sump capacity L</td>
<td>290～360</td>
<td>280～380</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Cooling method</td>
<td>Water cooling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Oil pressure MPa</td>
<td>0.40～0.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Rotation direction of crankshaft</td>
<td>Clockwise rotation if viewed from output end (flywheel end)</td>
<td></td>
<td></td>
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</table>
### Exhaust temperature, °C

<table>
<thead>
<tr>
<th></th>
<th>Manifold pipe:</th>
<th>Main pipe:</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>530</td>
<td>580</td>
</tr>
<tr>
<td></td>
<td>≤560</td>
<td>≤610</td>
</tr>
</tbody>
</table>

### Fuel type
- Light diesel fuel (0°); Heavy diesel fuel (10°, 20°, 30°)
- HFO (RIS 600s, 1000s, 1500s; 3500s heavy fuel only applicable for engine of power per cylinder not more than 100kW)

### Oil type
- CD-40 lube oil. Refer to the Manual for the oil used in diesel engine burning heavy fuel oil.

### Specific fuel consumption, g/kW·h
- ≤205
- ≤197
- ≤200

### Specific oil consumption, g/kW·h
- ≤1.0
- ≤1.0

### Advanced angle of fuel delivery (crank angle)

<table>
<thead>
<tr>
<th></th>
<th>14°+1°</th>
<th>16°+1°</th>
<th>16°+1°</th>
<th>12°+1°</th>
</tr>
</thead>
</table>

### Initial injection pressure, MPa
- 24+0.8 (non-cooling type nozzle used for burning diesel oil and HFO); 30+0.8 (cooling type nozzle for burning heavy fuel oil)

### Air pressure of starter, MPa
- 0.8~1
- 0.8~3.0

### Volume of cooling water in cylinder, L
- 150
- 200

### Capacity of expansion tank, L
- 150
- 150

### Net weight, kg
- 10900
- 13500

**Note:**
- ① 200 series diesel engines other than basic model shall be supplied as per technical agreement
- ② Rated output is subject to the standard conditions (GB/T 6072.1-2000) of 100kPa atmospheric pressure, 25℃ ambient temperature, 25℃ charge water temperature in intercooler. If the actual condition differs from the standard one, it should be revised.
- ③ Advanced angle of fuel supply depends on models of diesel engines, and is stamped on nameplate of engine.

If the diesel engine is used for generating set, the letters ZC in above model are modified to ZD. The two configurations are identical. Seawater pump is called external circulating pump in the case of land-based engine.

### Operating requirement of diesel engine

According to CB/T3253-1994 Technical Specifications of Marine Diesel Engine, 15° list, 5° trim, 22.5° roll and 7.5° pitch are permitted.
## Model 900r/min

<table>
<thead>
<tr>
<th>S/N</th>
<th>Items</th>
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<th>16V</th>
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<tbody>
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<td>XCW12V200ZC-4</td>
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<td>1</td>
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<td>1080</td>
<td>1296</td>
</tr>
<tr>
<td>2</td>
<td>Rated speed r/min</td>
<td>900</td>
<td>900</td>
</tr>
<tr>
<td>3</td>
<td>Quantity of cylinder</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>Type</td>
<td>4-stroke, water cooling, V-type, direct injection</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Bore / stroke mm</td>
<td>200/270</td>
<td>200/270</td>
</tr>
<tr>
<td>6</td>
<td>Total displacement L</td>
<td>101.784</td>
<td>135.68</td>
</tr>
<tr>
<td>7</td>
<td>Mean piston speed m/s</td>
<td>8.1</td>
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</tr>
<tr>
<td>8</td>
<td>Compression ratio</td>
<td>13.37</td>
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</tr>
<tr>
<td>9</td>
<td>Max. explosion pressure MPa</td>
<td>≤11.5</td>
<td>≤12.5</td>
</tr>
<tr>
<td>10</td>
<td>Air intake type</td>
<td>Supercharging intercooling</td>
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</tr>
<tr>
<td>11</td>
<td>Mean effective pressure MPa</td>
<td>1.415</td>
<td>1.698</td>
</tr>
<tr>
<td>12</td>
<td>Valve clearance mm (cold state)</td>
<td></td>
<td>Inlet valve: 0.5, exhaust valve: 0.7</td>
</tr>
<tr>
<td>13</td>
<td>Valve timing</td>
<td>Inlet valve opens: 50° before TDC; Inlet valve closes: 20° after BDC Exhaust valve opens: 60° before BDC Exhaust valve closes: 50° after TDC</td>
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</tr>
<tr>
<td>14</td>
<td>Included angle between two banks</td>
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<td>45°</td>
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<tr>
<td>15</td>
<td>Starting method</td>
<td>Started by air</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Wet oil sump capacity L</td>
<td>290～360</td>
<td>280～380</td>
</tr>
<tr>
<td>18</td>
<td>Cooling method</td>
<td>Water cooling</td>
<td>Water cooling</td>
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<tr>
<td>19</td>
<td>Oil pressure MPa</td>
<td>0.40～0.50</td>
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<tr>
<td>20</td>
<td>Rotation direction of crankshaft</td>
<td></td>
<td>Clockwise rotation if viewed from output end (flywheel end)</td>
</tr>
<tr>
<td>21</td>
<td>Exhaust temperature, °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manifold pipe</td>
<td>&lt;530</td>
<td>&lt;560</td>
</tr>
<tr>
<td></td>
<td>Main pipe</td>
<td>≤580</td>
<td>≤610</td>
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<td></td>
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</tr>
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<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Fuel type</td>
<td>Light diesel fuel (0°); Heavy diesel fuel (10°, 20°, 30°) HFO (RIS 600s, 1000s, 1500s; 3500s heavy fuel only applicable for engine of power per cylinder not more than 100kW)</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Oil type</td>
<td>CD-40 lube oil. Refer to the Manual for the oil used in diesel engine burning heavy fuel oil.</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Specific fuel consumption g/kW·h</td>
<td>205</td>
<td>205</td>
</tr>
<tr>
<td>25</td>
<td>Specific oil consumption g/kW·h</td>
<td>≤1.0</td>
<td>≤1.0</td>
</tr>
<tr>
<td>26</td>
<td>Advanced angle of fuel delivery (crank angle) *②</td>
<td>14° +1°</td>
<td>16° +1°</td>
</tr>
<tr>
<td>27</td>
<td>Initial injection pressure MPa</td>
<td>24+0.8 (non-cooling type nozzle used for burning diesel oil and HFO); 30+0.8 (cooling type nozzle for burning heavy fuel oil)</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Air pressure of starter MPa</td>
<td>0.8~1</td>
<td>0.8~3.0</td>
</tr>
<tr>
<td>29</td>
<td>Volume of cooling water in cylinder L</td>
<td>150</td>
<td>200</td>
</tr>
<tr>
<td>30</td>
<td>Capacity of expansion tank L</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>31</td>
<td>Net weight kg</td>
<td>10900</td>
<td>13500</td>
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</tbody>
</table>

**Note:**
* ① 200 series diesel engines other than basic model shall be supplied as per technical agreement.
* ② Rated output is subject to the standard conditions (GB/T 6072.1-2000) of 100kPa atmospheric pressure, 25°C ambient temperature, 25°C charge water temperature in intercooler. If the actual condition differs from the standard one, it should be revised.
* ③ Advanced angle of fuel supply depends on models of diesel engines, and is stamped on nameplate of engine. If the diesel engine is used for generating set, the letters ZC in above model are modified to ZD. The two configurations are identical. Seawater pump is called external circulating pump in the case of land-based engine.
## 2. Main specifications of accessories

### Model 1000r/mi

<table>
<thead>
<tr>
<th>S/ N</th>
<th>Parts' name, item, and unit</th>
<th>Technical parameters</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
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<td>CW16V200ZC</td>
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<tr>
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</tr>
<tr>
<td></td>
<td>Type</td>
<td>Gear pump</td>
</tr>
<tr>
<td></td>
<td>Speed (r/min)</td>
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</tr>
<tr>
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<tr>
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</tr>
<tr>
<td></td>
<td>Type</td>
<td>Centrifugal vane pump</td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td>Centrifugal vane pump</td>
</tr>
<tr>
<td></td>
<td>Speed (r/min)</td>
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</tr>
<tr>
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<td>Pressure (MPa)</td>
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<tr>
<td></td>
<td>Type</td>
<td>Centrifugal vane pump</td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td>Centrifugal vane pump</td>
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<tr>
<td></td>
<td>Speed (r/min)</td>
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<td>Pressure (MPa)</td>
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<td></td>
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<td>Power (kW)</td>
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<tr>
<td>4</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td>Gear type</td>
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<td></td>
<td>Type</td>
<td>Gear type</td>
</tr>
<tr>
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<td>Speed (r/min)</td>
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</tr>
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<td></td>
</tr>
<tr>
<td></td>
<td>Model</td>
<td>Individual pump, plunger type</td>
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<td>Plunger dia. (mm)</td>
<td>Φ17</td>
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<tr>
<td></td>
<td>Lift (mm)</td>
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<tr>
<td></td>
<td>100 × fuel capacity per cylinder (L)/ speed (r/min)</td>
<td>90/500</td>
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<td>Governor</td>
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<td></td>
<td>Type</td>
<td>Hydraulic</td>
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<tr>
<td></td>
<td>Model</td>
<td>Woodward UG8 or YT111</td>
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<td>Adjustable range of steady state speed-adjusting rate</td>
<td>0~10%</td>
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<tr>
<td>7</td>
<td>Fuel type</td>
<td>Multi-orifice type</td>
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<td>Type</td>
<td>Multi-orifice type</td>
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### Manual for operation & maintenance of 200 series V-type engines with individual injection pump

<table>
<thead>
<tr>
<th>Component</th>
<th>Details</th>
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</thead>
<tbody>
<tr>
<td>Injector</td>
<td>Qty. of orifice × aperture mm: Qty. of orifice: 4+5; Aperture depends on power and speed of diesel engine. Please see the drawing No. on the fuel injector.</td>
</tr>
<tr>
<td>Opening pressure MPa</td>
<td>24+0.8 (Non-cooling nozzle for diesel fuel and heavy fuel) 30+0.8 (Cooling nozzle for heavy fuel)</td>
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<table>
<thead>
<tr>
<th>8</th>
<th>Inter-cooler</th>
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<th>KLQ46H</th>
<th>KLQ55H</th>
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<tbody>
<tr>
<td></td>
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<td>Cooling area m²</td>
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<td>55</td>
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<tr>
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<th>T/C</th>
<th>Type</th>
<th>Mixed flow</th>
<th>Mixed flow</th>
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<tbody>
<tr>
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<td>Air flow kg/s</td>
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<td>3.56</td>
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<table>
<thead>
<tr>
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<tbody>
<tr>
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<td>Cooling area m²</td>
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<table>
<thead>
<tr>
<th>11</th>
<th>Fresh water cooler</th>
<th>Drawing No.</th>
<th>C12.19.07.1000</th>
<th>C16.19.01.1000</th>
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<tbody>
<tr>
<td></td>
<td>Cooling area m²</td>
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<td>11</td>
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<thead>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Specification:</td>
<td>60~75°C</td>
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<table>
<thead>
<tr>
<th>13</th>
<th>F.W. temp. regulator</th>
<th>Drawing No.</th>
<th>C12.19.11.000</th>
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<tbody>
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</tbody>
</table>

<table>
<thead>
<tr>
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<th>Air starter</th>
<th>Type</th>
<th>Controlled by air/power</th>
<th>Controlled by air/power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model</td>
<td>QQ-3C</td>
<td>HST500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Starting air pressure MPa</td>
<td>0.8~1.0</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Power kW</td>
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<td>16.5×2</td>
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<table>
<thead>
<tr>
<th>13</th>
<th>Air bottle</th>
<th>Volume × number dm³</th>
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<tbody>
<tr>
<td></td>
<td>Pressure MPa</td>
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<table>
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<th>14</th>
<th>Monitor</th>
<th>Model</th>
<th>ED200-12V-4A</th>
<th>ED200-16V-1</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Monitoring data</td>
<td>Exhaust temperature of cylinders, oil/fresh water temperature, oil pressure, speed, boosted air pressure.</td>
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<table>
<thead>
<tr>
<th>15</th>
<th>Oil fine filter</th>
<th>Model</th>
<th>SWL100 (C12.25.01.1000)</th>
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<tbody>
<tr>
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<td>Flow m³/h</td>
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<td>80</td>
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<tr>
<td></td>
<td>Pressure MPa</td>
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<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Filter rating mesh/inch</td>
<td>363</td>
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<table>
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<tr>
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<th>SWL25 (C12.25.02.2000)</th>
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<tr>
<td></td>
<td>Pressure MPa</td>
<td>0.6~1</td>
<td>0.6~1</td>
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<tr>
<td></td>
<td>Filter rating mesh/inch</td>
<td>363</td>
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</tbody>
</table>

**Note:** All of these parameters are values when the engine rotates at 1000r/min. As for the technical data and operation of the main parts such as turbocharger, governor and fuel injection pump, please refer to technical agreement.
## Manual for operation & maintenance of 200 series V-type engines with individual injection pump

### Model 900r/mi

<table>
<thead>
<tr>
<th>S/N</th>
<th>Parts’ name, item, and unit</th>
<th>Technical parameters</th>
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</thead>
<tbody>
<tr>
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<td></td>
<td>Speed r/min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pressure MPa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flow m³/h</td>
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<tr>
<td></td>
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<td>2</td>
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<td>Flow m³/h</td>
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<td>Power kW</td>
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<tr>
<td>3</td>
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<td>Type</td>
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<td></td>
<td>Power kW</td>
</tr>
<tr>
<td>4</td>
<td>Fuel delivery pump</td>
<td>Type</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flow m³/h</td>
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<tr>
<td></td>
<td></td>
<td>Pressure MPa</td>
</tr>
<tr>
<td>5</td>
<td>Fuel injection pump</td>
<td>Model</td>
</tr>
<tr>
<td></td>
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<td>Plunger dia. mm</td>
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<tr>
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<td></td>
<td>Lift mm</td>
</tr>
<tr>
<td>6</td>
<td>Governor</td>
<td>Type</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Model</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Work capacity N·m</td>
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<td></td>
<td>Adjustable range of steady state speed-adjusting rate</td>
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<tr>
<td>7</td>
<td>Fuel injector</td>
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<td></td>
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<td>Qty. of orifice × aperture mm</td>
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<td>---</td>
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<td><strong>8</strong></td>
<td>Inter-cooler</td>
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<tr>
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<td>T/C</td>
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<td><strong>Cooling area</strong></td>
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<td>Model</td>
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</tr>
<tr>
<td></td>
<td>Starting air pressure</td>
<td>0.8~1.0</td>
</tr>
<tr>
<td></td>
<td>Power</td>
<td>20</td>
</tr>
<tr>
<td><strong>13</strong></td>
<td>Air bottle</td>
<td><strong>Volume × number dm³</strong></td>
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<td>Pressure in bottle MPa</td>
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<tr>
<td><strong>14</strong></td>
<td>Monitor</td>
<td><strong>Model</strong></td>
</tr>
<tr>
<td></td>
<td>Monitoring data</td>
<td>Exhaust temperature of cylinders, oil / fresh water temperature, oil pressure, speed, boosted air pressure.</td>
</tr>
<tr>
<td><strong>15</strong></td>
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<td>Pressure</td>
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<td><strong>16</strong></td>
<td>Fuel fine filter</td>
<td><strong>Model</strong></td>
</tr>
<tr>
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<td>Flow</td>
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</tr>
<tr>
<td></td>
<td>Pressure</td>
<td>0.6~1</td>
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<td></td>
<td>Filter rating mesh/ inch</td>
<td>363</td>
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</table>

**Note:** All of these parameters are values when the engine rotates at 900r/min. As for the technical data and operation of the main parts such as turbocharger, governor and fuel injection pump, please refer to technical agreement.
3. Tightening torque of main bolts (screws) of diesel engine

3.1 Tightening torque of main bolts (screws)

<table>
<thead>
<tr>
<th>S/ N</th>
<th>Position of thread</th>
<th>Thread size</th>
<th>Lubricant</th>
<th>Tightening torque</th>
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<tbody>
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<td></td>
<td></td>
<td></td>
<td>No.1 step (N•m)</td>
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<tr>
<td>01</td>
<td>Crankcase and engine feet</td>
<td>M24</td>
<td>MoS₂</td>
<td>100</td>
</tr>
<tr>
<td>02</td>
<td>Crankcase and engine feet</td>
<td>M20</td>
<td>MoS₂</td>
<td>100⁺₁₀</td>
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<tr>
<td>03</td>
<td>Engine feet and frame base (foundation)</td>
<td>M20</td>
<td>MoS₂</td>
<td>200</td>
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<tr>
<td>04</td>
<td>Reamed bolt hole between engine hole and frame base</td>
<td>M24</td>
<td>MoS₂</td>
<td>200</td>
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<tr>
<td>05</td>
<td>Counter-weight and crankshaft</td>
<td>M24</td>
<td>MoS₂</td>
<td>250⁻²⁵</td>
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<tr>
<td>06</td>
<td>Flywheel and crankshaft</td>
<td>M20</td>
<td>MoS₂</td>
<td>100</td>
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<tr>
<td>07</td>
<td>Main bearing cap bolt</td>
<td>M30</td>
<td>MoS₂</td>
<td>200</td>
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<tr>
<td>08</td>
<td>Main bearing cap bolt (transverse direction)</td>
<td>M24</td>
<td>MoS₂</td>
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<tr>
<td>09</td>
<td>Connecting rod bolt (splined nut)</td>
<td>M16</td>
<td>MoS₂</td>
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<tr>
<td></td>
<td>Connecting rod bolt (Spiralock hexagonal nut)</td>
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<td>MoS₂</td>
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<td>10</td>
<td>Stud bolt and crankcase</td>
<td>M30</td>
<td>MoS₂</td>
<td>100</td>
</tr>
<tr>
<td>11</td>
<td>Stud bolt and nut</td>
<td>M30</td>
<td>MoS₂</td>
<td>100</td>
</tr>
<tr>
<td>12</td>
<td>Gear and vibration damper</td>
<td>M12</td>
<td>Loctite 242</td>
<td>80</td>
</tr>
<tr>
<td>13</td>
<td>Gear and governor shaft</td>
<td>M30×2</td>
<td>Loctite 242</td>
<td>300⁻³₀</td>
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<td>14</td>
<td>Stud bolt for fixing injector</td>
<td>M10</td>
<td>MoS₂</td>
<td>30⁻¹⁰</td>
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<td>Seawater pump transmission shaft and coupling half</td>
<td>M22</td>
<td>Loctite 242</td>
<td>250⁻²⁵</td>
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<tr>
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<td>Bolt for fixing injection pump</td>
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<td>MoS₂</td>
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<tr>
<td>17</td>
<td>Shaft flange of Injection pump</td>
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<td>MoS₂</td>
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<tr>
<td>18</td>
<td>Exhaust pipe and cylinder head</td>
<td>M12</td>
<td>Antisticking agent</td>
<td>60</td>
</tr>
<tr>
<td>19</td>
<td>Exhaust pipe and turbocharger</td>
<td>M16</td>
<td>Antisticking agent</td>
<td>140</td>
</tr>
</tbody>
</table>

Tightening methods depend on the importance of threaded adapters. Methods adopted vary with situations as follows:

1. **Unimportant threaded adapter**: If there are no special requirements for tightening, screw it down according to general tightening torque for bolts. The thread adapter is operated by standard socket wrench or double offset ring spanner or open-ended spanner and the extension rod is unnecessary.
② **The threaded adapter to be tightened to specified torque:** They shall be fastened by tension wrench, and the use of lubricant must be in accordance with specification, because the MnS₂ lubricant and lube oil differ from each other greatly in respect of torque requirement. Generally, the bearing face and threads of nut or bolt head shall be applied with MnS₂ lubricant with friction coefficient 0.09–0.12. The determination of lubricant also depends on the temperature of threaded adapter during running of engine.

③ When unscrew the threaded adapter with tension wrench, it shall be kept in mind that the used torque moment shall not exceed the specified limit of wrench. The extension rod must not be used anyway. The excessive stress forced upon the wrench would influence meter reading. So we recommend that the user should calibrate the reading of tension wrench regularly.

④ **Threaded adapter to fastened to specified torque angle (also called tightening angle or torsional angle):** Screw down the bolt or nut with open-ended spanner or socket wrench or double offset ring spanner to a degree in such a way that they are be appropriate for assembling; or screw it down with tension wrench to certain torque moment, then tighten it to the specified value listed in following table. Extension rod is advisable.

---

**Note:** When tightening screws to a given torque, only the lubricant specified could be used.

### 3.2 Recommended torque for undefined general bolt

**Expression for recommended torque for undefined general bolt**

**Tightening torque**

\[
\text{Tightening torque} = \text{Conversion coefficient} \times \text{Tightening torques for 8.8 strength grade of bolts}
\]

<table>
<thead>
<tr>
<th>Conversion coefficient table</th>
<th>Coefficient of friction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength class</td>
<td>5.6</td>
</tr>
<tr>
<td>Conversion coefficient ( x )</td>
<td>0.47</td>
</tr>
</tbody>
</table>

### 3.3 Tightening torque for 8.8 strength grade of bolts
<table>
<thead>
<tr>
<th>Thread size</th>
<th>Tightening torque (N•m)</th>
<th>Thread size</th>
<th>Tightening torque (N•m)</th>
<th>Thread size</th>
<th>Tightening torque (N•m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M5</td>
<td>4</td>
<td>M20</td>
<td>275</td>
<td>M33</td>
<td>1270</td>
</tr>
<tr>
<td>M6</td>
<td>7</td>
<td>M20×1.5</td>
<td>295</td>
<td>M33×2</td>
<td>1350</td>
</tr>
<tr>
<td>M8</td>
<td>17</td>
<td>M20×2</td>
<td>285</td>
<td>M36</td>
<td>1640</td>
</tr>
<tr>
<td>M10</td>
<td>34</td>
<td>M22</td>
<td>370</td>
<td>M36×3</td>
<td>1710</td>
</tr>
<tr>
<td>M12</td>
<td>60</td>
<td>M22×1.5</td>
<td>395</td>
<td>M39</td>
<td>2115</td>
</tr>
<tr>
<td>M14</td>
<td>95</td>
<td>M22×2</td>
<td>380</td>
<td>M39×3</td>
<td>2190</td>
</tr>
<tr>
<td>M14×1.5</td>
<td>100</td>
<td>M22×2</td>
<td>380</td>
<td>M42</td>
<td>2630</td>
</tr>
<tr>
<td>M16</td>
<td>140</td>
<td>M22×2</td>
<td>380</td>
<td>M42×3</td>
<td>2760</td>
</tr>
<tr>
<td>M16×1.5</td>
<td>150</td>
<td>M22×2</td>
<td>380</td>
<td>M45</td>
<td>3260</td>
</tr>
<tr>
<td>M18</td>
<td>200</td>
<td>M22×2</td>
<td>380</td>
<td>M45×3</td>
<td>3415</td>
</tr>
<tr>
<td>M18×1.5</td>
<td>215</td>
<td>M22×2</td>
<td>380</td>
<td>M48</td>
<td>3950</td>
</tr>
<tr>
<td>M18×2</td>
<td>205</td>
<td>M22×2</td>
<td>380</td>
<td>M48×3</td>
<td>4185</td>
</tr>
</tbody>
</table>

4. Fit clearance and worn limit of major parts

<table>
<thead>
<tr>
<th>S/N</th>
<th>Measuring position</th>
<th>Clearance for new engine (mm)</th>
<th>Maximum clearance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Radial clearance of main bearing (vertical)</td>
<td>0.21~0.29</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>Axial clearance of thrust bearing (bearing collar)</td>
<td>0.25~0.53</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>Crankpin bearing (vertical)</td>
<td>0.08~0.18</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>Piston pin bearing</td>
<td>0.09~0.15</td>
<td>0.20</td>
</tr>
<tr>
<td>2</td>
<td>Piston: Dimensions other than ring groove are not given as the salient factor limiting the service life of the piston is the ring grooves.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Axial clearance of No.1 piston ring</td>
<td>0.130~0.162</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>Split clearance</td>
<td>0.550~0.800</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Axial clearance of No.2 piston ring</td>
<td>0.110~0.142</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>Split clearance</td>
<td>0.550~0.800</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Axial clearance of No.3 piston ring</td>
<td>0.110~0.142</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>Split clearance</td>
<td>0.550~0.800</td>
<td>2.0</td>
</tr>
</tbody>
</table>
### Manual for operation & maintenance of 200 series V-type engines with individual injection pump

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3</strong></td>
<td>Axial clearance of No.4 piston ring</td>
<td>0.073 − 0.108</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>Split clearance</td>
<td>0.400 − 0.60</td>
<td>2.0</td>
</tr>
<tr>
<td>*</td>
<td>Piston rings must be replaced if there is any abnormal wear at surface of piston ring.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>Diameter of cylinder liner in new engine</td>
<td>Φ200 + 0.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. admissible wear</td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. admissible ovality</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td><strong>5</strong></td>
<td>Clearance of inlet and exhaust valve stem</td>
<td>0.08 − 0.118</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Inlet valve clearance (cold state)</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exhaust valve clearance (cold state)</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Idler wheel bearing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Radial clearance</td>
<td>0.030 − 0.106</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Axial clearance</td>
<td>0.200 − 0.500</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td><img src="image" alt="Diagram" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A=0.145 ~ 0.248</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B=0.136 ~ 0.236</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C=0.145 ~ 0.215</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td><strong>6</strong></td>
<td>Radial clearance of camshaft bearing</td>
<td>0.090 − 0.247</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Axial clearance of camshaft</td>
<td>0.200 − 0.600</td>
<td>0.8</td>
</tr>
</tbody>
</table>
Chapter 2 Quality requirements for fuel oil, lube oil and cooling water

1. Quality requirements of fuel oil

Quality requirements of light diesel fuel

According to the standard GB252, the light diesel fuel shall meet the requirements as follows:

<table>
<thead>
<tr>
<th>Items</th>
<th>0 °</th>
<th>Test method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinematic viscosity at 20°C mm²/s</td>
<td>3~8</td>
<td>GB/T265</td>
</tr>
<tr>
<td>Flash point °C (closed cup)</td>
<td>≥55</td>
<td>GB/T261</td>
</tr>
<tr>
<td>Condensation point °C</td>
<td>≤0</td>
<td>GB/T510</td>
</tr>
<tr>
<td>Carbon residue [micro method, 10% V/V distillation bottoms], % (m/m)</td>
<td>≤0.3</td>
<td>GB/T268</td>
</tr>
<tr>
<td>Ash % (m/m)</td>
<td>≤0.01</td>
<td>GB/T508</td>
</tr>
<tr>
<td>Water % (V/V)</td>
<td>≤-</td>
<td>GB/T260</td>
</tr>
<tr>
<td>Sulfur, % (m/m)</td>
<td>≤0.035</td>
<td>GB/T380</td>
</tr>
<tr>
<td>Mechanical impurity</td>
<td>None</td>
<td>GB/T511</td>
</tr>
<tr>
<td>Acid number mgKOH/100mL</td>
<td>≤7</td>
<td>GB/T258</td>
</tr>
<tr>
<td>Copper-strip test class (50°C 3h)</td>
<td>≤1</td>
<td>GB/T5096</td>
</tr>
<tr>
<td>Cetane number</td>
<td>≥45</td>
<td>GB/T386</td>
</tr>
</tbody>
</table>
2. Quality requirements of heavy fuel oil

2.1 According to the standard GB/T17411, marine residual fuel shall meet the requirements as follows:

<table>
<thead>
<tr>
<th>Items</th>
<th>RMA10</th>
<th>RMB30</th>
<th>RMD80</th>
<th>RME180</th>
<th>RMG180</th>
<th>RMG380</th>
<th>RMG500</th>
<th>RMG700</th>
<th>RMK380</th>
<th>RMK500</th>
<th>RMK700</th>
<th>Test method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinematic viscosity at 50°C (mm²/s) ≤</td>
<td>10</td>
<td>30</td>
<td>80</td>
<td>180</td>
<td>180</td>
<td>380</td>
<td>500</td>
<td>700</td>
<td>380</td>
<td>500</td>
<td>700</td>
<td>GB/T11137</td>
</tr>
<tr>
<td>Density to meet one of the following conditions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15°C (Kg/m³) ≤ 920</td>
<td>960</td>
<td>975</td>
<td>991</td>
<td>991</td>
<td>987.6</td>
<td>987.6</td>
<td>1010</td>
<td>GB/T1884 和 GB/T1888</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20°C (Kg/m³) ≤ 916.5</td>
<td>956.6</td>
<td>971.6</td>
<td>987.6</td>
<td>987.6</td>
<td>1006.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GB/T1884 和 GB/T1888</td>
</tr>
<tr>
<td>Sulphur content % (m/m) ≤ 2</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>GB/T7304</td>
</tr>
<tr>
<td>Flash point °C ≥ 60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>GB/T261</td>
</tr>
<tr>
<td>H₂S (mg/kg) ≤ 2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>IP570</td>
</tr>
<tr>
<td>Acid value (KOH)/(mg/g) ≤ 2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>GB/T7304</td>
</tr>
<tr>
<td>Total sediment % (m/m) ≤ 0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>SH/T0702</td>
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<tr>
<td>Coal residue % (m/m) ≤ 2.5</td>
<td>2.5</td>
<td>10</td>
<td>14</td>
<td>15</td>
<td>18</td>
<td>18</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>GB/T17144</td>
</tr>
<tr>
<td>Pour point °C Winter ≤ 0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>GB/T3535</td>
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<tr>
<td>Summer ≤ 6</td>
<td>6</td>
<td>6</td>
<td>30</td>
<td>30</td>
<td>30</td>
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<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>GB/T3535</td>
</tr>
<tr>
<td>Water content % (V/V) ≤ 0.3</td>
<td>0.3</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>GB/T260</td>
</tr>
<tr>
<td>Ash content % (m/m) ≤ 0.04</td>
<td>0.04</td>
<td>0.07</td>
<td>0.07</td>
<td>0.07</td>
<td>0.1</td>
<td>0.1</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>GB/T508</td>
</tr>
<tr>
<td>Vanadium content mg/kg ≤ 50</td>
<td>50</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>350</td>
<td>450</td>
<td>450</td>
<td>450</td>
<td>450</td>
<td>450</td>
<td>450</td>
<td>IP501</td>
</tr>
<tr>
<td>Na (mg/kg) ≤ 50</td>
<td>50</td>
<td>100</td>
<td>100</td>
<td>50</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>IP501</td>
</tr>
<tr>
<td>Al+Si (mg/kg) ≤ 25</td>
<td>25</td>
<td>40</td>
<td>40</td>
<td>50</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>IP501</td>
</tr>
<tr>
<td>ULO/ (mg/kg) Fuel oil should not contain ULO, in line with one of the following conditions, that contain ULO fuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>IP501</td>
</tr>
<tr>
<td>Ca 和 Zn Ca&gt;30 and Zn&gt;15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>IP501</td>
</tr>
<tr>
<td>Ca 和 P Ca&gt;30 and P&gt;15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>IP501</td>
</tr>
</tbody>
</table>
2.2 Viscosity conversion of common marine fuel oil

<table>
<thead>
<tr>
<th>Kinematic viscosity, mm²/s50°C</th>
<th>Kinematic viscosity, mm²/s80°C</th>
<th>GB/T17411 Kinematic viscosity, mm²/s100°C</th>
<th>Redwood No.1 Second 100 °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>15</td>
<td>10 (RMA10)</td>
<td>300</td>
</tr>
<tr>
<td>80</td>
<td>25</td>
<td>15 (RMD15)</td>
<td>600</td>
</tr>
<tr>
<td>120</td>
<td>35</td>
<td>25 (RME25)</td>
<td>1000</td>
</tr>
<tr>
<td>180</td>
<td>45</td>
<td>35 (RMD35)</td>
<td>1500</td>
</tr>
<tr>
<td>380</td>
<td>75</td>
<td>35 (RMD35)</td>
<td>3500</td>
</tr>
</tbody>
</table>

Note: (1) RMD15-120 Marine fuel oil is equivalent approximately to RIS 1000s (100°F). It is used for 200 series marine main and auxiliary engines, on which nitriding cylinder liners, combined-type pistons with steel crown and aluminium skirt, fuel injectors with non-cooling type nozzle and cylinder heads are installed. But the inlet and outlet valves are the same as those on engines burning diesel fuel.

(2) RME25-180 Marine fuel oil is equivalent approximately to RIS 1500s (100°F). It is used for 200 series marine main and auxiliary engines, on which nitriding cylinder liners, combined-type pistons with steel crown and aluminium skirt, fuel injectors with cooling type nozzle and cylinder heads are installed. The inlet and outlet valves are of heavy fuel type.

(3) RME35-380 Marine fuel oil is equivalent approximately to RIS 3500s (100°F). It is used for 200 series marine auxiliary engines and land-used generating sets, on which nitriding cylinder liners, combined-type pistons with steel crown and aluminium skirt, fuel injectors with cooling type nozzle and cooling type cylinder heads are installed. The inlet and outlet valves are of heavy fuel type.

(4) 20# heavy diesel fuel in GB445 is equivalent approximately to DMC in GB/T17411.

(5) 1cSt=1mm²/s

2.3 Determination of preheating temperature for heavy fuel

Properties of fuel determine largely the operation of engine, service interval and working life of parts. Especially, when the engine burns heavy diesel fuel or heavy fuel, poor fuel atomization, inferior combustion, serious carbon accumulation may occur in the operation due to high density, viscosity, mechanical foreign matters, water content, elements as S, V, Na, etc. in heavy fuel. Therefore, it is necessary that perfect devices for separating, filtering, preheating and supplying are equipped to fuel system. Separating and filtering devices could remove solid matters and water in fuel (requirements: water ≤0.2%(V/V), solid matters content ≤50mg/kg, matter size ≤5 μm). Preheating device could ensure 12 mm²/s kinematic viscosity of fuel before
injection pump. The preheating temperature can be determined by Viscosity-Temperature Diagram.
3.4 Determination of preheating temperature of heavy fuel

Refer to Diagonal 3 in Viscosity-Temperature Diagram, the lower section of which meets horizontal lines 10 mm²/s, 12 mm²/s, 15 mm²/s respectively at A1, A2, A3. Then draw three vertical lines from A1, A2, A3 to meet Temperature-coordinate axis respectively. The values on Temperature-coordinate indicate the preheating temperature range, i.e., 108 ~ 126 °C. The preheating temperature should be 117 °C if the kinematic viscosity of heavy fuel is required to be 12 mm²/s before it flows into injection pump.

Note: The V-T Diagram is for reference only. In actual practice, the viscosity shall be measured by viscosimeter, then the required viscosity shall be controlled by fuel-controlling unit.

Note: Fuel shall be controlled in respect of temperature before flowing into injection pump, no matter heavy diesel oil or heavy fuel oil used. Its kinematic viscosity shall be kept from 10 mm²/s to 15 mm²/s, or the service life of relative components and parts will be shortened.

3 Fuel additives

The use of additives can optimize combustion of diesel fuel, decrease carbon deposit and wear of cylinder liners, pistons and piston rings, although the engine could run trouble-free without additives in fuel. So it is up to user to decide the use of additives in fuel according to actual circumstance.

Note: Jiajie JH-3 Fuel Conservation Additive is recommended.

Function: Rate of economizing light diesel fuel: 5%; Eliminating carbon deposit, and forming new film inside cylinder block to improve dynamic performance effectively, to lessen mechanical wear and to prolong working life of diesel engine; reducing service cost; diminishing emission and decreasing air pollution.

Method of application: Blending ratio of additive and fuel: 1:2000 (i.e. 500g JH-3 additive for 1 ton fuel). When using additive, it shall be blended fully with 0# diesel fuel in a container before the admixture is poured into empty fuel tank. Then fill the fuel tank with required fuel which shall be poured into fuel tank to dissolve fully the additive in admixture that has been in tank. If user does not obey above sequences, the fuel conservation function will be diminished vastly.
2. Quality requirements of lube oil

2.1 Quality requirements of lube oil for diesel engine

The quality of the lube oil used for CW200 series diesel engines shall be in accordance with the technical data of CD40 in Standard GB11122.

<table>
<thead>
<tr>
<th>Items</th>
<th>Quality index</th>
<th>Test method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity grade</td>
<td>40</td>
<td>Suitable</td>
</tr>
<tr>
<td>Kinematic viscosity at 100℃ (mm²/s)</td>
<td>12.5~16.3</td>
<td>GB/T265</td>
</tr>
<tr>
<td>Viscosity index</td>
<td>≥ 80</td>
<td>GB/T2541</td>
</tr>
<tr>
<td>Flash point (open cup), °C</td>
<td>≥ 225</td>
<td>GB/T3536</td>
</tr>
<tr>
<td>Water content %</td>
<td>≤ Trace</td>
<td>GB/T260</td>
</tr>
<tr>
<td>Pour point °C</td>
<td>≤ -10</td>
<td>GB/T3535</td>
</tr>
<tr>
<td>Foamability (foam tendentiousness/stability) mL/mL</td>
<td>24℃ ≤ 25/0</td>
<td>GB/T12579</td>
</tr>
<tr>
<td></td>
<td>93.5℃ ≤ 150/0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post-24 ℃ ≤ 25/0</td>
<td></td>
</tr>
<tr>
<td>Sediment %</td>
<td>≤ 0.01</td>
<td>GB/T6531</td>
</tr>
</tbody>
</table>

2.2 Quality requirements of additives

<table>
<thead>
<tr>
<th>Dissolvability</th>
<th>The additives must be dissolved in the oil. The ash as residue after combustion must be of soft structure.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning capacity</td>
<td>It must be so high that coke and tar-like residues occurring when fuel is combusted must not build-up.</td>
</tr>
<tr>
<td>Dispersing ability</td>
<td>The combustion sediment can be dispersed in the oil</td>
</tr>
<tr>
<td>Neutralization capacity</td>
<td>It must be so high that acidic products produced during combustion are neutralized.</td>
</tr>
<tr>
<td>Stabilizing capacity</td>
<td>The lube oil must not form a stable emulsion with water.</td>
</tr>
</tbody>
</table>

Lube oil must be CD40 in GB11122. Technical specifications of other types of lube oil used should be in compliance with requirements in above table, otherwise the manufacturer would not bear the service responsibility if the diesel engine does not operate normally due to inferior oil.

It is recommended to use special lube oil designated by Weichai Power.

1. Do not add oil during operation of engine.
2. Different types of oil must not be used together.

When the engine burning heavy fuel, acidic oxide would be produced easily during combustion since there are many foreign matters, especially high sulphur content in heavy fuel.
If the temperature of fresh water in cylinders is low, when the high temperature combusted gas contacts the cool surface of combustion chamber, sulfuric acid and sulfurous acid are easily generated. If flowing back to oil sump, the acids will lead to acidification and deterioration of oil, which aggravates the low temperature corrosion of components and parts. The marine engines work under foul conditions with poor lubrication, the lube oil inevitably mixes with water. So the oil for marine engine should be added with additive, such as metallic detergent, ashless dispersant and antioxygen, anticorrosion and antiwear water diversion additive, to increase the cleanness and dispersivity, stability under thermooxidizing condition, water diversion performance and anticorrosion of lubricating oil. The basic oil with which additives have been mixed must demonstrate the following characteristics:

1) The additives must be dissolved in the oil and must be of such a composition that an absolute minimum of ash remains as residue after combustion. The ash must be soft.

2) The cleaning capacity must be so high that coke and tar-like residues occurring when fuel is combusted must not build-up.

3) The dispersing capacity must be able to remove the combustion deposits from the used oil.

4) The neutralization capacity must be so high that the acidic products produced during combustion are neutralized.

5) The tendency to evaporate must make the lube oil not form a stable emulsion with water. Water should be separated rapidly from other foreign substance in separator.

Generally, additives in lube oil is determined by qualities of parts and fuel in HFO engine. High alkaline lube oils as API-CD grade and above are preferably used for turbocharged or intensified HFO engine. Low quality lube oil is permitted to be substituted with a higher one.

Therefore, only lube oil designed for marine mid-speed engine with trunk piston can be used for HFO engine, and shall be subjecto selection according to the properties of heavy fuel oil burned by engine.

Lube oil with 15mgKOH/g total base number (TBN) is suitable for lubricating cylinders and crankcase of engine burning heavy fuel, in which sulfer content is less than 1.5%.

Lube oil with 30mgKOH/g total base number (TBN) is suitable for lubricating cylinders and crankcase of engine burning heavy fuel, in which sulfer content is less than 3.0 %.

Note: We recommend Kunlun lube oil DCB4015 and DCB4030. They are designed for serving marine mid-speed HFO engine with trunk piston, and are applicable for lubricating cylinders and crankcase in main or auxiliary engine.
<table>
<thead>
<tr>
<th>Item</th>
<th>Specifications</th>
<th>Test method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Products</td>
<td>DCB4015</td>
<td>DCB4030</td>
</tr>
<tr>
<td>Viscosity grade</td>
<td>SAE40</td>
<td>SAE40</td>
</tr>
<tr>
<td>Kinematic viscosity(100°C)</td>
<td>14.5</td>
<td>14.5</td>
</tr>
<tr>
<td>TBN</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Viscosity index</td>
<td>88</td>
<td>88</td>
</tr>
<tr>
<td>Flash point, (open cup)</td>
<td>238</td>
<td>238</td>
</tr>
<tr>
<td>Water content</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Pour point</td>
<td>-15</td>
<td>-15</td>
</tr>
<tr>
<td>Rust test in liquid phase (synthetic seawater)</td>
<td>No rust</td>
<td>No rust</td>
</tr>
<tr>
<td>Sediment</td>
<td>0.008</td>
<td>0.01</td>
</tr>
<tr>
<td>Water separation</td>
<td>≥ 1.4</td>
<td>≥ 1.3</td>
</tr>
<tr>
<td>Emulsion ml</td>
<td>≤ 0.2</td>
<td>≤ 0.3</td>
</tr>
<tr>
<td>Carrying capacity (CL-100)</td>
<td>≥ 11</td>
<td>11</td>
</tr>
</tbody>
</table>

### 2.3 Changing oil

The oil quality should be received the proper care during the running of engine. Check oil quality regularly, especially its viscosity and water content. Oil must be changed if it is diluted, or else its viscosity grade and other performances will degenerate severely, and even explosive blended gas will be engendered in crankcase.

When replacing oil, scavenge oil should be drained out. Clean oil circulation system carefully. **Cotton yarn or rag or wool cloth is prohibited in cleaning.**

Change oil according to following points. However, its service life could be prolonged appropriately if its quality does not degenerate remarkably.

- Change oil for the first time after first 50 running hours of new engine.
- Change oil for the second time after 500 running hours.
- Change oil every 1500 running hour afterwards if in normal circumstance.

If oil system is equipped with oil separator, which can remove the water content and impurity in oil, the interval of oil change is permitted to be prolonged.

Examine oil regularly and change it as soon as any situation as follows is detected.

- Kinematic viscosity mm²/S: 25% higher or lower than that of new oil
- Flash point °C: less than 160;
Total alkalinity mg KOH/g: less than 50% of that of new oil.
Water content %: greater than 0.2.

3. Quality requirements of fresh water

3.1 The cooling water must be treated before commencement of start of engine. During running, examine regularly the quality indexes of cooling water to ensure that it maintains specified quality.

<table>
<thead>
<tr>
<th>Water type</th>
<th>Fresh water free from foreign matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total hardness</td>
<td>100mgCaO/L</td>
</tr>
<tr>
<td>PH value (at 20℃)</td>
<td>6.5~8.0</td>
</tr>
<tr>
<td>Chloride ion</td>
<td>Max. 50mg/L</td>
</tr>
<tr>
<td>Not suitable water</td>
<td>Sea water, brackish water, brines, industrial waste water.</td>
</tr>
</tbody>
</table>

3.2 Cooling water additives

Function: Additives can prevent water chamber of HFO engine from corrosion and cavitations. Chemical or anticorrosion emulsified oil are usually used. If the hardness of cooling water is lower than the level specified by the anticorrosion agent manuf actory, the user could consult with the maker of anticorrosion agent, if necessary.

We recommend NL emulsified antirust agent as anticorrosion emulsified oil, which contains compositions as follows:

- Petroleum sodium sulfonate: 36%
- Castor oil sodium soap: 19%
- Triethanolamine: 6%
- Benzotriazole: 0.2%
- 5#~7# high speed machine oil: 38.8%

After additives is added, in the ratio of 0.8%~1%, to the cooling water, a protective film will form on the metallic inner surface of cooling-water piping. The film will not bring negative influence on heat conduction, and will prevent from producing calcic layer on the metallic surface. The user should check regularly concentration and working condition of cooling water system, to ensure that additives forms stable bubble-free emulsion layer in water.

When the water temperature is lower than 0℃ or higher than 95℃, anticorrosive emulsified oil will be inapplicable. Change to antifreeze or chemical addition agent!

Note: If there have been anticorrosion emulsified oil in the cooling water, antifreeze should not be added in the water, or the emulsifying agent will be destroyed, and generate oil sludge in the system.
Manual for operation & maintenance of 200 series V-type engines with individual injection pump

Chapter 3  Main configuration and systems of diesel engine

1. Construction feature

1.1 Cylinder quantity and rotation direction (for example: CW12V200ZC)

Take model CW12V200ZC as an example. There, capital letter V means that two banks of cylinders are designed in V arrangement. The included angle of two banks is 45°. The number 12 means 12 cylinders, 6 cylinders at each bank. Viewed from output end (flywheel end), the left-hand bank of diesel engine is called Bank A, and the right-hand one called Bank B. So the cylinders are designated by a combination of a capital letter and a number, namely A1-A2-A3… or B1-B2-B3…, starting from the free end.

Rotation direction: It rotates clockwise if viewed from output end (flywheel end).

1.2 Overview of construction of diesel engine

1.2.1 Cylinder block and frame base assembly

The cylinder block is fabricated from high strength cast iron in integral casting. It can resist effectively deflection to minimize the distortion of cylinder liners and enhance reliable operation of piston. Air intake chamber integrated in cylinder block results in more reasonable structure and size to decrease the width of engine and reduce noise radiation. Inspection holes are provided on both sides of cylinder block, used for inspecting and mounting and disassembling main bearing and bigger end bearing of connecting rod.

The wet cylinder liner, which is made in special wear-resistant cast iron, is pressed into the cylinder block from the top. Cylinder liner’s top flange draws level with the surface of cylinder block, and its lower part can expand (stretch) freely. The upper part, together with the cylinder block, forms the cooling water chamber, which is the part of diesel engine that must be cooled concentrically. Ring-like cooling water chamber, surrounding almost 1/3 area of upper part of each cylinder head, leads to an even temperature field along the longitudinal direction of a
This design is suitable to resist low temperature corrosion. Four O-rings are mounted between cylinder liner and cylinder block. They shall be tightened evenly without any distortion. When pressing cylinder liner, apply an even film of molecular antisticking agent on the matched zone of cylinder block and liner and the O-rings ring to prevent adhesion at high temperature.

Inspect regularly whether there are pulling traces on the inner wall of cylinder liner. Push the piston to TDC, then view the inner wall of cylinder liner with a mirror reflecting upwardly from the crankcase. If there is something suspected, dismantle the cylinder head, then check it carefully. The cylinder liner must be replaced with a new one if there are some wide and deep longitudinal pulling traces.

The inner diameter of cylinder liner and piston are measured at the same time. The cylinder liner must be replaced if its inner diameter is worn severely or its cylindricity exceeds limited value.

After a long time of running, a layer of scale deposit accumulated on outside of cylinder liner will cause poor heat radiation. The user should eliminate scale deposit in the water chamber regularly according to the practical circumstance.

Water mixed in oil may be caused by corroded cylinder liner or poor sealing property of O-ring. If so, dismantle the leaking cylinder liner, replace the liner or O-ring, then carry out hydraulic test again. When reassembling the cylinder head, all rubber rings shall be replaced with new ones. A running-in test must be carried out after replacing cylinder liner.

1.2.2 Crankshaft and piston, connecting rod assembly

1.2.2.1 Crankshaft

The crankshaft is made from good quality alloy steel subject to continuous fiber upsetting,
so it possesses sufficient fatigue resistance, counter-bending rigidity and torsion-resistant rigidity.
The crankshaft is suspended under the cylinder block, fastened at cylinder block by main bearing
cap and bolts. Main bearing bolts are categorized into transversal and longitudinal bolt. Pay
attention to installation requirements. The crankshaft is equipped with counter-weight, which is
positioned by locating pin and fitted on the crankweb by two bolts, so that good balance is
brought to rotary mass. Main bearings and crankpin bearings is of sliding type. There is a thrust
bearing that is of steel back plated bearing alloy at the output end. Flywheel and timing gear
system are installed on the output end of crankshaft, while a sleeve spring vibration damper at
the free end.

Lubricating oil flows into main journal through oil hole of cylinder block, and into crank
pin through neighboring angular hole. At the same time, a part of lubricating oil enters bush of
small end of connecting rod, piston pin seat and piston cooling chamber along the connecting
rod body.

**Measurement of crankweb deflection**

1.2.2.1.1  Tools required

1. Crankweb deflection gauge
2. Note pad

![Diagram of crankshaft parts](image)
1.2.2.1.2 General

Crankweb deflections are indicative of the misalignment of the main bearings with relation to each other and of main bearings with relation to the bearings of the connected shaft. If the values measured exceed the permissible maximum, the crankshaft must be realigned. Possible causes are: uneven wear of main bearings, a dislocation of the driven shaft, or changes in the supports of the engine on the foundation or changes in the foundation itself.

1.2.2.1.3 Sequence of operations

(1) Remove crankcase covers.
(2) Turn crankshaft so as to move crank of cylinder No.1 into start-out position that is either UTL or UTR, which depends on revolution direction of engine (connecting rod has been installed on crankpin).
(3) Insert crankweb deflection gauge (crank spread gauge) into measuring points in the two webs and set dial gauge to “0” at about the middle of the measuring range.

Note: If measurements are taken in a warm engine, the crankweb deflection gauge must be...
first be placed near the running gear in the crankcase of the engine for approximately 15 minutes so as to bring the gauge up to the same temperature.

(4) Turn crankshaft in the normal direction of rotation to the different measuring points (see illustrations). Take deflection gauge readings, magnitude and direction (+ or -), shown as deflection from the starting position, in each of the measuring positions and enter them in the table (see measuring example).

(5) Measure remaining crankweb deflection in the same way.

(6) Remove crankweb deflection gauge and replace crankcase covers.

1.2.2.1.4 Measuring example (Unit: 0.01mm)

<table>
<thead>
<tr>
<th>Crank position</th>
<th>Cylinder No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1 Crank in UTR</td>
<td>0</td>
</tr>
<tr>
<td>2 Crank in ROT</td>
<td>+2</td>
</tr>
<tr>
<td>3 Crank in OT</td>
<td>+4</td>
</tr>
<tr>
<td>4 Crank in LOT</td>
<td>+3</td>
</tr>
<tr>
<td>5 Crank in UTL</td>
<td>0</td>
</tr>
<tr>
<td>Deflection OT-UT</td>
<td>+4</td>
</tr>
<tr>
<td>Deflection ROT-LOT</td>
<td>-1</td>
</tr>
<tr>
<td>Difference between OT values of adjacent cylinders</td>
<td></td>
</tr>
</tbody>
</table>

Note: The crankweb deflection is the difference in the distances between each pair of webs measured in the two positions displaced 180°.

When the crankweb deflection is measured with the connecting rod installed, the UT value must be derived from 0.5 (UTL+ UTR) whereupon deflection OT/UT can be calculated.

An increment in the distance between a pair of webs, compared with the datum position, is to be entered in the table with a plus sign (+), a minus sign (-) is to be used when the distance grows smaller.

Increase distance  Decrease distance

The following additional information must also be entered in the measuring record:

(1) The condition of assembly of the engine, especially the condition of assembly of the running gear, coupling with driven machines, condition of foundation, etc;

(2) Oil and cooling water temperatures, when measurements were taken in a warm engine;
(3) The normal direction of rotation of the engine;

1.2.2.1.5 If admissible max. crankweb deflection is exceeded, realignment of crankshaft and check of foundation are required.

<table>
<thead>
<tr>
<th>Engine state</th>
<th>cold</th>
<th>hot</th>
<th>Number of measured cylinder</th>
</tr>
</thead>
<tbody>
<tr>
<td>New engine in release test or installation in user’s site; Don’t transport out power.</td>
<td>-0.14mm</td>
<td>-0.16mm</td>
<td>At No.6 cylinder in 6-cyl. engine; At No.8 cylinder in 8-cyl. engine;</td>
</tr>
<tr>
<td></td>
<td>-0.08mm</td>
<td>-0.10mm</td>
<td>At No.5 cylinder in 6-cyl. engine; At No.7 cylinder in 8-cyl. engine;</td>
</tr>
<tr>
<td></td>
<td>±0.03mm</td>
<td>±0.05mm</td>
<td>Other cylinders</td>
</tr>
<tr>
<td>New engine in release test or installation in user’s site; Transport out power.</td>
<td>-0.14mm</td>
<td>-0.16mm</td>
<td>At No.6 cylinder in 6-cyl. engine; At No.8 cylinder in 8-cyl. engine;</td>
</tr>
<tr>
<td></td>
<td>-0.10mm</td>
<td>-0.12mm</td>
<td>At No.5 cylinder in 6-cyl. engine; At No.7 cylinder in 8-cyl. engine;</td>
</tr>
<tr>
<td></td>
<td>±0.07mm</td>
<td>±0.09mm</td>
<td>Other cylinders</td>
</tr>
<tr>
<td>It is recommended to realign shafting if crankweb deflection is detected to reach or exceed these value in maintenance and service</td>
<td>-0.17mm</td>
<td>-0.19mm</td>
<td>At No.6 cylinder in 6-cyl. engine; At No.8 cylinder in 8-cyl. engine;</td>
</tr>
<tr>
<td></td>
<td>-0.13mm</td>
<td>-0.15mm</td>
<td>At No.5 cylinder in 6-cyl. engine; At No.7 cylinder in 8-cyl. engine;</td>
</tr>
<tr>
<td></td>
<td>±0.09mm</td>
<td>±0.11mm</td>
<td>Other cylinders</td>
</tr>
<tr>
<td>Shafting must be realigned if crankweb deflection is detected to reach or exceed these value in maintenance and service</td>
<td>-0.19mm</td>
<td>-0.21mm</td>
<td>At No.6 cylinder in 6-cyl. engine; At No.8 cylinder in 8-cyl. engine;</td>
</tr>
<tr>
<td></td>
<td>-0.14mm</td>
<td>-0.16mm</td>
<td>At No.5 cylinder in 6-cyl. engine; At No.7 cylinder in 8-cyl. engine;</td>
</tr>
<tr>
<td></td>
<td>±0.11mm</td>
<td>±0.13mm</td>
<td>Other cylinders</td>
</tr>
</tbody>
</table>

Calculation:

BDC crankweb deflection \[ UT = \frac{UTR + UTL}{2} \]

Horizontal deflection \[ = ROT - LOT \]

Vertical deflection \[ = OT - UT \]

Difference between OT values of adjacent cylinders (cylinder No.1/ cylinder No.2) = \[ |OT_1 - OT_2| \]

Assessment method: crankweb deflection whatever from measurement or calculation shall not exceed the specified value in above table.

1.2.2.2 Piston

The piston for engine burning light diesel fuel or heavy diesel fuel is made from integrally cast aluminum alloys, and that for engine burning heavy fuel is of combined-type with steel crown and aluminum skirt. Piston skirt is designed as middle-convex and varying ellipse, surrounded by three chrome plated gas rings and one oil-ring. This construction is easily to be guided and form oil film. The top of piston exhibits shallow dish. The piston is cooled by
pressure oil from an oil passage in the connecting rod.

1.2.2.1 Dismantlement and installation of piston

Tools required

1 Piston ring pliers
1 Cleaning rod M12/M10
2 Stopping block of crankpin bearing
1 Eye bolt M12 (for one-piece piston)
2 Eye bolts M10 (for combined type piston)
2 Hexagonal nut M14
1 Open end wrench
1 Lifting gear with rope

Starting position

Crankcase open, crankgear in TDC position, big end bearing cover removed, and cylinder head removed.

1.2.2.1.1 Sequence of operations 1: Removal

(1) Using the cleaning rod, clean taphole in piston (3).

(2) Lower piston slightly by cranking, remove carbon deposits from top of running surface of cylinder liner (4). Then reset piston to TDC position to remove loosened carbon deposits in cylinder.

(3) Screw eye bolt into piston, and, lift piston out by using lifting tool and rope.

Note: The connecting rod cap has been removed and the connecting rod bolts has been taken out before pulling the piston out.

(4) Lift piston (together with connecting rod) carefully out by using lifting tool. Remove upper shell of connecting rod after it is lifted properly. Be sure that the cylinder liner is not lifted and prevent the upper shell of connecting rod that is not taken out from dropping to damage crankpin.

(5) Deposit piston with connecting rod on wooden support.

(6) Clean and check piston, repair it if necessary, assemble it with connecting rod (bearing shell has been fixed).

(7) Clean cylinder liner. Place crankgear in TDC position.

1.2.2.1.2 Sequence of operations 2: Installation
(Note: Piston, connecting rod, cylinder liner must be cleaned and dried by compressed air before installation.)

(1) Screw eye bolt into piston and fasten with rope to lifting gear.
(2) Lubricate piston rings and piston running surface with clean lube oil.
(3) Arrange the butting joints of the compression rings to be alternately offset by 180°.
(4) Lubricate inner hole of conical ring and put it onto cylinder liner.
(5) Using the lifting gear, position piston vertically over the cylinder and lower connecting rod carefully into cylinder liner as far as lightly before crankpin. When doing so, pay attention to piston mark ST to control side.
(6) Inspect and fit upper shell before installing connecting rod on crank pin. Then place piston together with connecting rod on the crankpin.
(7) Install connecting rod cap (lower half shell has been mounted on connecting rod cap), then tighten bolts and nuts with specified tightening torque.
(8) Remove eye bolt, rope and conical ring
(9) Refit cylinder head.

**Note:** When mounting piston rings, the first piston ring and the second and the third one must not be installed mistakenly and conversely.

### 1.2.2.2.2 Dismantlement and installation of piston ring and piston

**1.2.2.2.2.1 Tools required**
- 1 Piston ring expanding pliers
- 1 Circlip pliers
- 1 set of open-end wrenches
- 1 Note pad

**1.2.2.2.2.2 Maintenance**

Pull and check piston at specified intervals (see section Maintenance Schedule). Interval of piston overhauls depends on operating conditions, i.e. on engine load, fuel used, quality of combustion, lubrication and cooling. For inspection, piston rings shall not be removed as they are subjected to high stresses during removal and refitting. Check lubricating condition of piston and cylinder liner.
Starting position

Piston with connecting rod pulled and placed on wooden support.

1.2.2.2.2.3 Sequence of operations:
(1) Check condition of piston and piston rings.
(2) Measure and note down axial clearance of piston rings in their grooves.
(3) Clean piston of carbon deposits. When doing so, take care not to roughen surface of piston crown. Clean the running surface cautiously. The graphite-treated layer must be retained.

Note: The piston running surface should exhibit an even bearing pattern (contact pattern) without scoring or other damage. Sever shaving or scuffing is an indicative of engine having been overloaded, cooling-disturbed, insufficient-lubricated, etc. Scoring is caused by foreign matter that had been wedged between piston and cylinder liner.

(4) Remove compression rings by use of piston ring expanding pliers and make a close inspection, replace rings if necessary.

Note: On no account must piston rings be exchanged without the use of the piston ring expanding pliers. When removing, note position of rings in their grooves. They must be installed in the same groove as when removed, unless new rings are fitted.

(5) When fitting new rings, measure gap clearance (butting joint) by placing the piston ring into lower third of the cylinder liner (if possible a new one).

(6) Carefully clean ring groove in piston and determine wear.

Note: Tapered out ring groove flanges are an indication of excessive liner wear.

(7) Roll off piston ring in groove to determine the groove depth.

(8) Using the piston ring expanding pliers, fit piston ring and measure ring clearance in groove. Enter data into engine log.

Note: When fitting a used piston in another cylinder liner, gas rings and oil ring must be replaced in any case. The engine is then to be run at reduced load for a short time.

(9) Use the circlip pliers to remove one of the circlip rings (4), if necessary heat the piston.

(10) Push piston pin (5) out while holding the connecting rod (6), then lift off and set it down.

(11) Clean carefully the inside of the piston, blow compressed air through the oil ducts and check for signs of damage (cracks).

(12) Measure clearance from piston pin to bush by means of feeler gauge and enter measurements in engine log.

(13) Oil piston pin, insert it into piston, insert connecting rod, and push piston pin to bottom.
(14) Using pliers, insert circlip ring carefully.

**Arrangement of piston rings (right cutline)**

(a) In the first groove from the top, a chromium-plated gas ring 1 with inside chamfer and crowned running surface is fitted.

(b) The second and third grooves from the top take chromium-plated taper-face gas rings 2 with inside chamfer.

(c) Fitted in the fourth groove from the top is the oil ring 3.

**Note:** Do not attempt to remove or install piston rings without the use of the ring expanding pliers as rings would be over-extended and deformed.

Piston ring 1 has a mark of “TOP1” and ring 2 a mark of “TOP2”. Install piston rings with the side marked “TOP” up, i.e. facing the combustion chamber. Chromium-plated gas ring 1 or 2 must be replaced when the plating is worn off at any spot or the gap clearance exceeds the maximum permissible value.

**Note:** The piston ring must not be installed conversely for position or upper and lower surface. It not only could not scrape the oil, but also may result in oil leading to combustion chamber.

### 1.2.2.3 Connecting rod and shell

The connecting rod is fabricated from forging forged from high-quality steel and a split joint is normal to axis of the rod at the big end. The cap is fastened on connecting rod body by four bolts and nuts. Quality requirements of the assembly should be met when installing piston and connecting rod. Marks shall be stamped at each cylinder. Attention shall be paid to reposition when installing. **The stamped side of connecting rod cap and body should be on the same side.**

**Removing connecting rod shell**

Tools required:

- Combination of lock plate; Socket wrench; Reversible ratchet 12.5; Eye bolt M12; 1 Feeler gauge; 1 Set open-end wrenches; 1 Lifting and gear with rope; 1 Note pad; Torque wrench 80-300N.m

Starting position:

- Crankcase is open, crankgear in suitable position, cylinder head taken off.

1.2.2.3.1 Sequence of operations 1: Removing
1. Put combination of lock plate (9) on the top of connecting rod bolt (2) to prevent from its turning. Loosen and remove four connecting rod nuts (7) by use of torque wrench (8).

2. Take out connecting rod cap (6) together with lower shell (5) sideway. Pay attention not to damage crankshaft.

3. Pull out lower shell (5) out of connecting rod cap, and mark an indication on it.

4. Screw eye bolt into piston, lift piston until the upper shell (3) is turned out of connecting rod (1) in correspondent direction, and mark it.

5. Clean both shell halves carefully, using care not to damage them.

6. Check condition of the running surfaces.

7. Measure shell halves and replace them if the measured value exceeds the permitted level. The thickness of shell is measured at the middle of shell, then compared to the original measurement.

**Note: If the bearing clearance exceeds permissible value, or if the working surface of shell is damaged, the shell must be replaced.**

Bearing clearance can be measured by putting feeler gauge between the lower half shell (5) and crankpin (4) if the shell halves have been installed, and also can be measured after the connecting rod is dismantled. In such case, install shell halves and tighten the connecting rod bolt properly (see illustration of Sequence of operations 2), measure the inner diameter of bearing hole and outer diameter of crankpin with micrometer. The bearing clearance is the difference between above two diameters.

**Note: Spare connecting rod shells are machined to finished condition and must not be reworked because it may damage the thin working surface.**

1.2.2.3.2 Sequence of operations 2: Installation

1. Oil back of the shells and running surface sparingly.

2. Put upper half shell (3) into big end hole of piston (1) by hand. Take care to locating gap and mark.

3. Cautiously lower piston together with connecting rod (1) onto the crankpin (4).
4. Insert lower half shell (5) into connecting rod cap. Take care to locating gap and mark.
5. Place connecting rod cap (6) in position by hand and screw on the nuts (7).
6. Tighten nuts alternately to specified torque.
7. Measure bearing clearance and enter measurements in Engine Log.

1.2.2.3.3 Sequence of operations 3: Checking piston pin bearing
1. Pull out piston together with connecting rod.
2. Separate connecting rod from piston.
3. Insert piston pin in bearing bush.
4. Using a feeler gauge, measure clearance between pin and bush at several points on the circumference and note the results down.
5. Enter the clearances as measured into the Engine Log.

Note: If the maximum permissible clearance has been reached, this requires to insert a new bush or to install the spare connecting rod. Replacing the bush should be carried out in a service workshop as the bush is to be cooled down before being pressed in. Projection of a new bush when pressed in must be equal on either side.

1.2.2.4 Torsional vibration damper

Checking torsional vibration damper
Tools required
1 Eye bolt M16
1 Inner hexagon spanner, size 6
1 Box wrench. Size 17
MoS2 grease
1 Lifting gear with rope
1 Air adapter

Note: 1. The torsional vibration damper is provided with lubricating oil through passages in the crankshaft and is, therefore, free of maintenance. In case of extensive overhauling or when doing repairs on the timing gear, the sleeve spring packs and the lift limiting bolts should be checked.
2. Uneven run or hard knocking during engine operation may be the indication of lack
of lubricating oil or break of sleeve springs.

Checking:

The torsional vibration damper can be seen after the cover at the free end is detached.

1. Unscrew 8 hexagon bolts (9), and take off face plate (1).

**Note:** The back plate (6) is tightened on damper mass (5) by two Allen screws (10).

2. Extract locating pin (3) and sleeve spring pack (4) and check springs for breakage. If sleeve springs are damaged, replace complete spring pack.

3. Blow out lubricating oil passages in damper hub (2) with the air hose.

4. Check remaining sleeve spring packs in the same manner and one after the other, and reinstall them in the same borehole as removed.

**Note:** New locating pins and sleeve springs (of the packs) must be coated individually with MoS₂-based lubricant prior to installation. When removing all sleeve spring packs, watch marking M of damper hub (2) and damper mass (5) for proper alignment.

5. Refit face plate (1), tighten it with 8 hexagon bolts (9).

6. Check whether all hexagon bolts are all screwed in correctly (the bolts need not locking device for tightness).

**Note:** The vibration damper need not be removed in the course of any maintenance work. Should any damage occur, it is recommended that repairs be carried out by one of our service stations since pressing off the damper hub requires the use of special tools and dismantlement of crankshaft.

1.2.2.5 Main bearing bolt

Lifting gear (prepared by user)  Adhesive tape (prepared by user)

Torque spanner (80-300N·m)
1.2.2.5.1 Starting position

The crankcase is open, the crank gear is in the position so that the main bearing bolts are easily accessible. Crankshaft is secured against unintentional turning.

Note: According to the pulling direction of rope (i.e. loosening or tightening screws), lifting gear must be placed at exhaust or control side of outmost bearing respectively. In the case of main bearings at other journals, the lifting gear could be placed right or left to the camshaft side of the main bearing at given journals.

1.2.2.5.2 Sequence of operations 1: Removing

1. Loosen and remove the two transverse bearing bolts (6).
2. Screw out the screw plug (8) from corresponding hole.
3. Push rope (2) through the hole. Screw down the rope guide (1) into the hole and fasten it.
4. Place spanner (9) on main bearing screw in such a way that the spanner axis meets vertical line at 30° angle. Fix spanner with knurled screw (5).
5. Fix the rope in the shackle (10) and hook the tackle into the rope loop. Do not let the unprotected rope run over edge.
6. Amply oil the rope and rope guide.
7. Loosen main bearing bolt as possible with lifting gear.

   Note: Loosen rope if necessary, and change the position of spanner to a new initial position.
   Repeat steps 4~6.
8. Loosen rope, and place spanner to the next main bearing screw to be dismantled (see step 3 and 4).
9. Unscrew the second main bearing bolt according to above mentioned steps.
10. Remove the tools for dismantling and installing main bearing bolt.

1.2.2.5.3 Sequence of operation 2: Installation

(Note: Apply molybdenum disulphide lubricant to threads and impacted surface prior to installation.)

1. Extract main bearing bolt (4). Tighten transverse bearing bolt (6) by hand.
2. Tighten transverse bearing bolts (6) of Bank A and B alternatively with torque spanner according to specified torque (100N.m).
3. Measure side clearance (S), which must be less than 0.03mm.

4. Tighten main bearing bolt (4) to 300N.m in two steps with torque spanner (first step: to 200N.m; Second step: to 300N.m).

Measure the clearances (T) between two outmost bearing caps and crankcase, which must be less than 0.03mm.

5. Tighten transverse bearing bolts (6) of Bank A and B alternatively with torque spanner according to specified tightening angle (60°).

6. According to the pulling direction of rope, push rope (2) through the corresponding taped hole. Screw down the rope guide (1) into the hole and fasten it.

7. Place spanner (9) on main bearing screw in such a way that the spanner axis meets vertical line at 30° angle. Fix spanner with knurled screw (5).

8. Fix the rope in the shackle (10) and hook the tackle into the rope loop. Do not let the unprotected rope run over edge.

9. Mark the rope with adhesive tape using a suitable edge as reference.

10. Amply oil the rope and rope guide.

11. Operate the tackle until a rope distance of 130mm has been reached.

Note: 130mm rope distance corresponds to the specified turning angle 60°.

12. Unload the rope, take out of the fishplate and place the spanner on the second main bearing bolt. (as under steps 6~11).

13. Remove the tools for dismantling and installing main bearing bolt.

14. Verify that all tools and foreign bodies have been removed from the engine.

15. Coat the screw plugs (8) with sealing agent and screw in place.

16. Replace crankcase covers.
1.3 Cylinder head

1.3.1 Cylinder head

Cylinder head is one of important parts that constitute combustion chamber. It is made of grey cast iron, and secured to the cylinder block by four bolts, one cylinder head for each cylinder. Each cylinder head has an inlet and an exhaust valve, valve spring, valve-turning mechanism, valve guide, fuel injector, and rocker arm. Cooling water flows into cooling chamber of cylinder head through cooling water passage from top of cylinder block.

A guide sleeve is inserted in cylinder head to improve thermal diffusivity of injector nozzle to advance nozzle reliability during working. After cooling water flows into cylinder head, intermediate wall and rib force cooling water flowing to overheated place to ensure good thermal diffusivity. Cooling water passes through water space near exhaust valve, then discharges from cylinder head. Water is collected, through collecting connection between two cylinder heads, to water outlet of output end.

Each cylinder head has an inlet and an exhaust valve, and each valve is inserted with valve seat made of special material and valve guide made of wearable alloy cast iron. A seal ring is mounted on the valve guide to prevent oil from flowing air passage through gap of valve guide. Heat-resistant high-strength alloy steel is adopted as material of valve. Valve disk of inlet and outlet valve is hardfacing-welded. Every top of valve stem is equipped with valve-turning mechanism so that valve and valve seat wear away equally.

Rocker arm on cylinder head, driven directly by camshaft, is housed into a case; thus makes the structure of engine simple and reliable, and easy for service.

Fuel injector is installed in a bushing between two rocker arm casings, impacted by two
bolts and a tension block.

Oil lubricating rocker arms and air valves flows through hollow screw of positioning rocker arm shaft into cylinder head, then enters into camshaft housing through a pipe between cylinder and camshaft housing. At last, it reaches oil sump.

Power indicating valve is mounted on screw hole at side face of cylinder head. There is a removable cover on the cylinder head. If removing the cover, inspection and adjustment of valve clearance could be carried out.

Note: Cylinder head for engine burning light diesel fuel varies from that for engine burning HFO in structure.

1.3.2 Inlet and exhaust valve

Dismantling and installing rocker arm and valve

Tools required:

1 Sleeve, 1 Plate, 1 Set of tools for dismantling and installing, 1 Screwdriver, 1 Double end box wrench 19X22, 1 Hexagon screw M12, 1 Feeler gauge, 1 Mandrel dia. 30, 1 Hammer (approx. 1kg), 1 Wooden block

Starting position

Run crank of respective cylinder in ignition TDC. Inlet and exhaust rocker arm slack if turning then by hand. Cylinder head and its plate are removed.

1.3.2.1 Sequence of operations 1: Removal

1. Remove necked-down bolt (4) and dog point screw (5).
2. Move rocker arm axle (1) inwards, using wood block and hammer (see Fig.) and remove seal ring (3).
3. Pull out rocker arm axle (1) and remove rocker arm (7).

Note: if the seal ring (3) is not removed before the axle is being pulled out, it will be damaged at the edges of the bore!

4. Bolt down plate, place sleeve onto spring plate (13) and compress valve spring (12) by use of hexagon bolt until collet (14) can be removed.
5. Relax valve spring, remove tool and take out individual parts of valve.
6. If valve guide (15) is worn, remove it with suitable (Φ30) mandrel.
7. Clean all parts, and check for wear and measure off-size.
8. Replace the worn components when necessary.

Note: If several cylinder heads are disassembled at the same time, make sure that the individual parts are not mixed up if they are not replaced by new ones.
1.3.2.2 Sequence of operations 2: Installing

1. Oil all drill holes, axles and valve guides.

2. To install, reverse sequence of operations outlined above, making sure of the following points:

3. Insert seal ring (16) carefully into valve guide (15), making sure not to damage it.

4. Install valve spring (12) correctly. Put the end with mark (M) onto spring plate (13).

5. When installing valve (11), make sure that the 2 pieces of collet (14) is installed correctly.

Note: In order to not damage valve stem, when installing valve spring (12), make sure that the collets (14) have been engaged in the groove of the valve cone stem.

6. When installing a new bearing bush (8), note position of oil hole.

7. Install rocker arm axle (1) as follows:
   a. Fit seal ring (3) in groove.
   b. Push lubricated rocker arm axle into bore and mount rocker arm (7), drive in, if necessary, with wood block and hammer, making sure that the bore for necked-down bolt is in its correct position.
   c. Push roller arm axle inwards until new seal ring (3) can be fitted in groove.
   d. Use tool to tighten the rocker arm axle, screw in necked-down bolt (4), seal (6) and dog point screw (5).

8. Reassemble cylinder head and mount it completely on cylinder block.

9. Measure valve clearance and correct it if necessary.

Note: Do not remove roller (10) and roller axle (9) from rocker arm. If marks (M) do not coincide or if roller axle (9) can be turned or roller (10) is damaged, replace the complete rocker arm.
1. Crankshaft gear (42 teeth)  2. Stepped gearwheel (56/30 teeth)
3. Stepped gearwheel axle  4. Intermediate wheel (53 teeth)
5. Intermediate wheel axle  6. Intermediate wheel (49 teeth)
7. Intermediate wheel axle  8. Camshaft gear (45 teeth)
1.4.1 Camshaft and timing gear system

Camshaft is fabricated from alloy steel, which is of two-section type, connected by bolts and pins. An axial oil passage runs through camshaft, whose ends are plugged up with nuts. There is an open oil tubule on each bearing and cam, leading to axial oil passage, to force to lubricate moving components with hydraulic oil.

Each cylinder has an inlet cam, an exhaust cam and an injection cam, to drive directly roller of inlet rocker arm and outlet rocker arm respectively; thus valve mechanism becomes simple because valve lifter is cancelled. The injection cam drives injection pump with roller tappet rod.

Each bank of cylinders is equipped with one camshaft. Entire camshaft is installed axially in camshaft case on side face of cylinder heads from flywheel end. The camshaft cases of Bank A and B are positioned at cylinder block with bolts respectively. Timing gear and camshaft are interference fit. Its dismantlement and installation require specific tools.

Timing gear system is arranged at output end. The gearwheels are hooded in corresponding gear cases at the end of cylinder block. The crankshaft gear drives stepped gearwheel and intermediate gearwheel to further drive the camshaft gear.

Checking timing gear

Tools required:
1. Feeler gauge; 1 Socket wrench, size 36; 1 T- handle; 1 Joint 20-12.5; 1 Open-end wrench; 1 Note pad

Checking method:
1. Remove the lateral plate of timing gear.
2. Measure gear backlash by use of the feeler gauge, record measurements and compare with the values listed.
3. Check proper functioning of spray nozzles, with the priming pump (if provided) switched on for a short period of time. Blow out clogged spray nozzles with an air hose.
4. Check to see that oil is escaping from all bearing axles of the intermediate wheels.
5. Replace lateral covers.

Note: The tooth flanks should be visually inspected whenever there is an opportunity. In the event of damage of the timing gear drive requiring replacement of the gearwheels, it is recommended that the work shall be carried out in one of our service stations. Upon assembly, the match marks on the drive wheels must register.
2. Fuel system

The fuel system is used, according to working circumstance, to filter fuel oil so as to generate high pressure, and to inject regularly atomized fuel oil in a certain quantity and pressure rhythm into cylinders. The oil mixed with air combusts quickly and perfectly.

Fuel system is composed of low-pressure fuel supply pump (for burning light diesel fuel), low-pressure fuel pipe, diesel oil filter, injection pump, fuel pressure pipe, fuel injector and oil return pipe.

The above figure illustrates work flow of fuel system. When diesel engine works, fuel oil is delivered from day tank through supply pipes to supply pump (9) that is mounted on camshaft case and driven by camshaft (no supply pump mounted on HFO engine). The supply pump can also be mounted separate from engine and driven separately. From the outlet of supply pump, the fuel is forced through the twin filter and the supply pipe (8) to the fuel injection pump (5) which
forces the fuel oil through fuel pressure pipes (3) and injector (2) into the combustion space in the cylinders. Spare pump that can be not mounted on is connected to twin filter to clean the piping when diesel engine stops.

Only part of fuel oil supplied to injection pump is injected through injection pump into cylinders. The volume of injected fuel oil depends on the real load of diesel engine. Needless fuel oil flows back into day tank via return pipes (7) and nonreturn valve (10), the purpose of which is to keep pressure at fuel inlet side of injection pump.

The fuel oil leaking from fuel injector enters gathering pipe (11) through return pipe (1), then into day tank.

The fuel pressure pipes (3) are bundled with protective sleeves (4). The fuel oil leaking from loose thread adaptors or damaged pipes is collected in protective sleeves, then streams into Oil return branch pipe (6) via short-span connections. The Oil return branch pipe can be linked with gathering tank equipped with a meter for leakage amount if the user requests.

**Note:** The arrangement of fuel system of HFO engine is same as that of engine burning light diesel fuel, except for the supply pump.

1. The arrangement of peripheral piping is assumed by enduser. A support should be fitted to the piping connecting with diesel engine.
2. We still recommend elastic tubes to link to diesel engine even if the diesel engine is rigid-supported.
2.1 Dismantling and installing injection pump

1. Hexagon nut
2. Delivery flange
3. Delivery valve
4. Delivery pipe connect
5. Gasket
6. Seal ring
7. Pump casing
8. Pump barrel
9. Baffle screw
10. Pump plunger
11. Seal ring
12. Spring plate
13. Pressure spring
14. Control sleeve
15. Guide sleeve
16. Spring plate
17. Circlip
18. Dowel pin
19. Lifting hook
20. Pump rack
21. Camshaft
22. Roller tappet
23. Cocking ring
24. Gasket
25. Sleeve
26. Hexagon screw
27. Gasket
28. Protective cap
29. Pointer
30. Injection pump
31. Round seal ring
32. Roller pin
33. Roller
34. Shim
35. Special tool for dismantling and refitting
Starting position

Tension spring between pump rack and fuel control linkage unhooked. Camshaft in top
dead center of change of charge (both valves open).

1.1 Sequence of operations 1: removal and dismantlement
1. Unscrew bolts in flanges of fuel inlet and outlet.
2. Disconnect oil discharge pipe, fuel return pipe and injection pipe and fuel lines.
3. Unscrew the 4 bolts (26) securing the pump, and remove the pump, noting that the
   pump compression spring will partly relax.
4. Apply the dismantling tool (35) to the injection pump.
   Note: Insert the long hook in the hole first, then press down the compression spring with
   the tool and swing the short hook into the opposite hole.
5. Remove the circlip (17) with pliers.
6. Relax the compression spring and remove the tool.
7. Take out the guide sleeve (15), plunger (10) with spring plate (16) and pressure
   spring (13), and control sleeve (14) with spring plate (12).
8. Unscrew and remove 4 nuts (1) on the delivery flange (2).
9. Press out the barrel (8) and the delivery valve (3).
10. Clean all parts in fuel. Blow through all holes with compressed air
11. Inspect running surfaces for wear and take measurements.
12. Inspect all seal rings for deformation and damage, and replace as necessary.
13. The pump rack (control rod) (20) and the two baffle screws (9) are normally not
    removed.
    Note: If several pumps are dismantled at the same time, be sure to keep parts separated so
    as to not mix them up. This also applies to the shims (34). When replacing pump parts,
    note that the pump barrel (8) and the pump plunger (10) as well as the complete delivery
    valves (3) are to be renewed in sets.
14. The roller tappet (22) can be removed downwards after removal of the locking ring
    (23).
15. Clean roller tappet and check for wear (tappet, roller and bolt). If necessary, renew
    round seal ring (31).

1.2 Sequence of operations 2: Reassembly and refitting
Reassembly is a reversal of dismantling. The following points should be noted:
1. Before assembling, oil the thoroughly cleaned parts sparingly (light mineral oil).
2. Metal to metal sealing and seating surfaces must be installed in absolutely dry condition.

3. When assembling, all parts must be fitted without exerting any force.

Note: When fitting the barrel (8), make sure that the dowel pin (18) is not sheared off. Therefore, proceed as follows:

4. Lightly oil the seal ring (11) and fit in its position. Oil the barrel (8) lightly on its shank and press in by hand so that the direction of the groove is aligned with the locating dowel pin (18).

5. If the locating dowel pin does not engage, move the barrel back and forth with the hook (19) and at the same time exert some pushing force in order to bring it into exact alignment position.

6. Check the seating of the pump barrel on the seal ring by measuring check dimension Y.

7. When installing the pump plunger (10) and the control sleeve (14), see that the match marks on barrel and plunger as well as on pump rack (20) and sleeve register.

Note: Providing the pump has been correctly reassembled, the dimension (X) amounts to approx. 30mm, with the pump rack at Zero position.

8. Use tool (35) for installing the pressure spring (13).

9. Tighten the hexagon nuts (1) cross-wise to the specified torque.

10. If roller tappet (22) was removed, make sure during reassembly that the fixing projection engages in the roller groove of the tappet. Fit the locking ring (23) so that it is forced into the position shown on the drawing when the pump is installed.

11. Clean contact-making surfaces between pump and camshaft case and fit new seal (gasket) (24) if necessary.

12. After correct positioning of the injection pump, tighten the bolts (26) cross-wise to specified torque (60 N.m). With pumps mounted at the engine ends, tighten the bolt in the corner manually, then with the box wrench.

13. Reconnect all pipelines and check for tightness.

14. Reconnect fuel control linkage to racks of fuel pumps.

Note: The structure of HFO injection pump is same as that of light fuel injection pump.
## Clearance

<table>
<thead>
<tr>
<th>Mark</th>
<th>Dimensions (mm)</th>
<th>Clearance (new)</th>
<th>Limit</th>
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<td>17 (12)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>B</td>
<td>—</td>
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<td>—</td>
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<tr>
<td>D</td>
<td>25h6</td>
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Note: The dismantlement and reassembly of injection pump should be carried out under the instruction of our professionals or experts.
2.2 Dismantling and reassembling fuel control linkage

29. Double end rod  30. Link rod  31. Woodward UG8 or PSG governor  32. Link rod  
33. Two-arm crank rod  34. Link rod  35. Rod  36. Link rod

2.2.1 Tools required:
1 Set open-end wrenches and viscid lubricating oil

2.2.2 Sequence of operations 1: Assembling and checking free movement of control linkage.

1. Disconnect and remove link rod (18) or (36) from the governor tappet top.
2. Disconnect force assistor (12), if it is mounted, from rod (8).
3. Unhook pull spring (5) from pull spring (7) and pump rack (6).

4. Inspect visually all bearing points, ball and fork joints (clearances and sliding surfaces)
5. Lubricate all sliding joints and moveable linkage with viscid lubricating oil, and check the free movement of control linkage by moving it forth and backward.
6. If a servo motor is mounted, it is recommended to shift input rod and output rod to check free movement. The oil sealability should be inspected during the running of diesel engine.
7. Hook the pull springs (7 and 5) onto pump rack.
8. Reassemble governor together with fuel control linkage and force assistor (12) together with rod (8) (If it is provided.)
9. Inspect all thread joints for tightness.
10. Check working condition of emergence shut-down device.

2.2.3 Sequence of operations 2: Dismantling

1. Dismantle emergence shut-down device.
2. Unhook pull springs (5 and 7), loosen and separate the link between the control linkage (6) and Link rod (30) at two sides of cylinder block.
3. Unscrew roller (1) and dismantle control linkage (6).
4. Check wear of roller and replace it if necessary.
5. If any other parts need to be dismantled, they must be marked distinctly, including the positions of all rods to corresponding shafts, to prevent from mistakenly reassembling.

Note: Make sure that the length setting of these joints is not being changed when loosening the link joints.

Sequence of operations: Reassembling and adjusting

1. Reassembly is a reversal of dismantling.
2. Lubricate all bearing points and siding surfaces with viscid lubricating oil.
3. Assemble emergence shut-down device.
4. Set all pump racks and fuel control linkage and governor tappet at STOP position.

Note: When reassembling and adjusting the fuel control linkage, it is important to check that with the control linkage (6) in position STOP, all pump racks (3) of the injection pump must be in position STOP, too. At the position STOP, the measured distance A between pump rack and pump housing is 55mm. Otherwise it may prove impossible to shut the engine down due to individual pumps still delivering.

2.3 Calibrating injector
2.3.1 Tools required:
   1 Nozzle testing device complete, including hand pump with delivery tubes
   1 Receptacle for cleaning tools
   1 Chuck
   1 Cleaning wire, Φ0.25mm
   1 Cleaning wire, Φ0.30mm
   1 Set of graded thickness washers

Starting position:
Injection valve has been removed, the outside cleaned. Nozzle testing device is bolted onto a suitable support.

The injection valve is tested for opening
**pressure, tightness, opening behavior and spray pattern of nozzle.**

2.3.2 Sequence of operation 1: Preparation for testing:

1. Clamp injector (5), nozzle down, in vice so that the nozzle holder (4) will not be damaged, paying attention to the seal ring (2).
2. Connect delivery tube to pressure connection of injector and tighten nut well.
3. Fill tank of nozzle testing device with corrosion inhibiting oil or with clean fuel oil.
4. Open vent screw (10) and operate hand lever (11) until fuel escapes from the hole of vent screw free of air bubbles.
5. Tighten vent screw and continue to operate hand lever until fuel escapes from the connection fitting (7) without air bubbles.
6. Connect injection valve with delivery tube to nozzle testing device.
7. Place a collecting tray beneath the injection valve in such a position that the valve sprays into it.

Note: When testing injector that are to be kept in reserve, it is recommended that corrosion inhibiting oil be used as the injector will thus be preserved at the same time (required viscosity approx. 13mm²/s/20°C).

2.3.3 Sequence of operation 2: Checking opening pressure of injector

1. With the pressure gauge (8) connected, open the shut-off valve (9), push hand lever (11) slowly downwards until the nozzle sprays.
2. Read opening pressure on pressure gauge.

WARNING: With the pressure gauge connected, make the pressure increase slowly, especially pay attention to decrease the pressure slowly, to avoid damaging the gauge.

3. If necessary, adjust or correct the opening pressure by insertion of graded thickness washers (2) to 24+0.8MPa (engine burning light diesel fuel) or 30+0.8MPa (engine with cooling type nozzle burning heavy fuel oil).
4. Recheck opening pressure.

2.3.4 Sequence of operation 3: Checking injector tightness
2.3.5 Sequence of operation 4: Checking opening behavior and spray pattern of nozzle

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>①</td>
<td>Operate hand lever of pump until the pointer of the pressure gauge has reached a value 2MPa below the specified opening pressure.</td>
</tr>
<tr>
<td>②</td>
<td>The injector holds tightness if there is no oil drop falling within 10 seconds.</td>
</tr>
</tbody>
</table>

**Note:** During the transition period from pushing slowly hand lever to pushing rapidly (item 2 to 3), fuel columns are sprayed from the nozzle, without being atomized, and without changing sound from high to low or sound of “Pu-Pu”. These characteristics are indicative of a good nozzle. The absence of one of the reference characteristics may be the result of:

a) **A distorted nozzle clamp nut**
   - Repair: Loosen nozzle clamp nut (3), and move nozzle (1) up and down on its seat. Re-tighten clamp nut to specified torque. If this is of no avail, replace nozzle clamp nut.
   - Tightening torque of the nut after oiling: 80N.m (light diesel fuel)
   - 170N.m (heavy fuel, cooling type nozzle)

b) **Nozzle orifices are deposited with carbon or plugged.**
   - Repair: Dismantle injector and clean it.

1. Shut off pressure gauge when performing this test.
2. Keep away from the fuel jet, as they are capable of penetrating the skin and will then cause painful inflammation.
3. Open fire must be prohibited at the work site!
2.4 Inspecting fuel-delivery advance angle

The fuel-delivery time of injection pump influences directly the performances of engine. Generally, user needn’t adjust it, because it has been adjusted at optimal position before engine is delivered. However, if the engine works abnormally, it is necessary to inspect the fuel-delivery advance angle, as the following will show:

a. Open indicator valves on cylinder heads.
b. Dismantle high-pressure fuel pipe and fuel delivery valve of injection pump of the first cylinder at Bank A and B.
c. Measure injection pump plunger lift by using special tool.
d. Crank engine according to direction of revolution of engine until injection pump plunger moves upwards by 4.1mm.

At this time, scale value at flywheel indicated by TDC indicator is the starting position of fuel supply of the cylinder. According to this, the advance angle can be determined. Carry out
these steps two times. The measurement error should be less than 1° crank angle.

3. Oil system

The oil system undertakes to delivery clean oil with preference temperature and pressure to lubricate all friction surface to ensure all parts and components to work properly. The usage of lubrication oil includes decreasing friction, cooling, cleaning, sealing and rust prevention.

The oil pump (21) draws the oil from the oil sump via interface (22) and oil charge pipe (17)
and delivers it through the temperature regulating valve (18), oil cooler (16), or through a bypass, to the oil filter (15) and further to the oil inlet (28) continuously. The pre-supply pump (19) serves preliminarily oil to bearing before engine starting. The pump also can draw oil from oil sump and delivers it to oil system passing non-return valve. The pre-supply pump cannot be used as spare pump since its delivery volume is not large enough. A pressure regulating valve (29) is equipped at the oil inlet (28), a draw-off pipe (23) returning joint (22). Oil pump (21) is mounted with a discharge valve that could confine the pressure of delivered oil to a set value.

The oil level is checked by means of the dipstick (14). The oil filler provides for filling or replenishing oil. Oil mist produced from cylinder block and timing gear passes through pipes installed respectively on oil filler and timing gear into an oil-mist separator (35) opened to external environment. The oil discharged from gathering line (separator) returns to timing gear case via siphon pipe (36).

The oil comes into oil inlet (28), flows along the header pipe (34) cast integrally with cylinder block and via drill hole into main bearings, then into big-end bearings of connecting rods and bearings of piston pin through oil hole of crankshaft.

The teeth of intermediate gear (10) on timing gear system are lubricated by the spray nozzle (3) connecting with the end of header pipe (34). A part of oil passes into camshaft housing and to camshaft via the end of header pipe, then along the camshaft drilled at its intermediate part to all oil outlets of cams to lubricate the cams. The roller and the post rod of injection pump (12) are lubricated by the oil splashed by the action of camshaft. Oil drawn out by the post rod and coming into injection pump flows to return branch pipes (13) of cylinders, then to waste oil tank via the output end of engine. Transudatory oil gathered at the bottom of injection pump housing is drained off to waste oil tank through the oil-leaking pipes (20) at the free end and output end of engine. The oil from the camshaft case greases intermediate gear bearing along the drill hole passage on the wall surface of cylinder block and through supporting shaft of intermediate gear. The oil from the header pipe (34) lubricates rocker arm bearings along the drill hole passages of branch pipes and rocker arm shaft.

The torsional vibration damper at free end is lubricated by oil from drill hole passage on the crankshaft. Cooling water pump (24 and 27) and governor (25) mounted at the free end of engine get oil through the branch pipe connector at the oil inlet (28) of engine. The transmission gears of cooling pumps and governor are lubricated by the oil overflowed from the bearings. A slim oil tube (26) dependent on the type of governor can be connected to the oil pipe of the governor so as to provide oil to the governor when starting the engine.
The pistons are cooled by oil. Passing through the oil hole of crankpin, oil flows into the drill hole of connecting rod body, then from the small end bush to the cooling chamber of piston via spray nozzle (1). Oil from cooling chamber of piston returns freely to cylinder block via oil outlet.

Two thermometers for inspecting oil temperature are mounted respectively on the front and back of the oil cooler. Another automatic monitors for inspecting oil pressure and temperature can be chosen on the ground of the type of diesel engine.

The turbocharger is linked with compulsory lubricating system, delivering oil into turbocharger through supply pipe (7) and distributor (6).

**Note:** HFO engine is equipped with dry oil sump, and oil tank, fuel suction pump additionally. (Flow rate of suction pump shall be greater than that of engine-driven oil pump), to draw out oil from dry oil sump to oil tank.

```
1. Welding slag and foreign matters must be cleaned thoroughly from the peripheral piping before the piping guides oil into engine.
2. A support must be set up and a flexible connecting must be adopted for peripheral piping to prevent the additional stress produced from the running of engine from damaging the accessories and piping
```
4. Cooling water system

The fresh water is circulated in a closed circuit and cooled in the cooler by seawater, so the diesel engine could keep the most approved working temperature under various loads.

Depended on the requirement of engine, cooling water is compelled into cylinder block through water elbow pipe (13) by the centrifugal pump (11) mounted on or separated from the...
dieSEL engine. The water space encloses the upper third of each cylinder liner almost ring-like. There are water passages connecting among cylinders so that a part of water from each cylinder flows along a cooling water passage (4) into the cylinder head. Intermediate walls and ribs direct the water in a positive flow to the hot spots (e.g. injector and valve seats), so that good heat dissipation is ensured. The cooling water is passed from one cylinder head to the next, through a short connecting pipe (6) between the cylinders, to the cooling water outlet (2) on the end of the engine. If the temperature of cooling water (fresh water) is low enough, the temperature-regulating valve (3) can control automatically cooling water to return to freshwater pump without being cooled by cooler (2). But if the temperature of cooling water rises highly, the temperature-adjusting valve (3) will allow the cooling water to return to freshwater pump after being cooled by cooler (2). A thermometer equipped at the water outlet indicates the temperature of cooling water. Any air pocket forming in slanting cylinder head can be eliminated by the screw plug (15) at the free end of diesel engine.

The diesel engine could be connected with a spare cooling water pump via an interface flange (9). In such a case, a non-return valve should be fitted between the water pump and cylinder block to avoid that water returns to the non-operative pump.

At the lowest point of the cooling system, there is a plug screw (10) for draining the cooling water from the cylinder block.

Water condensed in and leaked from the intercooler will escape through drain cock (14), which are designed for this purpose.

4.2 Seawater system

The sea water system, an opened circuit, is used to cool intercooler (8), oil cooler and fresh water cooler (2). Entire seawater from seawater pump runs into intercooler (8) after which it divides into two currents, one to oil cooler, and another to freshwater cooler (8). The seawater is drained off outboard after passing through oil cooler and fresh water cooler. The seawater in a generating set on land can be cooled by cooling tower to recycle for using.

4.3 Cooling system for fuel injector

In the case of engine burning HFO, the injector shall be of cooling type and equipped with a set of cooling system to keep its temperature within 85~90 °C.

4.4 Cleaning cooling system

Supposing cooling water represents poor quality or has not be treated properly, a layer of encrustation will accumulate on the inner surface of whole cooling system in short order, thus the cooling effect on the components will be weakened.

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If corrosion preventing agent is added in, it is the most important to keep water clean to ensure the stability of oil-water emulsion. Pay attention to add emulsion regularly and clean the cooling system when plenty of separated oil is found in expansion tank or the stability of emulsion cannot sustain no longer.

Check the pollution of cooling system periodically. Clean it immediately if it is polluted seriously.

Oil sludge, generated from oil leaking from cooling system or high concentration of corrosion preventing agent, could be eliminated by 4% soda solution, trisodium phosphate solution or soap-basis cleanser.

Sediment or encrustation can be wiped off with special solution that gets rid of boiler scale or with dilute hydrochloric acid or amidosulphuric acid if the effect of special solution is not ideal.

It is recommended that cleanser circulate in cooling system to get rid of carbon dioxide foam generated during dissolving encrustation and to prevent acid from contacting encrustation. The cleaning time depends on the thickness and constitution of encrustation. After being cleaned, the cooling chamber should be rinse thoroughly with fresh water to flush away the residual acid. Then the vestigial acid, regardless of hydrochloric acid or amidosulphuric acid, should be neutralized with 2% soda solution or triphosphate solution, alkalescent anticorrosive agent being admirable, which is pumped into the system and stays in it for a short time, then be flushed away with fresh water.

We recommend amidosulphuric acid used in corrosion resistant since, no matter how being flushed, infinitesimal hydrochloric acid remaining in the system will encourage point corrosion if it meets bleaching powder contained in water.

If anticorrosion oil is used, the rust in cooling system will decrease the stability of oil water emulsion. Rust together with ingredient that hardens water forms iron dross, depositing obviously at a place where velocity of flow is low. The rust can be removed with agent that dissolves boiler scale.

It is important to flush thoroughly the whole cooling system after using cleanser, because there should be no any residuary solution in the system.
5. Starting system

1. Oil supply pipe 2 Starting motor (air starter) 3. Automatic lubricating device

5.1 Operating principle of starting system of 12V diesel engine

The engine is started by means of an air-starting motor driven by compressed air supplied from a compressed air tank and turning the crankshaft via a pinion and a gear rim on the flywheel.

The air starting motor (2) is mounted on the right side of engine. The pinion is automatically engaged with the gear rim on the flywheel when the engine is being started. Fitted between the air tank (10) and connecting pipe (9) of air motor is the pressure reducing valve (8) which reduces the air pressure existing in the air tank (Max. 3MPa) to 0.8~1.0MPa which is the admissible pressure for the air motor. The air motor is actuated via the solenoid valve by starting switch of the monitor.

When the shut-off valve on the air tank is at open position (namely the air tank is open), air
pressure is present at the electric-control pneumatic valve (4). As the electric starting switch is being actuated, the solenoid valve (5) is electrified, and the electric-control pneumatic valve is opened and compressed air flows to the air starting motor and engage the pinion with the gear rim and then turn the crankshaft and thus start the engine.

After the engine is started, turn the starting switch back to the initial position, and close the compressed air valve, so the pinion disengage with rim automatically.

There is a manual-starting knob at low right of electric-control pneumatic valve, which is used on a crash basis when the starting solenoid is damaged. Once the starting solenoid valve damaged, turn clockwise the knob to start the engine. After the engine starting, turn anticlockwise the knob until its limit position.

There is an air strainer (7) in the pressure-reducing valve (8) to clean the starting air. The air strainer can be cleaned after unscrewing the hexagon nut.

Automatic lubricating device (3) on the air stater close to the air inlet supplies, for each start, through the oil supply pipe (1), a certain volume of lubrication oil to pressure air in it to lubricate the rotor in the starter.

5.2 Operating principle of dual-motor starting system of 16V diesel engine

When valve on starting air piping opens, the 3MPa compressed air is divided into three ways: one to solenoid valve (1), one to pneumatic valve (2), and the rest to two starting valves (3) respectively. After turning on solenoid valve (1) with starting key, compressed air flows into hole A of cylinder of two air starter respectively, and engages the pinion with the gear rim of flywheel. Then the air flows out from hole B of two starters into hole C of pneumatic valve (2) to open the valve (2), which will force the air waiting in hole D in pneumatic valves (2) to open starting valve respectively through two pneumatic valves. The compressed air waiting before the starting valves will drive the motor gear to rotate the flywheel.

Note: The starting system of CW16V200ZC is of dual-motor type with starting pressure 3MPa. Pressure reducing is not required.
Do not restart the engine before the flywheel is standstill to prevent from damaging gear rim and pinion.

Dual-motor starting system of 16V diesel engine
5.3 Starting and E. Shutdown Air System

**Diagram:**

- Compressed air prepared by users, pressure 0.56 MPa
- Pressure regulator
- Manual control valve
- Air pressure gauge
- Air release
- Air charging

*Notes:*
1. Starting air pressure 0.8-1.5 MPa.
2. Closing continuous operation of engine 0.8 MPa pressure of least to be kept before PART-44 restart.

Starting and E. Shutdown Air System
6. Control system

The engine speed is controlled by a hydraulic speed governor mounted on the free end of engine. The choice between UG8 Woodward Governor and YT111 Governor depends on the operating requirements. The governor controls the injection pump setting via the fuel control linkage.

The individual injection pumps (32) are mounted inverted below the two camshaft case, which are driven directly by camshaft. The injection pump racks (31) are connected through clamp blocks (1) and short tension springs (2) to the fuel control linkage (6) guided in axial
direction between roller pairs (33). The movement of the fuel control linkage (6) in the direction of full-load is transmitted to the pump racks by the force-locked eccentric cam (3) and clamp block (1), and in the direction of STOP elastically by the tension spring (2). This arrangement permits the fuel control linkage to be pulled in the direction STOP in the case of one or more injection pumps sticking, so that the engine can be shut-down in any case. The two adjustable brake blocks (5) limit the travel of the two control linkages (6) in the range between STOP and MAX. Scale plate (4) and pointer are used for adjusting and checking.

The two fuel control linkages (6) are moved by the transverse shaft (26) via the levers (12 and 29), rigidly mounted on the shaft, the double-end levers (10 and 29) and adjustable link rods (28 and 30). The crank lever (11) pivots on the transverse shaft. The connection between the bell crank lever (11) and the transverse shaft (26) in the direction of MAX. is force-locked through a clamp block and the lever (12), whereas in the direction of STOP it is connected elastically via a torsion spring (23). The stop bolt (22) and the pin of the emergency shut-down device (13) limit the travel of the lever (12) and thus of the pump racks in the directions of STOP and MAX. (full load). The actual pump setting (pump charge) is indicated on the scale plate (8) by means of the pointer (9) fixed on the double-end lever (10). The hand lever (24) is used to shut down the engine by hand. When the engine is shut down by hand or by the emergency shut-down device, the torsion spring (23) absorbs the movement in the opposite direction (pump racks at STOP, governor pulling in the direction of MAX.).

If the engine is equipped with a Woodward governor YT111 (18), the governor is linked via link rod (19) and lover arm of bell crank lever (11) with the fuel control linkage.

For setting and maintaining the desired speed, the governor may be equipped with an electric speed setting motor (20) or a pneumatic positioner (17).

The engine can be shut down either by means of the hand lever (24) directly, or, via the governor. Engine shut-down trip by safety instruments, e.g. over-speed etc., if provided, is via suitable switchgear by the governor, and additionally via the emergency shut-down device (13) which is tripped by the solenoid or pneumatic actuator (15). Here, the shut-down pin is released and this moves the lever (12) and thus the pump racks to stop position by means of a preloaded spring.

Where diesel engine over-speeds or is low in lubricating oil pressure, emergency shut-down device (13) will be actuated to stop engine. When the engine has been stopped by means of the emergency shut-down device, the latter must be reset after the reason for the shut-down has been removed before the engine is restarted. Air required by device (13) is
supplied by air bottle, which is connected to the port of solenoid valve or pneumatic actuator (15) with a tube by user. During running of engine, air pressure keeps at 0.8~1.0MPa.

The end switch (14) is used to switch the monitoring plant on and off.

If the engine is shut down by means of the hand lever (24), the lever may be arrested in the STOP position. Before restarting the engine, the lever must be unlatched and reset and engaged for fuel admission to enable the governor to move the fuel control linkage.

Note: Refer to the operation instruction issued by the governor manufacturer for its working principle and operation. Speed governor oil shall be clean and not prone to scum, settle and erode governor components. It is also required to be good in heat resistance and small in viscosity variation, and not to deteriorate if the temperature is over 100°C. Governor mounted on 200 series diesel engine requires 30# turbo oil in summer and 22# turbo oil in winter. It is advisable that operating oil temperature does not exceed 80°C. If the diesel engine is used frequently, it is recommended to change governor oil every three months. If the diesel engine is used intermittently, please change governor oil every six months.

7. Supercharging system

7.1 General

Supercharging technology, an effective mean of improving power and economical efficiency and reducing specific fuel consumption, could also decrease unit power-volume and unit power-weight of diesel engine. CW12V200ZC diesel engine has adopted pulse turbocharger with air intercooler.

Supercharging system is composed of exhaust piping, exhaust turbocharger and air-intercooler. Exhaust pipe is located between the two banks of cylinders; exhaust turbocharger and intercooler are installed on the flywheel end of engine.

The energy of exhaust gas discharged from all cylinders into exhaust pipe drives the turbine to turn, and the latter spurs the compressor impeller rotating with high speed to compress the air.

7.2 Exhaust piping

Exhaust pipes are made of cast iron. All of connection screws and nuts used to fasten pipes are made of heat-resisting stainless steel, and their surfaces are brushed with Loctite C5-A high molecular antisticking agent to prevent from stuck when heated. Thermocouple can be mounted on exhaust manifold of each cylinder to measure the temperature.

Bellow pipe is mounted between each two cylinders of exhaust pipes to make up the expansion of exhaust pipe in temperature change.
Each exhaust pipe is bundled with heat-insulation layer, to prevent from over-temperature in engine cabinet and from scald to operator.

### 7.3 Exhaust turbocharger

Mixed flow turbocharger is employed on CW12V200ZC diesel engine. An air cleaner is installed on the air intake of air compressor.

Oil that cools and lubricates turbocharger flows from the header pipe, leading into turbocharger from upper part, then out through lower part, finally entering into the oil sump.

It is required that the diesel engine should run for a while without load, then run with load, since turbocharger operates in a quite high speed. If the engine runs in high speed with heavy load, it is prohibited to stop immediately. The engine should run for a short time with decreased gradually load and speed; then run without load for a while, or the bearings of turbocharger will be damaged.

Please refer to manual of turbocharger issued by turbocharger manufactory for introduction of construction and maintenance.

### 7.4 Air cooler

Air cooler (intercooler) is used to cool turbocharger, so as to enhance the density of air flowing into cylinders. It is mounted at the flywheel end outside of engine. There is a hollow plug at the free end of cylinder block to inspect leakage of intercooler. If there is leakage, the diesel engine should be shut down at once. Restart the engine only after rectifying the trouble.

Intercooler possesses duct piece construction. Cooling elements include iron-copper pipes and cooling fins.

If the air passage of air cooler is badly contaminated and clogged, the pressure difference of air-in and air-out will increase, and the working performance of diesel engine will be influenced, even result in surging of turbocharger. Therefore, the operator should wash, clean or replace pipes regularly.

### 8. Safety and automatic stopping system

Each diesel engine is equipped with intellectualized testing alarming system with displaying, alarming and shutdown function. The instrument box on the engine, equipped with starting switch and shutdown button, could display the value of revolution speed, water temperature, oil temperature and pressure, boost pressure, and exhaust temperature.

#### 8.1 Alarming

The system alarms when the engine goes wrong as follows:

1. The oil pressure is lower than 0.20MPa.
Manual for operation & maintenance of 200 series V-type engines with individual injection pump

（2） The cooling water temperature is higher than 88+2°C.
（3） The oil inlet temperature is higher than 78+2°C.
（4） The engine overspeed is at 110±0.5% rated speed.

8.2 Automatic stopping

The engine should stop automatically under the conditions of:
(1) oil pressure less than 0.15Mpa.
(2) speed higher than 110±0.5% rated speed.

This system can be used for distant indication and alarming if it is equipped with remote displayer (for control console).
Chapter 4  Installation and coupling engine

1. Installation of diesel engine

Precautions and technical requirements

1) Before installation, the installation personnel should read the documents delivered with engine carefully to acquaint the engine structure and installation requirements, and design relative drawings for installation and maintenance.

2) Installation personnel must be experienced mechanical technician and electrical technician.

3) If actual installation conditions differ from the demands of this manual significantly, the installation must be carried out under the instruction of technician from the manufacturer. There should be ventilation equipments in engine room to guarantee normal operation. The most effective way of air renewal is to mount suction fan and exhausting fan. Pay attention to avoid short-circuit between outlet of suction fan and inlet of exhausting fan during mounting.

Air inlet and outlet of engine room

1.1 Air inlet requirement of engine room

Air cleaner of turbocharger of diesel engine has been installed and adjusted before it is delivered. It is forbidden to dismount it!

Natural air intake to engine room must meet the demand of combustion and dissipation of heat radiation. If natural air intake is insufficient, it is advisable to install blower at air inlet of engine room. Design a rain hood at blower inlet or a cabinet having a volume larger than 1m³ with a louver to ensure that rainy water and sea water cannot enter the engine room during engine operating. Inlet of engine room shall be close to air cleaner of turbocharger and 1m away from it, but shall not close up exhaust header after turbo.

Dimension and model of blower shall be determined according to engine room by user.

1.2 Air exhaust requirement

Outlet of engine room is near the free end of diesel engine. Exhaust could be performed by means of natural ventilation or with the aid of axial flow blower. Air outlet of engine room shall be provided with rain hood. The inlet and outlet of engine room are shown as below (the top view of diesel engine).
Outlet of oil gas separator must be ducted to the open air outside the room, and outlet of engine room must be far away from inlet of blower to avoid that the vented oily gas enters engine room again and is sucked into turbocharger to contaminate air cleaner and intercooler.

**Requirements of hoisting diesel engine**

**12V Diesel Engines**

Diesel engine run 1000 hours later, should be cleaned or replaced the stainless steel wire filler in the oil and gas separator.
Attention: when fixing hoisting tool, eye bolts must be tightened onto cylinder head studs (note: studs for receiving eye bolt is longer than other cylinder head studs).

### Installation requirements of diesel engine

#### 1.3 Alignment of diesel engine

Rabbet face of flywheel must align with input flange of gear box. Exam radial, axial and angle alignment with dial indicator. Alignment requirement at cold state:

- Radial runout: 0~0.15 mm
- Face runout: 0~0.20 mm

#### 1.4 Installation requirement of onboard engine base

Connection between engine feet and top plate of onboard engine base must be realized by dedicated connecting bolt delivered with engine. Welding is
forbidden strictly!

Onboard engine base must have enough rigidity, and thickness of steel plate shall not be less than the recommended shown in Fig.1/2/3. The bearing surface of top plate is to be machined before or after position welding to ensure its surface roughness not inferior to Ra 6.3 and binding rate between engine feet and bearing surface greater than 95%. Bolt holes on base shall be back-faced after drilled to make contact surface of bolt head normal to centerline of bolt hole.

Fig. 1 (CW12V200ZC engine burning LFO)

Fig.2 (CW16V200ZC engine burning LFO)
Number, location and dimension of reamer bolts on diesel engine feet, top plate of engine base are shown in Fig.4/5.
1.5 Connection between onboard engine base and engine feet

First step: Base according to locations shown in above figure to match up to bolt holes on engine feet. Drill the outside four Φ24 feet bolt holes use for reamer bolt, the other four Φ22 use for commen bolt in Fig.4 (16V Diesel Engines Drill the outside four Φ24 feet bolt holes use for reamer bolt, the other eight Φ22 use for commen bolt in Fig.5). Hoist diesel engine and place it onto top plate of onboard base. Screw one M20×2 adjusting bolt in spare parts box delivered with engine into bolt hole on each engine foot. Adjust the height of diesel engine and align the engine by changing the length of screw in engine feet. Please see right figure. Alignment shall be carried out according to 3.1.

Second step: After alignment, measure the distances between each engine foot and top plate of engine base and then fabricate adjusting shims (the thickness of shim shall not be less than 20mm and all shims are made of same material). After adjusting shims are fabricated, each engine foot shall be mounted with one M20×110 common bolt (strength grade: 10.9, in spare parts box delivered with engine), nut, flat washer and spring washer to locate the engine preliminarily (see the right figure). After that, recheck alignment. If alignment is not satisfactory, continue to fabricate adjusting shims and adjust engine position (refer to figure as below for adjusting shims).
Third step: After alignment, it is required to drill and ream the outside four nontapped holes (in Fig. 4 or 5) on engine feet to $\Phi 25H^{0.021}$ in assemble with the nontapped holes on top plate of frame base. Then use reamer bolts and castle nuts in spare parts box delivered with engine to fix diesel engine ultimately, and lock the bolts with split pins, as shown in right figure (locations of bolt holes on engine feet for adjusting and those for drilling and reaming in assembly are shown in Fig. 4/5).

Tighten all bolts and apply anti-rust oil onto the threads protruding nut.

Measure crankweb deflection again after connecting flywheel, coupling and gear box. Do not start engine unless crankweb deflection is satisfactory.

Max. permissible crankweb deflection:

<table>
<thead>
<tr>
<th>Engine state</th>
<th>cold</th>
<th>hot</th>
<th>Number of measured cylinder</th>
</tr>
</thead>
<tbody>
<tr>
<td>New engine in release test or installation in user’s site; Don’t transport out power.</td>
<td>-0.14mm</td>
<td>-0.16mm</td>
<td>At No. 6 cylinder in 6-cyl. engine; At No. 8 cylinder in 8-cyl. engine; At No. 5 cylinder in 6-cyl. engine; At No. 7 cylinder in 8-cyl. engine;</td>
</tr>
<tr>
<td></td>
<td>-0.08mm</td>
<td>-0.10mm</td>
<td>Other cylinders</td>
</tr>
<tr>
<td></td>
<td>±0.03mm</td>
<td>±0.05mm</td>
<td></td>
</tr>
<tr>
<td>New engine in release</td>
<td>-0.14mm</td>
<td>-0.16mm</td>
<td>At No. 6 cylinder in 6-cyl. engine;</td>
</tr>
</tbody>
</table>
Installation requirement of engine piping

Interior of pipes of diesel engine shall be clean, especially oil pipes. Iron filings, welding slag, etc. are definitely forbidden.

Operating requirement of diesel engine

According to CB/T3253-1994 Technical Specifications of Marine Diesel Engine, 15° list, 5° trim, 22.5° roll and 7.5° pitch are permitted.
Chapter 5  Operation of diesel engine

1. General

This series diesel engine should be started and stopped by authorized operating personnel only. The personnel should be trained for this purpose, possess complete understanding of the plant and should be aware of the existing potential risks. Basic knowledge and experience of the operation of diesel engines is an essential requirement.

All of important data and work operations (operating hours, fuel consumption, time of lubricating oil change, maintenance and overhaul work etc.) should be entered into an operation monitoring log, which must be kept. After change of personnel, on the basis of that record together with operating instructions, the personnel taking over must be in a position to operate and to maintain the engine appropriately. Apart from that, this will provide a better all-over picture in case of irregularities or operational failures when they occur.

The temperature of engine room should not be lower than 5°C. If the temperature drops lower than 5°C, the cooling water must be added with antifreeze, otherwise material cracks could occur. If the engine is taken out of operation for a longer period of time, the cooling water jackets are to be drained at any rate.

The running, maintaining and overhauling of the engine should conform to safety regulations. It is recommended that the safety regulations should be placarded at conspicuous place to remind the operator of accident danger. It must be very carefully when starting engine.

The use of fuel and lube oil represents an inherent fire hazard in the engine room. Particular attention is to be paid to ensure that fuel and oil pipes are not passing uninsulated hot engine components (exhaust gas line, exhaust turbocharger). After overhauling, all insulations and lagging are to be reattached completely and with great care. Inspect leak-proof of fuel and oil pipes regularly. Leakages of pipes and tanks are to be eliminated immediately. Fire extinguishing equipment is to be checked periodically.

In case of fire in the engine room, the supply of fuel and oil must be cut off immediately (turn off the valves, fuel supply pump and engine), attempts are be made to extinguish the fire by means of hand fire extinguishers. If the fire could not be extinguished or the engine room could not be entered in, all openings are to be sealed tightly, thus cutting off admission of air to quench the fire. It is a prerequisite though that all apertures are sealed (doors, skylights, fan
spiracle, ventilators and chimney). Fuel requires much oxygen for combustion, thus the isolation from air is one of the most effective measures of fighting the fire. **Fire extinguishing equipment based on carbon dioxide must not be used until it has been absolutely ensured that no one is left in the engine room.**

**Note:** In case of fire, the first minutes are the decisive ones, so the people should keep calm and act with deliberation.

### 2. Running-in of diesel engine

#### 2.1 General

No matter how careful and precise the machining is, the exiguous difference between inside diameter roundness and parallelism of piston ring and cylinder liner is inevitable. Moreover, the exiguous deformation resulted from assembling is inevitable. Therefore, the engine needs running-in.

During running-in, the relatively palpable unevenness on the surface of piston ring and cylinder is ground off. The running-in finishes when the piston rings seal the combustion chamber effectively. If the engine runs on full-load without adequate running-in, broiling combustion gas will leak from the gap between the piston ring and cylinder liner wall to destroy the oil film on the area. Thus, there will be local material damage (e.g. ablation point) on the working surface of piston rings and liners, which will result in increasing attrition, high oil consumption, and carbon deposition in ring groove to seize up the piston.

#### 2.2 Running-in of new engine

All engines leaving factory have experienced running-in. However, after engine is installed on working site, it is necessary to carry out running-in on site. This is because the pistons and bearings have to be dismantled to be checked after running-in on test bed. So there may be slight deformation on the pistons and liners during reassembling and transportation. Many factors make the engine require running-in after installing on site. The running-in time of marine engine should be in compliance with regulations of classification society.

#### 2.3 Running-in after overhauling

The engine must undergo running-in after overhauling, in which the cylinder liner, or piston or piston ring has been changed. Even if the cylinder liner was not changed, it also should be honed. If the piston ring groove is worn badly or worn to the allowable limit and has tendency of increasing oil consumption, it should be honed again and installed with thickened piston ring.
Even only a set of new ring to a piston are changed, the engine also needs running-in. The engine has been used for a period of time, if there is shining area on surface of cylinder liner or the cylinder liner is out of roundness, the running-in of engine should be paid more attention to after the new piston rings are installed.

When lifting piston out of cylinder or replacing the piston ring with new one after long-term operation, the cylinder liner should be measured carefully under the condition of room temperature. It must be replaced when its wear and ovality exceed the allowable limit.

2.4 Running-in after running with low load

Long-term running with low load will result in serious smudginess inside of the engine, carbon deposit accumulating on high-temperature area and in ring groove above the first piston ring, and even accumulating in air inlet passage. Moreover, there will be greasy filth accumulated in supercharging air pipe, exhaust manifold, intercooler and turbocharger.

The piston has matched the inside surface of cylinder liner well when the engine runs with low load. If the speed increases rapidly, the good match of piston and the inside surface of cylinder liner will change suddenly, which results in increasing rate of wearing and other damages (fleeing air on piston ring, or piston stuck).

3. Check and start before operation, running and stop

3.1 Checking the cooling water level

Check the cooling water level through the inspection glass on expansion tank. Check whether the tank is filled up with water before starting. Start the engine with low speed, and inspect whether the water level decreases. If so, full up the expansion tank with water until the level keeps stable.

3.2 Checking fuel oil level

Check the level of fuel oil before starting diesel engine. Drain off air in fuel piping. Check for leakage of fuel system; check for fixture and stabilization of fuel control linkage. Inspect the stop position of gear rack of injection pump. The bottom of fuel tank should be slightly higher than the inlet position of supply pump.

3.3 Checking lube oil level

Check the lube oil level in the oil sump (by yardstick). The oil level should keep between the upper scribed line and the lower one of oil dipstick. Fill in oil if it is insufficient.

Start the priming pump to supply oil to diesel engine. At the same time, make sure that there are no foreign matters and block in engine by turning engine several circles.
3.4 Checking emergency shut-down air piping

Check emergency shut-down air piping for its connectivity. Regulate pressure to 0.8~1.0 MPa.

3.5 Blowing off the engine

If the engine is started up initially or has been stored for a long time, it should be blown off before starting. Open the indicator valve on each cylinder head, and switch the fuel-control handle to the “shut down” position, then crank the engine manually or with air motor to blow off the condensate water or other foreign matters in combustion chamber.

3.6 Starting of diesel engine

The clutch hand lever of marine engine with clutch should be set at “no load” position. Set the fuel supply at the position of one third or half of full range to make the fuel injection pump at “supplying” position. Switch on the starting key on the monitor to start the engine. After starting, adjust the position of the hand lever of fuel supply to keep the speed at about 400rpm (idle speed). The engine at cold state is not allowed to run at high speed with load. Only when the oil temperature and water outlet temperature increases higher than 40°C, could the engine be allowed to run at high speed with load.

The engine should be inspected carefully for leakage and abnormal sound after starting. If the first starting fails, it could be started again after more than one minute (until the flywheel is standstill). If it takes long time to start the engine or the starting fails three times in succession, the operator should examine the cause.

Once diesel engine is started, take down the readings on monitor to verify the operation condition of engine.

Note: For the newly assembled engine, the first starting will be difficult because there is a little air in fuel oil pipe and fuel injection pump. So before the first time, the fuel-returning connection of fuel injection pump could be loosened to drain the remained air in pipe and pump.

Note: During operation, air pressure for emergency stop is kept between 0.8 and 1.0 MPa.

Air starting pressure of 12V diesel engine is 0.8~1 MPa (that of 16V diesel engine is 3 MPa) and the starting time shall not be greater than 10s. Close the main air pipe and valve after starting successfully.

3.7 Running of diesel engine
Running parameters (at rated point) as follows:

- Oil temperature at engine inlet: 60–75°C
- Oil pressure: 0.35–0.5 MPa
- Fresh water temperature at engine outlet: 70–85°C

During the running period, the reads of instruments and operating condition of engine must be kept in record regularly. When the engine is running, please take attention to observe and record the data as follows:

1. Fuel oil level in fuel tank and governor, water level in expansion tank. Check the oil level in oil sump and add up oil in due course. If the level in oil sump declines fast, it is most probable that there are leaks in the oil system. If the level rises, the cooling water or fuel oil may infiltrate into the oil sump. In such cases, the engine should be stopped to examine or assay the oil. Replace the oil when necessary.

2. Check exhaust temperature every 1–2 hours.

3. Check regularly the exhaust smoke. Observe the exhaust condition of oil-gas separator.

4. Open air-release valves on the cylinder heads regularly to check the combustion condition in cylinders.

5. Listen to the noise of engine and distinguish the abnormal. If there is piston knocking or bearing-loosening knocking or other abnormal shock and noise, the operator must stop the engine immediately and eliminate the failures.

6. Note all the tightening and locking of all exposed parts.

7. Check fuel system. If the high-pressure fuel pipe shocks violently and heats, it is possible that the fuel injector is blocked. It should be checked and eliminated immediately.

8. Note the evenness of running speed of engine. If the speed fluctuates extensively, the reason must be found out. The engine should be stopped and checked when necessary.

9. Record all positions of leakage and bad seal so that they can be eliminated as soon as possible.

10. Observe the hollow plug on the cylinder block, and check air cooler for leaks.

**When the new boat is put into trial trip, the marine main engine should be tested for rated speed under the condition of rated load of boat. If the engine could not meet the requirement of rated speed, the match of engine and propeller should be checked. The engine works would not bear the responsibility for the overloading
due to the match of engine and propeller or responsibility for the abnormal wear and failure due to deformation of base and improper operation.

The diesel engine is irreversible. When it serves as marine main engine, it can realize reversing of shafting via gearbox.

When switching over to burn heavy fuel oil, oil and fresh water temperature must exceed 45°C, and the temperature of water (oil) for cooling fuel injector shall keep from 85°C to 90°C. Switch over to burn light diesel oil before stopping engine, and care shall be taken to burn out heavy fuel oil in fuel filter and piping.

3.8 Stopping engine
3.8.1 Normal stopping

Handle the fuel supply grip to decrease the load gradually, so that the engine’s speed decreases to 40% of rated speed (about 400r/min). Then uncouple the clutch, so the engine runs at idle speed without load. When the temperate of oil and water decreases lower than 50°C, stop the engine. (Stop normally the engine by shutdown handle. The shutdown button on instrument box only serves as emergent stopping).

3.8.2 Emergency stop at abnormal condition

If the abnormal conditions such as noise, smoking, insufficient oil pressure (no readings displayed on the monitor or meters) occur during the running of engine, the engine with the stopping solenoid valve can be done emergent stopping through the shutdown button on instrument box. However, after the engine is stopped it should be supplied with oil for 5~10 minutes by spare oil pump and turned manually to prevent from high temperature of engine, which may result in overheating, seizing or scuffing of cylinder bore. At the same time, the operator should find out the cause and eliminate it.

The power indicating valve should be opened immediately after the engine is stopped. If the engine will not run, all valves that need to be closed in fuel system and cooling water system should be closed. In cold surroundings in which cooling water may freeze, if the engine is about to be stored for a long time, the cooling water should be drained when it is at 30~40 °C. After the engine has been stopped, open the crankcase cover, and check the bearing’s temperate and tightness of main screws and bolts if necessary. In addition, after the engine has been stopped, the operator should rectify the trouble in running so that the engine could be started whenever.

3.9 Emergency treatment for exhaust turbocharger

If one of turbochargers fails, it should be remedied as soon as possible. If it could not be temporarily refreshed, the engine is permitted to run with only one turbocharger on the emergent
condition, but it should be reduced power by decreasing load and oil supply. The output when the engine runs without supercharging depends on the revolution speed, exhaust temperature and smoke. Since the gas distribution timing is designed on supercharging, the air volume inhaled in cylinder as natural suction is less, which leads to rapidly increased exhaust temperature. This measure is only adopted for critical condition. In such case, the user must remove the failure turbocharger and mount a blind flange, prepared by the user for urgency, between the turbine casing and turbine interface.
Chapter 6  Regular check and maintenance

1. General

Planned maintenance is conducive to safe and reliable engine operation. It reduces failure rate and lowers the operating cost of the engine plant. The maintenance operations listed in the Maintenance Schedule should, therefore, be carried out at the specified intervals and with great care. Regular maintenance will help the operating personnel in recognizing incipient malfunction at an early stage, and evaluation of the maintenance work performed will indicate the need for overhauls in good time so that overhauls can be programmed to be carried out during scheduled service interruptions.

The extent and the time at which maintenance work has been carried out should be entered in the engine log to serve as evidence for subsequent investigations. The replacement or repair of engine components should also be made part of the record. Spare parts taken from stock should be complemented as soon as possible so that they are available when needed, since transport (and customs clearance) may delay the arrival of spare parts ordered.

Prior to starting with any maintenance and overhaul work, the pressure in all pipes should be relieved and it should be verified that they are pressure-less by reading the pressure gauges and by cautiously loosening the screw connections. When works are being carried out on the crank gear or other moving parts, it must be ensured that the engine cannot be started and cannot be turned inadvertently (close valve on air receiver, disconnect battery, put up warning board). Danger of accident! When breaking pipe connections, all pipes that are to be reinstalled must be carefully sealed, especially those for fuel oil, lubricating oil and air pipes. New pipes must be checked for cleanliness and, if necessary, flushed before installation. On any account, it must be avoided that foreign matter can get into the pipes. If the engine is to be stored for a prolonged period of time or if it is to be laid up, all individual parts must be carefully preserved. When repainting the engine, make sure that no paint can get into the link joints of the fuel control linkage.

2. Necessary repair

No matter how small the defect is, the repair should be carried out immediately as the repair often leads to consequential damage.

For the cleaning of the engine, and its individual parts, please use diesel fuel or special
solvents. The use of gasoline is not permitted in closed room due to its inherent risks of poisoning or explosion. For drying engine components, pressure air or soft cloth, instead of waste cotton yarn, is to be preferred.

Upon completion of repair and overhaul work, check to see that all tools, cleaning material and other foreign matter are removed from the engine. The exact setting as well as clearances of new or reinstalled parts must be checked and the data entered in the engine log.

A few hours after resuming operation, check lubricating oil filter for fouling, and clean them if necessary.

The fire risk prevailing in the engine room should be borne in mind, especially when carrying out welding work on pipe lines, etc. Fuel and lubricating oil pipes in the immediate vicinity should be covered up. The fire fighting equipment should be readily available. The restricted space existing in some engine rooms tends to increase the risk of accidents. Therefore, when installing or removing larger engine components, suitable lifting gear and the special tools supplied should be used. Attention should furthermore be paid to the good condition of ropes, shackles and the tools being used.

3. Maintenance

3.1 Maintenance after first 30~50 running hours of new or overhauled engine

(1) Check oil, water and air of system for leakages and remedy them in time.
(2) Verify that electrical elements and cable are in good condition.
(3) Check and adjust the clearance of air valve.
(4) Check the oil level and cooling water capacity and refill them.
(5) Check lube oil filter, fuel oil filter, and replace oil.
(6) Check looseness of fastening parts and connecting parts.
(7) Recheck the torque of connecting rod bolts. (In the case of spline nut, tightening torque is to be \(220\pm20\)N; in the case of hexagonal nut, tightening torque is to be \(280\pm20\)N.m.)
(8) Check crankweb deflection of crankshaft.

3.2 Daily maintenance

(1) Check used conditions of meters. Check oil, water and air of system for leakages and remedy them in time;
(2) Summarize and check the running log (Record carefully the faults and remedies that have happened);
3.2 First-class maintenance

In addition to all the checking items specified in daily maintenance, the following contents should also be included after 400 running hours:

1. Recheck tightening torque of connecting rod bolts.
2. The stability of fastening parts (for example, main bearing bolts).
3. Clean lubricating oil and fuel oil filter or replace filter element.
4. Replace oil according to water content and smudginess in oil. Clean oil sump when replace oil.
5. Check clearance of inlet and exhaust valve and advance angle of oil supply. Adjust them if necessary.
6. Clean impeller and inner chamber of compressor of turbocharger.
7. Check contamination for air filter. Clean it when necessary.
8. Check accumulated filth in oil and water cooler. Clean or replace anticorrosive zinc if necessary.
9. Check mobility of emergency stop device and action function of solenoid valve.
10. Check mobility of control linkage. Lubricate the joint.

3.4 Second-class maintenance

In addition to all the checking items specified in first-class maintenance, the following contents should also be included after 1000 running hours:

1. Check working equilibrium of cylinders. Readjust uniformity of fuel oil from fuel injection pump to cylinders if necessary.
2. Check injection pressure and atomization of fuel injector. Readjust and repair it if necessary.
3. Examine oil, water and air in system thoroughly. Check circuit elements and connecting and fastening condition of fastening parts.
4. Inspect water seal of water pump; polish or replace it when necessary.
5. Clean lubrication oil and fuel oil piping. Dry the piping by blowing after removing oil sludge.
6. Examine the worn condition of pinion of air starter and flywheel ring gear. Coat a film of molybdenum disulphide lubrication after cleaning it.
(7) Check the seal condition of oil delivery valve in injection pump; repair or replace it when necessary.

(8) Examine the working performance of needle valve couple. Replace it when necessary.

3.5 Third-class maintenance

In addition to all the checking items specified in second-class maintenance, the following contents should also be included after 2500 running hours:

(1) Clean air cooler, special oil sludge on radiation fins.

(2) Dismount two cylinders to check the degree of carbon deposit on piston top. Eliminate carbon deposit if necessary. Check sealability of air valves. Grind valves if necessary. Make a decision whether all cylinders should be dismounted according to actual situation.

(3) Clear water scale in cooling system. Replace anticorrosive zinc spelter.

(4) Check bearing clearance of turbocharger.

(5) Check working condition of oil pump if necessary. Readjust it if necessary.

(6) Exhaust air from air bottle. Unscrew the vent plug at bottom to eliminate accumulated water and dirt in bottle.

(7) Inspect the working performance of safety alarm and automatic shutdown device.

(8) Check the alignment of diesel engine.

3.6 Fourth-class maintenance

In addition to all the checking items specified in third-class maintenance, the following contents should also be included after 5000 running hours:

(1) Dismount all cylinder heads to clear carbon deposit in combustion chamber. Check worn condition of inlet and exhaust valves, rocker arms, bearings, valve guides and valve seats. Make a decision whether they should be replaced according to actual condition.

(2) Lift two pistons out from engine to check pistons and piston rings. Measure the clearance of rings. Check crank pin bearing and piston pin bearing and measure clearance of bearings, so that decide whether all pistons should be lifted out. Replace pistons or piston rings if necessary. (Record the numbers of cylinder from which the pistons are lifted, so that examine pistons from other cylinders next time.);

(3) Check working surface of two cylinder liners. Measure inner diameter, and calculate value of wear. Replace with new cylinder liners when they are worn away badly;
Check oil pump, fuel pump and cooling-water pump;

Check axial clearance of camshaft and radial clearance of bearings, and record the measured values;

Check crankweb deflection of all cylinders and record the measured values;

Check randomly two main bearings to examine worn condition of bearing shells, thus decide whether it is necessary to check other bearing shells and to replace them;

Start priming pump and check visually lubricating condition;

Measure all tooth spaces of driving gear and bearing clearances. Replace them if necessary;

Check looseness of connecting rod nuts and flywheel tightenig nuts. Tighten them to defined value if necessary;

Check governor. Replace worn parts and retest its performance;

Check fastening condition of bolts of turbocharger and governor;

Check fastening condition of engine frame base bolts;

Dismount turbocharger according to its instruction manual;

Readjust or replace all measuring meters, warning system, lines and leads on engine.

3.7 Fifth-class maintenance

In addition to all the checking items specified in fourth-class maintenance, the following contents should also be included after 10000 running hours:

Dismount all cylinder heads and check air valves, rocker arms, bearings, valve guides and valve seats. Check cooling water passages and sealing gaskets. Replace them if necessary.

Lift all pistons out from engine. Check pistons and piston rings. Measure clearance of rings. Check crank pin bearings and piston pin bearings. Measure bearing clearances. Replace them if necessary.

Lift out cylinder liners. Check wear condition of working surface and corrosive condition of outside surface. Replace them according to actual condition. Replace all O-rings.

Check all main bearings and thrust pieces. Replace them according to actual condition.

Check wear condition of all air valves and relative parts. Replace them if necessary.

Check wear condition of camshaft bearings and cams. Replace them if necessary.

Check working reliability of relief valve.

Check whether the sleeve springs of vibration damper are broken. They must be
replaced if the springs are broken.

(9) Check air starter. Replace its parts if necessary.

Explanation: Specified Items that shall be carried out regularly:

Check oil and water level (including oil, coolant and fuel oil) after engine stops. Unscrew the vent plug at the bottom of fuel filter to drain the accumulated water or dirt. Check and clean regularly starting decompression valve and air filter. Check the readings of meters to find out abnormal phenomenon.

It must be kept in mind that operating hours are not absolute values, and the operating conditions must be taken into consideration, which may prolong or shorten the interval of maintenance. The items mentioned above are a part of job instead of all. It is recommended that general overhauls be carried out with the guidance of personnel of our service stations.
Chapter 7 Typical failures and troubleshooting

1. Low quality oil

If oil quality deteriorates, abnormal wear of early phase will appear, and thus it will lead to raise noise of engine, aggravate vibration, increase fleeing air to crankcase, raise temperature of oil and cooling water, decrease oil pressure and overheat engine and so on. It can also influence the output of engine and thus result in damage of engine when the wear of moving parts reaches the limit.

So the user must pay more attention to the quality and brand of lubricating oil and use it exactly according to the prescribed.

The user should examine regularly the quality of oil during operation. A simple way is to unfold the cover of cylinder head and examine the oil accumulated in cylinder head. If there are many water globules in oil or the oil color turns to pale creamy white, it shows that the oil contains much water. If the oil turns to black or gluey, it shows that the oil quality is inferior or the oil has been used for a long time. The oil should be replaced with new one.

A simple method is employed to examine the viscosity of oil. Drop several unused and used oil globules on a smooth surface of metal or glass plate. Then incline the plate, and check the flow speed of oil globules. The flow speed of used oil is distinctly faster or slower than the unused oil if there is much difference between their viscosities. Generally speaking, in such case, it shows that the viscosity of used oil has been greatly changed. It must be replaced with clean one.

When replacing lube oil, it had better to clean the oil system and oil sump, and clean oil filter.

When change oil, filter the new oil and drained waste oil with fine strainer respectively. Inspect abnormal worn and components damage.

2. High cooling water temperature

Controlled automatically by temperature regulating valve, the temperature of cooling water, under normal conditions, should be generally stable. If outlet water temperature is too high (>85℃), following causes should be taken into consideration:

① Whether ambient temperature is too high;
② Whether cooling system, fresh water pump, fresh water cooler and seawater pump...
work normally;
③ Whether there is abnormal wear in engine;
④ Whether there is water scale accumulated in cooling chamber of cylinder block and cylinder head.
⑤ Whether the sensor of temperature regulating valve is stuck due to much water incrustation.

The first four causes can be check easily. The fifth cause is explained as follows:
The cooling water should be treated and added to rust inhibiting additive. If the user does not do so, water scale will accumulate in cooling chamber of engine after the engine operates a period of time. Water scale will result in insufficient heat elimination, thus the water temperature will rise. This failure is formed progressively.
Method of treatment: remove the scale in cooling water chamber with tank scale dissolver sold in market.

3. Insufficient output

The failure of insufficient output results from insufficient air input, insufficient oil supply or low cylinder pressure.
Generally speaking, the possible cause of insufficient output first lies on low-pressure oil circle. If the engine runs with the conditions of even speed, good exhaust smoke, normal operation of cylinders, proper oil-supply time, favorable seal property of cylinders and sufficient air input, and it still output insufficiently, the following causes can be taken into consideration:

1) Whether the low-pressure oil pipe is broken or leaks;
2) Whether the fuel filter is badly blocked and the oil/fuel piping is blocked or leaks.

The air valves, injection time and clearance of air valves shall be checked and adjusted when the air input is insufficient. In addition, the operator should check air filter, clearance of rotor and idle motion of turbocharger.

4. Black smoke

Black smoke is caused by following conditions: uneven oil-injection, poor atomization, insufficient cylinder pressure, inadequate combustion, lubricating oil fleeing into the combustion chamber, blocked in air filter, poor oil quality, damage on turbocharger and insufficient air put, etc.

The methods of eliminating the trouble:
① Reduce resistance in air inlet system. Clean the filtering element of air filter and air intercooler in time. Guarantee right valve timing and check turbocharger.

② Adjust properly fuel injection pump on inspection table, specially adjust advance angle of oil supply.

③ Check and adjust duly fuel injector to ensure favorable atomization.

④ Guarantee the sealability of the cylinder. Replace piston rings and cylinder liner if they are worn badly. Grind air valve if it could not seal well.

⑤ Use specified fuel oil with high cetane number(45~50) and low sulphur content.

⑥ Operate the engine properly.
5. Troubleshooting table

A failure of engine may be caused by many reasons. Only some common causes and remedies are described in following list.

<table>
<thead>
<tr>
<th>S/N</th>
<th>Disturbances</th>
<th>Possible causes and remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Crankshaft does not turn, turns too slowly or swings back..</td>
<td>1) Low pressure in air bottle; 2) Starting valve or air-starting motor defective; 3) Starter switch or cable to starter or starting valve defective; 4) No DC24V power supply, or starting solenoid valve does not work; 5) Leaks of air pipes result in starting pressure less than 1.0 MPa.</td>
</tr>
<tr>
<td>2</td>
<td>Engine reaches ignition speed without firing or firing discontinuously</td>
<td>1) Fuel tank run dry. 2) Fuel oil system air-bound. 3) Piping, fuel injection pump and fuel filter are not filled with fuel oil. Supply fuel oil with hand pump before starting; 4) Unsuitable fuel oil; 5) Water in fuel oil. Eliminate water from fuel oil with centrifugal separator. 6) Fuel too cold, and congealed in pipelines; 7) Engine too cold and lubricating oil too viscous. Preheat cooling water or oil; 8) Low fuel oil pressure before fuel injection pumps, supply pump defective. 9) Fuel oil filter clogged up. Clean or replace filtering element. 10) Excessive clearance of pump plunger in pump barrel or pump plunger stuck. 11) Shutdown solenoid valve does not open, and oil passage is obstructed; 12) No fuel oil or insufficient fuel oil enters to cylinder. Check the position of fuel injection pump rack, and adjust it if necessary. 13) The orifices of fuel injector clogged up or the element of needle valve bound. Clean or change fuel injector. 14) Leaks for inlet and outlet valve so that the air pressure is too low. Grind the valve.</td>
</tr>
<tr>
<td>3</td>
<td>Cylinders fire irregularly.</td>
<td>1) Fuel oil system air-bound. 2) Unsuitable fuel oil. 3) Water in fuel oil. 4) Low fuel oil pressure before fuel injection pumps, supply pump defective. 5) Fuel oil filter clogged up. 6) Individual fuel injectors defective. 7) Inlet or exhaust vales stuck, valve spring broken, drive defective. 8) Engine too cold, and lubricating oil too viscous. 9) Pump plunger stuck, spring broken. 10) Control sleeve or pump element bound. 11) Governor or fuel control linkage mal-adjusted. 12) Fuel control linkage bound or stuck.</td>
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</table>
## Engine does not reach full speed or output.

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<table>
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<tbody>
<tr>
<td>1</td>
<td>Fuel oil system air-bound.</td>
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<tr>
<td>2</td>
<td>Unsuitable fuel oil.</td>
</tr>
<tr>
<td>3</td>
<td>Water in fuel oil.</td>
</tr>
<tr>
<td>4</td>
<td>Low fuel oil pressure before fuel injection pumps, supply pump defective.</td>
</tr>
<tr>
<td>5</td>
<td>Fuel oil filter clogged up.</td>
</tr>
<tr>
<td>6</td>
<td>Beginning of injection too early.</td>
</tr>
<tr>
<td>7</td>
<td>Beginning of injection too late.</td>
</tr>
<tr>
<td>8</td>
<td>Excessive clearance of pump plunger in pump barrel.</td>
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<tr>
<td>9</td>
<td>Pump plunger stuck, spring broken.</td>
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<td>10</td>
<td>Control sleeve or pump element bound.</td>
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<tr>
<td>11</td>
<td>Delivery valve in fuel injection pump leaking.</td>
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<tr>
<td>12</td>
<td>Individual fuel injectors defective.</td>
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<tr>
<td>13</td>
<td>Nozzle orifices or injection pipes clogged up.</td>
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<tr>
<td>14</td>
<td>Fuel control linkage bound or stuck.</td>
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<tr>
<td>15</td>
<td>Inlet or exhaust vales stuck, valve spring broken, drive defective.</td>
</tr>
<tr>
<td>16</td>
<td>Ring clearance or ring gap excessive.</td>
</tr>
<tr>
<td>17</td>
<td>Piston rings stuck or broken.</td>
</tr>
<tr>
<td>18</td>
<td>Marine engines: propeller too large, damaged or hull fouled.</td>
</tr>
<tr>
<td>19</td>
<td>Turbocharger fouled or defective.</td>
</tr>
</tbody>
</table>

## Engine runs irregularly

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fuel oil system air-bound.</td>
</tr>
<tr>
<td>2</td>
<td>Low fuel oil pressure before fuel injection pumps, supply pump defective.</td>
</tr>
<tr>
<td>3</td>
<td>Fuel oil filter clogged up.</td>
</tr>
<tr>
<td>4</td>
<td>Beginning of injection too early.</td>
</tr>
<tr>
<td>5</td>
<td>Pump plunger stuck, spring broken.</td>
</tr>
<tr>
<td>6</td>
<td>Individual fuel injector defective.</td>
</tr>
<tr>
<td>7</td>
<td>Nozzle orifices or injection pipes clogged up.</td>
</tr>
<tr>
<td>8</td>
<td>Individual cylinder highly overloaded.</td>
</tr>
<tr>
<td>9</td>
<td>Inlet or exhaust vales stuck, valve spring broken, drive defective.</td>
</tr>
<tr>
<td>10</td>
<td>Piston pin bearing clearance excessive.</td>
</tr>
<tr>
<td>11</td>
<td>Crank or main bearing clearance excessive.</td>
</tr>
<tr>
<td>12</td>
<td>Piston or bearing running hot or beginning to seize.</td>
</tr>
</tbody>
</table>

## Speed fluctuates, caused by hunting of the governor.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Control sleeve or pump element bound.</td>
</tr>
<tr>
<td>2</td>
<td>Governor or fuel control linkage mal-adjusted.</td>
</tr>
<tr>
<td>3</td>
<td>Fuel control linkage bound or stuck.</td>
</tr>
<tr>
<td>4</td>
<td>Engine too cold, lubricating oil too viscous.</td>
</tr>
</tbody>
</table>

## Engine speed drops, engine comes to a stop.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fuel tank run dry.</td>
</tr>
<tr>
<td>2</td>
<td>Water in fuel oil or too much air in piping.</td>
</tr>
<tr>
<td>3</td>
<td>Low fuel oil pressure before fuel injection pumps, supply pump defective.</td>
</tr>
<tr>
<td>4</td>
<td>Fuel oil filter clogged up.</td>
</tr>
<tr>
<td>5</td>
<td>Fuel control linkage bound or stuck.</td>
</tr>
<tr>
<td>6</td>
<td>Safety shut-down device tripped.</td>
</tr>
<tr>
<td>7</td>
<td>Individual cylinder highly overloaded.</td>
</tr>
<tr>
<td>8</td>
<td>Piston or bearing running hot or beginning to seize.</td>
</tr>
<tr>
<td>9</td>
<td>Turbocharger fouled or defective.</td>
</tr>
<tr>
<td>8</td>
<td>Cooling water temperature is high/low.</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>1)</td>
<td>Individual cylinder highly overloaded.</td>
</tr>
<tr>
<td>2)</td>
<td>Indicating instruments defective.</td>
</tr>
<tr>
<td>3)</td>
<td>Lack of cooling water.</td>
</tr>
<tr>
<td>4)</td>
<td>Cooling water spaces or cooler fouled up.</td>
</tr>
<tr>
<td>5)</td>
<td>Cooling water pump defective.</td>
</tr>
<tr>
<td>6)</td>
<td>Temperature regulator defective.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9</th>
<th>Lubricating oil temperature is high/low.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Piston or bearing running hot or beginning to seize.</td>
</tr>
<tr>
<td>2)</td>
<td>Lack of oil in oil sump.</td>
</tr>
<tr>
<td>3)</td>
<td>Indicating instruments defective.</td>
</tr>
<tr>
<td>4)</td>
<td>Lack of cooling water.</td>
</tr>
<tr>
<td>5)</td>
<td>Cooling water spaces or cooler fouled up. Low heat-exchange rate of oil cooler.</td>
</tr>
<tr>
<td>6)</td>
<td>Cooling water pump defective.</td>
</tr>
<tr>
<td>7)</td>
<td>Temperature regulator defective.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10</th>
<th>Lubricating oil pressure is low.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Crank or main bearing clearance excessive.</td>
</tr>
<tr>
<td>2)</td>
<td>Lack of oil in oil sump.</td>
</tr>
<tr>
<td>3)</td>
<td>Oil pressure-regulating valve defective.</td>
</tr>
<tr>
<td>4)</td>
<td>Leaks for lubricating oil pipes.</td>
</tr>
<tr>
<td>5)</td>
<td>Oil filter clogged up.</td>
</tr>
<tr>
<td>6)</td>
<td>Indicating instruments defective.</td>
</tr>
<tr>
<td>7)</td>
<td>Suction pipe of oil pump obstructed or leaking.</td>
</tr>
<tr>
<td>8)</td>
<td>Oil pump defective.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11</th>
<th>Exhaust gas temperature is high.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Beginning of injection too late.</td>
</tr>
<tr>
<td>2)</td>
<td>Individual fuel injectors defective.</td>
</tr>
<tr>
<td>3)</td>
<td>Governor or fuel control linkage mal-adjusted.</td>
</tr>
<tr>
<td>4)</td>
<td>Individual cylinder highly overloaded.</td>
</tr>
<tr>
<td>5)</td>
<td>Inlet or exhaust valves stuck, valve spring broken or drive defective.</td>
</tr>
<tr>
<td>6)</td>
<td>Indicating instruments defective.</td>
</tr>
<tr>
<td>7)</td>
<td>Marine engines: propeller too large, damaged or hull fouled.</td>
</tr>
<tr>
<td>8)</td>
<td>Charge air temperature too high.</td>
</tr>
<tr>
<td>9)</td>
<td>Turbocharger fouled or defective.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>12</th>
<th>Difference of exhaust temperature is too large.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>The failure of fuel injection pump or one of fuel injectors results in low fuel supply or poor atomization. Check delivery valve of fuel injection pump, plunger element and spring. Check initial injection pressure and atomization.</td>
</tr>
<tr>
<td>2)</td>
<td>Some fuel injection value too high. Adjust the value of fuel supply.</td>
</tr>
<tr>
<td>3)</td>
<td>Air valves of some cylinders worn and leaking. Grind or replace them.</td>
</tr>
<tr>
<td>4)</td>
<td>Indicating instruments defective.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>13</th>
<th>Exhaust is sooty or dark.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Beginning of injection too late.</td>
</tr>
<tr>
<td>2)</td>
<td>Individual fuel injectors defective.</td>
</tr>
<tr>
<td>3)</td>
<td>Governor or fuel control linkage mal-adjusted.</td>
</tr>
<tr>
<td>4)</td>
<td>Individual cylinder highly overloaded.</td>
</tr>
<tr>
<td>5)</td>
<td>Inlet or exhaust valves stuck, valve spring broken, drive defective.</td>
</tr>
<tr>
<td>6)</td>
<td>Turbocharger fouled or defective.</td>
</tr>
</tbody>
</table>
| Exhaustr gas is bluish. | 1) Water in fuel oil.  
2) Piston ring clearance excessive.  
3) Piston ring stuck or broken.  
4) Oil level in oil sump too high.  
5) Seal ring in valve guide aged or broken.  |
|------------------------|---------------------------------------------------------------|
| Temperature difference at intercooler is too small. | 1) Indicating instruments defective.  
2) Lack of cooling water.  
3) Cooling water spaces or cooler fouled up.  
4) Cooling water pump defective.  |
| Fuel injection pump delivers irregularly. | 1) Fuel system air-bound.  
2) Fuel too cold, and congealed in pipelines.  
3) Low fuel oil pressure before fuel injection pumps, supply pump defective.  
4) Fuel oil filter clogged up.  
5) Pump plunger stuck, spring broken.  
6) Control sleeve or pump element bound.  
7) Delivery valve in fuel injection pump leaking.  |
| Noise from valve or fuel injection pump drive depends on speed. | 1) Pump plunger stuck, spring broken.  
2) Inlet or exhaust valves stuck, valve spring broken or drive defective.  
3) Drive rollers or rocker arms defective, or valve clearance excessive.  |
| Smoke escapes from crankcase vent, and booming sounds come out from crankcase. | 1) Piston ring clearance excessive;  
2) Piston pin bearing clearance excessive;  
3) Crank pin bearing or main bearing clearance excessive;  
4) Piston or bearing running hot or beginning to seize;  
5) Piston ring stuck or broken;  
6) Cylinder liner worn severely.  |
| Compressor of turbocharger surges and vibrates. | 1) Filtering element of air filter clogged up by filth.  
2) Compressor dirt.  
3) Air cooler dirt.  
4) Inlet and outlet valve dirt.  
5) Bearing, turbine, impeller of compressor damaged.  |
Annex

1. Correction of output at nonstandard condition

Explanation of power correction:

According to GB/T6072.1-2000 *Reciprocating internal combustion engines —Performance — Part 1: Standard reference conditions, declarations of power, fuel and lubrication oil consumptions, and test methods*, the rated power is the output of engine under the condition of rated speed and standard ambient situation. The standard ambient situation is:

- Atmospheric pressure: $P_0=100$ kPa (750 mmHg)
- Relative humidity: $\varphi_0=30\%$
- Ambient temperature: $T_0=298$K or $25^\circ$C

Coefficient of correction $C$: (relative humidity is not taken into consideration)

The ambient temperature, i.e. inlet temperature, is measured at the position that is within 150mm to air inlet of intake pipe. Because of various areas and seasons, the environmental condition would be different greatly. If the environmental condition makes against the running of...
engine, in order to guarantee the engine’s safety and reliable operation, the output value should be corrected, i.e. be decreased. The formula of output are modified as:

Actual permissible output value = rated power X C%

The coefficient of correction C could be found in following table. When the ambient condition differs from the value in the table, coefficient C could be calculated by interpolation method through the value in the table.

2. Torsional vibration calculation parameters of CW12V200ZC engine

2.1 Engine: CW12V200ZC (four strokes, single action)

<table>
<thead>
<tr>
<th>Cylinder number</th>
<th>12 Cyl, V type</th>
<th>Reciprocating mass of each cylinder</th>
<th>27.5kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder bore</td>
<td>200mm</td>
<td>Connecting rod ratio</td>
<td>0.260</td>
</tr>
<tr>
<td>Stroke</td>
<td>270mm</td>
<td>Crankpin dia.</td>
<td>133mm</td>
</tr>
<tr>
<td>Rated speed</td>
<td>1000r/min</td>
<td>Shaft journal dia.</td>
<td>180mm</td>
</tr>
<tr>
<td>Rated power</td>
<td>1200kW</td>
<td>Mechanical efficiency</td>
<td>0.89</td>
</tr>
<tr>
<td>Min. stable speed</td>
<td>400r/min</td>
<td>Firing order of each bank</td>
<td>1-4-2-6-3-5</td>
</tr>
</tbody>
</table>

2.2 Drawing No. of moving parts and torsional vibration parameters

<table>
<thead>
<tr>
<th>Crankshaft drawing No.</th>
<th>C12.03.01.0001</th>
<th>Reduced mass</th>
<th>77kg/ crank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance weight drawing No.</td>
<td>C62.03.01.0003</td>
<td>Mass</td>
<td>21.9kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reduced mass</td>
<td>29.4kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reduced mass</td>
<td>55.6kg</td>
</tr>
</tbody>
</table>

| Number of balance weight | 12 |
| Arrangement of balance weights | Two for every crank |
| Connecting rod drawing No. | XC62.04.05.0000 | Total mass | 28.5kg |
|                         |                | Rotating parts mass | 20.3kg (71.2%) |
|                         |                | Reciprocating parts mass | 8.2kg (28.8%) |
| One-piece piston drawing No. | C62.04.02.0000 | Total mass | 18.3kg |
| Combined-type piston drawing No. | C62.04.08.0000 | Total mass | 19.5kg |
2.3 Crank torsional vibration parameters:

<table>
<thead>
<tr>
<th>No.</th>
<th>Moment of inertia (kg.m²)</th>
<th>Torsional vibration Rigidity (N.m/radX10⁶)</th>
<th>Damping coefficient (kN.m.s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free end</td>
<td>15.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driving gear system</td>
<td>0.75</td>
<td>38.0</td>
<td></td>
</tr>
<tr>
<td>No. 1 crank</td>
<td>4.58</td>
<td>9.5</td>
<td>0.06</td>
</tr>
<tr>
<td>No. 2 crank</td>
<td>4.58</td>
<td>9.5</td>
<td>0.06</td>
</tr>
<tr>
<td>No. 3 crank</td>
<td>4.58</td>
<td>9.5</td>
<td>0.06</td>
</tr>
<tr>
<td>No. 4 crank</td>
<td>4.58</td>
<td>9.5</td>
<td>0.06</td>
</tr>
<tr>
<td>No. 5 crank</td>
<td>4.58</td>
<td>9.5</td>
<td>0.06</td>
</tr>
<tr>
<td>No. 6 crank</td>
<td>4.58</td>
<td>9.5</td>
<td>0.06</td>
</tr>
<tr>
<td>Crankshaft flange at flywheel end</td>
<td>1.10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.4 Vibration damper parameters

- Moment of inertia of active parts: 1.08kg•m²
- Moment of inertia of driven parts: 5.90kg•m²
- Coefficient of elasticity of springs: 2×8530N/cm (dynamic)
- Damping coefficient: 0.9kN•m•s
- Diameter of the position at which spring is installed: 400mm
- Number of springs: 8

2.5 Flywheel parameters

- Diameter: 995mm
- Width: 251mm
- Mass: 900kg
- Inertia: 125kg.m²

Note: The above-mentioned parameters of torsional vibration are provided to user, which should be combined with power unit type (such as shaft coupling, reduction gearbox, propeller shafting system and other load), and relative model parameters to be done the calculations of torsional vibration to determine that whether there is a resonance point. Necessarily some measures could be adopted to reduce the stress. The works will not bear the responsibility to the damage and lose caused from large amplitude if the resonance point have not been calculated and determined.
3. Torsional vibration calculation parameters of CW16V200ZC engine

### 3.1 Engine: CW16V200ZC (four strokes, single action)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder number</td>
<td>12 Cyl, V type</td>
</tr>
<tr>
<td>Reciprocating mass of each cylinder</td>
<td>27.5kg</td>
</tr>
<tr>
<td>Cylinder bore</td>
<td>200mm</td>
</tr>
<tr>
<td>Connecting rod ratio</td>
<td>0.260</td>
</tr>
<tr>
<td>Stroke</td>
<td>270mm</td>
</tr>
<tr>
<td>Crankpin dia.</td>
<td>133mm</td>
</tr>
<tr>
<td>Rated speed</td>
<td>1000r/min</td>
</tr>
<tr>
<td>Shaft journal dia.</td>
<td>180mm</td>
</tr>
<tr>
<td>Rated power</td>
<td>1760kW</td>
</tr>
<tr>
<td>Mechanical efficiency</td>
<td>0.89</td>
</tr>
<tr>
<td>Min. stable speed</td>
<td>400r/min</td>
</tr>
<tr>
<td>Firing order of each bank</td>
<td>1-3-5-7-8-6-4-2</td>
</tr>
</tbody>
</table>

### 3.2 Drawing No. of moving parts and torsional vibration parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crankshaft drawing No.</td>
<td>C16.03.01.0001</td>
</tr>
<tr>
<td>Reduced mass</td>
<td>72kg/ crank</td>
</tr>
<tr>
<td>Balance weight drawing No.</td>
<td>C62.03.01.0003</td>
</tr>
<tr>
<td>Mass</td>
<td>21.9kg</td>
</tr>
<tr>
<td>Reduced mass</td>
<td>29.4kg  Y=181mm</td>
</tr>
<tr>
<td>Reduced mass</td>
<td>55.6kg  l=215mm</td>
</tr>
<tr>
<td>Number of balance weight</td>
<td>16</td>
</tr>
<tr>
<td>Arrangement of balance weights</td>
<td>2 for each crank</td>
</tr>
<tr>
<td>Connecting rod drawing No.</td>
<td>XC62.04.05.0000</td>
</tr>
<tr>
<td>Total mass</td>
<td>28.5kg</td>
</tr>
<tr>
<td>Rotating parts mass</td>
<td>20.3kg  (71.2%)</td>
</tr>
<tr>
<td>Reciprocating parts mass</td>
<td>8.2kg  (28.8%)</td>
</tr>
<tr>
<td>One-piece piston drawing No.</td>
<td>C62.04.02.0000</td>
</tr>
<tr>
<td>Total mass</td>
<td>18.3kg</td>
</tr>
<tr>
<td>Combined-type piston drawing No.</td>
<td>C62.04.08.0000</td>
</tr>
<tr>
<td>Total mass</td>
<td>19.5kg</td>
</tr>
</tbody>
</table>
3.3 Crank torsional vibration parameters:

<table>
<thead>
<tr>
<th>No.</th>
<th>Moment of inertia (kg.m²)</th>
<th>Torsional vibration rigidity (N.m/radX10⁶)</th>
<th>Damping coefficient (kN.m.s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free end</td>
<td></td>
<td>15.5</td>
<td></td>
</tr>
<tr>
<td>Driving gear system</td>
<td>0.75</td>
<td>38.0</td>
<td></td>
</tr>
<tr>
<td>No. 1 crank</td>
<td>4.58</td>
<td>9.5</td>
<td>0.06</td>
</tr>
<tr>
<td>No. 2 crank</td>
<td>4.58</td>
<td>9.5</td>
<td>0.06</td>
</tr>
<tr>
<td>No. 3 crank</td>
<td>4.58</td>
<td>9.5</td>
<td>0.06</td>
</tr>
<tr>
<td>No. 4 crank</td>
<td>4.58</td>
<td>9.5</td>
<td>0.06</td>
</tr>
<tr>
<td>No. 5 crank</td>
<td>4.58</td>
<td>9.5</td>
<td>0.06</td>
</tr>
<tr>
<td>No. 6 crank</td>
<td>4.58</td>
<td>9.5</td>
<td>0.06</td>
</tr>
<tr>
<td>No. 7 crank</td>
<td>4.58</td>
<td>9.5</td>
<td>0.06</td>
</tr>
<tr>
<td>No. 8 crank</td>
<td>4.58</td>
<td>15.5</td>
<td>0.06</td>
</tr>
<tr>
<td>Crankshaft flange at flywheel end</td>
<td>1.10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.4 Vibration damper parameters

- Moment of inertia of active parts: 1.08kg*m²
- Moment of inertia of driven parts: 5.98kg*m²
- Coefficient of elasticity of springs: 2×8530N/cm (dynamic)
- Damping coefficient: 0.9kN*m*s
- Diameter of the position at which spring is installed: 400mm
- Number of springs: 8

3.5 Flywheel parameters

- Diameter: 995mm
- Width: 251mm
- Mass: 900kg
- Inertia: 125kg.m²

Note: The above-mentioned parameters of torsional vibration are provided to user, which should be combined with power unit type (such as shaft coupling, reduction gearbox, propeller shafting system and other load), and relative model parameters to be done the calculations of torsional vibration to determine that whether there is a resonance point. Necessarily some measures could be adopted to reduce the stress. The works will not bear the responsibility to the damage and lose caused from large amplitude if the resonance point have not been calculated and determined.
4. Diesel engine nameplate parameters meaning

4.1 Diesel engine nameplate

4.2 Parameters meaning

ICXN: Rated power /Rated speed

ION: Over load power/Over load speed

MCXN: Power at unrestricted range of service /Speed

MON: Over load power at unrestricted range of service /Speed