Operate or service the exhaust gas turbocharger only after you have read this manual and understood its contents.

Carefully store this manual in a fixed place so that it is immediately available for your reference when you need it.

- Issued: June 2013
- Version: 9A-2-0000-A
This manual is intended to provide users with an understanding of the structure of the Mitsubishi MET turbocharger, appropriate maintenance procedures, and proper response in the rare event of malfunctioning. Accordingly, this manual should always be placed in a location where it can be easily accessed from the vicinity of the turbocharger. Also, all personnel concerned with the engine to which the turbocharger is attached should carefully read this manual and understand its content. If the content requires further clarification, please make direct inquiries by facsimile, e-mail, etc.
In the event that the turbocharger becomes faulty in normal status of use, we will warrant as follows:

(1) The term of warranty is either 12 months after ship delivery or 18 months after the turbocharger delivery, whichever comes first.

(2) Should the turbocharger be faulty or damaged due to causes including faulty design, defective materials and poor workmanship, deemed to be the responsibility of the manufacturer (Mitsubishi Heavy Industries, Ltd. Herein after referred to as MHI), and such fault or damage be claimed by the customer during the term of the above (1), MHI will provide a substitute free of charge or repair at the site as necessary.

(3) Should the warranty work be performed outside of Japan, the cost equivalent to the cost that would be charged if such a warranty work is performed in Japan by the manufacturer will be paid to the customer.

(4) The following is excluded from the scope of the warranty:
   A) Any failure deemed to be caused by mis-handling or misuse of the customer after due consultation between the customer and MHI
   B) Any failure or disadvantage caused due to use of the parts which are not MHI’s genuine parts.
      Any service and maintenance for the turbocharger equipped with pirated parts or using them can not be accepted by the engineers from MHI and its authorized agent.
   C) Consumables subject to natural wear and/or tear
   D) Any failure caused due to natural disasters and/or force majeure

(5) MHI will not be responsible for any consequential damages caused by any failure.

The warranties set forth above are exclusive and in lieu of all other warranties.

MHI makes no warranty, either expressed or implied, except as provided herein, including, without limitation thereof, warranties as to marketability, merchantability or fitness for particular purpose.

MHI shall not be responsible for any damages or consequential damages including without limitation thereof or other costs resulting from any abuse, misuse, misapplication of the equipment supplied by MHI.
IMPORTANT INFORMATION

- MHI will not be held responsible for any loss or damage resulting from failure to observe the instructions described in this manual, any modification of Mitsubishi exhaust gas turbocharger (herein after referred to as turbocharger) or operation / maintenance without care which must normally be taken.

- The turbocharger is a turbo-machine with a high speed rotor. The rotational energy of the rotor during operation is, therefore, immense. For this reason, improper handling can result in substantial damage to the equipment, as well as the possibility of human injury.

- Only when the turbocharger is installed to the exclusive diesel engines, it compresses and supplies combustion air suitable for such diesel engines. Do not modify the turbocharger, remove from specified diesel engine or install to any other internal combustion engines. If the turbocharger is modified, removed from the specified engines or installed to any other engines, the warranty will not cover.

- MHI is not able to foresee all dangers in handling the turbocharger. We cannot tell all risks, warnings or cautions by this manual or labels adhered to the turbocharger. Consequently, when performing operation and daily inspection of the turbocharger, it is necessary to take measures in addition to the items described in this manual.

- It is obvious that the performance, failure, durability of the turbocharger depends on its design, materials and/or manufacturing technique. It also depends on the daily handling or maintenance.

- In order to avoid generating of injury and/or damage, do not exceed the original purpose of use of the turbocharger and the specification range, and also do not perform the operation and maintenance work unless it is instructed to do so in this instruction manual.

- When transferring or lending the turbocharger, attach the instruction manual together with the turbocharger so that they should be able to fully understand the contents. When transferring (or reselling), be sure to inform MHI of the resale place. In this case, submit all things which come with the turbocharger to the resale group. The reseller shall not hold anything duplicated or reproduced.

- This instruction manual is prepared for English native speaker. In case that person whose native language is not English handles this turbocharger, he or she must be instructed on safety by the customer.

- The contents of this instruction manual are subject to change without prior notice for improving the turbocharger.

- Your turbocharger may different from the illustrations in this manual. A part of the illustrations may be omitted in order to facilitate explanation about the inside of the turbocharger.

- This manual is copyrighted and all rights are reserved. This manual may not, in whole or part, be copied, photocopied, translated or reduced to any electronic medium or machine-readable form without prior written consent from MHI.

- If you lost or damaged the instruction manual, order from MHI immediately.

- For further questions or information, contact MHI (10. Where to Contact).
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<table>
<thead>
<tr>
<th>Name of Instruction Manual</th>
<th>Mitsubishi Exhaust Gas Turbocharger Model MET60MA</th>
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<tbody>
<tr>
<td>Document No.</td>
<td></td>
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<tr>
<td>Rev.</td>
<td>Date of issue</td>
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<tr>
<td>1-A</td>
<td>November 2006</td>
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<tr>
<td>2A-2-0000</td>
<td>August 2007</td>
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<td>3A-2-0000</td>
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<td>4A-2-0000</td>
<td>May 2009</td>
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<tr>
<td>4A-2-0000-A</td>
<td>July 2009</td>
</tr>
<tr>
<td>5A-2-0000-A</td>
<td>January 2010</td>
</tr>
<tr>
<td>6A-2-0000-A</td>
<td>October 2010</td>
</tr>
<tr>
<td>7A-2-0000-A</td>
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</tr>
<tr>
<td>8A-2-0000-A</td>
<td>June 2012</td>
</tr>
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1 Safety

1.1 About this Section

Safety precautions given in this section provide guidelines to prevent accidents resulting in injuries or death from occurring to operators for the turbocharger.

To ensure safety of the operators for the turbocharger, refer to the “Guidelines on occupational safety and health management systems ILO-OSH 2001”, and local rules and regulations including the following contents:

(1) Safety measures
(2) Customer’s responsibility to have their operators to understand about assurance of safety
(3) Customer’s responsibility to manage their operators and machines

To operate the turbocharger based on the occupational safety and health management systems established by the customer, provide safety educations and trainings periodically in addition to understanding and observing of the safety instructions described herein.

In this section, to ensure the safety as above, the following safety information is also provided for all the operators of the turbocharger.

(1) 1.4 and 1.5 --- Information for operators to ensure safety by themselves
(2) 1.6 --- How to rescue from accidents resulting in injuries or death
   Trainings in case of accidents, in addition to daily safety assurance activities, is required.
(3) 1.7---Information from MHI about “Occupational Safety and Health Management”
   executed by the customer
   This instruction manual (dangers, warnings and cautions), warning labels on the turbocharger and signals are important information to prevent anyone from accidents resulting in injuries or death.

To assure safety and/or to prevent damage of the turbocharger itself, warnings (dangers, warnings, cautions and notices) are described in the section “1.2.1 Warning description.”

For individual operation, understand and observe the contents of the manual.

In addition to “1.3 General Precautions”, the warnings are also important for individual works and operations.
1.2 Warnings

The following two methods are provided for the turbocharger to call attention of operators to danger.

- Warning descriptions in this manual
- Warning labels on the turbocharger

Read carefully all the safety warnings described in this manual.

Check the locations and the contents of all the warning labels adhered to the turbocharger before operating.

1.2.1 Warning description

The following four categories warn the dangerous situation that may occur during operation. If they are ignored, serious injuries or accidents corresponding to the respective warning sign may result. In extreme case, there is also a possibility of death, damage to the turbocharger or environmental fracture.

<table>
<thead>
<tr>
<th>Kinds</th>
<th>Meaning of Warnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>DANGER</td>
<td>Indicates an urgent (imminently) dangerous situation, which if mis-handled, will result in death, serious injury, serious property damage or environmental damage.</td>
</tr>
<tr>
<td>WARNING</td>
<td>Indicates dangerous situation, which if mis-handled, could result in death, serious injury, serious property damage or environmental damage.</td>
</tr>
<tr>
<td>CAUTION</td>
<td>Indicates a potentially dangerous situation, which if mis-handled, will result in minor or moderate injury, property damages or environmental damage.</td>
</tr>
<tr>
<td>NOTICE</td>
<td>Indicates to emphasize important or helpful information.</td>
</tr>
</tbody>
</table>

Meanings of the symbols (extracted from ISO3864-1 (2002))

The following three symbols indicate signals for danger.

<table>
<thead>
<tr>
<th>Symbols</th>
<th>Meanings</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>✗ Prohibition sign</td>
<td>Indicates prohibition of dangerous actions. The illustration inside or near the symbol is stylized prohibited action.</td>
<td>☑ (Prohibition)</td>
</tr>
<tr>
<td>◼ Direction sign</td>
<td>Indicates direction about the works and/or operations. The illustration inside or near the symbol is stylized required action. This action is necessary to avoid danger.</td>
<td>⚠ (General direction)</td>
</tr>
<tr>
<td>△ Caution sign</td>
<td>Indicates warnings about the dangerous places or actions, or that the dangerous situation may result due to neglect of safety obligation or carelessness. The illustration inside the symbol is stylized danger.</td>
<td>⚠ (General caution)</td>
</tr>
</tbody>
</table>
1.2.2 Warning labels

- Precautions in handling

- The turbocharger is provided with warning labels stating important precautions. Fully understand the meanings of the warning labels for safety operations which will not cause damages to the turbocharger.
- Never operate the turbocharger unless fully understanding the meanings of the labels. If you do not fully understand meaning of any label, contact MHI.
- Always observe the instructions of the warning labels on the turbocharger and warnings described in the manual.
- Do not tear off or damage the warning labels, or do not wipe them using solvent.
- When re-painting the turbocharger, do not paint the warning labels.
- If the warning labels adhered on the turbocharger became illegible, damaged or peeled, purchase them from MHI and replace as per the arrangement shown in the next page.
- If any part with a warning label is replaced, adhere a new warning label to the new part in the same manner as before.
Locations of warning labels

- Locations of warning labels are shown in the diagram.
- CAUTION: Rotate the fan and drive train
- CAUTION: Do not touch the high-speed rotating machinery.
- CAUTION: Clean the air filter before the air filter pressure loss exceeds 200mmHg.
- WARNING: Do not touch the area mentioned.
- WARNING: Do not touch the area mentioned when the engine is running at normal speed.

(Adhere this label to either place whichever prominent.)
Locations of main nameplates and caution plates

During the shop test, this filter protector should be took off. Please re-install this protector in turbocharger when delivered.

CAUTION

<table>
<thead>
<tr>
<th>INTERVALS</th>
<th>100 HOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIR PRESS</td>
<td>0.4~0.9MPa</td>
</tr>
<tr>
<td>MET</td>
<td></td>
</tr>
</tbody>
</table>

During the shop test, this filter protector should be took off. Please re-install this protector in turbocharger when delivered.

During the shop test, this filter protector should be took off. Please re-install this protector in turbocharger when delivered.
1.3 General Precautions

The safety precautions describe herein provide guidelines to prevent accidents resulting in injury or death, property damage or environmental pollution. It is necessary to always observe the precautions when handling the turbocharger. If not observed, it may cause serious injury to operators, damage to the turbocharger and environmental pollution. Be sure to, therefore, understand the precautions before handling the turbocharger.

1.3.1 Modification and specification change of the turbocharger

**WARNING**

Do not modify the turbocharger or change the specification without prior consent of MHI.

When screws from the turbocharger main unit are used to fasten other components, or when other components are welded to the turbocharger main unit, be sure to consult with MHI first.

- It may deteriorate the performance or reliability of engines as well as the turbocharger.

Never use any parts or components other than genuine parts supplied by MHI for the turbocharger.

- It may deteriorate the performance or reliability of engines as well as the turbocharger.

1.3.2 During operation

**WARNING**

Do not enter the danger zone during operation.

The silencer air inlet port sucks in large amounts of air and, in the event of sudden surging, there is a possibility of the reverse flow of high-pressure air from the silencer.

- If not observed, you may trip over and get injured.

Do not put anything in a pocket of working wear during operation.

Take anything out of the pocket of the working wear.

- The air inlet of the silencer inhales large amounts of air. There is a possibility that small objects you have on such as pens are sucked in.
  - If not observed, small objects may be sucked into the silencer, resulting in damage of the impeller.

Do not directly touch the surface of the turbocharger during operation of the engine.

If the insulation on the surface is damaged or peeled, cover it with flame-retardant mats, etc. temporarily, and then consult with MHI.

- There is high temperature areas, which may cause heat injury.
WARNING

If you smell order of exhaust gas emitted from the exhaust gas piping or turbocharger, immediately stop the engine and then check to find gas-leaking places.

A part of the exhaust gas or a component of the gas from diesel engines is known for toxic gas causing cancers, birth defects and other toxicity of reproduction.

- Inhaling of the gas may result in tracheal disorders or heat injury.

There is also a possibility that the turbocharger would suck in exhaust gas through the silencer, resulting in that sufficient air would not be supplied to the engine and that the temperature of the compressor impeller would rise, thus leading to unexpected accidents.

If you have to approach any danger zone during operation, the actions must be completed within a possible minimum time.

- There is a possibility that the rotating parts inside the turbocharger become damaged and then jump out, leading to accidents resulting in injury or death.

If such leakage occurs, immediately stop the engine, and take appropriate measures to eliminate the leakage.

- If oil leaks from the lubricant piping connected to the turbocharger, particularly in the high-pressure inlet piping, there is a possibility of ignition and fire due to the discharge of lubricant.

CAUTION

Wear an ear protection equipment (ear plugs, etc.) when approaching the danger zone during operation.

- If not observed, hearing disorder may be caused due to noise around the turbocharger.

NOTICE

- While the engine is operating, the air filter must be kept mounted. If the air filter is torn off or damaged, replace with a new one. If the air filter is peeled or mis-mounted, immediately stop the engine or decelerate the engine to exhaust air pressure of 0.03MPa or less before re-mounting the filter appropriately.
### 1.3.3 Maintenance, disassembly and assembly

The turbocharger is designed for those who have skills of disassembling and assembling general large-size equipment. It is possible to disassemble and assemble the turbocharger by reading this manual thoroughly without any special training. Disassembling or assembling of the turbocharger, however, is accompanied by dangerous work such as lifting heavy loads. Anyone handling the turbocharger must have skill and knowledge to perform disassembly and assembly safely, and such work must be performed under an appropriate safety management system.

<table>
<thead>
<tr>
<th>WARNING</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Do not disassemble or assemble the turbocharger when you are under influence of drinking, short of sleep or in poor physical condition.</strong></td>
<td>It may cause unexpected accidents.</td>
</tr>
<tr>
<td><strong>Do not use fire while the turbocharger is cleaned using any flammable liquids such as kerosene.</strong></td>
<td>It may cause fire due to flash ignition.</td>
</tr>
<tr>
<td><strong>Do not go under any equipment or part which is suspended.</strong></td>
<td>The equipment or part may fall off due to failure of the lifting tool, causing accidents resulting in injury or death.</td>
</tr>
<tr>
<td><strong>Check the clogged status of the filter everyday with the manometer installed to the silencer.</strong></td>
<td>Be sure to clean or replace the filter before the pressure measured with the manometer exceeds 2.0 kPaG (200 mmAq).</td>
</tr>
<tr>
<td></td>
<td>If not observed, the air volume of the engine may become insufficient, resulting in reduction of output and generation of surging. Then, the element of the air filter may be clogged and then ventilation resistance may become large, causing incomplete combustion due to the insufficient air, discharging gases harmful to the environment.</td>
</tr>
<tr>
<td><strong>If the oil labyrinth or housings are damaged or worn out exceeding the standard value of the gap, replace with a new one.</strong></td>
<td>The damaged or worn out oil labyrinth or housing may cause not only oil leakage but also a problem that the oil drops are discharged to outside through the air extractor of the turbocharger.</td>
</tr>
<tr>
<td><strong>Operation of cranes and slinging must be performed by an authorized person.</strong></td>
<td>The owner is obliged to give their employee who handles suspending equipment (chain block) training on safety. (Observe the national rules and regulations.) Only the persons who are trained on safety and designated by the owner may handle the suspending equipment.</td>
</tr>
<tr>
<td></td>
<td>If the suspended loads are unbalanced during transportation or fall off due to mis-slinging, it may cause accidents resulting in injury or death or damage of the turbocharger.</td>
</tr>
<tr>
<td><strong>Before using materials to suspend the machine or parts (wires, slings, tools, etc.), check the weight of the object to be suspended. Use a material of sufficient strength.</strong></td>
<td>If load exceeding the allowable value of the suspending material is applied, such a material may be broken and then the suspended object may fall off, causing accidents resulting in injury or death. There also is a possibility that broken wires or slings may jump out and hit a person, causing accidents resulting in injury or death.</td>
</tr>
</tbody>
</table>
**WARNING**

Load to be applied to a suspending material will change depending on the angle of suspending. Consider it when selecting the size.

Do not select the size of the suspending material unless you understand the meaning of the instruction above.

* If not observed, it may cause unexpected accidents.

Dispose of any suspending materials a part of which is broken. Use a new one.

Before using the suspending material, check if it is normal.

* If any abnormal material tool is used, it may break during suspending work, causing accidents resulting in injury or death.

When suspending any equipment or part, place the hook in the center of the gravity of the suspended object.

Adjust the position so that each wire is applied with the same load.

* If not observed, the object may be unbalanced when suspended or a certain wire is applied with large load and then broken, causing accidents resulting in injury or death.

After disassembling the silencer of the turbocharger and casing at inlet of the gas, if the rotor of the turbocharger is rotating, take measures of 5.2.

- Never touch the impeller or turbine blade while it is rotating.
- Do not try to stop the rotation of the rotor by applying a piece of wood or waste cloth.

Even when the engine is stopped, upward flow may be generated inside the duct due to afterheat of the exhaust duct or exhaust gas economizer, which makes the rotor of the turbocharger rotating. Such low rotational speed may not be detected by the rotational speed counter. Thus, even if the rotational speed counter reads “0”, the rotor may not be stopped.

* If not observed, you may get entangled in, or some foreign substances may hit the rotor.

To prevent accidents in disassembling and assembling, inspect required tools and exclusive tools beforehand.

* If neglected, unexpected accidents may occur.

Take care not to step off or not to drop any object during the work.

If the scroll of the compressor in the turbocharger is removed, the intake of the duct for discharge air of the compressor will be turned downward.

* There is a possibility of injury.

**CAUTION**

Wait until the turbocharger is cooled enough after it is stopped before disassembling.

* There is a possibility of heat injury.
1.3.4 Allowable turbocharger temperature and speed

The allowable turbocharger temperature and speed (rpm) are stated on the main nameplate (refer to the figure below). These values are not exceeded during normal operation. However, particular care is required under the following circumstances, as the allowable values may be exceeded, possibly resulting in serious damage or accidents.

1. Occurrence of turbocharger surging (phenomenon in which reverse flow of air from the compressor is accompanied by intermittent loud noise)
2. Failure of fuel system of engine.
3. Leakage of air and/or exhaust gas
4. Excessive exhaust gas energy due to irregular combustion in the engine

1.3.5 Clothing and personal protective equipment

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
</table>

When performing works around the turbocharger while it is operating, wear protective equipment.

It may make noise of 85 db or more while it is operating.

* Work or operation without wearing the ear protective equipment (ear plugs, etc.) may cause hearing disorder.

Get tidily dressed and your hair arranged tidy when performing works around the turbocharger.

* Dressed untidily or untidy hair may cause accidents resulting in injury or death.

1.3.6 Others

- To prevent surging, not only periodical cleaning inside the turbocharger but also the maintenance of the engine is necessary. For further information about the engine, refer to the instruction manual of the engine.
- When abnormal combustion occurs due to failure of the engine or aging, the rotational speed of the turbocharger will increase extraordinarily, resulting in death or serious injury due to jumping out of pieces of broken parts as well as serious damage to the turbocharger. Keep the engine in a good condition by maintenance following the manual of the engine.
1.4 Operating Procedure inside the Danger Zone

The turbocharger has the following danger zone. When troubleshooting, adjusting, cleaning or maintaining inside the danger zones and caution zones, follow the procedure below:

■ Approaching method

Before approaching the danger zones, stop the turbocharger.

■ Approaching caution zones

Inside the caution zones, follow the instructions in “1.3 General Precautions”.

The rotational speed of the compressor impeller and turbine blade of the turbocharger exceed the speed of sound, and the associated energy is very high. Accordingly, standing in the caution zones indicated below should be avoided unless there is a specific reason to do so. When approaching the turbocharger to perform measurements, inspection, etc., these actions must be completed in the minimum possible time.
1.5 Protection of Human Body

To protect those handling the turbocharger, observe the following requirements.

- Put on protective footwear.
- Put on a hard hat.
- Working wear must be neatly fit to the body. The cuffs must be firmly fastened.
- Do not wear a tie, sort of accessories, etc. There is a possibility of being entangled. Long hair may be entangled in the turbocharger. Put on a hat as necessary.
- For handling cleaning liquids and solvents, observe the instructions shown on MSDS (1.7.3 Dangerous and harmful materials).
- Put on protective gloves when handling tools and suspending wires, etc.
- When operating or working, wear appropriate cloths.
  - Wearing loose clothing or high-heeled shoes, long hair, pendants or ties may cause accidents such as tumbling over or entanglement.
  - Wearing clothing with half sleeves or short pants may cause injury in case of contact with some objects.
- Adopt instructions above in your work rules.
1.6 Measures for Emergencies

1.6.1 Dealing with accident resulting in injury or death

It is very important to determine a course of action during an emergency to come to the aid and rescue operators who are involved in the accidents of the turbocharger.

Examples of steps included in a course of action during an emergency are shown below:

(1) Assigning of persons to contact as personnel to assist in rescue operation
(2) Procedure sheet outlining how to release hand, fingers and other body parts entangled in the turbocharger
(3) Posting at least one person trained on rescue operation in one shift
(4) Appropriate tools and equipment to achieve a successful rescue

1.6.2 Dealing with environmental damage

In case of accidental spill of waste oil, etc., follow the instruction below:

(1) Contact the places concerned.
   (Understand where to contact in case of emergency)
   For example:
   (a) Public institution to perform regional environmental management
   (b) Fire department
   (c) Police department
   (d) Fishermen’s union
   (e) MHI or authorized service agency

(2) Take action according to the instructions given by the public institution.
1.7 Occupational Safety and Health Management

This section describes the occupational safety and health management the customer must follow. In order to prevent accidents resulting in injury or death, property damage and environmental damage, make sure of this information along with legislations enforced by the national, state or local government, and independent safety management items of your own.

1.7.1 Training program

The technical skill related to safety can be improved by training in the same manner for technical skills for other operations. Be sure to include items related to safety in the education training programs provided by the customer.

All employees of the customer must be aware of potential dangers and keep the warning in mind. It is also necessary for the employees to improve their awareness of safety in order to quickly respond to danger and follow predetermined procedures.

If employees’ safety awareness is increased, they can grasp the situation, avoid dangerous actions and dangerous zones, and eliminate potential danger to protect themselves.

The following are considered to be the minimum necessities for safety education and training.

(1) The following safety information is included in this manual.
   - 1.3 General Precautions
   - 1.4 Operating Procedure inside the Danger Zone
   - 1.5 Protection of Human Body
   - 1.6 Countermeasures for Emergency
   - 1.7.3 Dangerous and harmful materials
   - 1.7.5 Housekeeping
   - 1.7.6 Fire prevention

(2) Items which must be stated in the warning descriptions (danger, warning and caution) in this manual and manuals for peripheral devices and warning labels attached on the turbocharger

(3) Measures that should be taken for non-English speakers to operate the turbocharger.
   - Drastic safety education for operators
   - Adhere warning labels translated into the native language of the operators to the turbocharger.

(4) Noise

(5) Other customer’s rule
1.7.2 Understanding and observing the instructions described in the manual

Operators must fully understand the following included in this manual and also trained to avoid any danger in handling the actual turbocharger.

(1) As described in the “IMPORTANT INFORMATION”, it is prohibited to disclose or photocopy the plans and technical reference, including this manual without prior written consent from MHI.

(2) As described in “LIMITED WARRANTY”, MHI is not responsible for any loss or damage resulting from operators’ failure to observe the instructions and warnings in this manual.

(3) About description of “1.3 General Precautions”

(4) About “1.6 Measures for Emergency”

(5) Items which must be stated in the warning descriptions in this manual.

NOTICE

• If non-English speakers operate the turbocharger, be sure to train about safety.
1.7.3 Dangerous and harmful materials

Exposure to chemical substances might cause serious health problems such as heart diseases, damages to kidneys or lungs, sterility, cancer, heat injury or rash.

Some of the chemical substances could cause fire, explosion or other serious disasters.

When purchasing such dangerous and harmful materials, obtain MSDS (material safety data sheet) from the manufacturer and keep it close to the area of first use.

Handling the dangerous and harmful materials requires transmission of necessary information, providing education and training to those who handle the dangerous and harmful materials in accordance with ISO 11014 (1994).

Inform, educate and apply training to those who handle chemical substances based on the warnings shown below as well as MSDS (material safety data sheet).

(1) Secure enough ventilation to the zones where dangerous or harmful materials are used.
(2) Follow the methods recommended by the manufacturer to handle and store dangerous or harmful materials.
(3) Label the container of dangerous and harmful materials. Follow the directions given by the manufacturer to handle them. Keep chemical materials away from heat, sparks or flames. Store them in cool and dry places.
(4) Check the MSDS (material safety data sheet) before handling dangerous or harmful materials. Follow the directions shown in the sheet.
(5) Operators must wear personal protective equipment (gloves, aprons, etc.) to handle dangerous and harmful materials as directed in the MSDS (material safety data sheet) given by the manufacturer.
(6) If there is a possibility that dangerous or harmful materials could harm operators’ eyes, inform the operators about the location and usage of the EYE WASHER beforehand.
(7) Operators who handle dangerous or harmful materials must wash their hands before eating or smoking.

Disposal of waste liquid, solutions and materials

Discarding chemical materials such as solutions used for the turbocharger and waste cloths stained with such materials are subject to various regulations for environmental protection. It is requested to control these materials by observing registrations enforced by national and local government and regulations of your own. Companies certified by ISO 14001 must observe their own regulations.

MSDS (MSDS: Material Safety Data Sheet)

MSDS (material safety data sheet) with ISO11014 (1994) reflected to is shown in the next page. MSDS states detailed information about dangerous points on health and safety, influence on the environment, safety handling and countermeasures for emergency.
Material Safety Data Sheet

1. Information on chemical and company
   Name of chemical (product code)
   Name of company
   Person in charge
   Address
   Telephone No.

2. Outline of dangerous and harmful property
   Important dangerous and harmful property
   Effect on human body:
   Effect on environment:
   Physical and chemical dangerousness:
   Specific dangerous and harmful property:

3. Information on composition and component
   Chemical name:
   GAS No.:
   Other name:

4. Emergency measures
   In case of inhaling:
   In case of contact to skin:
   In case of getting in eyes:
   In case of swallowing:

5. Measures for fire
   Extinguishing agent:
   Extinguishing method:
   Protection of those who extinguish a fire:

6. Measures for leakage
   Cautions for human body:
   Protective equipment and emergency measures:
   Cautions for environment:
   Collection, neutralizing:
   Preventions of secondary disaster:

7. Cautions in handling and storing
   Handling: Technical measures, cautions for local ventilation, entire ventilation and
             occurrence of prevention of aerosol and dust. Special safety handling cautions
   Storage: Storage condition (appropriate and avoiding storage conditions)
             Safety container packaging materials (recommended materials and inappropriate materials)
1. Safety

8. Exposure prevention and protective measures
   Allowable density: Protective equipment of hand:
   Measures for equipment: Protective equipment for eyes:
   Protective equipment for respiration apparatus: Protective equipment for skin and body:

9. Physical and chemical property
   Appearance
      Physical property:
      Color:
   Odor: Vapor density:
   pH: Gravity:
   Melting point and freezing point Solubility:
   Boiling point, initial boiling point and boiling range Spontaneous ignition temperature:
   Flash point: Decomposition temperature:
   Explosive range: Lower limit: Upper limit: Flammability:
   Vapor pressure:

10. Stability and reactivity
    Stability:
    Dangerous and harmful reactivity:
    Conditions to be avoided:
    Mixed touch dangerous materials:

11. Information on harmfulness
    Acute toxicity
    Skin corrosivity, irritating property:
    Serious damage to eye, irritating property:
    Sensitizing property to respiration apparatus and skin:
    Reproduction cell mutagenic property:
    Oncogenic property:
    Reproductive toxicity:
    Specific target organ, systemic toxicity - Single exposure:
    Specific target organ, systemic toxicity - Repetitive exposure:
    Harmful effect on respiration apparatus in aspiration:

12. Information on environmental effect
    Ecologic toxicity
    Persistent property / resolvability:
    Bioaccumulation potential
    Migratory property in soil

13. Cautions on disposal

14. Cautions on transportation
    International regulation:

15. Applicable rules or regulations

16. Other information
1.7.4 Noise

There is a danger that operators might suffer permanent hearing loss if they work in an environment at a dangerous noise level. Noise is a critical issue in safety and health management in a plant. Hearing disorder is caused by the following unsafe behaviors.

- Entering danger zone without wearing ear protection equipment (ear plugs, etc.)
- Spending long hours in danger zone without ear protective equipment (ear plugs, etc.), or with inappropriate protective equipment.

1.7.5 Housekeeping

Poor housekeeping might cause operators' tripping or falling down at the things on the floor. Housekeeping also has effects on the efficiency of operations. It is proven that good housekeeping improves efficiency and causes less injury.

The following are about the housekeeping.

1. Thoroughly wipe off oils (lubricating oil) on the floor. If adhered to the backside of the shoes, there is a high possibility of slippage.
2. Store all the tools outside the aisles.
3. Apply marking to show the permanent isles and regular isles.
4. Before operating the turbocharger, clear all the used waste cloths, tools and equipment from the turbocharger and its vicinity.
5. Clean all the isles and equipment and do not leave anything which is not related to the work on them.

Examples of troubles caused by poor housekeeping.

- Things left on the floor: Operators might trip on them.
- Slippery surface on the floor: Operators might slip and fall down.
- Things placed at high locations above head: They might fall on operators.
- Things that are not placed at the designated locations: Operators might bump against them.
- Untidily stacked things: They might fall down and hit operators.
- Tools that are not stored in an appropriate manner: They might cut or hit operators.
- Trash scattered work places: They might deteriorate operators' working manners and habits.

The following are examples for methods to improve housekeeping ability.

- Decide places to put things back (for all things).
- Return everything to its original place after use.
- Put cans, bottles, wrapping paper, etc. into appropriate refuse container or recycling container.
1.7.6 Fire prevention

Though it is important to prevent the fire, it is also necessary to provide training for case of fire. It is also necessary to provide training in case of fire.

The general fire preventive actions are as follows:

• Do not put anything flammable near the place at which fire is used.
• When using fire temporarily, obtain permission to do so.
• Prepare a fire extinguisher and water while using fire.
• Clean up after using fire.
• Replace or install fire extinguisher or fire hydrant periodically.
• If the cover of the electric wiring is damaged, repair or replace immediately.
• To prevent fire due to aging of the wiring equipment, check or replace.

Always perform measures as well as those described above to prevent fire.

1.7.7 Communication with manufacturer

Communicate with the manufacturer if you notice anything about safety at the time of contact, delivery and during operation of the turbocharger thereafter.

If you need further information or question about the contents of the manual, contact MHI or our service agency.

NOTICE

• When taking protective measures, refer to the instruction manual submitted by the manufacturer above and “information on use” such as descriptions on the warning labels on the turbocharger.
Because the turbocharger runs automatically as a result of the energy contained in exhaust gas from the engine, it does not usually require any special manipulation when the engine is operating normally. However, the turbocharger plays an essential role in supplying combustion air to the engine, and it is therefore important to maintain its performance in order to ensure the performance and reliability of the engine itself.

2.1 Turbocharger Structure

2.1.1 Exhaust gas energy and air compression

A turbocharger is a device that utilizes the energy contained in exhaust gas from the engine in order to compress fuel combusting air and send to the engine. Thus, a turbocharger consists of a turbine for the conversion of exhaust gas energy into motive force and air compressor driven by this force.

Exhaust gas released from the engine is channeled to the turbocharger inlet casing (26, 27), and after being expanded and accelerated by means of a nozzle (22), it comes into contact with the turbine blades (61). This serves to efficiently convert the energy into rotational motive force.

A turbine blade (61) and compressor impeller are positioned at either end of the rotor, and the motive force of the turbine directly drives the compressor impeller. As the compressor impeller rotates, external air is channeled through the silencer (50) to the impeller (66), and is accelerated to obtain high velocity and pressure. The high level of energy contained in the air exiting the impeller (66) is recovered in the form of pressure as it passes through the diffuser (45). Then, after passing through the scroll (40, 44), air having the required pressure and flow volume is sent to the engine.
The ratio, the energy obtained by pressurization of the surrounding air, divided by the energy lost as the exhaust gas passes through the turbocharger turbine, is known as the turbocharger efficiency, and this is a basic measure of turbocharger performance. Fouling and wear affecting the turbine and compressor are causes of reduced efficiency, and these factors can result in failure to deliver air having the requisite pressure and flow volume to the engine. It is therefore important to perform periodic maintenance of the turbocharger in order to maintain its performance.

### 2.1.2 Bearing and lubrication

In operation, the rotor rotates at very high speeds, and the bearing that support it are specially designed to prevent the occurrence of harmful vibration. In particular, vibration is inhibited by the distinct internal shape journal bearing (70, 75) that support the weight of the rotor, as well as by the lubricant layer formed between the journal bearing periphery and the housing.

The pressure of the exhaust gas and air that act on the turbine blades and compressor impeller produce force on the rotor in the axial direction (thrust), which is applied to the thrust bearing (71, 73). Because this thrust acts on the compressor side during normal operation, the thrust bearing (73) on the compressor side is larger than that on the turbine side.

The lubricant is externally supplied to the turbocharger at a specified pressure and temperature. Engines are normally equipped with instrumentation for the monitoring of turbocharger lubricant pressure and temperature, as well as equipment for the protection of the turbocharger in the event of abnormalities. For detail, refer to the engine manual.

The lubricant head tank is integrated with the upper part of the turbocharger bearing pedestal (30). This allows lubrication to continue for about 10 minutes in the event that the lubricant supply is cut off for some reason and/or the engine stops.
2.1.3 Lubricant and exhaust gas seals

Oil labyrinth (35, 37) are used to seal the lubricant so as to prevent leakage from the turbocharger, while a gas labyrinth (24) is used to seal the exhaust gas within the turbine discs. Sealing air is also channeled from the scroll to prevent oil and gas leakage from inside the turbine discs.

In case of low load on the engine, the scroll can be subject to negative pressure due to the suction of air from the engine side. This creates negative pressure in the air channels for the sealing air mentioned above, and a vacuum breaker is therefore installed along the sealing air channel in order to prevent oil from being sucked out.
## 2.2 Specification

<table>
<thead>
<tr>
<th></th>
<th>Impeller size</th>
<th>2</th>
<th>—</th>
<th>3</th>
<th>16,010 min(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Max. allowable rotating speed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Continuous max. allowable temperature</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>580°C</td>
</tr>
<tr>
<td><strong>Short-time max. allowable temperature</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>610°C</td>
</tr>
<tr>
<td><strong>Lubricant lubrication method</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>External forced lubrication method</td>
</tr>
<tr>
<td><strong>Lubricant type</strong></td>
<td>Equivalent to SAE20 to 30</td>
<td></td>
<td></td>
<td></td>
<td>Equivalent to SAE40</td>
</tr>
<tr>
<td><strong>Turbocharger inlet lubricant pressure (standard)</strong></td>
<td>MPa</td>
<td>0.06 to 0.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Turbocharger inlet lubricant temperature (standard)</strong></td>
<td>°C</td>
<td>35 to 50</td>
<td></td>
<td></td>
<td>35 to 60</td>
</tr>
<tr>
<td><strong>Turbocharger outlet lubricant temperature (allowable value)</strong></td>
<td>°C</td>
<td>85</td>
<td></td>
<td></td>
<td>90</td>
</tr>
<tr>
<td><strong>Total weight (per unit)</strong></td>
<td></td>
<td>4,260 kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Combination of casings</strong></td>
<td>After approval with rubric on the outside dimensional drawing, return it to MHI.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Paint</strong></td>
<td>Heat-resistant silver</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# 3 Inspection Before and After Startup

Be sure to complete the following inspection and other listed steps before/after startup.

## 3.1 Before startup

<table>
<thead>
<tr>
<th>Inspection item</th>
<th>Inspection content</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Lubricant inlet oil pressure</td>
<td>Is oil pressure showing on the engine side gauge within the specified value?</td>
<td>Refer to Table 1</td>
</tr>
<tr>
<td>2 Lubricant inlet oil temperature</td>
<td>Is oil temperature showing on the engine side gauge within the specified value?</td>
<td>Refer to Table 1</td>
</tr>
<tr>
<td>3 Air filter</td>
<td>Is there any damage to air filter or obvious blockage?</td>
<td></td>
</tr>
<tr>
<td>4 Turbocharger underside</td>
<td>Is there any lubricant leakage?</td>
<td></td>
</tr>
<tr>
<td>5 Lubricant inlet and outlet piping</td>
<td>Is there any lubricant leakage?</td>
<td></td>
</tr>
<tr>
<td>6 Heat-resistant lagging</td>
<td>Is there any loss or other damage?</td>
<td></td>
</tr>
<tr>
<td>7 Lubricant filter</td>
<td>Is there any abnormal rise in differential pressure?</td>
<td></td>
</tr>
</tbody>
</table>

## 3.2 After startup

**WARNING**

Do not enter the danger zone during operation.

The silencer air inlet port sucks in large amounts of air and, in the event of sudden surging, there is a possibility of the reverse flow of high-pressure air from the silencer.

- If not observed, you may trip over and get injured.

<table>
<thead>
<tr>
<th>Inspection item</th>
<th>Inspection content</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Lubricant inlet oil pressure</td>
<td>Is oil pressure showing on the engine side gauge within the specified value?</td>
<td>Refer to Table 1</td>
</tr>
<tr>
<td>2 Lubricant inlet oil temperature</td>
<td>Is oil temperature showing on the engine side gauge within the specified value?</td>
<td>Refer to Table 1</td>
</tr>
<tr>
<td>3 Exhaust gas, air piping</td>
<td>Is there any exhaust gas or air leakage?</td>
<td></td>
</tr>
<tr>
<td>4 Turbocharger underside</td>
<td>Is there any lubricant leakage?</td>
<td></td>
</tr>
<tr>
<td>5 Turbocharger main unit</td>
<td>Is there any abnormal vibration or sound?</td>
<td></td>
</tr>
<tr>
<td>6 Exhaust gas temperature</td>
<td>Is there any difference as compared with the past measurement values?</td>
<td></td>
</tr>
<tr>
<td>7 Scavenging air pressure</td>
<td>Is there any difference as compared with the past measurement values?</td>
<td></td>
</tr>
<tr>
<td>8 Turbocharger speed</td>
<td>Is there any difference as compared with the past measurement values?</td>
<td></td>
</tr>
<tr>
<td>9 Bearing pedestal side surfaces</td>
<td>Is air blowing normally? Does blown air contain oil mist?</td>
<td></td>
</tr>
</tbody>
</table>
### Table 1  Utilization standards for lubricating oil

<table>
<thead>
<tr>
<th></th>
<th>Min.</th>
<th>Standard</th>
<th>Max. (Dead slow/stop)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lubricant inlet oil pressure (At turbocharger center height)</td>
<td>0.06 MPa</td>
<td>0.06 - 0.15</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>0.6 kg/cm²</td>
<td>0.6 - 1.5</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>0.6 bar</td>
<td>0.6 - 1.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Lubricant inlet oil temperature, °C</td>
<td>25</td>
<td>35 - 50</td>
<td>55</td>
</tr>
<tr>
<td>Lubricant outlet oil temperature, °C</td>
<td>-</td>
<td>-</td>
<td>85</td>
</tr>
<tr>
<td>Oil supply time following engine stop, min.</td>
<td>30</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* : If lubricating oil temperature is 25 deg. C or lower at engine stand-by or low loaded manoeuvring condition, maximum oil pressure can be 2.5 bar considering increased oil inlet pressure.

**NOTICE**

- Please be sure to use lubricant having properties that satisfy the conditions shown in the following table (Table 2).

### Table 2  Lubricant properties

<table>
<thead>
<tr>
<th></th>
<th>Spec. for new lubricants</th>
<th>Spec. for lubricants in-service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Engine oil</td>
<td>Turbine oil *</td>
</tr>
<tr>
<td>Viscosity grade</td>
<td>SAE#20, 30, 40</td>
<td>VG68, 100</td>
</tr>
<tr>
<td>Kinematic viscosity ν 40°C mm²/s</td>
<td>-</td>
<td>61.2 - 110</td>
</tr>
<tr>
<td></td>
<td>100°C mm²/s</td>
<td>5.6 - 16.3</td>
</tr>
<tr>
<td>Flash point COC method °C</td>
<td>&gt; 190</td>
<td>&gt; 190</td>
</tr>
<tr>
<td>Pour point °C</td>
<td>&lt; -10</td>
<td>&lt; -10</td>
</tr>
<tr>
<td>Water content Wt%</td>
<td>&lt; 0.01</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Total base number (TBN) mgKOH/g</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total acid number (TAN) mgKOH/g</td>
<td>-</td>
<td>&lt; 0.3</td>
</tr>
<tr>
<td>Pentane insoluble (B method) wt%</td>
<td>&lt; 0.01</td>
<td>-</td>
</tr>
<tr>
<td>RBOT life min.</td>
<td>-</td>
<td>&gt; 250</td>
</tr>
<tr>
<td>Sludge resistance</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* : Used in case of the independent lubrication system.

** : Initial Value
## 4 Maintenance / Inspection

### 4.1 Cautions for maintenance and inspection

<table>
<thead>
<tr>
<th>WARNING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Do not use fire while the turbocharger is cleaned using any flammable liquids such as kerosene.</strong></td>
</tr>
<tr>
<td>* It may cause fire due to flash ignition.</td>
</tr>
<tr>
<td><strong>Do not go under any equipment or part which is suspended.</strong></td>
</tr>
<tr>
<td>* The equipment or part may fall off due to failure of the lifting tool, causing accidents resulting in injury or death.</td>
</tr>
<tr>
<td><strong>If the oil labyrinth or housings are damaged or worn out exceeding the standard value of the gap, replace with a new one.</strong></td>
</tr>
<tr>
<td>* The damaged or worn out oil labyrinth or housing may cause not only oil leakage but also a problem that the oil drops are discharged to outside through the air extractor of the turbocharger.</td>
</tr>
<tr>
<td><strong>Operation of cranes and slinging must be performed by an authorized person.</strong></td>
</tr>
<tr>
<td>The owner is obliged to give their employee who handles suspending equipment (chain block) training on safety. (Observe the national rules and regulations.) Only the persons who are trained on safety and designated by the owner may handle the suspending equipment.</td>
</tr>
<tr>
<td>* If the suspended loads are unbalanced during transportation or fall off due to mis-slinging, it may cause accidents resulting in injury or death or damage of the turbocharger.</td>
</tr>
<tr>
<td><strong>Before using materials to suspend the machine or parts (wires, slings, tools, etc.), check the weight of the object to be suspended. Use a material of sufficient strength.</strong></td>
</tr>
<tr>
<td>* If load exceeding the allowable value of the suspending material is applied, such a material may be broken and then the suspended object may fall off, causing accidents resulting in injury or death. There also is a possibility that broken wires or slings may jump out and hit a person, causing accidents resulting in injury or death.</td>
</tr>
<tr>
<td><strong>Load to be applied to a suspending material will change depending on the angle of suspending. Consider it when selecting the size.</strong></td>
</tr>
<tr>
<td>Do not select the size of the suspending material unless you understand the meaning of the instruction above.</td>
</tr>
<tr>
<td>* If not observed, it may cause unexpected accidents.</td>
</tr>
<tr>
<td><strong>Dispose of any suspending materials a part of which is broken. Use a new one.</strong></td>
</tr>
<tr>
<td>Before using the suspending material, check if it is normal.</td>
</tr>
<tr>
<td>* If any abnormal material tool is used, it may break during suspending work, causing accidents resulting in injury or death.</td>
</tr>
<tr>
<td><strong>When suspending any equipment or part, place the hook in the center of the gravity of the suspended object.</strong></td>
</tr>
<tr>
<td>Adjust the position so that each wire is applied with the same load.</td>
</tr>
<tr>
<td>* If not observed, the object may be unbalanced when suspended or a certain wire is applied with large load and then broken, causing accidents resulting in injury or death.</td>
</tr>
</tbody>
</table>
### 4.2 Periodic Maintenance and Inspection Check List

In order to keep the turbocharger in a good condition and prevent troubles from occurring, perform periodic inspections and maintenance including cleaning with the following table as the target.

<table>
<thead>
<tr>
<th>Inspection item</th>
<th>Work</th>
<th>Frequency</th>
<th>Refer to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbocharger Operating State</td>
<td>Inspection</td>
<td>Twice a day or more</td>
<td>4.3</td>
</tr>
<tr>
<td>Turbine under operation</td>
<td>Washing</td>
<td>Every 100 hours after an initial operation (until 2000 hours elapses after the start of operation or cleaning of the turbine)</td>
<td>4.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The frequency should increase / decrease thereafter depending on the performance value.</td>
<td></td>
</tr>
<tr>
<td>Compressor under operation</td>
<td>Washing</td>
<td>Arrival in / leaving a port</td>
<td>4.13</td>
</tr>
<tr>
<td>Thrust bearing</td>
<td>Inspection / Replacement</td>
<td>When performing initial check of bearing and every time when overhaul inspection in 4.4 is performed</td>
<td>4.5.1</td>
</tr>
<tr>
<td>Thrust collar</td>
<td>Inspection / replacement</td>
<td>Every time when overhaul inspection in 4.4 is performed</td>
<td>4.5.1</td>
</tr>
<tr>
<td>Journal bearing</td>
<td>Inspection / replacement</td>
<td>Every time when overhaul inspection in 4.4 is performed</td>
<td>4.5.2</td>
</tr>
<tr>
<td>Rotor Shaft</td>
<td>Inspection / replacement</td>
<td>Every time when overhaul inspection in 4.4 is performed</td>
<td>4.6</td>
</tr>
<tr>
<td>Impeller dye-check</td>
<td>Inspection</td>
<td>Every time when overhaul inspection in 4.4 is performed</td>
<td>4.7</td>
</tr>
<tr>
<td>Compressor Impeller</td>
<td>Inspection / Washing</td>
<td>Every time when overhaul inspection in 4.4 is performed</td>
<td>4.7</td>
</tr>
<tr>
<td>Turbocharger internal cleaning</td>
<td>Cleaning</td>
<td>Every time when overhaul inspection in 4.4 is performed</td>
<td>4.4</td>
</tr>
<tr>
<td>Sealing air passage</td>
<td>Inspection</td>
<td>Every time when overhaul inspection in 4.4 is performed</td>
<td>4.8.1</td>
</tr>
<tr>
<td>Vacuum breaker</td>
<td>Inspection</td>
<td>Every time when overhaul inspection in 4.4 is performed</td>
<td>4.8.2</td>
</tr>
<tr>
<td>Head tank</td>
<td>Cleaning</td>
<td>Every time when overhaul inspection in 4.4 is performed</td>
<td>4.8.3</td>
</tr>
<tr>
<td>Turbine blade wear</td>
<td>Inspection / Replacement</td>
<td>In 25,000 hours after an initial operation Every time when turbine inspection in 4.4 is performed thereafter</td>
<td>4.9</td>
</tr>
<tr>
<td>Nozzle wear</td>
<td>Cleaning / Inspection / Replacement</td>
<td>In 25,000 hours after an initial operation Every time when turbine inspection in 4.4 is performed thereafter</td>
<td>4.10</td>
</tr>
<tr>
<td>Gas outlet guide wear</td>
<td>Inspection</td>
<td>In 25,000 hours after an initial operation Every time when turbine inspection in 4.4 is performed thereafter</td>
<td>4.4</td>
</tr>
<tr>
<td>Air Filter</td>
<td>Washing</td>
<td>Every 1,000 hours</td>
<td>4.11</td>
</tr>
</tbody>
</table>
4.3 Monitoring of the Turbocharger Operating State

⚠️ **WARNING**

Check the manometer installed to the silencer everyday for clogged status of the air filter.

Before the manometer indicating pressure exceeds 2.0 kPaG (200 mmAq), be sure to wash or replace the filter.

* If not observed, it will cause insufficient air to the engine, resulting in decrease of the engine output. The decreased output of the engine may cause surging.

Also, air resistance may be increased due to clogging of the element of the air filter, resulting in incomplete combustion due to the insufficient air, which may discharge some gas polluting environment.

Record temperature, pressure, and turbocharger speed, etc. related to the turbocharger at regular intervals in accordance with guidelines for such record-keeping established by the engine manufacturer or independently by the user. These records are important in ascertaining the normal operating state of the turbocharger.

In particular, changes in scavenge air pressure, turbocharger speed, and exhaust gas temperature are reflective of changes in turbocharger performance, and must be periodically measured and recorded.

The temperature of the air sucked into the turbocharger silencer will have a significant impact on the above-noted measurement values. For accurate evaluation of turbocharger performance, it is necessary to measure inlet temperature near the silencer, preferably at several points around the circumference.

The silencer is equipped with a manometer for measuring the pressure downstream from the air filter (refer to the right figure).
4.4 Turbocharger Overhaul Intervals

Turbochargers are subject to the following changes over time:
- Wear of the bearing
- Fouling of the rotor, nozzle, etc.
- Wear of the turbine blades, nozzle, gas labyrinth, oil labyrinth, and gas outlet guide.

For recommended turbocharger overhaul intervals, refer to the table below.

<table>
<thead>
<tr>
<th>MET</th>
<th>Initial check of bearing (Compressor side)</th>
<th>Turbine inspection, and manual cleaning</th>
<th>Overhaul</th>
</tr>
</thead>
<tbody>
<tr>
<td>90MA</td>
<td>Approx. 8,000 Hrs after ship's delivery</td>
<td>Every 15,000 - 20,000</td>
<td>Every 30,000 - 35,000</td>
</tr>
<tr>
<td>90SE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>83MA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>83SEII</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>83SE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>83SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>71MA</td>
<td>Approx. 8,000 Hrs after ship's delivery</td>
<td>Every 12,000 - 15,000</td>
<td>Every 25,000 - 30,000</td>
</tr>
<tr>
<td>71SEII</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>71SE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66MA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66SEII</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66SE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60MA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>53MA</td>
<td>Approx. 7,000 Hrs after ship's delivery</td>
<td>Every 10,000 – 13,000</td>
<td>Every 22,000 – 27,000</td>
</tr>
<tr>
<td>53SEII</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>53SE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>53SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42MA</td>
<td>Approx. 6,000 Hrs after ship's delivery</td>
<td>Every 10,000 - 13,000</td>
<td>Every 20,000 - 25,000</td>
</tr>
<tr>
<td>42SEII</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42SE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33MA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33SEII</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33SE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33SD</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTICE**
- Overhaul includes cleaning and inspection for turbine side and bearing inspection.
- Turbine inspection and cleaning can be performed by removal of gas inlet inner casing only (except MET42 and MET33)
- Initial thrust bearing inspection is recommended to ensure no damage by remained particles in the oil pipe during assembling work.
- Required time for bearing inspection and overhaul is valid for turbocharger with standard silencer. If the turbocharger has air intake housing, it may take longer.
Among these items, the progress of bearing wear is not apparent from factors such as engine performance, and there is no way to accurately check this other than inspection of the bearing. If bearing wear reaches the point of seizure, major damage will be caused to the turbocharger rotor and other components.

- Because bearing wear occurs mainly due to the inclusion of foreign object in the lubricant, the influence of the lubricant supply system on bearing lifetime is substantial. The least amount of wear can be expected with an independent lubrication system dedicated solely to the turbocharger, or with a system that is shared only by equipment external to the engine such as reduction gear etc. In addition, the use of a 30 micron continuous back-flushing type lubricant filter dedicated to the turbocharger is effective in prolonging the lifetime of the bearing.

- It is also envisioned that foreign object introduced during installation work on the turbocharger may not be fully removed by flushing. Accordingly, regardless of the lubricant supply system being used, the initial thrust bearing inspection should be performed according to the table in page 4-4. In the event that this inspection reveals wear or sliding damage with foreign matters to the thrust bearing, it will be necessary to inspect the journal bearing as well.

- If the lubricant properties are kept in good condition and bearing wear is not allowed to progress, the risk that the turbocharger cannot be operated suddenly is greatly reduced. Normally, bearing wear will progress very slowly if an independent lubrication system is used. Therefore, bearing inspections conducted during turbocharger overhauls will be sufficient.

- However, when the overhaul interval is substantially extended, turbocharger performance will tend to gradually decline due to fouling of the internals and wear-down of the turbine blades and nozzle. This will necessarily have a negative impact on engine performance. It is therefore important from the standpoint of maintaining turbocharger performance to perform regular inspection and cleaning of at least the turbine side. Mitsubishi MET model turbochargers are designed for easy inspection of the turbine side, simply by removing the gas inlet inner casing (refer to the figure below).
4.5 Inspection of Bearing

**NOTICE**

- For disassembly / assembly of the bearing, refer to “5 Disassembly” and “6 Re-assembly”.

Bearing wear proceeds as the bearing metal is abraded by foreign object in the lubricant. Hardly any bearing wear occurs when the lubricant layer is extremely thick compared to the size of the foreign particles, however wear proceeds quickly when the particle size is about the same as the lubricant film.

In cases where system oil from the engine is used as the lubricant for the turbocharger, a suitable lubricant filter is installed on the engine side to remove damaging particles. However, smaller particles cannot be completely removed, and these induce bearing wear. Accordingly, maintaining the engine lubricating oil in good condition is important from the standpoint of the turbocharger bearing. For more detailed information, refer to the engine manual.

4.5.1 Thrust bearing

Thrust bearing are of the tapered land type, consisting of a tapered part and a flat part. Oil is pulled into the wedge-shaped opening formed between the thrust collar and the tapered part of the bearing by means of the rotating action of the thrust collar, thus creating oil pressure that supports the thrust load. When the thrust bearing become worn, the ratio occupied by the flat part increases.

The limit of service life for thrust bearing is as follows:

- Length of tapered part: Length of flat part = 2:1 (for compressor side, refer to figure below.)
- = 1:1 (for turbine side, refer to figure below.)

However, even if the ratio has not yet reached 2:1 (compressor side) or 1:1 (turbine side), replace the bearing when it is anticipated that the ratio will reach 2:1 (compressor side) or 1:1 (turbine side) before the next inspection.

Regarding the inspection procedure for the ratio of the tapered part to the flat part, please refer to the next page.
**Inspection procedure for the tapered: flat part ratio**

1. Color the thrust collar or base plate lightly and evenly using a red-lead paint.

2. Lightly place the colored side against the metal surface of the thrust bearing.

3. Rotate the thrust collar or base plate in one direction so that the red-lead paint contacts the thrust bearing.

4. Remove the thrust collar or base plate, and check the transfer of the red ink in order to determine the need for replacement.

- If a long, deep scratch of 20 mm in length or greater are found on the thrust bearing metal surface, or if multiple deep scratches add up to a total length of 50 mm or more, replace the thrust bearing with new ones.
- Any visible exfoliation or cracking of the thrust bearing metal surface also indicates the need for replacement.
4.5.2 Journal bearing

1 After removing the rotor, insert it through the journal bearing.

2 Using a dial gauge, measure the clearance between the inner surface of the journal bearing and the rotor shaft with the upper side of the inner surface of the journal bearing put against the shaft on the sliding part of the journal bearing.

3 Compare the measured results with the clearance standard table shown in Section 9.1.
   - Do not fix the dial gauge to the rotor when measuring (as magnetic force will remain on the rotor shaft).
   - If the clearance is greater than the allowable value, it will be necessary to check whether the rotor shaft and/or the journal bearing have become worn. Refer to Section 4.6 in determining whether the rotor shaft has become worn.

4 If the rotor shaft is not worn and the clearance between the shaft and the journal bearing is greater than the standard value, replace the journal bearing with new ones.

Knock pin

A knock pin for locking is located on the journal bearing.

If the pin diameter has been worn by 20% or more, or if it is damaged, replace the journal bearing with new ones.
4.6 Inspection of Rotor Shaft

**NOTICE**
- For disassembling / assembling the rotor shaft, refer to “5. Disassembly” and “6 Re-assembly.”

The part of the rotor shaft that slides against the journal bearing is known as the journal part, and the shaft side is also subject to wear.

Close observation of the rotor shaft will reveal the sliding width relative to the journal bearing. Wear on the journal part of the shaft is determined by measuring the diameters of the journal bearing sliding parts and the areas outside (C and T).

If the outer diameter of the sliding part is at least 0.02 mm less than the diameter of the adjacent area outside, consult with MHI.

Note that the diameter of the center part of the shaft is slightly less than the journal part at the time of manufacture.
4.7 Inspection and Washing of Compressor Impeller

NOTICE

- For disassembling / assembling the impeller, refer to “5. Disassembly” and “6 Re-assembly.”

4.7.1 Inspection

- Check that there are no abnormalities such as peeling and cracking on the claw clutch on the back side. Perform dye-check on the back side of the compressor impeller, as well as all surfaces of the blades. If any defects are detected by the test, replace the impeller with a new one.

- Light contact with the labyrinth fins on the back side of the impeller is not a problem, and the impeller may continue to be used.

- Similarly, light contact between the impeller blade tips and the air guide casing (such that a metallic luster is exhibited) is not a problem, and the impeller may continue to be used. However, if contact results in burrs on the blade tips, consult with MHI.

- If the leading edges of the impeller blades are dented from collision with a foreign object, note the location and size, and consult with MHI.

4.7.2 Washing

The impeller is made of heat-resistant aluminum alloy. Use a soft object such as a sponge for washing, with surface dirt removed using kerosene or warm water. Do NOT use a wire brush or any similar hard object.

When using any cleaning agent commercially available, be sure to check that it will not have any negative effect on aluminum material.
4.8 Inspection and Washing of Pedestal

4.8.1 Sealing air channel

There is an inlet for sealing air located in the vicinity of the diffuser blades on the pedestal compressor side.

- Check that there is no evidence of lubricant leakage into the sealing air channel.
- Check that air flows through the air channel out to the turbine side when general service air is fed in.

4.8.2 Vacuum breaker

The vacuum breaker is attached to the side of the pedestal. Remove the bolt to pull out the vacuum breaker, and check that there is no abnormality with the valve disc and that the valve operates smoothly.

4.8.3 Head tank

MET turbochargers contain a head tank built into the pedestal. Refer to the following subsections for the procedure and cautionary points for cleaning the inside of the head tank.

1. Preparation for cleaning

1 Stop the oil pump.

2 After 20 minutes or more of the stop of the pump, check that the oil pump is stopped and the turbocharger inlet lubricant pressure is 0.

3 In order to ensure that foreign object does not enter inside the tank from the gas outlet duct, etc., wrap the duct using vinyl or other suitable material.
2. Cleaning procedure

1. Remove the head tank cover.
   - If the packing material becomes damaged when removing the cover, replace it with new material. Use sealant bond to affix the lid and the new packing.

2. Wipe off any remaining oil from the tank using a sponge or clean waste rags, etc.

3. If there is heavy fouling, use a spatula or similar object to remove it from the inner walls of the tank.
   - Do NOT use a wire or nylon brush to wipe off fouling. (This is because bristle ends can break off and introduce new fouling.)
   - When cleaning, take care that fouling does not enter L.O. channels [1] and [2] (refer to the next section).

4. Wipe off any remaining fouling using clean rags, etc.

3. Recovery

1. Blow compressed air to the L.O. channels to remove any dirt between the channels.

2. Clean the flange surface of the pedestal, making sure that foreign object does not enter between the packing and the pedestal flange surface.

3. Make sure again that there are no fouling left inside the tank, and replace the cover. (Do not use sealant bond between the pedestal side and the packing.)
4.9 Inspection and Cleaning of Turbine blades

**NOTICE**
- For disassembling / assembling the turbine blades, refer to “5. Disassembly” and “6 Re-assembly.”

### 4.9.1 Wear of turbine blade tips

Although turbine blade tip wear does not immediately lead to turbocharger damage, it does cause a gradual deterioration of turbocharger performance, thus raising the temperature of engine exhaust gas, and increasing the rate of fuel consumption. Consequently, if the turbine blades appear as illustrated in the figure below, replace the turbine blades at a suitable opportunity such as dry dock. Turbine blade replacement requires specialized technology and equipment; consult with a service company authorized by MHI.

#### Standards for replacement due to turbine wheel tip wear

<table>
<thead>
<tr>
<th>Model</th>
<th>B (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>33SD/SE/SEII/MA</td>
<td>10</td>
</tr>
<tr>
<td>42SD/SE/SEII/MA</td>
<td>12</td>
</tr>
<tr>
<td>53SD/SE/SEII/MA</td>
<td>16</td>
</tr>
<tr>
<td>60MA</td>
<td>18</td>
</tr>
<tr>
<td>66SD/SE/SEII/MA</td>
<td>20</td>
</tr>
<tr>
<td>71SE/SEII/MA</td>
<td>21</td>
</tr>
<tr>
<td>83SD/SE/SEII/MA</td>
<td>24</td>
</tr>
<tr>
<td>90SE/MA</td>
<td>27</td>
</tr>
</tbody>
</table>

04-321
4.9.2 Wear of turbine blade trailing edges

When the turbine blades are subjected to long-term use, there are cases in which the trailing edges become worn as well as the tip. If the trailing edges become thin, and unevenness is caused by corrosion of the surface, cracks may appear that can lead to turbine blade breakage. If the thickness of the turbine blade trailing edge reaches the values indicated in the figure below, replace the turbine blade.

Standards for replacement due to turbine wheel trailing edge wear

<table>
<thead>
<tr>
<th>Model</th>
<th>Measurement position (mm)</th>
<th>Allowable thickness (mm)</th>
<th>Measurement position (mm)</th>
<th>Allowable thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>12.5</td>
<td>0.4</td>
<td>14.4</td>
<td>0.6</td>
</tr>
<tr>
<td>42</td>
<td>25.0</td>
<td>0.3</td>
<td>28.8</td>
<td>0.3</td>
</tr>
<tr>
<td>53</td>
<td>15.5</td>
<td>0.5</td>
<td>17.8</td>
<td>0.7</td>
</tr>
<tr>
<td>60</td>
<td>31.0</td>
<td>0.4</td>
<td>35.6</td>
<td>0.4</td>
</tr>
<tr>
<td>66</td>
<td>19.6</td>
<td>0.6</td>
<td>22.6</td>
<td>0.8</td>
</tr>
<tr>
<td>60</td>
<td>39.3</td>
<td>0.4</td>
<td>45.2</td>
<td>0.4</td>
</tr>
<tr>
<td>66</td>
<td>39.3</td>
<td>0.4</td>
<td>50.3</td>
<td>0.5</td>
</tr>
<tr>
<td>71</td>
<td>24.5</td>
<td>0.7</td>
<td>28.1</td>
<td>0.9</td>
</tr>
<tr>
<td>71</td>
<td>49.0</td>
<td>0.5</td>
<td>56.2</td>
<td>0.5</td>
</tr>
<tr>
<td>83</td>
<td>31.0</td>
<td>1.0</td>
<td>35.6</td>
<td>1.1</td>
</tr>
<tr>
<td>83</td>
<td>62.0</td>
<td>0.6</td>
<td>71.2</td>
<td>0.6</td>
</tr>
<tr>
<td>90</td>
<td>-</td>
<td>-</td>
<td>39.3</td>
<td>1.2</td>
</tr>
<tr>
<td>90</td>
<td>-</td>
<td>-</td>
<td>78.6</td>
<td>0.7</td>
</tr>
</tbody>
</table>

4.9.3 Non-destructive testing of turbine blades

Because the turbine blades used in MET turbochargers are made of magnetic material, magnetic particle test can be conducted. Periodic magnetic particle test is recommended during turbine blade inspections. Particularly in cases where the trailing edges have become thin in 4.9.2 but the blades cannot be immediately replaced, magnetic particle examination must be carried out. Perform non-destructive testing by persons who are fully experienced in test procedures.
4.9.4 Turbine blade washing

Hard carbon deposits on turbine blades not only reduce performance, but are also a cause of surging as well as shaft vibration and bearing damage due to imbalance.

1. Soak the blade into a suitable container filled with warm water in order to remove the deposited scale.
   - The addition of a commercially available cleaning agent is effective, but it must be checked that the cleaning agent used will not corrode the rotor shaft or turbine blade materials. It is important to remove the scale in a uniform manner.
   - Even in cases where the carbon is hard and difficult to remove, do NOT use a chisel or similar tool.

2. Dry sufficiently after cleaning.

3. Coat with rust-preventing oil for anti-rust treatment during the recovery period.

4.9.5 Contact between the turbine blade tips and the gas outlet guide

The clearance between the turbine blade tips and the gas outlet guide is normally set to the minimum distance at which there is no contact, but sudden changes in engine load, surging, etc. can make the turbine blade tips touch the casing. As long as the trailing edges of the turbine tips are lightly and uniformly touching the gas outlet guide, this will have almost no effect on rotor shaft balance, and the turbocharger can continue to be used in this state.

4.9.6 Turbine blade abnormalities

If the following abnormalities are observed, discontinue the use and immediately consult with MHI.

- Excessive contact by the turbine blade tips
- Dents due to collision of the turbine blades with a foreign object
- Wave of the turbine blade trailing edges
- Turbine blade misalignment in the axial direction
4.10 Inspection and Washing of Nozzle

**NOTICE**
- For disassembling / assembling the nozzles, refer to “5. Disassembly” and “6 Re-assembly.”

4.10.1 Cleaning of the nozzle

1. Soak the nozzle into warm water to remove fouling.
   - Avoid striking with a chisel, hammer, etc. It will cause deformation of the nozzle blades, which is likely to induce surging and/or a reduction in performance.

2. Dry sufficiently after cleaning.

3. Coat with rust-preventing oil for anti-rust treatment during the recovery period.

4.10.2 Inspection of the nozzle

Inspect the nozzle with the nozzle placed horizontally and stably, in a well-lit location.

After washing, visually inspect the nozzle while observing the following:
- Uniform removal of fouling from the nozzle blades
- Formation by the nozzle blade trailing edges of a continuous line, with no bending, etc.
- Uniform evidence of contact between the nozzle outer ring and the gas outlet guide
- No cracks in the welded part

If abnormalities are discovered, consult with MHI.

If the nozzle is installed on the gas inlet (inside) casing, there may be clearance between the nozzle outer ring and the gas inlet casing. This is not a problem, however, as exhaust gas is sealed by the contact surface between the gas outlet guide and the nozzle outer ring.
4.11 Inspection and Washing of Air Filter

Cautions for washing the air filter (round silencer) are noted below.

4.11.1 Washing period

Conduct washing when the filter pressure loss exceeds 2.0kPaG (200mmAq), or at least once every two months.

4.11.2 Washing method

1. Dissolve detergent in lukewarm water, and soak the filter in for 2-3 hours.

2. Lightly wash using hands. (Refer to the figure below.)
   - Do not use a washing machine, etc., as this will damage the fibers.
   - Do not use a scrub brush, etc. and take care not to rub the filters each other strongly.

3. After washing, dry sufficiently in a shaded location with good airflow before reusing.
   - Dust collection effectiveness may reduce if the filter is used before it has been dried fully.

4.11.3 Point for special caution

Exercise sufficient and constant caution so that the fibers do not stand up on end.
4.12 Turbine Cleaning Procedure during Operation

MET turbochargers can be equipped with a solid-particle cleaning device on the turbine side. The introduction of this cleaning with plant solid particles is recommended as a suitable means of turbine cleaning for non-cooled MET turbochargers designed in response to these circumstances.

4.12.1 Overview of solid-particle cleaning method on turbine side

In the solid-particle cleaning method, solid particles are introduced upstream of the turbine, and are accelerated by means of exhaust gas. The impact force serves to remove deposits from the turbine nozzle, turbine blades, etc.

There is no need to reduce the engine load to the low speed during cleaning, and the engine can be cleaned in a short time with a normal load applied. In addition, there is no thermal shock to the casings of the exhaust gas channels.

As turbine side cleaning is for the purpose of preventing the build-up of turbine fouling, it should be performed periodically.

4.12.2 Plant solid-particle cleaning device

- Overview of device

The figure on the right presents an overview of the plant solid cleaning device.
Cleaning medium

(a) Types of cleaning medium:

<table>
<thead>
<tr>
<th>Cleaning medium</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walnut shell</td>
<td>2.0 - 2.8 mm (marine grit #8)</td>
</tr>
<tr>
<td>NOTICE</td>
<td></td>
</tr>
<tr>
<td>• Milled walnut shell can be sourced from Hikawa Marine Co., Ltd.</td>
<td></td>
</tr>
<tr>
<td>Grain (rice, wheat, etc.)</td>
<td>Within 3.0 mm</td>
</tr>
</tbody>
</table>

(b) Amount of cleaning medium to be used

Table below shows the initial recommended amount for the first cleaning, according to the turbocharger model. As an excessive amount can result in surging, the appropriate value should be determined in conjunction with the engine status/condition. In doing so, refer to Section 4.12.3, 3.

<table>
<thead>
<tr>
<th>Plant solid cleaning device capacities</th>
</tr>
</thead>
<tbody>
<tr>
<td>33SD 33SE 33SEII 33MA</td>
</tr>
<tr>
<td>42SD 42SE 42SEII 42MA</td>
</tr>
<tr>
<td>53SD 53SE 53SEII 53MA</td>
</tr>
<tr>
<td>60MA</td>
</tr>
<tr>
<td>66SD 66SE 66SEII 66MA</td>
</tr>
<tr>
<td>71SE 71SEII 71MA</td>
</tr>
<tr>
<td>83SD 83SE 83SEII 83MA</td>
</tr>
<tr>
<td>90SE 90MA</td>
</tr>
<tr>
<td>Amount of solid cleaning medium</td>
</tr>
<tr>
<td>(liters/implementation)</td>
</tr>
<tr>
<td>0.4 0.7 1.6 2.1 2.6 3.0 3.5 3.5</td>
</tr>
</tbody>
</table>

4.12.3 Cleaning procedure

1. Cleaning interval

Initially, clean at least once every 100 hours (2 to 3 times a week) (for approx. 2,000 hours after initially used or cleaned after disassembly). Subsequently, the interval should be adjusted up or down in accordance with performance values such as exhaust temperature, scavenge air pressure, and turbocharger rpm (When the temperature of the exhaust gas reaches over 20°C, perform once every 24 hours).

2. Turbocharger rpm during cleaning

The following table indicates limits for turbocharger speed and turbine inlet temperature value during cleaning.

If actual values are higher at normal load, then the load should be reduced.

<table>
<thead>
<tr>
<th>Allowable maximum speed and turbine inlet temperature during cleaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
</tr>
<tr>
<td>Turbocharger maximum speed (min⁻¹)</td>
</tr>
<tr>
<td>Turbine inlet temperature</td>
</tr>
</tbody>
</table>
3. Cleaning procedure

1. Open the valve [3] and then valve [1], and supply air for 1 to 2 minutes to cool down the device.

2. Close the valve [1] and then [3].

3. Open the cap of the tank [2], and put a specified amount of plant solid particle as cleaning medium.

4. Be sure to close the cap on tank [2].

5. Open the valve [1] and then valve [3] to supply air before pouring the cleaning medium into.

6. Close the valve [3] and then valve [1].

4. Repeat cleaning

- If the engine performance changes suddenly when the cleaning medium is put into, for example if severe surging occurs, try cleaning using about half of the recommended amount of cleaning medium in Table of the previous page. After checking that there is no sudden engine performance change, repeat the cleaning process.
- After completion of cleaning, and assuming no improvement in performance values in exhaust temperature, scavenge air pressure and turbocharger speed, repeat the procedure described above. If no change is observed after several repetitions, it will be necessary to perform overhaul and conventional cleaning.
### 4.13 Compressor Washing Procedure during Operation

MET turbochargers can be equipped with a compressor side water washing device. The compressor side water washing should always be performed within the designated turbocharger speed range. This speed is lower than for normal operation, and it is necessary during washing to reduce engine load.

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease the speed of the turbocharger when performing the compressor side water washing.</td>
</tr>
<tr>
<td>It is desirable to do this when arriving in or leaving port.</td>
</tr>
<tr>
<td>* Compressor side water washing conducted at high speeds will result in excessive stress on the compressor impeller blades, and can cause serious damage to the blades.</td>
</tr>
</tbody>
</table>
4.13.1 Compressor water washing procedure

If, due to various engine conditions, it proves difficult as a result of severe compressor side fouling to maintain performance until the next scheduled overhaul, follow the procedure below for compressor side water washing.

- Observe the procedure shown in the table below for compressor side water washing.
- Water supply method must be a natural water supply method (refer to the figure below.)
- Check by running water through them if there is not any foreign object or object inside the tank and hose.
- Supply water to the tank a little at a time using a small container. Do not supply directly from a spigot or large container.

<table>
<thead>
<tr>
<th>MET model</th>
<th>90SE 90MA</th>
<th>83SD 83SEII 83MA</th>
<th>71SE 71SEII 71MA</th>
<th>66SD 66SEII 66MA</th>
<th>60MA</th>
<th>53SD 53SEII 53MA</th>
<th>42SD 42SEII 42MA</th>
<th>33SD 33SEII 33MA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbocharger speed (min⁻¹)</td>
<td>4500 - 6000</td>
<td>4500 - 6000</td>
<td>5000 - 7000</td>
<td>5500 - 7500</td>
<td>6300 - 8500</td>
<td>7000 - 9500</td>
<td>8500 - 12000</td>
<td>11000 - 15000</td>
</tr>
<tr>
<td>Amount of feed water (liters) (sec.)</td>
<td>3.0</td>
<td>3.0</td>
<td>2.75</td>
<td>2.5</td>
<td>2.25</td>
<td>2.0</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>60 - 120</td>
<td>60 - 120</td>
<td>55 - 110</td>
<td>50 - 100</td>
<td>45 - 90</td>
<td>40 - 80</td>
<td>30 - 60</td>
<td>20 - 40</td>
</tr>
</tbody>
</table>

**CAUTION**

Be sure to keep the turbocharger speed within the designated range during cleaning. Do NOT perform cleaning at normal turbocharger speed.

- It may cause damage to the compressor impeller.
5 Disassembly

5.1 Cautions for disassembly

⚠️ WARNING

Do not disassemble or assemble the turbocharger when you are under influence of drinking, short of sleep or in poor physical condition.

* It may cause unexpected accidents.

Do not go under any equipment or part which is suspended.

* The equipment or part may fall off due to failure of the lifting tool, causing accidents resulting in injury or death.

Operation of cranes and slinging must be performed by an authorized person. The owner is obliged to give their employee who handles suspending equipment (chain block) training on safety. (Observe the national rules and regulations.) Only the persons who are trained on safety and specified by the owner may handle the suspending equipment.

* If the suspended loads are unbalanced during transportation or fall off due to mis-slinging, it may cause accidents resulting in injury or death.

Before using materials to suspend the machine or parts (wires, slings, tools, etc.), check the weight of the object to be suspended. Use a material of sufficient strength.

* If load exceeding the allowable value of the suspending material is applied, such a material may be broken and then the suspended object may fall off, causing accidents resulting in injury or death. There also is a possibility that broken wires or slings may jump out and hit a person, causing accidents resulting in injury or death.

Load to be applied to a suspending material will change depending on the angle of suspending. Consider it when selecting the size.

Do not select the size of the suspending material unless you understand the meaning of the instruction above.

* If not observed, it may cause unexpected accidents.

Dispose of any suspending materials a part of which is broken. Use a new one.

Before using the suspending material, check if it is normal.

* If any abnormal material tool is used, it may break during suspending work, causing accidents resulting in injury or death.

When suspending any equipment or part, place the hook in the center of the gravity of the suspended object. Adjust the position so that each wire is applied with the same load.

* If not observed, the object may be unbalanced when suspended or a certain wire is applied with large load and then broken, causing accidents resulting in injury or death.

To prevent accidents in disassembling and assembling, inspect required tools and exclusive tools beforehand.

* If neglected, unexpected accidents may occur.

Take care not to step off or not to drop any object during the work.

If the scroll of the compressor in the turbocharger is removed, the intake of the duct for discharge air of the compressor will be turned downward.

* There is a possibility of injury.
### CAUTION

<table>
<thead>
<tr>
<th>![Warning Symbol]</th>
<th>Wait until the turbocharger is cooled enough after it is stopped before disassembling.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• There is a possibility of heat injury.</td>
</tr>
</tbody>
</table>

### NOTICE

- The chain block should be suspended from a strong beam, etc. capable of supporting a load of at least the weight of 2 ton. Wire ropes must also be capable of withstanding the weight of 2 ton.

### 5.2 When the turbocharger rotor is rotating in stop of the engine

### WARNING

<table>
<thead>
<tr>
<th>![Warning Symbol]</th>
<th>After disassembling the silencer of the turbocharger and casing at inlet of the gas, if the rotor of the turbocharger is rotating, take the following measures.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Never touch the impeller or turbine blade while it is rotating.</td>
</tr>
<tr>
<td></td>
<td>• Do not try to stop the rotation of the rotor by applying a piece of wood or waste cloth.</td>
</tr>
<tr>
<td></td>
<td>Even when the engine is stopped, upward flow may be generated inside the duct due to afterheat of the exhaust duct or exhaust gas economizer, which makes the rotor of the turbocharger rotating. Such low rotational speed may not be detected by the gap sensor. Thus, even if the gap sensor reads “0”, the rotor may not be stopped.</td>
</tr>
<tr>
<td></td>
<td>• If not observed, you may get entangled in, or some foreign substances may hit the rotor.</td>
</tr>
</tbody>
</table>

1. Remove the gas inlet casing.

2. **Blow the edge of the turbine blade with compressed air in counterclockwise direction to stop the rotor.**
   - If the rotation of the rotor does not stop, remove the bolt of the flange at the gas outlet, and either insert a cover board or remove the inspection manhole if it is provided to the duct of the downstream of the gas outlet flange.

3. When the rotor stops rotating, put some soft object such as a waste cloth, etc. to the edge of the turbine blade so as not to rotate again.
5.3 Removing the silencer

| Weight | Approx. 400 kg |

1. Remove the gap sensor cable from the junction box.

2. Disconnect the cable installed to the engine side.
   - Fix the disconnected cable with tape or other means to prevent it from getting in the way during the work.

3. Suspend the silencer 50 with a wire rope, and then remove the nuts 502 and washers 501.

4. Remove the silencer 50 from outer scroll 40 in accordance with the figure on the right.
   - Take care not to allow the silencer to interfere with the conduit tube of the gap sensor cable.

**NOTICE**
- Fix the removed silencer in a safe location, using rope or other means to prevent it from falling over or rolling.
5.4 Removing the air guide casing

| Weight | Approx. 180 kg |

1. Measure the clearance (A) (refer to 9.1) between the air guide casing 47 and the impeller with a feeler gauge at 4 points, top, bottom, left and right.
   - The value will be useful as references during re-assembly.

2. Install the shackle T-39 to the arm of slinging device T-76.

3. Install the slinging device T-76 to the flange on the air guide casing 47 using bolts T-16.

4. Remove the bolt 473 and spring washer 474.

5. Lift slowly using a wire rope suspended from a chain block.

6. While slowly screwing the lifting screw T-22 into the threaded hole in the flange of the air guide casing 47, pull off the air guide casing 47.

**NOTICE**
- Take extreme care so that the air guide casing 47 does not come into contact with the impeller blades.
5.5 Removing the scroll

Weight | Approx. 390 kg
---|---

1. Remove the hex. bolt 444 using a hex. headed spanner T-29.

2. Install the slinging device T-76 to the flange on the scroll 44 using bolt T-15.

3. Screw the two lifting screws T-22 into the threaded holes on the left and right of the flange at the same time.
   - Be sure that the screw depth of the bolts on the left and right is the same.
   
   **NOTICE**
   - Do NOT use a compressed air driven wrench or other power tool to screw in the lifting screws.

4. Install the shackle T-39 to the arm of slinging device T-76.

5. Lift slowly using a wire rope suspended from a chain block.

6. Screw in the lifting screws T-22 further, and pull out the scroll 44.
   - Fix the scroll 44 in a suitable location using a rope, etc. so that it does not roll. The diffuser 45 is installed to the scroll 44. When moving and/or temporarily storing the scroll 44, take care so as not to damage diffuser 45.
   
   **NOTICE**
   - Upon removal of the scroll 44, the air outlet leading to the engine side will be uncovered. Be sure not to drop any objects or to step inside this opening. If an object is dropped inside, refer to the engine manual in order to open the appropriate section of the engine for retrieval.

7. Remove the O-ring 449.

   **NOTICE**
   - O-ring 449 is a consumable. Replace with a new one in reassembly.
5.6 Removing the gas inlet inner casing

When performing inspection and cleaning only with respect to the turbine blades and nozzle, or disassembling the turbocharger completely (overhauling), please be sure to follow the instructions below.

| Weight | Approx. 330 kg |

1. **Remove the heat-resistant lagging from the mounting flange on the gas inlet inner casing 26.**

2. **Be sure to remove all of the nuts 267 from the flange for mounting the gas inlet inner casing 26.**

3. **Screw the two lifting screws T-22 into the threaded holes on the left and right of the flange.**
   - Be sure that the screw depth of the bolts on the left and right is the same (refer to the figure on the right).

**NOTICE**
- Do NOT use a compressed air driven wrench or other power tool to screw in the lifting screws.

4. When the gas inlet inner casing 26 protrudes about 10 mm, install the slinging device T-85 to the flange on the gas inlet inner casing 26 using bolts T-15.

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
</table>
| Do not use any bolts longer than T-15.  
- The flange may break. |

5. **Install the shackle T-39 to the arm of slinging device T-85.**

6. **Lift slowly using a wire rope suspended from a chain block.**

7. **Screw in the lifting screws T-22 further, and pull out the gas inlet inner casing 26.**

**NOTICE**
- Nozzle 22 is installed to the casing.
- Fix the casing in a suitable location so that it does not roll.  
  If removing the nozzle, place it with the flange side down.
8 Measure the clearance (L) (refer to 9.1) between the gas outlet guide casing 23 and the tips of the turbine blades 61 with a feeler gauge at 4 points, upper, lower, left and right.
   • The value will be useful as references during re-assembly.

9 Also measure thrust clearance (H). Please refer to 6.11 for measurement procedures.

10 Install the stay T-67 to the gas inlet outer casing 27 as shown in the figure on the right, using the nut 267, roller support table T-47, nut T-1 and bolts T-14.

11 Remove any dirt or foreign object from the threaded hole in the end of rotor shaft using compressed air, etc.

12 Screw the rotor pulling out tube assemblies T-65, T-66 into the end of the rotor shaft.

13 Insert the lifting screws T-22 into the rotor pulling out tube T-65, T-66, and fix with nut 267.
   • This serves to prevent the rotor shaft from slipping in turbine-side direction when loosening the impeller.

14 Screw in the lifting screw T-24 to lift up the roller support table T-47 to raise the rotor shaft a little from the journal bearing.
5.7 Removing the impeller

| Weight | Approx. 140 kg |

1 Remove the impeller end cap 69 and the fastening bolt 691 and tongued washer 692, as illustrated in the figure on the right.

2 Measure the distance S from the edge of the locking nut 67 to end of the shaft with a depth gauge, etc.
   • The value will be useful as references during re-assembly.

3 Put a dial gauge to the rotor shaft end.

4 Manually rotate the rotor clockwise and measure the deflection of the shaft edge with the dial gauge.
   • The value will be useful as references during re-assembly.
After checking the shaft deflection, apply the dial gauge in the axial direction.

Measure the axial movement of the rotor when pushed by hand (the thrust clearance).
- The value will be useful as references during re-assembly.

Screw the guide bar for hydraulic jack T-48 into the threaded hole in the shaft end.

Screw the hydraulic jack T-60 into the shaft end.
- Also, be sure to check that the ram of the hydraulic jack T-60 has been retracted (refer to the figure on the right).
- In order to prevent the hydraulic jack T-60 from falling and damaging the impeller, support the weight of the jack with your hands until it is fully screwed in.

After it has been screwed in, be sure to give the hydraulic jack T-60 one reverse turn.

Place the hydraulic pump T-61 on a flat surface.

Connect the hose T-62 to the hydraulic jack T-60.

Close the handle of the escape valve of the hydraulic pump T-61 by turning clockwise.

**NOTICE**
- Hydraulic pump T-61 is sometimes in common use with main engine. In this case, please use the one for main engine.
13 Move the handle of hydraulic pump T-61 up and down by hand until the hydraulic pressure reaches the specified value.

- The hydraulic pressure can be checked using the pressure gauge installed to the pump.

For the impeller tightening pressure, please refer to the table below.

### Impeller tightening pressure

<table>
<thead>
<tr>
<th>Model</th>
<th>Impeller tightening pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>MET33MA</td>
<td>—</td>
</tr>
</tbody>
</table>
| MET42MA | 44.6 [MPa]
|        | 455 [kg/cm²]               |
| MET53MA | 50.0 [MPa]
|        | 510 [kg/cm²]               |
| MET60MA | 61.2 [MPa]
|        | 625 [kg/cm²]               |
| MET66MA | 51.0 [MPa]
|        | 520 [kg/cm²]               |
| MET71MA | 57.8 [MPa]
|        | 590 [kg/cm²]               |
| MET83MA | 62.9 [MPa]
|        | 640 [kg/cm²]               |
| MET90MA | 68.6 [MPa]
|        | 700 [kg/cm²]               |

14 Insert the rod T-32 through the slot of the hydraulic jack T-60 into the hole in the periphery of the shaft nut, and loosen the nut by turning counterclockwise several revolutions.

**NOTICE**
- There are cases in which the nut may not loosen even when the hydraulic pressure of the jack reaches the specified level. In such cases, first lower the pump pressure, and then raise it again to 120% of the specified level and again attempt to loosen the nut. Also, in the event that the engine has just been stopped and the impeller temperature is still high, it will not be possible to loosen the nut at the specified pressure due to the effect of impeller heat expansion. In this case, cool the impeller by evenly applying compressed air.

15 Open the escape valve on the hydraulic pump T-61 by turning the handle counterclockwise to lower the pressure.

16 Retract the ram of the hydraulic jack T-60 by hand.

17 Carefully remove the hydraulic jack T-60 from the shaft.

18 Remove the impeller shaft nut 67 by hand.

19 Remove the washer 68 using the threaded bar T-21.
20 Screw the protection bolt T-13 into the end of the rotor shaft.

21 Use tape to thinly cover the threaded part of the rotor shaft end for protection.

22 Install the impeller draw-out tube T-46 to the boss of the impeller 66 using bolt T-13.

23 Install the handle T-23.

24 While holding the impeller 66 with one hand, slowly turn the handle T-23 with the other hand, and pull out the impeller 66.
   - When the impeller 66 has been pulled out to a certain extent using the handle, it can then be pulled out the rest of the way with your hands.

25 Remove the handle T-23.

26 Use the handle T-23 to screw slinging device T-76 into draw-out tube T-46.

27 Install shackle T-39 to the arm of slinging device T-76.

28 Lift slowly using a wire rope suspended from a chain block.

29 With the chain block supporting the weight, carefully remove the impeller.
   - Store it horizontally in a safe location.

30 Remove the protection bolt T-13 for the rotor shaft end.
5.8 Removing the support and thrust collar

The claw clutch of sleeve 64 will be visible upon removal of the impeller.

1. Screw threaded bar T-21 into the threaded hole in the claw clutch, and pull out sleeve 64.

2. Remove the bolt 363 and the spring washer 364 mounting the support 361.

3. Install guide bar T-52.

4. Screw the lifting screws T-22 into threaded holes in the flange on the support 361, and pull out the support 361.

**NOTICE**
- Compressor side oil labyrinth 37 and compressor side thrust bearing 73 are installed to the support 361. When storing the support 361, place the thrust bearing side up, and take extreme care so as not to damage the metal surfaces of the thrust bearing during storage.

5. Remove the thrust collar 63.
- As the clearance between the thrust collar 63 and the shaft is narrow, remove the thrust collar 63 slowly and carefully.
5.9 Removing the rotor shaft

Check that there are no damages, burrs, or dirt on the support T-87 and rotor guide protection tube T-63. If there are any burrs or damage, repair is required.

| Weight | Approx. 170 kg |

1. Screw in the rotor guide protection tube T-63 to compressor side of the rotor shaft.

2. Install the support T-87 with the hex. bolt T-16 to compressor side of the bearing pedestal.

3. Screw the pulling out tube assemblies T-65, T-66 into rotor shaft from the turbine side.

4. Screw the lifting bolt T-24 to lift the roller support table T-47 to raise the rotor shaft slightly from the journal bearing.

5. Pull by hand, and pull out the rotor shaft to the position of the stay T-67.
6 Place wire rope around the root part of the disc side of the rotor shaft.

⚠️ CAUTION

Do not place it around the journal part of the shaft.
  • In case of a metal wire rope, it may damage the journal.

7 Suspend the wire rope using a chain block, hoist, etc.

8 Remove the stay T-67.

9 Pull out the rotor completely.

10 While stabilizing it using your hands, move it to a safe location for storage.
  • While storing the rotor shaft, remove pulling out tubes T-65, T-66, and set it on wooden blocks, etc so as to avoid contact between the turbine blades and the floor.

NOTICE

• When tilting the rotor shaft, install a nut to the end of the rotor shaft and tilt it using a nylon sling, rope, etc. so that it does not slip.

⚠️ CAUTION

Do not use wire.
  • Wires may damage the shaft.

Do not use an eyebolt on the end of the shaft.
  • With an eyebolt, the rotor shaft may rotate when the shaft is lifted and the bolt becomes loose, which allows it to come off.

11 Remove the rotor guide tube T-63.

12 Remove the support T-87.
5.10 Removing the bearing and labyrinth

5.10.1 Turbine side oil labyrinth 35 and turbine side journal bearing 75

1 Remove the mounting bolts 352 and spring washer 351.

2 Using the lifting screw T-24, remove the turbine side oil labyrinth 35 while lifting.

3 The turbine side journal bearing 75 can be removed using threaded bar T-21.
5.10.2 Turbine side thrust bearing 71 and compressor side journal bearing 70

1 Use hex. headed spanner to remove the hex. socket-headed bolt 713 and spring washer 714.

2 Remove the turbine side thrust bearing 71 by hand.

3 The compressor side journal bearing 70 can be removed using threaded bar T-21.

5.10.3 Compressor side thrust bearing 73 and compressor side oil labyrinth 37

Compressor side thrust bearing 73 and compressor side oil labyrinth 37 are installed to the support 361.

1 Use hex. headed spanner to remove hex. bolt 733 and spring washer 734.

2 Screw the same bolt 733 into the threaded hole in the compressor side thrust bearing 73. Lift off the bearing.

3 Remove the compressor side thrust bearing 73.

4 Remove the O-ring 362.

5 Turn over the support 361 and remove the bolts 372 and the spring washer 371.

6 Lift up the compressor side oil labyrinth 37 and take out using the lifting up bolt T-24.

7 Remove the O-ring 373.
5.11 Removing the nozzle

1 Remove nozzle mounting bolts 225 and W-tongued washer 226.
   • If the bolt 225 proves difficult to loosen, spray with commercially available penetrant, or gently heat the inner ring of the nozzle.

2 Screw the bolt 225 into the threaded hole for lifting located in the inner ring of the nozzle 22.
   • The nozzle bolts are made of stainless steel. Be sure to store them so that they can be distinguished from other similar items.

5.12 Removing the gas outlet guide

It is not normally necessary to remove gas outlet guide 23 for cleaning. However, in case of replacement due to wear, etc., remove the mounting bolts 234 and pull it out.
5.13 Removing the gas labyrinth

It is not normally necessary to remove gas labyrinth 24, however, in case removal is required, remove it in accordance with the following procedure.

1. Remove the mounting bolt 241 and spring washer 242.

2. Install the guide bar T-131.

3. Screw the bolt into the threaded hole to lift off and remove the gas labyrinth 24.

4. Remove the gas seal ring 251.
6 Re-assembly

Refer to Section 4 for parts inspection procedures following disassembly.

The order of re-assembly is essentially the reverse of that for disassembly, however, there are points deserving of caution. Mistakes in re-assembly, use of components other than genuine MHI parts, and use of worn parts can cause not only loss of turbocharger performance, but also accidents leading to human injury.

As parts inspection procedures are listed in Section 4, use this section as a reference in determining whether parts can be reused or not.

Before starting re-assembly work, be sure to read this section carefully and understand its content. In case any point(s) is/are unclear, suspend work and contact MHI or an authorized service company for confirmation.

6.1 Cautions for re-assembly

![WARNING]

Do not disassemble or assemble the turbocharger when you are under influence of drinking, short of sleep or in poor physical condition.
  * It may cause unexpected accidents.

Do not go under any equipment or part which is suspended.
  * The equipment or part may fall off due to failure of the lifting tool, causing accidents resulting in injury or death.

Operation of cranes and slinging must be performed by an authorized person.
The owner is obliged to give their employee who handles suspending equipment (chain block) training on safety. (Observe the national rules and regulations.) Only the persons who are trained on safety and designated by the owner may handle the suspending equipment.
  * If the suspended loads are unbalanced during transportation or fall off due to mis-slinging, it may cause accidents resulting in injury or death of the turbocharger.

Before using materials to suspend the machine or parts (wires, slings, tools, etc.), check the weight of the object to be suspended. Use a material of sufficient strength.
  * If load exceeding the allowable value of the suspending material is applied, such a material may be broken and then the suspended object may fall off, causing accidents resulting in injury or death. There also is a possibility that broken wires or slings may jump out and hit a person, causing accidents resulting in injury or death.

Load to be applied to a suspending material will change depending on the angle of suspending. Consider it when selecting the size.

Do not select the size of the suspending material unless you understand the meaning of the instruction above.
  * If not observed, it may cause unexpected accidents.
### WARNING

Dispose of any suspending materials a part of which is broken. Use a new one.

Before using the suspending material, check if it is normal.

- If any abnormal material tool is used, it may break during suspending work, causing accidents resulting in injury or death.

When suspending any equipment or part, place the hook in the center of the gravity of the suspended object.

Adjust the position so that each wire is applied with the same load.

- If not observed, the object may be unbalanced when suspended or a certain wire is applied with large load and then broken, causing accidents resulting in injury or death.

To prevent accidents in disassembling and assembling, inspect required tools and exclusive tools beforehand.

- If neglected, unexpected accidents may occur.

Take care not to step off or not to drop any object during the work.

If the scroll of the compressor in the turbocharger is removed, the intake of the duct for discharge air of the compressor will be turned downward.

- There is a possibility of injury.

---

### 6.2 Replacement of consumables

Replace all tongued washers, O-rings, packing, tongued (both-end) washer, and stainless steel wires with new ones. Do NOT reuse these parts.

---

### 6.3 Tightening the nozzle mounting bolt

Because nozzle mounting bolt 225 is easily subject to seizure, coat it with anti-seizure agent, and take care not to over-tighten it.
6.4 Seizing prevention and application of lubricant agent

**CAUTION**

To prevent seizing, do not use any paste type agent containing solid lubricants such as copper.

- Such agents will go into the lubricant of the turbocharger, which may result in clogging of the lubricant filter.

The following figure shows the locations to be applied with anti-seizure agent and lubricant agent. The items specified in the following table are suitable as an anti-seizure agent.

<table>
<thead>
<tr>
<th>Anti-seizure agent</th>
<th>Coating location</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOLYKOTE 1102 GASCOCK GREASE</td>
<td>E, G, H</td>
</tr>
<tr>
<td>MOLYKOTE 1000 PASTE</td>
<td>A, B, C, D, F</td>
</tr>
</tbody>
</table>

Use unused lubricant agent for the turbocharger or unused regular industrial lubricant.
6.5 Bearing re-assembly

**WARNING**

Prior to inserting any of the bearing in the turbocharger, use compressed air, etc. after cleaning to completely remove all dirt and dust from the metal surfaces and lubricant grooves.

* If the dirt and other foreign object are not all removed, the bearing may be damaged.

Before inserting any of the bearing, be sure to lightly coat them with lubricant.

* If the bearing is not applied with lubricant, it may be damaged during re-assembly.

When inserting bearing, use clean bare hands; do not use gloves, etc.

* Dirt and dust will adhere to the bearing, which may damage the bearing.

1. Install compressor side journal bearing 70 to the bearing pedestal, using threaded bar T-21.

2. Install turbine side thrust bearing 71.

3. Use a hex. headed spanner to install hex. socket-headed bolt 713 and spring washer 714.

4. Install turbine side journal bearing 75 to the journal pedestal, using threaded bar T-21.

5. Install turbine side oil labyrinth 35.

6. Install the mounting bolt 352 and spring washer 351.
6.6 Inserting the rotor

1 Install the support T-87 to the compressor side of the pedestal with the hex. bolt T-16.

2 Install the rotor guide protection tube T-63 to the compressor side of the rotor shaft.

3 Install pulling out tubes T-65 and T-66 to the turbine side of the rotor shaft.

4 Completely remove all dirt and dust from the rotor shaft protection tube and rotor shaft surface.

**CAUTION**

Check that the rotor protection tube is free from damages or all dirt and dust.

- Any damage can cause damage to the journal bearing, rendering them unusable.

5 Sufficiently apply lubricant over the periphery surface of the rotor shaft protection tube and the rotor shaft which pass the bearing.
6 Place wire rope around the root part of the disc side of the rotor shaft.

**CAUTION**

Do not place it around the journal part of the shaft.

* In case of a metal wire rope, it may damage the journal.

7 Suspend the wire rope using a chain block, hoist, etc.

8 Insert the rotor shaft into the pedestal.

- Take extreme care so as to avoid damage to the turbine side oil labyrinth fins when inserting the rotor.

9 When insert it halfway, install stay T-67 and roller support table T-47 in the same manner as disassembly (refer to page 5-7), and then insert completely.
6.7 Inserting the support

1 After inserting the rotor shaft into the pedestal, remove the hex. bolts T-16 and the support T-87.

2 Remove the rotor guide tube T-63.

3 Apply lubricant to the turbine side thrust bearing 71 and thrust collar 63.

4 Insert the thrust collar 63 into the rotor shaft.

5 Attach guide bar T-52.

6 Mount the support 361 with the compressor side thrust bearing 73 and the compressor side oil labyrinth 37 assembled into to the bearing pedestal.

7 Install the mounting bolt 363 and spring washer 364.
6.8 Installing the impeller

1. Use the threaded bar T-21 to insert the sleeve 64 into the rotor shaft halfway.

2. Align the sleeve 64 with the match mark of the rotor shaft.

3. While supporting the weight with the chain block, install the impeller 66.

4. Remove the lifting bolt T-23.

5. Remove the bolt T-13 and then draw-out tube T-46.
Align the claw clutch of the impeller 66 with the sleeve 64.

- Match marks are engraved on the rotor shaft, sleeve, and impeller. Adjust the positions of the sleeve, rotor shaft, and impeller so that these match marks are in alignment.

- In order to facilitate visual check of the engagement between the sleeve and impeller, pull the sleeve 64 forward before placing the impeller on the rotor shaft.

Insert the stopper T-49 between the sleeve 64 and the support 361.

- It prevents the sleeve from being pushed back when the impeller is pushed.

Push the impeller on while observing its back surface to engage the claw clutch of the impeller and sleeve 64.

Pull out the stopper T-49 upon confirmation of the engagement between the claw clutch of impeller and the sleeve.

Push the impeller all the way and assemble it into the rotor shaft.
6.9 Tightening the impeller

If the tightening force of the impeller is insufficient, the friction force of the contact face between the impeller backside and the sleeve will decrease, and shaft torque transmitted from the turbine will act drastically on the claw (claw clutch) of the impeller backside. Thereby some great stress is applied to the impeller backside, resulting in damage of the impeller. The decrease in the tightening force of the impeller will decrease the rigidity of the entire rotor, which allows the rotor to vibrate more, resulting in damages of the rotor. Thus, take care when tightening the impeller.

1. Install the washer 68 with hand.

2. Screw the nut 67 onto the end of the shaft, also by hand.

3. Screw the guide bar for hydraulic jack T-48 into the threaded hole in the shaft end.

4. Screw the hydraulic jack T-60 into the end of the shaft.
   • Here, check that the impeller is at room temperature. Tightening at a high temperature may result in insufficient tightening during operation.

5. After screw in completely, return the hydraulic jack T-60 by one rotation.

6. Connect the hose T-62 of the hydraulic pump T-61 to the hydraulic jack T-60. Then, move the lever of the hydraulic pump T-61 to increase the hydraulic pressure to the specified value.

7. Turn the nut 67 from the slot of the hydraulic jack T-60 with the handle T-32 clockwise until it stops.

8. Open the escape valve on the hydraulic pump T-61 by turning the handle counterclockwise to lower the pressure.

NOTICE
• Hydraulic pump T-61 is sometimes in common use with main engine. In this case, please use the one for main engine.
9 Raise the pressure again to the specified level. Check whether the nut 67 can be turned further. For the impeller tightening torque, refer to the below table.

<table>
<thead>
<tr>
<th>MET</th>
<th>Impeller tightening pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>MET33MA</td>
<td>—</td>
</tr>
<tr>
<td>MET42MA</td>
<td>44.6 [MPa] 455 [kg/cm²]</td>
</tr>
<tr>
<td>MET53MA</td>
<td>50.0 [MPa] 510 [kg/cm²]</td>
</tr>
<tr>
<td>MET60MA</td>
<td>61.2 [MPa] 625 [kg/cm²]</td>
</tr>
<tr>
<td>MET66MA</td>
<td>51.0 [MPa] 520 [kg/cm²]</td>
</tr>
<tr>
<td>MET71MA</td>
<td>57.8 [MPa] 590 [kg/cm²]</td>
</tr>
<tr>
<td>MET83MA</td>
<td>62.9 [MPa] 640 [kg/cm²]</td>
</tr>
<tr>
<td>MET90MA</td>
<td>68.6 [MPa] 700 [kg/cm²]</td>
</tr>
</tbody>
</table>

10 Open the escape valve of the hydraulic pump T-61 to decrease the hydraulic pressure and pull the ram of the hydraulic jack T-60 by hand to store it.

11 Remove the hose T-62 of the hydraulic pump T-61, and then hydraulic jack T-60.

12 Measure the distance (S) between the edge of the Locking nut 67 and the end of the shaft, using slide (vernier) calipers or a depth gauge, and compare the value with that obtained before disassembly.
   • If the difference is 0.10 mm or greater, consult with MHI.
6.10 Measuring the rotor shaft deflection

1. After tightening the impeller, turn the rotor shaft counterclockwise by hand.
   • Check that it rotates smoothly without any contact noise.

2. Measure the deflection of the end of the rotor shaft using a dial gauge.
   • Deflection of 0.10 mm or more indicates the inclusion of foreign object on the contact surfaces of the impeller, sleeve, thrust collar, and/or rotor shaft, causing inclination of the rotor shaft.
   Remove the impeller again, and check the above-noted contact surfaces. Re-measure the deflection of the end of the rotor shaft prior to tightening of the impeller.
6.11 Measuring the thrust clearance of the rotor

1 After checking the shaft deflection, apply the dial gauge in the axial direction.

2 Measure the axial movement of the rotor when pushed by hand (the thrust clearance).

3 Check that the clearance is the same as before disassembly.
   • The thrust clearance should normally be in the range of 0.26 - 0.36 mm.
   • If the value is outside this range, remove the impeller, and check that there is no foreign matter on the contact surfaces of the impeller, sleeve, thrust collar, and/or rotor shaft. Please consult with MHI in cases where the thrust clearance value cannot be obtained in the designated range.

- Measuring the respective clearances

   After installing the air guide casing, measure the impeller blade tip clearance A and the turbine blade tip clearance L. Refer to the clearance table in Section 9.1 for acceptable values.
6.12 Installing the scroll

1. Install the impeller end cap 69 the fastening bolt 691 and tongued washer 692.

2. Install the O-ring 449.

3. Lift the scroll 44 slowly using a wire rope suspended from a chain block.

4. Assemble the inner scroll 44 into the outer scroll 40.

5. Install hex. bolt 444 using hex. headed spanner T-29.
   - Take care not to allow the impeller to get contact with the scroll.

6. Remove the shackle T-39 from the arm of the slinging device T-76.

7. Remove the bolt T-15, and then the slinging device T-76.
6.13 Installing the air guide casing

1 Lift the air guide casing 47 using a wire rope suspended from a chain block and assemble into the scroll.

⚠️ CAUTION
Pay attention to prevent the contacting of impeller with the air guide casing.
» The impeller may be damaged.

2 Install bolt 473 and spring washer 474.

3 Remove the bolt T-16, and then slinging device T-76.

4 Remove the shackle T-39 from the arm of the slinging device T-76.

5 Measure the clearance (A) between the air guide casing 47 and the impeller with a feeler gauge at 4 places, upper, lower, right and left.
  • For the standard value, refer to the clearance table in Section 9.1.
6.14 Installing the silencer

1 Lift the silencer 50 with a wire rope, and assemble it to the outer scroll 40.

2 Install all of the washers 501 and nuts 502.

3 Connect the cable of the gap sensor with the junction box.

6.15 Installing the gas inlet inner casing

1 Install the slinging device T-85 to the flange on the gas inlet casing 26 using bolts T-15.

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do not use any bolts longer than T-15.</td>
</tr>
<tr>
<td>* The flange may break.</td>
</tr>
</tbody>
</table>

2 Install the shackle T-39 to the arm of slinging device T-85.

3 Lift the gas inlet inner casing 26 with the chain block through wire rope and assemble to the gas inlet outer casing 27.

4 Install all of the nuts 267 to the flange for mounting the gas inlet inner casing 26.

5 Unscrew bolts T-15 and remove the slinging device T-85.
# 7 Turbocharger Troubleshooting

If the problem occurred during operation is not resolved by means of the action(s) recommended in the table below, or if turbocharger overhaul cannot be performed, consult with MHI.

## 7.1 Compressor surging

<table>
<thead>
<tr>
<th>Immediate action</th>
<th>Cause</th>
<th>Remedy</th>
<th>Refer to</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Reduce speed to load at which surging stops.</td>
<td>Air filter fouling</td>
<td>Remove and clean air filter</td>
<td>4.11</td>
</tr>
<tr>
<td>• If necessary, open the air cooler inspection hole to stop surging (be careful of elevated exhaust temperature).</td>
<td>Turbine side fouling</td>
<td>Overhaul and clean turbine side</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>Turbine blade wear damage</td>
<td>Replace turbine blades (consult with MHI)</td>
<td>4.9</td>
</tr>
<tr>
<td></td>
<td>Air cooler fouling</td>
<td>Refer to engine manual.</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Exhaust gas protection grill blockage</td>
<td>Refer to engine manual.</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Problem with fuel pump</td>
<td>Refer to engine manual.</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Exhaust gas boiler contamination</td>
<td>Refer to vessel manual.</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Problem with engine room ventilation</td>
<td>Check ventilation fan operation.</td>
<td>–</td>
</tr>
</tbody>
</table>

### Remedies for Compressor Surging

- **Causes:**
  - Air filter fouling
  - Turbine side fouling
  - Turbine blade wear damage
  - Air cooler fouling
  - Exhaust gas protection grill blockage
  - Problem with fuel pump
  - Exhaust gas boiler contamination
  - Problem with engine room ventilation

### Remedies

- **Immediate Action:**
  - Reduce speed to load where surging stops.
  - If necessary, open the air cooler inspection hole to stop surging (be careful of elevated exhaust temperature).

## 7.2 Oil leakage from main unit and/or oil mist mixed with discharged air

<table>
<thead>
<tr>
<th>Immediate action</th>
<th>Cause</th>
<th>Remedy</th>
<th>Refer to</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Check whether there is any abnormal vibration.</td>
<td>Excessive inlet lubricant pressure</td>
<td>Adjust oil pressure at orifice, etc.</td>
<td>3</td>
</tr>
<tr>
<td>• If so, reduce speed to load at which vibration is alleviated, and immediately overhaul turbocharger.</td>
<td>Problem with air bleeder piping</td>
<td>Check size of air bleeder piping. Check that there is no inclination where oil has accumulated.</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Loose impeller</td>
<td>Check whether impeller is tightened at specified pressure.</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>Vacuum breaker sticking</td>
<td>Overhaul vacuum breaker.</td>
<td>4.8.2</td>
</tr>
<tr>
<td></td>
<td>Oil labyrinth damage</td>
<td>Overhaul turbocharger, inspect parts, and clean channels.</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>Bearing damage</td>
<td>Overhaul turbocharger, inspect parts, and clean channels. Inspect or clean L.O. filter for turbocharger.</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>Sealing air channel blockage</td>
<td>Overhaul turbocharger, inspect parts, and clean channels.</td>
<td>4.8.1</td>
</tr>
<tr>
<td></td>
<td>Problem with oil return tubing</td>
<td>Check whether interim valves are closed. Check size of oil return tubing.</td>
<td>–</td>
</tr>
</tbody>
</table>

### Remedies for Oil Leakage

- **Causes:**
  - Excessive inlet lubricant pressure
  - Problem with air bleeder piping
  - Loose impeller
  - Vacuum breaker sticking
  - Oil labyrinth damage
  - Bearing damage
  - Sealing air channel blockage
  - Problem with oil return tubing

### Remedies

- **Immediate Action:**
  - Check whether there is any abnormal vibration.
  - If so, reduce speed to load at which vibration is alleviated, and immediately overhaul turbocharger.
### 7.3 Exhaust gas mixed with discharged air

<table>
<thead>
<tr>
<th>Immediate action</th>
<th>Cause</th>
<th>Remedy</th>
<th>Refer to</th>
</tr>
</thead>
<tbody>
<tr>
<td>• If amount of exhaust gas is low, continue using turbocharger until next overhaul.</td>
<td>Gas sealing ring wear/damage</td>
<td>Remove rotor and replace sealing ring.</td>
<td>5.9</td>
</tr>
<tr>
<td>• If amount is high, and gas is ingested from the turbocharger silencer such that intake air temperature is higher than the engine room temperature by 10°C or more, reduce speed of engine immediately and overhaul turbocharger as soon as possible.</td>
<td>Sealing air channel blockage</td>
<td>Remove rotor, check sealing air channel, and clean.</td>
<td>4.8.1</td>
</tr>
<tr>
<td></td>
<td>Gas labyrinth damage</td>
<td>Remove rotor and replace gas labyrinth.</td>
<td>5.9</td>
</tr>
</tbody>
</table>

### 7.4 Abnormal vibration and/or noise from main unit

<table>
<thead>
<tr>
<th>Immediate action</th>
<th>Cause</th>
<th>Remedy</th>
<th>Refer to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce speed to load at which vibration is alleviated, and overhaul turbocharger as soon as possible.</td>
<td>Turbine blade and/or compressor impeller damage</td>
<td>Overhaul turbocharger</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>Bearing damage</td>
<td>Remove rotor and inspect bearing</td>
<td>4.5</td>
</tr>
</tbody>
</table>
7.5 Abnormally high turbocharger speed, Speed increases regardless of engine load

<table>
<thead>
<tr>
<th>Immediate action</th>
<th>Cause</th>
<th>Remedy</th>
<th>Refer to</th>
</tr>
</thead>
<tbody>
<tr>
<td>• If both scavenge air pressure and exhaust gas temperature are high, or if exhaust temperature is abnormally high, reduce engine load and inspect turbocharger and engine as soon as possible.</td>
<td>Abnormal engine combustion</td>
<td>Stop engine and inspect according to engine manual.</td>
<td>_</td>
</tr>
<tr>
<td>• Do not approach turbocharger.</td>
<td>Substantial scavenge air leakage</td>
<td>Identify location of scavenge air leakage and perform countermeasures.</td>
<td>_</td>
</tr>
<tr>
<td>If scavenge air pressure and exhaust gas temperatures are normal, reduce engine load and test output signal from turbocharger tachometer.</td>
<td>Abnormality with tachometer</td>
<td>Check rpm from frequency of signal in tachometer junction box near turbocharger. Identify problem point and replace part(s).</td>
<td>_</td>
</tr>
</tbody>
</table>

7.6 High exhaust gas temperature

<table>
<thead>
<tr>
<th>Immediate action</th>
<th>Cause</th>
<th>Remedy</th>
<th>Refer to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce engine load to point at which engine reaches allowable temperature, and inspect engine.</td>
<td>Turbocharger internal fouling</td>
<td>Overhaul turbocharger and clean</td>
<td>4.4</td>
</tr>
<tr>
<td>Refer to section 7.5</td>
<td></td>
<td>Refer to section 7.5</td>
<td>_</td>
</tr>
</tbody>
</table>

7.7 Failure of turbocharger to start up

<table>
<thead>
<tr>
<th>Immediate action</th>
<th>Cause</th>
<th>Remedy</th>
<th>Refer to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspect turbocharger.</td>
<td>Blockage due to combustion residue on turbine blade tips</td>
<td>Clean turbine side.</td>
<td>4.9</td>
</tr>
<tr>
<td></td>
<td>Blind plate for turbocharger shutdown extending into gas inlet</td>
<td>Remove blind plate.</td>
<td>_</td>
</tr>
</tbody>
</table>
(Blank)
8 Disposal

In case of disposal of the turbocharger, observe rules and regulations.
Before disposing of the turbocharger, be sure to inform MHI of the method of the disposal.
(Blank)
9 Attached Diagrams and Tables

9.1 Clearance Table

<table>
<thead>
<tr>
<th>POINT</th>
<th>TYPE</th>
<th>MET60MA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DESIGN</td>
<td>LIMIT</td>
</tr>
<tr>
<td>A</td>
<td>0.45~1.35</td>
<td>1.45</td>
</tr>
<tr>
<td>B</td>
<td>1.70~1.90</td>
<td>2.00</td>
</tr>
<tr>
<td>D</td>
<td>0.05~0.45</td>
<td>0.50</td>
</tr>
<tr>
<td>E=F</td>
<td>0.34~0.38</td>
<td>0.44</td>
</tr>
<tr>
<td>G</td>
<td>0</td>
<td>———</td>
</tr>
<tr>
<td>H</td>
<td>0.26~0.36</td>
<td>———</td>
</tr>
<tr>
<td>J</td>
<td>0.05~0.55</td>
<td>0.65</td>
</tr>
<tr>
<td>L</td>
<td>Top</td>
<td>0.90~1.20</td>
</tr>
<tr>
<td></td>
<td>Starboard Port</td>
<td>1.00~1.30</td>
</tr>
<tr>
<td></td>
<td>Bottom</td>
<td>1.10~1.40</td>
</tr>
</tbody>
</table>

- Note: Thrust clearance H indicated represents the standard value to refer to when renewing the thrust bearing and is not the value to be used as yardstick for evaluating the bearing wear.

- Note: スラスト隙間Hはスラスト軸受換装時の隙間基準であり，スラスト軸受の摩耗判断のための数値ではありません。
9.2 Rotor Locking Procedure
### 9.3 Dimension and Weight Table of Main Parts

<table>
<thead>
<tr>
<th>T/C COMPLETE</th>
<th>ROTOR COMPLETE</th>
<th>GAS INLET CSG</th>
<th>SILENCER</th>
<th>OTHER CSGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MET53MA</td>
<td>2451 x 1417 x 1435</td>
<td>1035 x about 600 x 190kg</td>
<td>633 x 940 x 1006 x 550kg</td>
<td>680 x φ1380 x 290kg</td>
</tr>
<tr>
<td>MET60MA</td>
<td>2825 x 1500 x 1570</td>
<td>1188 x about 700 x 240kg</td>
<td>813 x 1106 x 1153 x 680kg</td>
<td>750 x φ1500 x 400kg</td>
</tr>
<tr>
<td>MET66MA</td>
<td>3004 x 1785 x 1716</td>
<td>1271 x about 750 x 330kg</td>
<td>848 x 1220 x 1284 x 890kg</td>
<td>790 x φ1730 x 530kg</td>
</tr>
<tr>
<td>MET71MA</td>
<td>3036 x 1820 x 1865</td>
<td>1318 x about 800 x 400kg</td>
<td>849 x 1290 x 1319 x 1100kg</td>
<td>790 x φ1730 x 610kg</td>
</tr>
<tr>
<td>MET83MA</td>
<td>3700 x 2250 x 2188</td>
<td>1555 x about 1000 x 600kg</td>
<td>1053 x 1482 x 1671 x 1700kg</td>
<td>1052 x φ2130 x 800kg</td>
</tr>
<tr>
<td>MET90MA</td>
<td>4130 x 2465 x 2370</td>
<td>1723 x about 1050 x 850kg</td>
<td>1106 x 1655 x 1826 x 2180kg</td>
<td>1140 x φ2310 x 1200kg</td>
</tr>
</tbody>
</table>
9.4 Cross-sectional Diagrams and Part Numbers
Pedestal Periphery
Rotor Periphery
### 9.5 Part Numbers and Names

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Part Name</th>
<th>Part No.</th>
<th>Part Name</th>
<th>Part No.</th>
<th>Part Name</th>
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<tr>
<td>10</td>
<td>Exhaust gas outlet casing</td>
<td>38</td>
<td>Lube oil inlet pipe</td>
<td>80</td>
<td>Flange</td>
</tr>
<tr>
<td>13</td>
<td>Flange</td>
<td>381</td>
<td>Bush</td>
<td>801</td>
<td>Packing</td>
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<td>Packing</td>
<td>39</td>
<td>Escape pipe</td>
<td>802</td>
<td>Spring washer</td>
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<td>132</td>
<td>Bolt</td>
<td>40</td>
<td>Outer scroll</td>
<td>803</td>
<td>Bolt</td>
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<td>134</td>
<td>Blank flange</td>
<td>401</td>
<td>Stud bolt</td>
<td>804</td>
<td>Flange</td>
</tr>
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<td>135</td>
<td>Spring washer</td>
<td>402</td>
<td>Stud bolt</td>
<td>805</td>
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<td>14</td>
<td>Panting plate</td>
<td>403</td>
<td>Name plate</td>
<td>806</td>
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<tr>
<td>141</td>
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<td>404</td>
<td>Number plate</td>
<td>807</td>
<td>Nut</td>
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<td>201</td>
<td>Nut</td>
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<td>Driving-fit screw</td>
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<td>406</td>
<td>Parallel pin</td>
<td>81</td>
<td>Flange</td>
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<td>22</td>
<td>Nozzle</td>
<td>44</td>
<td>Inner scroll</td>
<td>83</td>
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<td>443</td>
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<td>226</td>
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<td>444</td>
<td>Hexagon-socket-headed bolt</td>
<td>832</td>
<td>U-nut</td>
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<td>Gas outlet guide</td>
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<td>O-ring</td>
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<td>Diffuser</td>
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<td>Air inlet guide</td>
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<td>L.O. Inlet flange</td>
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<td>Rubber cap</td>
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<td>844</td>
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<td>Gas inlet outer casing</td>
<td>54</td>
<td>Manometer</td>
<td>85</td>
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<td>Vinyl tube</td>
<td>853</td>
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<tr>
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<td>Parallel pin</td>
<td>542</td>
<td>Oval head screw</td>
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<td>Spring washer</td>
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<td>274</td>
<td>Bolt</td>
<td>58</td>
<td>Band</td>
<td>871</td>
<td>Packing</td>
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<tr>
<td>30</td>
<td>Bearing pedestal</td>
<td>60</td>
<td>Rotor shaft</td>
<td>872</td>
<td>Bolt</td>
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<td>305</td>
<td>Stud bolt</td>
<td>61</td>
<td>Turbine blade</td>
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<tr>
<td>306</td>
<td>Plug</td>
<td>612</td>
<td>Blade stopper</td>
<td>874</td>
<td>Vacuum breaker</td>
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<tr>
<td>307</td>
<td>Plug</td>
<td>63</td>
<td>Thrust collar</td>
<td>885</td>
<td>Spring pin</td>
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<tr>
<td>308</td>
<td>Plug</td>
<td>64</td>
<td>Sleeve</td>
<td>95</td>
<td>Cover</td>
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<tr>
<td>35</td>
<td>Oil labyrinth packing (turbine-side)</td>
<td>66</td>
<td>Impeller wheel</td>
<td>951</td>
<td>Machine screw</td>
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<tr>
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<td>Spring washer</td>
<td>67</td>
<td>Locking nut</td>
<td>96</td>
<td>Cover</td>
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<td>Bolt</td>
<td>68</td>
<td>Washer</td>
<td>961</td>
<td>Machine screw</td>
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<tr>
<td>354</td>
<td>O-ring</td>
<td>69</td>
<td>Cap</td>
<td>98</td>
<td>Gap sensor</td>
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<td>36</td>
<td>Air labyrinth</td>
<td>691</td>
<td>Bolt</td>
<td>983</td>
<td>Conduit tube</td>
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<td>Support</td>
<td>692</td>
<td>Tongued washer</td>
<td>985</td>
<td>Band</td>
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<tr>
<td>362</td>
<td>O-ring</td>
<td>70</td>
<td>Journals bearing (compressor-side)</td>
<td>986</td>
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<td>Hexagon-socket-headed bolt</td>
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<td>Bolt</td>
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<td>366</td>
<td>Washer</td>
<td>714</td>
<td>Spring washer</td>
<td>991</td>
<td>Spring washer</td>
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<td>Thrust bearing (compressor-side)</td>
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<td>Washer</td>
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<td>Oil labyrinth packing (compressor-side)</td>
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<td>Hexagon-socket-headed bolt</td>
<td>993</td>
<td>Band</td>
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<td>734</td>
<td>Spring washer</td>
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<td>372</td>
<td>Bolt</td>
<td>75</td>
<td>Journal bearing (turbo-side)</td>
<td>995</td>
<td>Band</td>
</tr>
<tr>
<td>373</td>
<td>O-ring</td>
<td></td>
<td></td>
<td>996</td>
<td>Rubber cap</td>
</tr>
</tbody>
</table>
9.6 Tool Numbers and Names

Please refer to the attached “Tool List”.
10 Where to Contact

MHI-authorized turbocharger service companies are located throughout the world. In these organizations, there are engineers who have skills and knowledge required for the maintenance of the turbocharger described in this manual. If disassembly and re-assembly should pose any difficulties, these service companies can also be called upon.

10.1 MHI Contact Information

Parts Estimations and Orders

Marine Machinery Department
Marine Machinery & Engine Division
Power Systems
Mitsubishi Heavy Industries, Ltd.
1-1 Akunoura-machi, Nagasaki 850-8610 Japan
Marine Machinery Business Section
TEL +81-95-828-6070, 7094, FAX +81-95-828-6174

MHI Marine Engineering Co., Ltd.
6F, Tamachi Center Bldg.
5-34-7 Shiba, Minato-ku Tokyo 108-0014 Japan
TEL +81-3-3798-5941  FAX +81-3-3798-5943

Technical Support

Marine Machinery Department
Marine Machinery & Engine Division
Power Systems
Mitsubishi Heavy Industries, Ltd.
6-12 Saiwai-machi, Nagasaki 850-0046 Japan
Turbocharger Designing Section
TEL +81-95-821-2145, 2179, FAX +81-95-821-2279
E-MAIL: ATRS999@mhi.co.jp

Turbo Marine Consult ApS
Strandgards Alle 68, DK-3600, Frederikssund, Denmark
TEL/FAX  +45-4738-6501
E-MAIL: mail@turbomarine.dk

NOTICE

- When contacting the above, clearly state the serial No. of the turbocharger.
10.2 MET Turbocharger Authorized Service Organizations

**Europe**

**<Belgium>**

Maintenance Partners N.V.
Vitshoekstraat 6, Haven 1035, 2070 Zwijndrecht,
Tel: 32-3-541-7140 Fax: 32-3-544-3248
Web Site: http://www.maintenancepartners.com

**<Belgium>**

MAN Diesel Benelux N.V.
Noorderlaan 181, 2030 Antwerpen,
Tel: 32-3-543-8500 Fax: 32-3-541-7508
E-mail: turbo-benelux@mandiesel.com
Web Site: http://www.manrollo.com/man_rollo

**<Belgium>**

PJ Diesel Engineering A/S
Skudehavnsvæj 14 DK-2100 Copenhagen
Tel: 45-39-29-15-53 Fax: 45-39-27-10-54
E-mail: Service@pjdiesel.dk
Web Site: http://www.pjdiesel.dk

**<Denmark>**

Nippon Diesel Service GmbH
Hermann-Blohm-Str.1, D-20457 Hamburg
Tel: 49-40-317710-0 Fax: 49-40-311598
E-mail: info@nds-intl.com
Web Site: http://www.nds-intl.com

**<Germany>**

Scan-Turbo Handels-und Service GmbH
Kleiner Westring 15, 27572 Bremerhaven
Tel: 49-471-971-21-21 Fax: 49-471-971-21-23
E-mail: info@Scan-Turbo.com
Web Site: http://www.scan-turbo.com/

**<Germany>**

Turbo-Technik Reparatur-Werft GmbH & Co. KG
Hannoversche StraBe 11, 26384 Wilhelmshaven
Tel: 49-4421-3078-0 Fax: 49-4421-305086
E-mail: technical@turbotechnik.com
Web Site: http://www.turbotechnik.com

**<Greece>**

S.R.H. Marine Electronics S.A.
17-19 Gravias, 18545 Piraeus
Tel: 30-210-411-02-60 Fax: 30-210-417-77-84
E-mail: info@srmar.gr
Web Site: http://www.srmar.com/

**<Greece>**

S.R.H. Marine Electronics Ltd.
2 Ilias & Tripoleos Str. 188-63 Perama, Piraeus
Tel: 30-210-4002585 Fax: 30-210-4009290
E-mail: info@turbotechniki.gr
Web Site: http://www.turbotechniki.gr

**<Italy>**

La Meccanica Turbo Diesel Srl
Calata Gadda 16128 Genoa
Tel: 39-010-246-1111 Fax: 39-010-246-1144
E-mail: mtd@mtd.it
Web Site: http://www.mtd.it

**<Spain>**

Turbo Cadiz S.L.
Pol igono Industrial Pelagatos Calle del Progreso, 17A-20A,
Chiclan de la Frontera(Cadiz) 11.130
Tel: 34-956-407-949 Fax: 34-956-407-951
E-mail: tc@turbocadiz.com
Web Site: http://www.turbocadiz.com

**<The Netherland>**

Fuji Trading B.V.
Sluicejesdijk 109, 3087 AE Rotterdam
Tel: 31-10-429-8833 Fax: 31-10-429-5227
E-mail: info@fujitrading.nl
Web Site: http://www.fujitrading.nl/

**<The Netherland>**

Tru-Marine Rotterdam
Nieuwe Waterweg Straat 17, 3115 HE Schiedam Portno 534
Rotterdam
Tel: 31-10-4267-383 Fax: 31-10-4733-050
E-mail: turbo@trumarine.nl
Web Site: http://www.turbo.nl

**<The Netherland>**

Turbo Ned Service B.V.
Kreekweg 10, 3336 LC Zwijndrecht
Tel: 31-7-8620-5252 Fax: 31-7-8612-3230
E-mail: info@turboned.nl
Web Site: http://www.turboned.nl/turboiex/index.html

**<Turkey>**

GTS Turbo Diesel Service Ltd.
Organize Den Sanayii Bölgesi, 12. Yol L1/6 Parsel 34944
Tuzla/ Istanbul/Turkey
Tel: 90-216-591-07-23 Fax: 90-216-591-07-27
E-mail: turbintr@superonline.com
Web Site: http://www.gtsturbo.com
<U.K.>
Marine Turbo Engineering Ltd.
Abbey House, Abbey Street Priory Trading Estate, Birkenhead
CH41 5JU
Tel : 44-151-647-8141  Fax : 44-151-666-2143
E-mail : service@marineturbo.co.uk
Web Site : http://www.marineturbo.co.uk

<U.K.>
Turbo Service International Ltd.
190 Commercial Road, Totton, Southampton, Hampshire, SO40 3AA
Tel : 44-2380-861000  Fax : 44-2380-863000
E-mail : service@tsi.eu.com
Web Site : http://www.tsi.eu.com

Africa
<South Africa>
Majestic Engineering C.C.
186 Evans Road, Glenwood Durban 4001
Tel : 27-31-205-1041  Fax : 27-31-205-0417
E-mail : turbocharger@telkomsa.net

North America
<Canada>
Dynamic Engineering Inc.
1270 Frances Street, Vancouver, BC, V6A 1Z5
Tel : 1-604-253-4427  Fax : 1-604-253-3553
E-mail : turbo@dynamicengineering.com
Web Site : http://www.dynamicengineering.com

<Canada>
Marine Tech Industries Ltd.
Tel : 12628, 82nd Ave., Surrey BC, V3W 3G1
Tel : 1-604-507-0880  Fax : 1-604-507-0881
E-mail : info@marinetech.com
Web Site : http://www.marinetech.com

<U.S.A.>
Goltens New York Corp.
160 Van Brunt Street, Brooklyn, New York 11231
Tel : 1-718-855-7200  Fax : 1-718-802-1147
E-mail : newyork@goltens.com
Web Site : http://www.goltens.com/g-newyork_contact.htm

<U.S.A.>
Motor-Services Hugo Stamp Inc.
Tel : 3190 SW 4th Ave., Fort Lauderdale, FL 33315
Tel : 1-954-763-3660  Fax : 1-954-763-2872
E-mail : turbo@mshs.com
Web Site : http://www.mshs.com

<U.S.A.>
Rolls-Royce Commercial Marine Inc.
2445 N. Palm Drive, Suite 104  Signal Hill, California 90755, USA
Tel : 1-562-989-0291  Fax : 1-562-989-0281
Web Site : http://www.rolls-royce.com/marine

<U.S.A.>
Turbo USA Inc.
2950 SW 2 AVE FT LAUDERDALE, FL 33315
Tel : 1-954-767-8631  Fax : 1-954-767-8632
E-mail : info@turbo-usa.com
Web Site : http://www.turbo-usa.com

<U.S.A.>
United World Enterprise
(1) 6310 Winfree Dr.Houston, Texas 77087
Tel : 1-713-641-1915  Fax : 1-713-641-2717
(2) 2913 S. 47th St. Tampa Florida 33619
Tel : 1-813-248-8425  Fax : 1-813-242-4208
E-mail : TOEIENG@aol.com
Web Site : http://www.unitedworldenterprise.com

South America
<Argentina>
Turbogen s.r.l.
Lugones 1851/55, RA-1430 Buenos Aires
Tel : 54-11-4521-5667/1914  Fax : 54-11-4521-8283
E-mail : turbogenruffa@arnetbiz.com.ar
Web Site : http://www.turbogen.com

<Brazil>
Metalock do Brasil Ltd. (Santos & Rio de Janeiro)
Rua da Gamboa 281, 20220-321 Rio de Janeiro RJ
Tel : 55-21-2516-5561  Fax : 55-21-2516-5562
E-mail : santos@metalock.com.br
Web Site : http://www.metalock.com.br

<Chile>
Turbodal S.A.
Baron de Juras Reales nr 5050, Conchali, Santiago
Tel : 56-2-8994065  Fax : 56-2-8994065
E-mail : autoturbos@turbodal.cl
Web Site : http://www.turbodal.com/empresa/empresa_quines_somos.htm
Middle East

<U.A.E.>
Albwardy Marine Engineering (L.L.C.)
AL JADAF P.O. Box 6515, Dubai
Tel : 971-4-3241001    Fax : 971-4-324-1005
E-mail : repairs@albwardymarine.com
Web Site : http://www.albwardymarine.com

<U.A.E.>
MAN Diesel & Turbo Middle East L.L.C
PO Box 57091 Dubai, U.A.E
Tel : 971-4-345-4045    Fax : 971-4-345-4048
E-mail : primeserv-ae@mandiesel.com
Web Site : http://www.mandieselturbo.com

<U.A.E.>
Nico International
P.O. Box 12068, Dubai
Tel : 971-4-338-2135    Fax : 971-4-338-1832
E-mail : nicouae@topaz-engineering.com
Web Site : http://www.topazworld.com/nicoin.html

<China>
K & C Global Ltd.
Block M, Yiu Lian Dockyards, No.1-7 Sai Tso Wan Road, Tsing Yi Island
Tel : 852-2435-7880    Fax : 852-2432-1001
E-mail : kcservices_co@yahoo.com

<China>
Kemklen Technical Services Ltd.
Shop No. 8, G/F, Block B, Vigor Industrial Building, 14-20 Cheung Tat Road Tsing Yi Island, N.T., Hong Kong
Tel : 852-2861-2812    Fax : 852-2861-2465, 852-2861-1168
E-mail : service@turbokts.com
Web Site : http://www.turbokts.com

<China>
Shang Hai Mazar Technology Co. Ltd.
Room 806, No. 2005 lane, Huang Xing Road, Shanghai
Tel : 86-21-5506-1663    Fax : 86-21-5509-7869
E-mail : mazar@vip.163.com

<China>
Tru-Marine Machinery Engineering Guangzhou Co. Ltd.
No.1168 Kangnan Road, Yunpu Industrial Park Huangpu District, Guangzhou 510760
Tel : 86-20-8222-7678    Fax : 86-20-8222-7578
E-mail : turbo@trumarineguangzhou.cn
Web Site : http://www.trumarine.com

<China>
Tru-Marine Machinery Engineering Shanghai Co. Ltd.
No.318 Cheng Ying Road, Shanghai, 200444
Tel : 86-21-6520-4220    Fax : 86-21-6520-6639
E-mail : shanghai@trumarine.com.cn
Web Site : http://www.trumarine.com

<India>
Dalwin Marine Turbo Engg. Pvt. Ltd.
R-307, T.T.C. Ind.Area, Rabale, M.I.D.C, Navi, Mumbai
Tel : 91-22-2760-2239    Fax : 91-22-2760-2931
E-mail : powertech@dalwin.com
Web Site : http://www.dalwin.com

<India>
Ras Tek Pvt. Ltd.
Tel : 91-22-2764-2021    Fax : 91-22-2764-2024
E-mail : marine@ras-tek.com

Asia

<China>
Dalian Cosco Rikky Ocean Engineering Co. Ltd.
116600, No. 37 Dong Bei Road, E.T.D.Z. District, Dalian,
Tel : 86-411-3922-6509    Fax : 86-411-3922-6300
E-mail : rikkyocean@cosco-shipyard.com
Web Site : http://www.coscorog.com

<China>
Fischer Engineering Co. Ltd.
No.1 Dadong Road, Chongming , Shanghai , China , 202155
Tel : 86-21-5969-8104    Fax : 86-21-5969-8102
E-mail : info@fischer-sh.com.cn

<India>
Dalwin Marine Turbo Engg. Pvt. Ltd.
R-307, T.T.C. Ind.Area, Rabale, M.I.D.C, Navi, Mumbai
Tel : 91-22-2760-2239    Fax : 91-22-2760-2931
E-mail : powertech@dalwin.com
Web Site : http://www.dalwin.com

<China>
K & C Global Ltd.
Block M, Yiu Lian Dockyards, No.1-7 Sai Tso Wan Road, Tsing Yi Island
Tel : 852-2435-7880    Fax : 852-2432-1001
E-mail : kcservices_co@yahoo.com

<China>
Kemklen Technical Services Ltd.
Shop No. 8, G/F, Block B, Vigor Industrial Building, 14-20 Cheung Tat Road Tsing Yi Island, N.T., Hong Kong
Tel : 852-2861-2812    Fax : 852-2861-2465, 852-2861-1168
E-mail : service@turbokts.com
Web Site : http://www.turbokts.com

<China>
Shang Hai Mazar Technology Co. Ltd.
Room 806, No. 2005 lane, Huang Xing Road, Shanghai
Tel : 86-21-5506-1663    Fax : 86-21-5509-7869
E-mail : mazar@vip.163.com

<China>
Tru-Marine Machinery Engineering Guangzhou Co. Ltd.
No.1168 Kangnan Road, Yunpu Industrial Park Huangpu District, Guangzhou 510760
Tel : 86-20-8222-7678    Fax : 86-20-8222-7578
E-mail : turbo@trumarineguangzhou.cn
Web Site : http://www.trumarine.com

<China>
Tru-Marine Machinery Engineering Shanghai Co. Ltd.
No.318 Cheng Ying Road, Shanghai, 200444
Tel : 86-21-6520-4220    Fax : 86-21-6520-6639
E-mail : shanghai@trumarine.com.cn
Web Site : http://www.trumarine.com

<India>
Dalwin Marine Turbo Engg. Pvt. Ltd.
R-307, T.T.C. Ind.Area, Rabale, M.I.D.C, Navi, Mumbai
Tel : 91-22-2760-2239    Fax : 91-22-2760-2931
E-mail : powertech@dalwin.com
Web Site : http://www.dalwin.com

<India>
Ras Tek Pvt. Ltd.
Tel : 91-22-2764-2021    Fax : 91-22-2764-2024
E-mail : marine@ras-tek.com
<Japan>
株式会社大洋マリン工業/TAIYO MARINE ENGINEERING CO.
〒220-0072 横浜市西区浅間町2-98-7TYビル2-98-7
Tel: 81-45-322-7001 Fax: 81-45-322-7000
E-mail: support@taiyo-marine.com
Web Site: http://www.taiyo-marine.com

<Japan>
神戸マリーン工業株式会社
〒652-0832 神戸市兵庫区鍛冶屋町1丁目3番21号
Tel: 81-78-681-7421 Fax: 81-78-681-7424
E-mail: k-marine@aioros.ocn.ne.jp
Note: For only domestic customer

<Korea>
Jonghap Maritime Engineering Inc.
188-38, Dongsam-Dong, Youngdo-Ku, Busan
Tel: 82-51-403-2381 Fax: 82-51-403-2409
E-mail: jme@jonghap-jme.co.kr
Web Site: http://www.jonghap-jme.co.kr

<Philippine>
TURBONED INC. (PHILS.)
15334 Valarao St., Airpot Vill., Moonwalk, Paranaque City,
Manila
Tel: 63-2-547-0809/0813 Fax: 63-2-822-4440
E-mail: ihiturbophil@hotmail.com

<Singapore>
AC Marine Pte. Ltd.
2, Bukit Batok St. 24 Sky Tech Building #02-14 Singapore
659480
Tel: 65-6560-0801 Fax: 65-6560-0835
E-mail: atago@acmarine.com.sg

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Daikai Engineering Pte. Ltd.
128 Pioneer Road, Singapore 639586
Tel: 65-6863-2856 Fax: 65-6863-2876
E-mail: info@daikai.com.sg
Web Site: http://www.ras-tek.com

<Singapore>
Polestar Marine Engineering Pte. Ltd.
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Tel: 65-6863-0822 Fax: 65-6863-0688
E-mail: polestar@polestarmarine.sg
Web Site: http://polestarmarine.sg

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Web Site: http://www.trumarine.com.sg/

<Singapore>
Turbo Exchange Service Pte. Ltd.
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637514
Tel: 65-6897-8297 Fax: 65-6897-8298
E-mail: sales@turboexchange.com.sg
Web Site: http://www.turboexchange.com.sg

<Singapore>
Turbo Ned Singapore Pte. Ltd.
53, Tuas View Loop. Singapore 637703
Tel: 65-6898-5169 Fax: 65-6898-9190
E-mail: kmpillai@tnsingapore.com

<Taiwan>
Shang Mao Engineering Ltd.
5F-1 No.363 Chung Hwa 2nd Rd, Kaohsiung
Tel.: 886-7-321-9755 Fax: 886-7-321-9756
E-mail: shang.mao363@msa.hinet.net

Oceania

<Australia>
MTQ Engine Systems (Aust) Pty Ltd.
1 Westside Drive, Laverton North. Melbourne, Victoria 3026
Tel: 61-3-9315-1633 Fax: 61-3-9315-3984
E-mail: info@mtqes.com.au
Web Site: http://www.mtqes.com.au
10.3 Inquire / Order sheet

Refer to the attached document “Inquire / Order sheet”.
Inquire / Order sheet

It is requested that the inquiry about the turbocharger components be made to MHI, MHI Marine Engineering, Authorized repair agents, etc., after clearly indicating the following information.

<table>
<thead>
<tr>
<th>① Type of inquiry/問い合わせ内容</th>
<th>Estimate 見積</th>
<th>Order 注文</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please check the right box</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parts/部品</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Dispatching of MHI service engineer エンジニア派遣</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>② Turbocharger type/過給機型式</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>③ Turbocharger Serial number/製造番号</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>④ Ship name/船名</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>⑤ Ship builder &amp; ship number/建造所及び船番</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>⑥ Turbocharger specification/過給機仕様 &amp; running hours (運転時間)</th>
</tr>
</thead>
</table>

Spec:
- Running hours from the last overhaul
- Total running hours from delivery

<table>
<thead>
<tr>
<th>Parts name 部品名称</th>
<th>Parts number 部品番号</th>
<th>Order quantity 注文数量</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>⑦</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>⑧ 受注要因 (Reason of parts inquiry)</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Over run/オーバーラン</td>
</tr>
<tr>
<td>□ Trust bearing burn out/スラスト軸受焼損</td>
</tr>
<tr>
<td>□ Entering external object/異物飛込</td>
</tr>
<tr>
<td>□ Unknown/不明</td>
</tr>
<tr>
<td>□ Stock/ストック在庫</td>
</tr>
<tr>
<td>□ Overhaul/メンテナンス</td>
</tr>
<tr>
<td>□ Other/その他</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>⑨ Delivery date 納期</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>⑩ Delivery address 納入先</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>⑪ Remark 備考</th>
</tr>
</thead>
</table>

コピーして使用下さい。copy and use this sheet
項目④～⑥は分かる範囲で記入下さい。 Please fill out from item No4 to No,6 to the best of your knowledge.