# Operation Manual

A135-H56

**HT587285 English**
Original Operation Manual

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Operating limits and replacement intervals

The recommended replacement intervals and the corresponding operating limits in chapter 3 are jointly defined with the enginebuilder. This information is specific to the product.

Non-observance of the recommended replacement intervals and the operating limits increases the risk of unpredictable component failures.
# Introduction

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1 Introduction

1.1 Purpose of the manual

This Operation Manual belongs to the turbocharger with the identical serial number (01), see chapter 3 (Safety data sheet) and the rating plate on the turbocharger.

**Operation Manual**

The Operation Manual explains the turbocharger and contains instructions for safe operation.

The Operation Manual is a complement to and expansion of existing national regulations for occupational safety, accident prevention and environmental protection.

**Target group**

The Operation Manual is aimed at engineers and trained mechanics responsible for the proper operation of the engine and for the turbocharger connected to it.

**Availability of the Operation Manual**

The Operation Manual must be available where the turbocharger is used.

All persons operating or working on the turbocharger must have read and fully understood the Operation Manual.
1.2 Symbols, definitions

Symbols
The following symbols are used in this document:

► Indicates an action step.
1. Indicates a numbered action step.
→ Refers to a page number.

Definition of Note

<table>
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<td>Note</td>
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<td>The note provides advice which facilitates the work.</td>
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Definition of mandatory signs
Mandatory signs show the protective equipment to be worn for a task. The mandatory signs are described in chapter Safety and must be complied with.

Definition of Caution / Warning
Caution and warning signs are described in chapter Safety.

ABB Turbo Systems

ABB Turbo Systems Ltd is identified as ABB Turbo Systems in this document.

Official service stations of ABB Turbo Systems

Official service stations are identified in this document as ABB Turbocharging Service Stations. They are regularly audited and certified by ABB Turbo Systems. Also see chapter Contact information →7.
Definition of pictograms

The following pictograms can occur in this document. These point out actions that must be taken in accordance with the meaning of the relevant pictogram.

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Table 1: Definition of pictograms
1.3 Storage of new turbochargers and spare parts

Storage of new turbochargers and spare parts for up to 6 months

New turbochargers and spare parts can be stored in their closed packages for 6 months from the date of delivery without additional mothballing measures, indicated by the VCI label on the package.

Fig. 2: Volatile Corrosion Inhibitor (VCI)

Only dry rooms with 40...70 % atmospheric humidity, in which no water condensation can form, are suitable as storage locations.

Storage of new turbochargers and spare parts for more than 6 months

WARNING

Health protection when handling VCI

VCI products are not hazardous in terms of the Ordinance on Hazardous Substances. Nevertheless, the following points must be observed when handling VCI:

› Observe information in material safety data sheet
› Ensure proper space ventilation.
› Do not eat, drink or store food at the workplace while working with VCI.
› Clean hands and face after working with VCI.
› For more information, see www.branopac.com.

Wear safety gloves to protect against mechanical hazards.

Every 6 months, the following mothballing measures are required:

› Open package.
› Remove VCI corrosion protection emitter from package and replace with a new VCI corrosion protection emitter of the same kind. New VCI corrosion protection emitters can be obtained from www.branopac.com.
› Old VCI corrosion protection emitters must be disposed of in an environmentally compatible, professional way and in compliance with locally applicable regulations.
› Close package. The more tightly the package is sealed, the longer the protection duration.
Long-term storage of replacement turbochargers or spare parts

The turbochargers or cartridge groups will be prepared for long-term storage if requested in the purchase order. The package is equipped with a hygrometer (see illustration).

Every 6 months, the following measures are required:

- Check the hygrometer (02) in the sight-glass. There is an opening (01) in the wooden crate to enable you to perform this check. If the 70% indicator field has changed colour, the maximum admissible atmospheric humidity has been exceeded. In this case, the turbocharger or cartridge group must be checked and repackaged by an ABB Turbocharging Service Station.
- Check the package for damage. If the package is damaged, the turbocharger or cartridge group must be checked and repackaged by an ABB Turbocharging Service Station.

After every 3 years, the following steps must be carried out by an ABB Turbocharging Service Station:

- Checking the component
- Replacing the desiccant
- Repackaging the component.

NOTICE

Replacement components which are ready for operation

If the 70% field of the hygrometer (02) has not changed colour and the package is not damaged, the replacement turbocharger or replacement cartridge group can be put into operation without previously having been checked by an ABB Turbocharging Service Station.

Unpackaging replacement turbochargers or spare parts

Once the material has been unpackaged from the VCI package, the corrosion protection is no longer effective.

To prevent condensation, the temperature of the package contents must be the same as the ambient temperature.
1.4 Contact information

Contact information for the ABB Turbocharging Service Stations is available online.

Scan the QR code to access our website.

ABB Turbo Systems Ltd
Bruggerstrasse 71a
CH-5401 Baden
Switzerland

www.abb.com/turbocharging
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1 Safety

1.1 Introduction

Turbochargers manufactured by ABB reflect the state of the art. The respective safety and health protection requirements are met. This ensures safe operation of the turbocharger. Nevertheless, there may be some residual risks during operation of and work on the turbocharger which:

- Are caused by the turbocharger itself or its accessories.
- Are caused by the operating equipment used or supplies and materials.
- Are a consequence of insufficient compliance with safety instructions.
- Are a consequence of insufficient or inappropriate performance of maintenance and inspection work.

The operating company is responsible for defining measures that regulate safe access to and safe handling of the turbocharger.

All instructions contained in this chapter must be observed for safe and trouble-free operation of the turbocharger and during all work on the turbocharger.

All further safety instructions contained and specifically identified in every chapter of this manual (Definition of safety instructions → 3) must also be observed.

1.2 CE conformity

Information

ABB turbochargers comply with the Machinery Directive 2006/42/EC and are partly completed machinery as defined by Article 2 g in this directive.
1.3 Definition of mandatory signs

To be worn at all times

- **Protective clothing**
- **Safety footwear** to protect against mechanical hazard and risk of falling

Table 1: Personal protective equipment to be worn at all times

To be worn specific to the respective task

- **Safety glasses**
- **Safety goggles**
- **Safety gloves** to protect against
  - Mechanical hazard
  - Chemical hazard
  - Thermal hazard
- **Respiratory mask** to protect against
  - Dusts
  - Gases
- **Safety helmet**
- **Ear protection**

Table 2: Personal protective equipment to be worn specific to the respective task

1.4 Definition of safety instructions

**WARNING**

Definition of Warning

Non-compliance or inaccurate compliance with working or operating instructions indicated by this symbol and the word **WARNING** can lead to serious injuries to personnel and even to fatal accidents.

- **Warning signs must always be observed.**

**CAUTION**

Definition of Caution

Non-compliance or inaccurate compliance with working or operating instructions indicated by this symbol and the word **CAUTION** can lead to serious damage to engine or property with grave consequences.

- **Caution signs must always be observed.**
1.5 Intended use

Use on internal combustion engines in general

ABB turbochargers are intended for turbocharging internal combustion engines.

To ensure compliance with the machinery directive 2006/42/EC when using on gas engines, the turbocharger must be operated in an engine room classified as "not at risk of explosion". This is in accordance with the position paper [2] relating to ATEX issued by EUROMOT [1].

For use on pre-mix gas engines with ignitable propellents in the gas control system, the enginebuilder must implement appropriate safety measures for explosion protection [3] (such as flame barriers in the inlet system, for example) to assure that there is no transient pressure increase exceeding a maximum of 12 bar before the turbocharger in case of a deflagration.

The turbocharger supplies the engine with the air volume or air/gas mixture and the associated charging pressure required for operation.

The turbocharger is solely intended to be operated with a clockwise direction of rotation as viewed from the turbine end.

The specific operating limits of the turbocharger were determined on the basis of information from the enginebuilder about the intended use. These data are given on the rating plate.

ABB accepts no liability and rejects all warranty claims for any non-intended uses.

[1] Euromot = The European Association of Internal Combustion Engine Manufacturers

⚠️ WARNING

Unapproved operation

Any operation of the turbocharger outside of its operating limits can be hazardous to personnel.

- Only operate the turbocharger within the operating limits.
- Only trained personnel must operate the turbocharger.

The intended use of the turbocharger includes compliance with all regulations and conditions. In particular, the following must be observed:

- Operation Manual
- Instructions of the enginebuilder
State of the art
The turbocharger is designed and manufactured according to the state of the art and is safe to operate.

Perfect condition
The turbocharger must only be used when it is in a technically flawless condition and operated in compliance with its intended use.

ABB excludes any liability for damage resulting from unauthorized modifications to the turbocharger or improper operation.

1.6 Deflagration on gas engines

ABB turbochargers can tolerate a deflagration with a transient pressure increase of 12 bar.

After a deflagration event ABB Turbo Systems recommends verifying the following points on the turbocharger:

- Position of the turbine and compressor casings to the bearing casing
- Shifting of the bearing casing in relation to the bracket
- Cracks in casings

If during external inspection anomalies are found or if a particularly strong deflagration event has taken place, it is also recommended to check the bearings of the turbochargers before the next start. An ABB Turbocharging Service Station should be instructed to carry out this inspection.
1.7  Warning plates on the turbocharger

Warning plates are attached to the turbocharger, which must be observed. The warning plates must always be present in the intended locations and must be legible.

If warning plates are not present in the intended locations or are not legible, they must be replaced with new warning plates. The necessary information can be found in the Operation Manual, Chapter 4 Product description.

Turbochargers supplied to the enginebuilder without insulation must be equipped later with warning plates on the insulation. This is the responsibility of the enginebuilder.
1.8 Turbocharger rating plate

![Turbocharger rating plate diagram]

Fig. 2: Rating plate

**Operating limits**

01 Turbocharger operating limits at engine overload (110 %). In test rig operation only, unless otherwise agreed with the enginebuilder.

02 Turbocharger operating limits during operation

**Recommended inspection and replacement intervals of turbocharger components**

03 Inspection interval of plain bearings in 1000 h

04 Replacement interval of compressor in 1000 h

05 Replacement interval of turbine in 1000 h

**Further data**

06 Customer part number

07 Designation for special design

08 Weight of turbocharger in kg

09 Turbocharger type

10 Serial number

11 Year of construction of turbocharger

12 Manufacturing plant
Explanations regarding the rating plate

The recommended inspection and replacement intervals and the corresponding operating limits are jointly defined with the enginebuilder. This information is specific to the system.

Operation above the indicated values $n_{\text{Bmax}}$, $t_{\text{Bmax}}$ can considerably shorten the recommended replacement intervals. In such a case, we recommend that you contact the nearest official service station of ABB Turbo Systems.

$n_{\text{Mmax}}$, $t_{\text{Mmax}}$ normally apply only when running at overload (110 %) during trials on the engine test bed. These limit values can also be permitted during operation for special applications. Operation above $n_{\text{Mmax}}$ and $t_{\text{Mmax}}$ is not permitted.

Non-observance of the recommended inspection and replacement intervals increases the risk of unpredictable component failures.

Locations of the rating plates

The locations of the rating plates are defined in the Operation Manual, Chapter 4 Product description.

1.9 Periodic check of the pressure vessels

The pressure vessels used by ABB Turbocharging, such as those for wet or dry cleaning, are so-called "simple pressure vessels".

- The locally applicable legal regulations regarding periodic checks of the pressure vessels must be observed.
- The operating company is responsible for the safe operation of the pressure vessel.

**WARNING**

Danger due to pressure vessels

The operating company must make sure the pressure vessels are in proper working condition and monitor them. Necessary repair or maintenance work must be performed promptly, and the required safety measures must be taken.

- Pressure equipment must not be operated if defects are present.
## 1.10 Lifting of loads

### WARNING

#### Suspended loads

Loads that are not attached according to regulations can cause injury to personnel or fatal accidents.

- Loads must always be fastened to properly functional lifting gear with a sufficient load limit.
- Pay attention to the correct attachment of loads on the crane hook.
- People must not stand beneath suspended loads.

Wear safety gloves to protect against mechanical hazards.

Wear safety helmet.

![attachment of loads on the crane hook](image1)

**Fig. 3**: Attachment of loads on the crane hook

If there are two or more suspension points, the attachment angle of 45° must not be exceeded. This prevents excessive loading due to diagonal pull.

- Before looping around the components of the turbocharger, let them cool down (maximum 80 °C).
- Attach components of the turbocharger as described in the respective action steps.
- Use a suitable edge guard if there are sharp edges.
- The assembly devices must be completely screwed in and must not unscrew during use.
- Use assembly devices only for the described applications.
- Put down dismantled components of the turbocharger in such a way that they cannot tip over.
1.11 Prerequisites for operation and maintenance

Responsibility of the operating company
In awareness of its responsibility, the operating company must ensure that only authorised personnel work on the turbocharger, who:

- Are versed in the general and locally applicable regulations for occupational safety and accident prevention
- Are equipped with the prescribed personal protective equipment
- Have read and understood the Operation Manual
- Have been instructed in the use of the turbocharger.

The safety-conscious work of the personnel and adherence to the Operation Manual must be checked periodically.

Suitable working materials and personal protective equipment must be kept in a perfect condition.

Only authorised personnel may remain in the vicinity of the turbocharger when the engine is running.

Competence of personnel
The turbocharger must only be operated and serviced by trained and authorised personnel. Basic mechanical training is a prerequisite.

Modifications to the turbocharger
Modifications to the turbocharger must be approved by ABB Turbo Systems.

WARNING
Use original parts
Operation of the turbocharger with non-original parts can impair the safety of the turbocharger and can cause serious damage to property and injury to personnel.

- Only use original parts from ABB Turbo Systems.

Original parts and accessories are specially designed by ABB Turbo Systems for the ABB turbochargers.

ABB accepts no liability for any damage resulting from the use of non-original parts and corresponding accessories.
1.12 Hazards during operation and maintenance

Noise hazards

The turbocharger's noise emission during operation is influenced by its installation and operating conditions. A noise level exceeding 85 dB(A) is harmful.

⚠️ WARNING

Danger due to noise

Exposure to noise can harm the hearing system, impair health and the psychological state and may lead to lack of attention and irritation.

- When the engine is running, always wear ear protection.
- Always wear ear protection if the sound pressure level exceeds 85 dB(A).

Wear ear protection.

Hazards due to hot surfaces

Surfaces of the turbocharger, attached parts and operating fluids (lubricating oil) get hot during operation. The surface temperature depends on the efficacy of the existing insulation. The temperature may rise to a level that can cause burns.

⚠️ WARNING

Danger of burns

Touching hot surfaces or contact with hot operating fluids can cause burns.

- Do not touch hot surfaces. Observe the warning plate on the turbocharger.
- Wear heat-resistant safety gloves and protective clothing.
- Wait for the turbocharger to cool down before carrying out any work.

Wear safety gloves to protect against thermal hazards.
1.12 Hazards during operation and maintenance

**WARNING**

**Hot surfaces on the non-insulated turbocharger**

Non-insulated turbochargers can cause serious injuries to personnel (burns).

The turbocharger is supplied with or without insulation in accordance with the purchase order received from the enginebuilder. If supply is without insulation, the enginebuilder is responsible for providing the turbocharger with proper insulation and for providing protection against contact with hot surfaces.

- Compliance with the instructions and specifications given by the enginebuilder to protect against hot turbocharger surfaces is compulsory.

Wear safety gloves to protect against thermal hazards.

**Hazards due to rotating parts**

**WARNING**

**Physical hazards**

Contact with rotating parts can cause severe injury. The turbocharger must never be used without the filter silencer or the air suction branch. With the engine stopped, the rotor can rotate due to the stack draught alone.

- Operate the turbocharger in compliance with the specifications.
- Secure the rotor against unintentional rotation during maintenance.

Wear safety gloves to protect against mechanical hazards.

**Hazards due to electrical installations (if present)**

**WARNING**

**Dangers during work on electrical installations**

Electrical installations use voltages that can lead to severe injury to personnel or accidents resulting in fatalities.

At the same time, electrical or electronic components and parts can also be damaged or destroyed.

- Only specially trained personnel should perform work on, or with, electrical components.
- Observe national regulations.
1.13 Safe operation

Mechanical hazards during operation
During standard operation, no mechanical hazards are caused by the turbocharger itself if it has been properly installed.

Safety during commissioning and operation

- Visually inspect your working environment before starting work.
- Remove any obstacles and objects littering the workplace.
- Check all pipes to and from the turbocharger for damage and leaks before commissioning.
- Check turbocharger for recognisable damage or defects every 12 hours of operation or at least once a day.
- Report any damage and any alterations of operational characteristics to the responsible department immediately.
- In case of damage, take the turbocharger out of operation immediately and safeguard against accidental/unauthorised use.
- When switching on operating energy supplies (hydraulics, pneumatics, electricity), pay attention to the risks that may occur as a consequence of this energy input.

**WARNING**

Absence of grounding on electrical installations
Missing or incorrectly fitted grounding conductors can lead to severe injury to personnel or accidents resulting in fatalities.
Electric shock or elevated electromagnetic disturbances can damage or destroy electrical and electronic components.

- Ground electrical installations properly with grounding conductors.
- Check the grounding connections on a regular basis and make sure they are properly connected.

- Switch off the power supply before working on any electrical installations.
- After switching off the power supply, wait for 5 minutes to allow capacitors to discharge and hot components to cool down.
- Ensure the power supply is switched off when working on electrical installations.
- Do not carry out any tests with regard to insulation resistance or voltage on the electrical components.
WARNING

Burst protection and insulation

Operation without burst protection and insulation or with the wrong combination of burst protection and insulation can cause serious injuries to persons or even fatal accidents.

- Only operate the turbocharger with burst protection fitted and insulation fitted in one of the following, permitted variants.

![Fig. 5](image)

**Variant A**  Insulation (01) with integrated burst protection from ABB Turbo Systems.

**Variant B**  Burst protection (03) and insulation (02) from ABB Turbo Systems.

**Variant C**  Burst protection (03) from ABB Turbo Systems with appropriate insulation from the enginebuilder.
1.14 Safe maintenance

Occupational safety

**WARNING**

**Injuries to persons**

Severe injuries to personnel or fatal accidents can be caused by mechanical influences as a consequence of hazardous and inadequate operational procedures or non-compliance with safety and health standards.

- When working on the turbocharger always wear safety footwear and protective clothing to protect against mechanical hazards.
- Keep personal protective equipment in perfect condition.
- Obey mandatory signs.
- Observe the general rules for occupational safety and prevention of accidents.
- Only perform operations that are described in this manual.
- Only perform operations for which you have received instruction or training.

Wear safety footwear to protect against mechanical hazard and risk of falling.

Wear protective clothing.

**WARNING**

**Risk of falling**

When working on the turbocharger, there is a risk of falling.

- Do not climb onto the turbocharger or onto attached parts and do not use them as climbing aids.
- Use suitable climbing aids and working platforms for work above body height.

- Comply with the general accident prevention regulations.
- Only perform work on the turbocharger when you are in a physically and psychologically stable condition.
- Only work with suitable tools, equipment and appliances that function properly.
- Power tools must be grounded and cables must be undamaged.
- Keep the workplace clean, clear away any loose objects and obstacles on the floor.
- Keep the floor, equipment, and turbocharger clean.
- Have oil binding agents ready and provide or keep oil pans at hand.
- Clean up any spills.
- Have fire protection means and extinguishing agents available.
Welding work in the vicinity of the turbocharger

- When performing welding work in the vicinity of the turbocharger, always cover the filter silencer to prevent the filter mat from being damaged.
- Keep flammable objects and substances out of the vicinity of flying sparks.
- Cover all connections on the turbocharger so that no foreign objects can enter the turbocharger.
- Wear personal protective equipment (PPE) for welding operations.

Safety during cleaning

If cleaning agents or solvents are used for cleaning, the corresponding material safety data sheet and the safety instructions in section Hazards due to operating materials and supplies must be observed.

- Observe the material safety data sheet for the cleaning agent or solvent.
- Wear personal protective equipment (PPE) according to the material safety data sheet.
- Inspect the electric cables for abrasion and damage before and after your cleaning work.

Safety during disassembly, assembly, maintenance and repair

- Observe the procedures for set-up, service and inspection work and the inspection intervals.
- Inform the operating staff before starting any service or repair work. Make sure the engine is not started while work is being conducted on the turbocharger.
- Before taking off any cover or removing any guard from the turbocharger, switch off the engine and wait until the turbocharger has come to a standstill.
- Make sure that the oil supply is interrupted, especially with an external oil supply.
- Only restart the engine after all parts have been properly fitted again and oil supply is ensured.

**CAUTION**

Mechanical operations on the turbocharger

Components of the turbocharger can be damaged or destroyed as a result of improper procedures.

- Only perform operations that are described in this manual.
- Only perform operations for which you have received instruction or training.

Safety when taking out of operation or preparing for mothballing

- Secure rotor against turning. The rotor can rotate due to the stack draught alone.
- Observe the material safety data sheet for the cleaning and mothballing agents.
- Wear personal protective equipment (PPE) according to the material safety data sheet.
Mechanical hazards when working on the turbocharger

**WARNING**

**Physical hazards due to rotating parts**
The rotor can rotate due to the stack draught alone. Contact with rotating parts can cause severe injury.
- Secure rotor against turning.

**WARNING**

**Mechanical hazards**
Severe injuries to personnel or fatal accidents can be caused by mechanical influences as a consequence of hazardous and inadequate operational procedures.
- Observe the general rules for occupational safety and prevention of accidents.
- Ensure workplace safety.
- Only perform operations that are described in this chapter.
- Only perform operations for which you have previously received instruction or training.

Hazards due to operating materials and supplies
Operating materials and supplies are substances required for the operation of the turbocharger or for the performance of maintenance work. Oils, greases, coolants, detergents and solvents, acids and similar substances can be classified as hazardous substances.

**WARNING**

**Handling operating materials and supplies**
Swallowing or inhaling vapours of operating materials and supplies or contact with them may be harmful to health.
- Do not breathe in these substances and avoid contact with the skin.
- Ensure proper ventilation.
- Observe the information in the material safety data sheet for the operating materials and supplies.
- Wear personal protective equipment (PPE) according to the material safety data sheet.
- Comply with local legislation.

- Wear safety goggles.
- Wear safety gloves to protect against chemical hazards.
- Wear a respiratory mask to protect against gases.
**WARNING**

**Danger of fire or explosion**

Flammable and combustible operating materials and supplies can catch fire or resulting vapours can lead to an explosion.

- Observe the information in the material safety data sheet for the operating materials and supplies.
- Comply with local legislation.
- Do not allow any exposed flame or ignition source during cleaning work.
- Carry out cleaning in the open or provide sufficient ventilation.

**CAUTION**

**Environmental hazard**

Improper handling of operating materials and supplies can lead to environmental damage.

- Observe the information in the material safety data sheet for the operating materials and supplies.
- Comply with local legislation.

**Hazards due to the handling of insulation materials**

**WARNING**

**Danger from insulation materials**

Dust or fibres from insulation materials can have adverse effects on the health or cause irritations. Unsuitable and combustible insulation materials are a fire hazard.

- Only use suitable and non-combustible insulation materials.
- Ensure good ventilation at the workplace.
- Avoid whirling up dust.
- Use dust-free tools and working methods.
- Remove package at the workplace only.
- Proceed with particular care when removing old insulation materials.
- Dispose of insulation materials properly and in an environmentally compatible manner in compliance with the legal regulations.

Wear safety goggles.

Wear a respiratory mask to protect against dusts.

Wear safety gloves to protect against chemical hazards.
# Safety data sheet

**A135-H56**

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<th>HT587285</th>
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Application according to the Operation Manual

Made in Switzerland
# Product description

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1 Introduction

1.1 Essential information

Design variants
This document is valid for different design variants of turbochargers. There may be sections and descriptions of components that are not relevant for a specific turbocharger variant.

Please contact an ABB Turbocharging Service Station if you have any questions regarding a design variant (see Contact information at www.abb.com/turbocharging).

Accuracy of illustrations
The illustrations in this document are general in nature and intended for ease of understanding. Differences in detail are therefore possible.

1.2 Registered trademarks
The trademarks of outside companies are used in this document. These are marked with the ® symbol.

1.3 Related documents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Document number</th>
</tr>
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<td>Operation Manual / 1 Introduction</td>
<td>HZTL4005</td>
</tr>
<tr>
<td>Operation Manual / 2 Safety</td>
<td>HZTL4022</td>
</tr>
<tr>
<td>Operation Manual / 3 Safety data sheet *)</td>
<td>Serial number of the turbocharger</td>
</tr>
</tbody>
</table>

Table 1: Related documents

*) This chapter is only available in serialised operation manuals.
1.4 **Layout and function of the turbocharger**

Fig. 1: Layout and function of the turbocharger

- 01 Air suction branch
- 02 Compressor casing
- 03 Diffuser
- 04 Bearing casing
- 05 Axial thrust bearing
- 06 Radial plain bearing
- 07 Turbine
- 08 Gas outlet flange
- 09 Nozzle ring
- 10 Turbine casing
- 11 Turbine-end bearing flange
- 12 Compressor-end bearing flange
- 13 Compressor wheel
Mode of operation

The turbocharger is a turbomachine and consists of the following main components:

- Turbine
- Compressor.

The exhaust gases of the internal combustion engine flow through the turbine casing (10) and the nozzle ring (09) onto the turbine (07). The turbine (07) uses the energy contained in the exhaust gas to drive the rotor and, hence, the compressor wheel (13). The exhaust gases then reach the atmosphere through the exhaust gas pipe connected to the gas outlet flange (08).

The compressor wheel (13) sucks in fresh air through the air suction branch (01). In the compressor wheel (13), the energy required for building up the pressure is transferred to the air. By flowing through the diffuser (03) and the compressor casing (02), the air is compressed further and is then directed to the engine cylinders.

The rotor runs in two radial plain bearings (06) which are located in the bearing casing (04) between compressor and turbine. The axial thrust bearing (05) is located between the two radial plain bearings.

The plain bearings are connected to a central lubricating oil duct which is normally supplied by the lubricating oil circuit of the engine. The oil outlet always lies at the deepest point of the bearing casing (04).

1.4.1 Function of the compressor wheel cooling

Depending on the application of an A100 radial turbocharger, the turbocharger is equipped with compressor wheel cooling. With compressor wheel cooling, after the compressor air has cooled down by passing through the charge air cooler on the engine side, it is supplied to the turbocharger for cooling the compressor wheel. Cooling of the compressor wheel is compulsory to ensure the reliability and replacement intervals for the relevant operating conditions. In the turbocharger version with compressor wheel cooling, the cooling air is supplied through a lateral connection in the bearing casing (01).

In addition, the turbocharger version with compressor wheel cooling is indicated by the turbocharger type (H6..) on the rating plate.
1.5 Warning plates on the turbocharger

Warning plates are affixed at the following locations:

Fig. 3: Warning plate locations

If warning plates are not present in the designated locations or not readable, proceed as follows:

- Order new warning plates from ABB Turbocharging Service Stations.
- Remove any warning plates that have become unreadable.
- Clean and degrease the areas designated for the warning plates.
- Fit new warning plates and remove protective sheets.

Turbochargers supplied to the enginebuilder without insulation must be equipped later with warning plates on the insulation. This is the responsibility of the enginebuilder.
1.6 Locations of the rating plates

One rating plate (01) each is attached on the left and the right side of the turbocharger bearing casing.

Fig. 4: Locations of the rating plates
2 Removing and Installing

2.1 Turbocharger weight and transportation

Lifting gear with a sufficient load limit must be used for removing and installing the turbocharger. The following weight specification applies to the heaviest variant possible. Depending on the specification, the weight specified on the rating plate may be lower than the standard value specified here.

<table>
<thead>
<tr>
<th>Product</th>
<th>Weights [kg]</th>
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<tbody>
<tr>
<td>A130-H</td>
<td>190</td>
</tr>
<tr>
<td>A135-H</td>
<td>270</td>
</tr>
<tr>
<td>A140-H</td>
<td>460</td>
</tr>
</tbody>
</table>

Table 2: Weights of turbochargers A130-H.. – A140-H..

Fig. 5: Suspension of complete turbocharger unit
### 2.2 Removing the turbocharger

- Disconnect all pipes according to the instructions of the enginebuilder.
- If present: Loosen and remove the compressor wheel cooling connection. Close the compressor wheel cooling opening with a screw plug (01).

![Fig. 6: Removing the turbocharger](image)

- Apply penetrating oil to thread of stud (02) and nut and let it work in.
- If present: Disconnect the plug to the speed sensor (86505) and secure the rolled-up cable on the turbocharger. This protects the plug from being crushed.
- If present: Detach the support (61301) from the engine support.

Depending on the bracket version (04), two positioning pins (05) can be used for positioning and safeguarding against wrong fitting of the turbocharger. Therefore the turbocharger must always be removed from and installed on the bracket vertically.

The gas outlet casing (61001) can remain fitted in the exhaust gas pipe if the locking nuts are accessible. Otherwise the complete turbocharger unit including gas outlet casing must be removed.
2.2.1 **Fastening of the turbocharger**

**WARNING**

Risk of scalding from hot water

If the water connections are removed immediately after taking the turbocharger out of operation, the hot cooling water that flows out can cause scalding if it comes into contact with the skin.

- Allow turbocharger to cool down before removing the water pipes.
- Wear safety gloves to protect against thermal hazards.

**CAUTION**

Freezing of the cooling water in the bearing casing

Serious damage to property can be the consequence if the cooling water freezes in the pipes and in the bearing casing.

- For transport and storage of the turbocharger, drain the cooling water in the bearing casing via two openings of the water connections.

### Manual loosening

To remove the turbocharger from the bracket, proceed as follows:

- Loosen and remove water connections. Close the openings of the water connections with screw plugs.
- Attach lifting gear to the suspension eye.
- Loosen and remove nuts (C).

### Hydraulic loosening (round special nut)

If the turbocharger was fitted by the enginebuilder using a hydraulic tool, disassembly is also done using a hydraulic tool (see instructions of the enginebuilder).

When doing this, proceed as follows:

- Attach lifting gear to the suspension eye.
- Remove the turbocharger.
- Cover the oil connections (03) at the engine side to protect against contamination.
2.2.2 Loosening the clamping nut

**CAUTION**

Incorrect procedure can make loosening impossible

Never relieve individual pressure screws completely. If this procedure is not complied with, the pressure screws can get compressed, thus making it impossible to loosen them.

- Comply with the following steps for loosening the pressure screws.

**CAUTION**

Do not clean pressure screws

The pressure screws are equipped with a permanent sliding layer that must not be removed.

Do neither clean nor lubricate the pressure screws. In case of non-compliance, it cannot be ensured that the necessary tension force is reached.

- Do not clean pressure screws.
- Do not lubricate pressure screws.

---

Fig. 7: Loosening the clamping nuts

- Break loose each of the pressure screws and rotate them back immediately.
- Working in a circle, repeat the previous step until all of the screws have been relieved.
- Loosen clamping nut by hand.
2.2.3 Positioning the turbocharger for storage

**WARNING**

Risk of tipping

If the turbocharger is not positioned stably, it may tip over. This can result in serious personal injury.

- Place the turbocharger on a clean, level support.
- Secure the turbocharger to prevent it from tipping over by using wooden beams and wedges and by taking the centre of gravity into account.

![Fig. 8: Putting down the turbocharger](image)

- Remove turbocharger from engine support, set it down properly in an appropriate place and secure it.
- Close or cover the openings of the turbocharger and support.
2.3 Installing the turbocharger

2.3.1 Inserting gaskets

**CAUTION**

Inserting the gaskets

Gaskets that are forgotten, damaged or improperly inserted will lead to oil leaks.

- Always use new gaskets and insert them carefully into the slot.

The oil is supplied (02) and drained (03) through the bracket (01).

The necessary sealing is provided by O-rings. The O-rings are not included in the ABB Turbo Systems scope of delivery.

![Diagram](image)

Fig. 9: Inserting gaskets into the bracket

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td>Bracket</td>
<td>04</td>
<td>Slot for O-ring</td>
</tr>
<tr>
<td>02</td>
<td>Oil supply</td>
<td>05</td>
<td>O-rings</td>
</tr>
<tr>
<td>03</td>
<td>Oil drain</td>
<td>06</td>
<td>Pin (optional)</td>
</tr>
</tbody>
</table>

Pin (06) as installation safety device

Turbochargers can have an oil inlet either on their right or left side; the oil inlet position can be different for the turbocharger fitted on the left and on the right engine bank.

A pin can be installed in every support as an installation safety device to prevent inadvertent incorrect fitting. This pin fits into the respective slot on the foot of the bearing casing. Instructions of the enginebuilder must be observed.
2.3.2 Fitting threaded rods

1. Lightly oil the surfaces of the threaded rods (02) to be screwed in.
2. Screw the threaded rods into the bracket with the aid of locknuts (01).
3. Remove nuts (01) again.

Requirements for the threaded rods

<table>
<thead>
<tr>
<th>Product</th>
<th>Diameter Threaded rod [mm]</th>
<th>Material DIN / ISO 898 (Part 1)</th>
<th>Thread length L1 [mm]</th>
<th>Length of threaded rod L2 [mm]</th>
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<tr>
<td>A130</td>
<td>Ø 16 / M16</td>
<td>10.9 / 12.9</td>
<td>≥ 30</td>
<td>250</td>
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<td>A135</td>
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<td>≥ 30</td>
<td>325</td>
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<tr>
<td>A140</td>
<td>Ø 24 / M24</td>
<td>10.9 / 12.9</td>
<td>≥ 70</td>
<td>410 ... 420</td>
</tr>
</tbody>
</table>

Table 3: Requirements for threaded rods

Fastening material, scope of delivery

The threaded rods and nuts for fastening the turbocharger on the bracket are not included in the ABB Turbo Systems scope of delivery.

The clamping nuts are included in the ABB Turbo Systems scope of delivery.
2.3.3 Placing the turbocharger on the bracket

1. Make sure that the O-rings (03) are undamaged and positioned correctly in the slots.
2. Clean the expansion bushes (42190) and the contact surfaces of the expansion bushes in the bearing casing.
3. Attach the lifting gear to the suspension eye of the bearing casing (42001) and loop around the gas outlet casing.
4. Position the turbocharger on the bracket (04) and align it. If present, pay attention to the positioning pin (05) in the bracket.
5. When fixing with a standard nut (C), fit the expansion bushes in the correct position in the slot.

**Safeguard against wrong fitting (only for water-cooled bearing casings)**

Depending on the bracket version (04), two positioning pins (05) can be used for positioning and safeguarding against wrong fitting of the turbocharger. Therefore the turbocharger must always be removed from and installed on the bracket vertically.
Observe the instructions for the fastening variant at hand.
- Fastening the turbocharger with a standard nut \(\rightarrow16\) (A130 - A140)
- Fastening the turbocharger with a clamping nut \(\rightarrow17\) (A140 only)

### 2.3.4 Fastening the turbocharger with a standard nut

Fit the nuts and tighten them according to variant 1 or 2 in the table below.

**When the turbocharger is mounted on the engine support, the bolt threads and screw heads must be lightly oiled (assumed friction coefficient \(\mu = 0.12\) for tightening torque)**

<table>
<thead>
<tr>
<th>Product</th>
<th>Through hole in bearing casing [mm]</th>
<th>Fixing screws [mm]</th>
<th>Variant 1: Tightening torques [Nm] **)</th>
<th>Variant 2: Hydraulic pretensioning forces [kN]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A130</td>
<td>Ø 17</td>
<td>M16</td>
<td>280</td>
<td>110</td>
</tr>
<tr>
<td>A135</td>
<td>Ø 21</td>
<td>M20</td>
<td>560</td>
<td>175</td>
</tr>
<tr>
<td>A140</td>
<td>Ø 25</td>
<td>M24</td>
<td>960</td>
<td>250</td>
</tr>
</tbody>
</table>

Table 4: Tightening torques for standard nuts

- Remove the lifting gear.
2.3.5 Fastening the turbocharger with a clamping nut

Preparations for tightening the clamping nut

⚠️ CAUTION

Do not clean pressure screws (04)
The pressure screws are equipped with a permanent sliding layer that must not be removed.

Do neither clean nor lubricate the pressure screws. In case of non-compliance, it cannot be ensured that the necessary tension force is reached.

- Do not clean pressure screws.
- Do not lubricate pressure screws.

In order to correctly fit the clamping nuts, the pressure screws (04) must not protrude from the clamping nuts (03) in the direction of the thrust washer (02).

- Make sure the pressure screws do not protrude in the direction of the thrust washer.

Fig. 13: Preparing the clamping nut for the tightening procedure

1. Check whether the expansion bushes (42190) with recess are correctly positioned and do not touch the flange of the core hole cover (A).
2. Clean the thread of the bolt (01) and the contact surface.
3. Lightly oil the bolt thread.
4. Position the thrust washer (02) in place.
5. Tighten clamping nut (03) by hand.
6. Unscrew clamping nut (03) by ¼ of a turn (90°).

The distance between the thrust washer and the clamping nut is now about 1 mm.
2.3 Installing the turbocharger

Tightening pressure screws

Fig. 14: Tightening pressure screws

<table>
<thead>
<tr>
<th>Torque-controlled tightening</th>
</tr>
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<tbody>
<tr>
<td>Product</td>
</tr>
<tr>
<td>A140</td>
</tr>
</tbody>
</table>

Table 5: Pressure screw tightening torque

1. Screw in pressure screws crosswise by hand until reaching the stop.
2. Tighten pressure screws crosswise to 50% of the tightening torque specified in the table.
3. Tighten pressure screws crosswise to 100% of the tightening torque specified in the table.
4. Work in a circle to tighten all pressure screws to 100% of the tightening torque specified in the table.
5. Tighten pressure screws to 100% in 5 … 7 rounds until the required residual tightening angle of < 20° is achieved.
2.3.6 Connecting the turbocharger

- Connect the cable to the speed sensor (86515).
- Connect all exhaust gas, water and air lines according to the instructions of the engine builder.

Version with compressor wheel cooling

**CAUTION**

Failure of compressor wheel cooling

Any prolonged failure of the compressor wheel cooling will shorten the replacement interval of the compressor wheel.

- Make sure there is an uninterrupted supply of cooling air during operation.

![Fig. 15: Connecting the compressor cooling air intake](image)

- Remove the screw plug on the connection for the compressor wheel cooling (06) and fit the cooling air line.

2.3.7 Attaching the support

![Fig. 16: Attaching the support](image)

- If present: Attach support (61301) to engine support or to a connecting piece.
3 Commissioning

3.1 Oil supply

3.1.1 Introduction

In all operating states, a functioning and carefully executed oil supply is an important prerequisite for trouble-free operation of the turbocharger.

The lubrication of the turbocharger is usually carried out with oil from the engine oil circulation.

- Comply with the enginebuilder's specifications regarding the selection of lubricating oil and the oil change intervals.

3.1.2 Oil filtering

Filtering the lubricating oil with a filter mesh width of $\leq 0.034 \text{ mm}$ is sufficient for this turbocharger.

3.1.3 Oil pressure

Comply precisely with the oil pressure before the turbocharger for trouble-free operation. Different oil pressures must be taken into account here for different operating states, such as, for example, idling mode and when the engine is started.

The admissible values are specified in chapter Monitoring operation →25.

3.1.4 Starting the engine for the first time after a turbocharger or engine overhaul

When starting the engine for the first time after a turbocharger or engine overhaul, proceed as follows:

- Switch on the oil pump.
- Build up oil pressure (see Table 6: Lubricating oil pressure at oil inlet before turbocharger →25).
- Do not exceed a pre-lubrication time of 2 minutes.
- Start the engine.
- Let the oil pump run until the pump driven by the engine generates sufficient pressure.
3.1.5 Oil orifice in the bearing casing

With an oil inlet pressure of more than 3 bar of overpressure (with engine under load) upstream of the turbocharger, the bearing casings are equipped with an orifice at the oil inlet as standard.

Fig. 17: Oil orifice

| 01 | Bearing casing |
| 02 | Oil orifice    |
| 03 | Circlip       |

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3.2 Inspection procedures

3.2.1 Introduction

Inspection procedures include preventative visual controls, monitoring and measuring work before and during commissioning. Inspection procedures enable changes to the turbocharger to be detected. Machine damage can be prevented.

3.2.2 Checks before commissioning

Filter mat (if available)

► Check for damage and contamination.

Lubricating system

⚠️ CAUTION

Contaminated oil

Serious damage to engine or property can be caused by dirt and solid material particles in the oil.

► For the initial commissioning phase and after all service work, flush the complete lubricating system with warm oil.
► Use special running-in filters when running in the engine and after all service work on the lubricating system.

► Check that the oil filter is clean before commissioning.
► Check the oil pressure in the oil supply pipes.

Warning plates

► Check whether warning plates are present and legible.
► Check whether the protective sheets have been removed from new warning plates.

Version with compressor wheel cooling:

⚠️ CAUTION

Failure of compressor wheel cooling

Any prolonged failure of the compressor wheel cooling will shorten the replacement interval of the compressor wheel.

► Make sure there is an uninterrupted supply of cooling air during operation.

► Check whether the compressor wheel cooling is fitted on the bearing casing.
Version with water-cooled bearing casing

**CAUTION**

Failure of bearing casing cooling

Any prolonged failure of the water cooling will shorten the lifetime of the turbocharger.
- Make sure that an uninterrupted supply of cooling water is provided during operation.

- Check whether the water pipes are fitted on the bearing casing.

### 3.2.3 Checks after commissioning (engine in idle mode)

**Lubricating system**
- Keep to the lubricating oil pressure at the inlet.
- Keep to the lubricating oil temperature at the inlet.
- Refer to chapter Monitoring operation →25 for admissible values.

**Leaktightness of pipes**

**WARNING**

Risk of burning from hot gas

Escaping gases are hot and will lead to serious burns in the event of contact.
- Check all pipes for leaks in accordance with the enginebuilder's instructions.

### 3.2.4 Checks when starting up the engine

If present:
- Measure speed, oil pressure and charging pressure at various engine performances.
- Measure the exhaust gas temperature before and after the turbine.
- Measure the air temperature before and after the compressor.
- Compare the measured values with the values of the acceptance report. Different operating conditions indicate a malfunction (see chapter Eliminating malfunctions →51).

Lubricants and pastes used during assembly can liquefy or vaporise and escape as oily fluids during the initial hours of operation. Continual escape of an oily fluid indicates an oil leak. If there is a leak, contact an ABB Turbocharging Service Station.
3.3 Commissioning after taking out of operation

If present

- Remove cover plates (blind flanges) from the compressor casing, the gas inlet and the gas outlet.
- Remove the screw plugs on the water connections and fit the water pipe.

Version with compressor wheel cooling:

- Remove the screw plug on the cooling air connection and fit the cooling air line.

General

- Check the exhaust gas pipe before and after the turbine for combustion residues or water residues and clean it. Remove any foreign objects that may be present.
- Check and clean filter silencer or air supply line, and remove any foreign objects that may be present.
- Put engine-side oil circulation to the turbocharger into operation.
- Prepare the turbocharger for operation (see Checks before commissioning →22).
- The turbocharger is now ready for operation.
4 Monitoring operation

4.1 Oil pressure, oil temperature

Lubricating oil pressure, oil inlet

To limit the oil flow rate through the turbocharger to the admissible values with the engine at full load, an oil orifice is mandatory or already fitted at the turbocharger oil inlet if the oil inlet pressure is > 3 bar.

**CAUTION**

Assuring lubricating oil pressure

Serious damage to the engine or property can result from a missing or insufficient lubricating oil supply.

- The lubricating oil pressure must be monitored during operation and the necessary pressure assured at the oil inlet.

<table>
<thead>
<tr>
<th>Status for operation</th>
<th>Pressure at oil inlet upstream of the turbocharger [bar]</th>
<th>Overpressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal operation</td>
<td>2.0 &lt; p_{oil} ≤ 4.5</td>
<td></td>
</tr>
<tr>
<td>Engine start: Cold oil, admissible for a maximum of 15 minutes</td>
<td>&lt; 8.0</td>
<td></td>
</tr>
<tr>
<td>Engine idling, admissible for a maximum of 1 hour</td>
<td>0.5 &lt; p_{oil} ≤ 2.5</td>
<td></td>
</tr>
<tr>
<td>Pre-lubrication and post-lubrication (engine stopped)</td>
<td>0.5 &lt; p_{oil} ≤ 1.0</td>
<td></td>
</tr>
<tr>
<td>Warning signal: (n ≥ 0.5 x n_{max})</td>
<td>&lt; 1.25</td>
<td></td>
</tr>
<tr>
<td>Alarm signal: Not admissible. Stop the engine immediately.</td>
<td>&lt; 0.5</td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Lubricating oil pressure at oil inlet before turbocharger

For monitoring the lubricating oil pressure, ABB Turbo Systems recommends installing a "P" manometer immediately upstream of the turbocharger oil inlet before the orifice. If the pressure is controlled electronically, the relevant signals should be triggered at the warning and alarm values.

*) If the drain pipe is vented, the lubricating oil temperature measuring point can be installed at the outlet in the vent tank. Otherwise the measurement should be taken in the drain pipe as close to the turbocharger as possible.
Lubricating oil temperature at the inlet

**CAUTION**

**Machine damage**

If the oil temperature at the oil inlet exceeds the admissible range, this may lead to engine damage.

- Observe oil temperature at the oil inlet according to the following table.

<table>
<thead>
<tr>
<th>Status for operation</th>
<th>Oil temperature at the inlet $T_{o\text{il,inlet}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admissible</td>
<td>$30 \ldots 105$ °C</td>
</tr>
<tr>
<td>Temporarily admissible (&lt; 1 h) → alarm</td>
<td>$&gt; 105$ °C</td>
</tr>
<tr>
<td>Not admissible → stop engine</td>
<td>$&gt; 110$ °C</td>
</tr>
<tr>
<td>Not admissible → do not start engine (before start: preheat oil)</td>
<td>$&lt; 30$ °C</td>
</tr>
</tbody>
</table>

Table 7: Lubricating oil temperature at the inlet

Lubricating oil temperature at the outlet

The oil temperature at the outlet is mainly dependant on:
- Lubricating oil temperature and pressure at the oil inlet
- Engine load and turbocharger speed
- Exhaust gas temperature

The maximum admissible oil temperature at the outlet is listed in the following table. The specified oil outlet temperature is to be considered as alarm value for the turbocharger operation and must be monitored according to the current regulations.

<table>
<thead>
<tr>
<th>Status for operation</th>
<th>Oil temperature at the outlet $T_{o\text{il,outlet}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admissible</td>
<td>$\leq 160$ °C</td>
</tr>
<tr>
<td>Temporarily admissible → alarm</td>
<td>$&gt; 160$ °C</td>
</tr>
<tr>
<td>Not admissible → stop engine</td>
<td>$&gt; 180$ °C</td>
</tr>
<tr>
<td>Admissible</td>
<td>$\leq T_{o\text{il,inlet}} + 55$ K</td>
</tr>
<tr>
<td>Temporarily admissible → alarm</td>
<td>$&gt; T_{o\text{il,inlet}} + 55$ K</td>
</tr>
</tbody>
</table>

Table 8: Lubricating oil temperature at the outlet

If the turbocharger was operated for a longer period of time outside of the admissible range, ABB Turbo Systems recommends to have the turbocharger inspected by an ABB Turbocharging Service Station.
4.2 Exhaust gas temperature before turbine

⚠ CAUTION

Factors influencing replacement intervals
Operation above the operating limits defined on the rating plate can shorten the recommended replacement intervals considerably.
- Measure exhaust gas temperature upstream of turbine.
- Comply with operating limits on rating plate.

- Definition and explanations concerning rating plate: refer to chapter 2 of Operation Manual / Safety.
- Operating limits: refer to chapter 3 of Operation Manual / Safety data sheet or examine rating plate.
4.3 Turbocharger speed

4.3.1 Introduction

A speed measuring system enables the constant monitoring of the turbocharger speed.

⚠️ CAUTION

Do not strain cables
If you pull the speed measurement cables too hard, contacts can be pulled out.
► Do not strain the speed measurement cables by pulling.

4.3.2 Layout and overview

Fig. 18: Layout and overview of speed measurement system

- 86505 Speed sensor
- 86515 Cable connector
- 86526 F/I converter
- 86528 Tachometer
- 32109 Sealing disc with cams
- 42188 Screw plug
- 42189 Gasket
- 01 Plug with integrated voltage limiter
- *) Installation variant for speed sensor
4.3.3 **Speed differences with several turbochargers per engine**

The speeds of all turbochargers on an engine vary only slightly from each other in standard operation.

The difference between the highest and the lowest turbocharger speed must not be more than 3 %, relative to the speed limit \( n_{B\max} \).

If this permissible range of difference is exceeded, the following steps must be carried out:

- Reduce the engine performance immediately to the point at which the maximum turbocharger speed does not exceed 70 % of \( n_{B\max} \).
- If the engine cannot be stopped, it can continue to be driven at this reduced engine load or turbocharger speed.
- If a turbocharger surges continuously, the engine performance must be reduced further.
- Measure the temperatures in the air lines and gas piping from and to the turbochargers and compare with normal values. If clear deviations of temperature are found, the nearest ABB Turbocharging Service Station has to be contacted.
- Check the pressure loss of the alternative air inlet and compare it with normal values.

If the engine can be stopped temporarily:

- Inspect air lines, gas piping and the turbochargers and remedy any malfunctions.
- In any case, contacting the nearest ABB Turbocharging Service Station is recommended.

4.3.4 **Malfunctions on the speed measurement system**

In the case of malfunctions of the speed measurement system, refer to the chapter entitled Troubleshooting/Speed measurement system →57.
4.3.5 Replacing the speed sensor

**WARNING**

Hot speed sensor
Danger of burns. The speed sensor can reach temperatures of more than 100 °C during operation.

- Wear safety gloves when disassembling the speed sensor.

Wear safety gloves to protect against thermal hazards.

The speed sensor supplied by ABB is equipped with a sealing lip and an O-ring. No additional gasket is required during assembly.

![Fig. 19: Replacing the speed sensor](image)

<table>
<thead>
<tr>
<th>Part number</th>
<th>A130</th>
<th>A135</th>
<th>A140</th>
</tr>
</thead>
<tbody>
<tr>
<td>86505</td>
<td>M12 x 1.5</td>
<td>15 Nm</td>
<td>M12 x 1.5</td>
</tr>
</tbody>
</table>

Table 9: Tightening torque (86505)

- Reduce the engine performance to idling and then stop the engine. Pay attention to post-lubrication ([Stopping the engine →39](#)).
- Switch off the lubricating oil supply to the turbocharger.
- Disconnect cable connector (86515) from speed sensor (86505).
- Unscrew and remove defective speed sensor (86505).
- Screw in new speed sensor (86505) as far as it will go and tighten.
- Connect cable connector (86515) to speed sensor (86505).
- Switch on lubricating oil supply to the turbocharger.
5 Operation and service

5.1 Noise emission

⚠️ WARNING

Danger due to noise

Exposure to noise can harm the hearing system, impair health and the psychological state and may lead to lack of attention and irritation.

► When the engine is running, always wear ear protection.
► Always wear ear protection if the sound pressure level exceeds 85 dB(A).

Wear ear protection.

The emission sound pressure level (A-weighted) is measured at a distance of 1 meter from the turbocharger.

The highest value of the emission sound pressure level\(^1\) reaches a maximum of 105 dB(A) near the filter silencer. The following prerequisites must be fulfilled with regard to the turbocharger to observe this limit value:

- Air-inlet system has been fitted
- All standard, noise-reducing measures\(^2\) have been fitted
- Bellows at the air outlet has been acoustically insulated by the enginebuilder (see Fig. 20: Noise insulation, bellows → 32).

The enginebuilder is responsible for insulating the charge air/scavenging air line and the charge air cooler.

1) Directive 2006/42/EC, 1.7.4.2 / u / Paragraphs 5 + 7: A-weighted emission sound pressure level
2) The enginebuilder must provide acoustically equivalent measures in case of deviating insulation versions
Suggestion for noise insulation, bellows

Fig. 20: Noise insulation, bellows

01  Compressor casing
02  Bellows
03  Charge air duct / scavenging air duct
04  Insulation cushion
05  Insulation mat (at least 15 mm)
06  Sheet metal cover
5.2 Service work

Service work includes visual controls, monitoring, measuring and inspection as well as functional checks. Service work enables the detection and rectification of changes to the turbocharger and ensures full operability of the turbocharger.

⚠️ CAUTION

Service intervals

Any service work on the turbocharger that is omitted or performed too late can cause excessive contamination, wear and operating failures.

▶ Carry out the service work at the specified time intervals.

⚠️ CAUTION

Shortened service intervals

Exceptional stresses such as several starts/stops per day, harsh environmental conditions, poor fuel quality or high system vibrations can lead to untimely machine damage even if the prescribed service intervals are observed.

▶ Agree on a shortened service interval with ABB Turbo Systems.

To prevent machine damage caused by ageing and downtime, we recommend having an inspection carried out by an ABB Turbocharging Service Station no later than 5 years after the last service.
5.2.1 Service work every 25 ... 50 hours

**CAUTION**

Unknown operational changes
Impairment to the degree of a possible operating failure can be the consequence.

- Have any unknown causes clarified by an ABB Turbocharging Service Station.

- Visual check for air, exhaust gas, water and oil leaks.
- Record operating data and enter in the engine logbook.
- In case of deviations, determine the cause.

5.2.2 Service work at 100 hours after commissioning

- Clean or replace the oil filter located in the supply pipe to the turbocharger while the engine is stopped.

5.2.3 Service work according to instructions of enginebuilder

- Clean or replace the oil filter located in the supply pipe to the turbocharger while the engine is stopped.

5.2.4 Service work according to data on the rating plate

(Usually after 8000 ... 12000 operating hours)

The rotor and bearing parts must be checked and assessed by an ABB Turbocharging Service Station. The following work can be carried out as preparation.

- Remove turbocharger from engine, dismantle and measure clearance (see Dismantling and fitting, general).
- Clean nozzle ring, turbine casing, compressor casing and diffuser, and check for cracks and erosion/corrosion.

**Application with frequent engine start/stop cycles (Peak shaving)**

If the turbocharger is used for the 'Peak shaving' mode with frequent engine start/stop cycles, the number of successful engine start/stop cycles must be taken into account in addition to the inspection interval for the bearing parts specified on the rating plate (in operating hours).

- ABB Turbo Systems recommends having the rotor and bearing parts, as well as the casing parts on the turbine end, including the nozzle ring, checked and maintained by an ABB Turbocharging Service Station after 5000 successful engine start cycles.
5.2.5 Other service work

If a protective grid is installed in the radial or axial gas outlet casing (61001) by ABB Turbo Systems:

![Fig. 21: Replacing the protective grid](image)

- Remove the protective grid (61205) after 50000 hours and replace it with a new one.

**Pre-mix gas engines**

⚠️ **CAUTION**

*Replace the protective grid of pre-mix gas engines after 20000 hours*

Applications on pre-mix gas engines result in a high thermo-mechanical load on the protective grid. To ensure proper functionality of the protective grid even under these conditions, the protective grid of pre-mix gas engines must be replaced after 20000 hours.

- Replace the protective grid of pre-mix gas engines after 20000 hours.
5.2.6 **Entries in the engine logbook**

Monitoring the engine system makes it possible to draw conclusions on the operating behaviour of the turbocharger.

The following operating data and measured values must be entered regularly into the engine logbook of the enginebuilder:

- Number of times the engine is started successfully (possible aborted start cycles do not need to be recorded)
- Performance and speed of the engine
- Air intake temperature
- Pressure of the charge air
- Pressure loss in the charge air cooler
- Lubricating oil pressure and lubricating oil temperature.

If present:

- Speed of the turbocharger
- Air temperature after the compressor and after the charge air cooler
- Exhaust gas temperature before and after the turbine
- Pressure loss in the filter silencer.
5.3 Expected replacement intervals

Fuel
The expected replacement intervals apply to engine operation with pre-mix gas and diesel oil.

Applications with frequent engine start/stop cycles (Peak shaving)
In addition to the replacement intervals specified on the rating plate for the compressor and turbine wheel (in operating hours), the number of successful engine start/stop cycles must also be taken into account.

Rotating components
The recommended replacement intervals of the compressor and turbine wheels are specified with the aid of the safety concept for rotating parts (SIKO) and dependent on the operating conditions. These intervals are shown on the rating plate of the turbocharger.

When employing the ‘Peak shaving’ mode, ABB Turbo Systems generally recommends replacing the compressor and turbine wheel after 20000 successful engine start/stop cycles or after reaching the number of operating hours specified on the rating plate.

Non-rotating components
Depending on the system-specific operating conditions, a differentiation must be made between the intervals to be expected for:

- replacing the bearing parts and
- replacing the non-rotating components exposed to hot gas.

A decisive role is played by various influencing parameters which, in extreme cases, can drastically reduce the replacement interval of these parts.

When utilising the ‘Peak shaving’ mode with frequent engine start/stop cycles, the turbocharger components on the exhaust gas side are subjected to high thermal loads. This load can cause thermal fatigue when the operating time and number of engine start cycles increase, thereby resulting in wear and cracking of the components. ABB Turbo Systems therefore recommends having the components periodically inspected and replaced, if necessary, by an ABB Turbocharging Service Station based on the number of successful engine start cycles specified in the following table.

The individual components will generally be examined for wear and replaced, if necessary, during the prescribed periodic service work.
### Expected replacement intervals

<table>
<thead>
<tr>
<th>Component</th>
<th>Operating hours</th>
<th>Number of engine start cycles (Peak shaving mode)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbine casing</td>
<td>25000 ... 50000</td>
<td>5000 ... 10000</td>
</tr>
<tr>
<td>Nozzle ring</td>
<td>25000 ... 50000</td>
<td>5000 ... 10000</td>
</tr>
<tr>
<td>Gas outlet flange</td>
<td>25000 ... 50000</td>
<td>5000 ... 10000</td>
</tr>
<tr>
<td>Heat shield</td>
<td>25000 ... 50000</td>
<td>5000 ... 10000</td>
</tr>
<tr>
<td>Bearing casing</td>
<td>25000 ... 50000</td>
<td>5000 ... 10000</td>
</tr>
<tr>
<td>Bearing parts</td>
<td>12000 ... 24000</td>
<td>5000</td>
</tr>
<tr>
<td>Rotor components</td>
<td></td>
<td>20000</td>
</tr>
<tr>
<td>Other casings</td>
<td>50000</td>
<td>- -</td>
</tr>
</tbody>
</table>

Table 10: Expected replacement intervals

The specified values are guideline values and not guaranteed values; see Influencing parameters.

### Influencing parameters

The specified values are guideline values and are not guaranteed. The actual values can deviate considerably from the guideline values, for example, due to the following influences:

- Fuel quality and fuel treatment
- Load profile (thermal cycling, also number of starts/stops, emergency shutdowns, operating point)
- Gas inlet temperature
- Turbocharger specification.
- System-specific operating conditions (combustion quality, exhaust gas composition)

For bearing parts

- Lubricating oil quality (oil filtering, oil condition, oil monitoring)
- Load profile (speed, pressure conditions, temperature)
- Number of starts/stops
- Unbalance of the rotor (degree of contamination).
5.4 Stopping the engine

⚠️ CAUTION
Residual heat in the turbocharger
If the residual heat in the turbocharger is not adequately dissipated, it may damage the engine.
- Adequate cooling of the turbocharger must be ensured after stopping the engine.

Water-cooled turbocharger variant
- Post-lubricate as long as the rotor is turning.
- Observe the oil pressure while performing post-lubrication: \( 0.5 < p_{oil} \leq 1.0 \).
- Switch off post-lubrication as soon as the rotor is stationary or after no more than two minutes.

Deviating procedures must be coordinated with ABB Turbo Systems.
6 Periodic maintenance work

6.1 Foreword to maintenance

Maintenance work includes regular visual controls and cleaning operations which are intended to ensure the trouble-free functioning of the turbocharger.

<table>
<thead>
<tr>
<th>Maintenance interval</th>
<th>Maintenance work</th>
<th>Operating status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Similar to the service interval (usually every 8000 ... 12000 h) (^1)</td>
<td>Cleaning components mechanically (\rightarrow 41)</td>
<td>Engine stopped</td>
</tr>
</tbody>
</table>

Table 11: Maintenance table

\[^h\] = Hours of operation

\(^1\) ABB Turbo Systems recommends having mechanical cleaning carried out by an ABB Turbocharging Service Station during the service work.
6.2 Cleaning components mechanically

6.2.1 Preparation

**CAUTION**

Component damage and corrosion

If mechanical cleaning is carried out incorrectly, this can lead to damage and corrosion on the components.

▷ Pay attention to the specifications in this chapter pertaining to mechanical cleaning.

**CAUTION**

Selection of cleaning tools

Turbocharger components are sensitive and easily sustain mechanical damage. The use of needle descalers (for example) or other striking tools damages the components. Depending on the specification, nozzle rings or turbine casings may have protective coatings which can also be damaged.

▷ Use only soft tools such as rags, brushes or wire brushes.

▷ In case of heavy contamination, the cleaning methods described in this chapter (such as soaking, for example) can be repeated until a satisfactory result is achieved.

The disassembly and assembly of the components is described in chapter **Dismantling and fitting → 58**.

▷ Contaminated water and cleaning agents must be disposed of in an environmentally compatible, professional way and in compliance with locally applicable regulations.
6.2.2 Cleaning the filter silencer

Cleaning the filter ring (if present)

- Remove filter ring (81265).
- Clean filter ring (81265) as required or every 500 hours of operation and replace after the fifth cleaning process at the latest. Contamination of the filter ring depends on the degree of purity of the sucked-in air.
- Rinse the filter ring (81265) with water and mild detergent or, in the case of heavy contamination, soak and carefully push through. Rinse in cold water. Avoid high mechanical loads (water jet).
- Let the filter ring dry completely before assembling.
- Dirty water and mild detergent must be disposed of in compliance with locally applicable regulations.
Cleaning the absorption segments

(see Fig. 22: Cleaning the filter silencer →42)

- Loosen the tension bands (81270).
- Remove the cover grid (81266).
- Pull out and bend up the sheet-metal coverings (81137), and remove the absorption segments (81136).
- Clean the absorption segments (81136).
  When cleaning, note that the absorption segments (81136) must only be cleaned lightly with compressed air, a soft brush or a moist cleaning cloth.
- Have any heavily contaminated absorption segments replaced by an ABB Turbocharging Service Station.

Fitting the filter silencer

(see Fig. 22: Cleaning the filter silencer →42)

- Insert the absorption segments (81136) into the sheet-metal coverings (81137).
- Bend the sheet-metal coverings (81137) back to their original shape and insert into the slotted guides in the filter silencer body (81135).
- Fit the cover grid (81266).
- Fit the tension bands (81270) and tighten them at the locks (81271).
- Any tension bands that have become damaged must be replaced.
- Fit the filter ring (81265), if present.
### 6.2.3 Compressor-end, non-rotating parts

**WARNING**

**Handling operating materials and supplies**
Swallowing or inhaling vapours of operating materials and supplies or contact with them may be harmful to health.
- Do not breathe in these substances and avoid contact with the skin.
- Ensure proper ventilation.
- Observe the information in the material safety data sheet for the operating materials and supplies.
- Wear personal protective equipment (PPE) according to the material safety data sheet.
- Comply with local legislation.

- Wear safety goggles.
- Wear safety gloves to protect against chemical hazards.
- Wear a respiratory mask to protect against gases.

The following parts, which are relevant in terms of performance, can be cleaned in accordance with the description below.

- 72000 Compressor casing
- 77000 Wall insert
- 79000 Diffuser

- Clean the above-mentioned components with steam or ultrasound. Alternatively, soak in diesel oil or water containing household cleaning agent. After soaking, remove contamination with a brush.
- Dry components completely.
- Spray cleaned surfaces with penetrating oil. Do not spray the outer surfaces of the turbocharger.
- Dispose of contaminated water and cleaning agents in accordance with the information in the material safety data sheet.
6.2.4 Turbine-end, non-rotating parts

**WARNING**

Handling operating materials and supplies
Swallowing or inhaling vapours of operating materials and supplies or contact with them may be harmful to health.

- Do not breathe in these substances and avoid contact with the skin.
- Ensure proper ventilation.
- Observe the information in the material safety data sheet for the operating materials and supplies.
- Wear personal protective equipment (PPE) according to the material safety data sheet.
- Comply with local legislation.

Wear safety goggles.

Wear safety gloves to protect against chemical hazards.

Wear a respiratory mask to protect against gases.

Baked layers of contamination, for example, from coked oil occur at the turbine end. The following parts, which are relevant in terms of performance, can be cleaned in accordance with the description below.

![Fig. 24: Turbine end, non-rotating parts](image)

51000  Turbine casing
57002  Gas outlet flange
56001  Nozzle ring
56005  Lamellar sealing ring

- Dismantle the lamellar sealing ring (56005) in the nozzle ring.
- Place contaminated parts in hot water or in a liquid such as brake cleaner to soften the contamination.
- Brush away the contamination or remove with a steam cleaner.
- Repeat the soaking and brushing if necessary.
- Use clean water to remove all traces of solvent from parts.
6.2 Cleaning components mechanically

- Dry components completely.
- Spray cleaned surfaces with penetrating oil. Do not spray the outer surfaces of the turbocharger.
- Dispose of contaminated water and cleaning agents in accordance with the information in the material safety data sheet.

6.2.5 Cartridge group, general

**CAUTION**

**Corrosion**
If the cartridge group is not put back into operation immediately after cleaning, parts may corrode.
- Immediately after cleaning, install the cartridge group and put it back into operation.

Compressor wheels can be heavily contaminated due to poorly filtered suction air; turbines can be heavily contaminated due to coked oil. Contamination such as this must be removed during the standard service intervals (see service work chapter).

- Remove turbocharger from engine (see chapter Removing and Installing →8).
- Remove cartridge group (see chapter Dismantling and fitting →58).

First clean the compressor end and then the turbine end according to the following description.
6.2.6 Cleaning the cartridge group on compressor end

⚠️ CAUTION
Selection of the cleaning agent
Cleaning agents which contain chlorine attack metals.
- Use only pH-neutral cleaning agents which do not attack metals.
- Observe safety data sheet.

⚠️ CAUTION
Water and contamination in the cartridge group
If water or contamination penetrates the cartridge group, this can impair the function of the turbocharger and damage parts inside the cartridge group.
- Make sure that no water or contamination can enter into the cartridge group.

- Cleaning procedures should be selected that do not result in removal of the compressor wheel material or cause damage to its surfaces. Clean the compressor wheel with a rag or soft brush which has been soaked in water with a household cleaning agent. Do not use a wire brush!
- Dry the compressor wheel and the gap between the compressor and the bearing casing with low-pressure pressurized air.
- Lightly spray the compressor wheel and the gap between the compressor and the bearing casing with penetrating oil.
- Dispose of dirty water and cleaning agents in accordance with the material safety data sheet.
6.2.7 Cleaning the cartridge group on turbine end

Soaking the contamination

Baked layers of contamination from coked oil occur at the turbine end. The contamination can be removed by soaking and brushing. The procedure for soaking the layers of contamination as well as for cleaning the turbine are described in the following.

![Fig. 25: Soaking the turbine end](image)

<table>
<thead>
<tr>
<th>Product</th>
<th>A [mm]</th>
<th>B [mm]</th>
<th>C [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A130</td>
<td>108</td>
<td>17</td>
<td>205</td>
</tr>
<tr>
<td>A135</td>
<td>128</td>
<td>20</td>
<td>245</td>
</tr>
<tr>
<td>A140</td>
<td>157</td>
<td>25</td>
<td>300</td>
</tr>
</tbody>
</table>

Table 12: Value table for soaking

To soak the layers of contamination on the turbine, the cartridge group can be immersed vertically in a container (02) with fluid.

- Place the container (02) inside a larger container (03) so that the overflowing fluid can be collected.

⚠️ CAUTION

Selection of the cleaning agent

Cleaning agents which contain chlorine attack metals.

- Use only pH-neutral cleaning agents which do not attack metals.
- Observe safety data sheet.

- Fill the container (02) with soaking fluid. To shorten the soaking time, the fluid can be heated up to a maximum of 60 °C.


**WARNING**

Heating up of cleaning agents and operating fluids

When cleaning agents or operating fluids are heated up, explosive vapours can be produced which are hazardous to health.

- Observe the information in the material safety data sheet.

Wear a respiratory mask according to material safety data sheet.

**CAUTION**

Water and contamination in the cartridge group

If water or contamination penetrates the cartridge group, this can impair the function of the turbocharger and damage parts inside the cartridge group.

- Place the cartridge group on suitable supports (01) made of wood or metal.
- Observe dimension (B) for the supports (01) so that the cartridge group is not immersed too deeply.

- Let the layers of contamination on the turbine soak for four hours.

**Removing dirt**

**WARNING**

Health hazard due to soot particles

If soot particles enter the eyes or respiratory tract, this can be harmful to health.

- Avoid the formation of dust.
- Vacuum up dust with a suitable vacuum cleaner.
- Wear a respiratory mask to protect against particles (P1 or P2 mask).
- Wear safety goggles.

Wear safety goggles.

Wear a respiratory mask to protect against dusts.

Wear safety gloves to protect against mechanical hazards.

- Lift up the cartridge group and align it horizontally.
- Remove dirt manually using a soft brush or a wire brush.
CAUTION

Water and dirt in the cartridge group
If water or dirt enters the cartridge group, this can impair the function of the turbocharger and damage parts inside the cartridge group.
- Make sure that no water or dirt enters the gap between partition wall and turbine.

CAUTION

Non-permissible rotor unbalance after cleaning
Unevenly distributed residual contamination deposits lead to rotor unbalance. This can result in bearing or turbocharger damage.
- Remove all traces of contamination from the turbine.

- After brushing off the dirt, fill the container (02) with clean water and not with salt water.
- Immerse the turbine of the cartridge group in clean water so that any loose dirt comes off.
- Lift up the cartridge group and align it horizontally.
- Clamp the partition wall to the bearing casing.
- Dry the turbine and the gap between the turbine and the partition wall with low-pressure compressed air.
- Lightly spray the turbine and the gap between the turbine and the partition wall with penetrating oil.
- Dispose of dirty water and cleaning agents in accordance with the information in the material safety data sheet.
7 Eliminating malfunctions

7.1 Malfunctions when starting

Delayed start-up

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbocharger turbocompressor</td>
<td>Clean (see chapter Periodic maintenance work)</td>
</tr>
<tr>
<td>bearing damaged</td>
<td>Contact ABB Turbocharging Service Station</td>
</tr>
<tr>
<td>rotor rubbing</td>
<td></td>
</tr>
<tr>
<td>foreign object in the turbocompressor</td>
<td></td>
</tr>
</tbody>
</table>

Table 13: Malfunctions when starting – Delayed start-up

Vibrations

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>turbocompressor rotor unbalance</td>
<td>Contact ABB Turbocharging Service Station</td>
</tr>
<tr>
<td>turbine or compressor damaged</td>
<td></td>
</tr>
<tr>
<td>bearing damaged</td>
<td></td>
</tr>
<tr>
<td>engine vibrations from engine</td>
<td>Contact enginebuilder</td>
</tr>
</tbody>
</table>

Table 14: Malfunctions when starting – Vibrations

Rubbing of rotating parts

Normal behaviour, not a malfunction

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>turbocompressor</td>
<td>A slight amount of uniform wear at the circumference of the rotor components caused by slight local rubbing against adjacent components is permitted. This causes the compressor or turbine blades to be somewhat shortened. To prevent significant loss of efficiency, specific tolerances must be fulfilled.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 15: Malfunctions when starting – Rubbing of rotating parts
7.2 Malfunctions during operation

Lubricating oil pressure too low

![WARNING]

**Danger of fire and explosion due to lubricating oil leaks**

Leaking oil may ignite on hot surfaces. This can result in serious injuries to personnel or fatal accidents.

- Cordon off danger area.
- Raise the alarm and, depending on the situation, stop the engine.
- Seal the oil leak.
- Soak up oil and dispose of in an environmentally compatible manner.

Wear safety gloves to protect against thermal hazards.

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbocharger Axial clearance of the rotor excessive</td>
<td>Contact an ABB Turbocharging Service Station</td>
</tr>
<tr>
<td>Engine Oil filter heavily contaminated</td>
<td>Clean</td>
</tr>
<tr>
<td></td>
<td>Oil pump in lubricating system defective</td>
</tr>
<tr>
<td></td>
<td>Manometer displays incorrectly</td>
</tr>
</tbody>
</table>

Table 16: Malfunctions during operation – Lubricating oil pressure too low

**Speed reduces**

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbocharger Turbine and/or nozzle ring severely contaminated</td>
<td>Clean (see chapter Periodic maintenance work →40)</td>
</tr>
<tr>
<td>Rotor components or bearing damaged</td>
<td>Contact ABB Turbocharging Service Station</td>
</tr>
<tr>
<td>Engine Defects on the connected cylinders in pulse charging</td>
<td>Contact enginebuilder</td>
</tr>
<tr>
<td>Pipes Defects, such as leaks, in the exhaust gas</td>
<td>Repair</td>
</tr>
<tr>
<td>pipes or charge air ducts</td>
<td></td>
</tr>
</tbody>
</table>

Table 17: Malfunctions during operation – Speed reduces

**Speed increases**

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbocharger</td>
<td>Light to medium contamination of the turbine and/or nozzle ring (with 4-stroke application)</td>
</tr>
</tbody>
</table>

Table 18: Malfunctions during operation – Speed increases
### Exhaust gas temperature too high

**Engine performance and engine speed unchanged**

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Turbocharger</strong></td>
<td></td>
</tr>
<tr>
<td>Insufficient air, for example, when filter silencer is blocked by contamination</td>
<td>Clean (see chapter Periodic maintenance work →40)</td>
</tr>
<tr>
<td>Compressor/turbine contaminated</td>
<td></td>
</tr>
<tr>
<td>Exhaust gas back pressure too high</td>
<td>Clean or repair boiler or exhaust gas silencer</td>
</tr>
<tr>
<td><strong>Engine</strong></td>
<td></td>
</tr>
<tr>
<td>Malfunction in the injection system</td>
<td>Repair or contact manufacturer</td>
</tr>
<tr>
<td><strong>Charge air cooler</strong></td>
<td></td>
</tr>
<tr>
<td>Cooler contaminated</td>
<td>Clean</td>
</tr>
<tr>
<td>Cooling water volume too low</td>
<td>Fill</td>
</tr>
<tr>
<td>Inlet temperature of cooling water too high</td>
<td>Check/clean cooling system</td>
</tr>
<tr>
<td><strong>Pipes</strong></td>
<td></td>
</tr>
<tr>
<td>Insufficient ventilation</td>
<td>Improve ventilation</td>
</tr>
</tbody>
</table>

Table 19: Malfunctions during operation – Exhaust gas temperature too high

### Charge air pressure too low

**Engine performance and engine speed unchanged, suction condition normal**

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Turbocharger</strong></td>
<td></td>
</tr>
<tr>
<td>Manometer display not correct</td>
<td>Replace manometer</td>
</tr>
<tr>
<td>Supply pipe to manometer not sealed</td>
<td>Repair leak</td>
</tr>
<tr>
<td>Filter silencer contaminated, therefore pressure drop too high</td>
<td>Clean (see chapter Periodic maintenance work →40)</td>
</tr>
<tr>
<td>Compressor end and/or turbine end contami nated</td>
<td></td>
</tr>
<tr>
<td>Compressor/turbine damaged</td>
<td>Contact ABB Turbocharging Service Station</td>
</tr>
<tr>
<td>Exhaust gas back pressure too high</td>
<td>Clean or repair boiler or exhaust gas silencer</td>
</tr>
<tr>
<td><strong>Engine</strong></td>
<td></td>
</tr>
<tr>
<td>Air receiver not sealed</td>
<td>Repair</td>
</tr>
<tr>
<td>Gas piping between engine and turbine leaking</td>
<td></td>
</tr>
<tr>
<td>Injection mistimed</td>
<td>Set correctly</td>
</tr>
<tr>
<td>Valve control misadjusted</td>
<td></td>
</tr>
<tr>
<td><strong>Pipes</strong></td>
<td></td>
</tr>
<tr>
<td>Pipes downstream to the compressor outlet not sealed.</td>
<td>Repair.</td>
</tr>
</tbody>
</table>

Table 20: Malfunctions during operation – Charge air pressure too low
Eliminating malfunctions / 7.2 Malfunctions during operation

**Charge air pressure too high**

Engine performance and engine speed unchanged, suction condition normal

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbocharger</td>
<td>Manometer display not correct Replace manometer</td>
</tr>
<tr>
<td></td>
<td>Increased speed due to contamination of nozzle ring</td>
</tr>
<tr>
<td></td>
<td>Periodic maintenance work → 40 or contact an ABB Turbocharging Service Station</td>
</tr>
<tr>
<td>Engine</td>
<td>Malfunction in the injection system Repair or contact manufacturer</td>
</tr>
<tr>
<td>Injection mistimed</td>
<td>Set correctly</td>
</tr>
<tr>
<td>Engine performance higher</td>
<td>Check engine performance</td>
</tr>
<tr>
<td>than indicated</td>
<td></td>
</tr>
</tbody>
</table>

Table 21: Malfunctions during operation – Charge air pressure too high

**Reduced compressor performance/efficiency and therefore engine performance losses**

⚠️ **CAUTION**

**Compressor damage**

A severely contaminated or corroded compressor wheel can reduce the compressor wheel's fatigue endurance limit and result in the turbocharger being damaged.

- Rectify malfunction in accordance with the following table.

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbocharger Compressor components severely contaminated by the ventilation gases that have been fed in</td>
<td>Clean (see chapter Periodic maintenance work → 40)</td>
</tr>
<tr>
<td></td>
<td>Optimize oil separation</td>
</tr>
<tr>
<td>Increased blade vibration, compressor blade damage due to the ventilation gases that have been fed in</td>
<td>Correct the feed of ventilation gases according to instructions of enginebuilder.</td>
</tr>
<tr>
<td>Material of the compressor wheel corroded due to the feeding in of ventilation gases containing corrosive components</td>
<td>Correct the feed of ventilation gases according to instructions of enginebuilder.</td>
</tr>
<tr>
<td>Material of the compressor wheel corroded due to intake air containing exhaust gases or salt</td>
<td>Prevent exhaust gas leakages in the engine space</td>
</tr>
<tr>
<td></td>
<td>Clean (see chapter Periodic maintenance work → 40)</td>
</tr>
</tbody>
</table>

Table 22: Malfunctions during operation – Engine performance losses
7.3 Turbocharger is surging

**WARNING**

Hot air escapes from the filter silencer

A surge blow is accompanied by a loud bang and escape of hot air from the filter silencer. This may result in injury to personnel.

- Keep a distance from the filter silencer while the turbocharger is surging.

**CAUTION**

Continuous or periodic surging

If the turbocharger surges continuously or periodically, parts of the turbocharger may be damaged.

- Gradually reduce the engine load.
- Have the cause clarified and remedied immediately by an ABB Turbocharging Service Station.
- Have parts assessed for damage and, if necessary, replaced by an ABB Turbocharging Service Station.

### Table 23: Malfunction – Turbocharger pumping

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbocharger</td>
<td>Filter silencer or diffuser contaminated</td>
</tr>
<tr>
<td></td>
<td>Clean (see chapter Periodic maintenance work →40)</td>
</tr>
<tr>
<td></td>
<td>Heavy contamination deposits in the turbine or in the nozzle ring</td>
</tr>
<tr>
<td>Engine</td>
<td>Protective grating in front of the turbocharger contaminated or damaged</td>
</tr>
<tr>
<td></td>
<td>Clean/replace</td>
</tr>
<tr>
<td>Charge air cooler</td>
<td>Cooler contaminated</td>
</tr>
<tr>
<td></td>
<td>Clean</td>
</tr>
<tr>
<td></td>
<td>Charge air duct blocked</td>
</tr>
</tbody>
</table>

### Sporadic surge blows

**Possible causes**

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine</td>
<td>Engine load reduced quickly when manoeuvring. When this happens, the flow direction in the compressor is momentarily reversed. Such sporadic surge blows do not impair the safe operation of the turbocharger.</td>
</tr>
<tr>
<td></td>
<td>- -</td>
</tr>
</tbody>
</table>

Table 24: Malfunction – Sporadic surge blows
7.4 Malfunctions when stopping

Runout noises

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbocharger contaminated</td>
<td>Clean (see chapter Periodic maintenance work (\rightarrow 40))</td>
<td></td>
</tr>
<tr>
<td>Bearing damaged</td>
<td>Check clearances (see chapter Axial clearance A and radial clearance B (\rightarrow 73)). If clearances are outside the tolerance or if in doubt, contact an ABB Turbocharging Service Station.</td>
<td></td>
</tr>
<tr>
<td>Rotor rubbing</td>
<td>Check clearances (see chapter Radial clearances N and R (\rightarrow 80)). If clearances are outside the tolerance or if in doubt, contact an ABB Turbocharging Service Station.</td>
<td></td>
</tr>
<tr>
<td>Foreign object in the turbocharger</td>
<td>Dismantle turbocharger (see chapter Dismantling and fitting (\rightarrow 58)). In case of damage, replace the corresponding parts or contact an ABB Turbocharging Service Station.</td>
<td></td>
</tr>
</tbody>
</table>

Table 25: Malfunctions when stopping – Runout noises

Runout time too short

The runout time must be noted down as a reference. Because the runout time depends on the oil viscosity, the runout time must always be measured at the same oil temperature.

If the runout time is significantly shorter in comparison to a previous measurement, the following table must be observed.

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbocharger contaminated</td>
<td>Clean (see chapter Periodic maintenance work (\rightarrow 40))</td>
<td></td>
</tr>
<tr>
<td>Bearing damaged</td>
<td>Check clearances (see chapter Axial clearance A and radial clearance B (\rightarrow 73)). If clearances are outside the tolerance or if in doubt, contact an ABB Turbocharging Service Station.</td>
<td></td>
</tr>
<tr>
<td>Rotor rubbing</td>
<td>Check clearances (see chapter Radial clearances N and R (\rightarrow 80)). If clearances are outside the tolerance or if in doubt, contact an ABB Turbocharging Service Station.</td>
<td></td>
</tr>
<tr>
<td>Foreign object in the turbocharger</td>
<td>Dismantle turbocharger (see chapter Dismantling and fitting (\rightarrow 58)). In case of damage, replace the corresponding parts or contact an ABB Turbocharging Service Station.</td>
<td></td>
</tr>
</tbody>
</table>

Table 26: Malfunctions when stopping – Runout time too short
7.5 Speed measurement system

No signal or poor signal amplitude of the speed measurement

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbocharger</td>
<td>The screw plug for the sensor is fitted with an additional gasket (copper ring).</td>
</tr>
<tr>
<td></td>
<td>For information regarding the disassembly and assembly of the speed sensor, refer to chapter Replacing the speed sensor → 30.</td>
</tr>
<tr>
<td></td>
<td>Install the speed sensor without the additional gasket (copper ring).</td>
</tr>
<tr>
<td>An enlarged distance between the sensor tip and the signal-emitting sealing disc reduces the voltage amplitude of the speed signal.</td>
<td></td>
</tr>
<tr>
<td>Sensor or cable defective</td>
<td>Contact an ABB Turbocharging Service Station.</td>
</tr>
<tr>
<td></td>
<td>Order new speed sensor (86505) (refer to chapter Ordering spare parts → 89).</td>
</tr>
<tr>
<td></td>
<td>Replacing the speed sensor → 30.</td>
</tr>
</tbody>
</table>

Table 27: Malfunction of the speed measurement system – No signal or poor signal amplitude

Measured speed too high

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbocharger</td>
<td>For information regarding the disassembly and assembly of the speed sensor, refer to chapter Replacing the speed sensor → 30.</td>
</tr>
<tr>
<td>Sensor tip contaminated, since it is magnetic and can attract metallic particles. This reduces the distance to the signal-emitting sealing disc, which can lead to amplification of the noise component and, hence, to false triggering.</td>
<td>Dismantle the sensor, clean the sensor tip, and fit the sensor back on with the specified tightening torque.</td>
</tr>
</tbody>
</table>

Table 28: Malfunction of the speed measurement system – Measured speed too high

Measured speed too low

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbocharger</td>
<td>Contact ABB Turbocharging Service Station</td>
</tr>
</tbody>
</table>

Table 29: Malfunction of the speed measurement system – Measured speed too low

If none of the measures described above remedy the malfunction, have the speed measurement system checked by an ABB Turbocharging Service Station.
8 Dismantling and fitting

8.1 Introduction

The precondition for the work described in the following is a turbocharger removed from the engine (see chapter Removal and installation).

⚠️ WARNING

Danger of burns
Touching hot surfaces or contact with hot operating fluids can cause burns.
- Do not touch hot surfaces. Observe the warning plate on the turbocharger.
- Wear heat-resistant safety gloves and protective clothing.
- Wait for the turbocharger to cool down before carrying out any work.

Wear safety gloves to protect against thermal hazards.

⚠️ WARNING

Cutting injuries when working on the turbocharger
Some parts on the turbocharger may have sharp edges. There is a risk of a cutting injury.
- Wear safety gloves against mechanical risks when conducting assembly and disassembly work.

Wear safety gloves to protect against mechanical hazards.

⚠️ CAUTION

Further operations
This Operation Manual may be used to carry out only those operations that are described in it. Further operations that are executed in an incorrect way can lead to serious damage to the machine.
- ABB Turbo Systems recommends having further operations carried out only by trained personnel from an ABB Turbocharging Service Station.

Mark the casing position for assembly.

Identification of the assembly devices
Not all assembly devices are marked with a part number. Identification is guaranteed by the tool list. This list is enclosed with the toolbox.
WARNING
Servicing the assembly devices
Assembly devices must be checked for damage before and after use.
- Visually inspect for corrosion, cracks, deformation and wear.
- Damaged assembly devices must no longer be used and must be replaced.

Customer spare part set
Before starting operations, make sure the required customer spare part set is available (see chapter Spare parts → 89).

Oil orifice
- When disassembling the turbocharger, an oil orifice fitted in the oil inlet must not be removed (see also chapter Removing the cartridge group → 69).

Tightening torques for components of the turbocharger
The specified tightening torques of the screw fittings must be observed (Table of tightening torques → 83).

Tightening torques for assembly devices
Unless described otherwise, the screws and nuts of the assembly devices supplied by ABB must be tightened so they rest firmly against the surface.

WARNING
Suspended loads
Loads that are not attached according to regulations can cause injury to personnel or fatal accidents.
- Only fasten the turbocharger, assemblies or individual parts on properly functional lifting gear with sufficient load limit.
- Pay attention to the correct attachment of loads on the crane hook.
- People must not stand beneath suspended loads.

Wear safety gloves to protect against mechanical hazards.
Wear safety helmet.

Definition of terms
- Suspension point
  Defined loading point on a component or an assembly (blind hole thread, eyelet, lug).
Assembly device
Devices that are fitted on the turbocharger in order to obtain a suspension point. Assembly devices are specially constructed and designed for the defined use; they are not commercially available products. Use assembly devices only for the described applications.

Lifting gear
Equipment for the lifting and transporting of loads (ropes, chain block, crane). Lifting gear is not supplied by ABB.

Swivel lifting eyes to be used
Two swivel lifting eyes are required for the safe lifting of loads, these are not supplied by ABB Turbo Systems.

<table>
<thead>
<tr>
<th>Swivel lifting eyes</th>
<th>Product</th>
<th>Thread</th>
<th>Length</th>
<th>Minimum load limit</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A130</td>
<td>M10</td>
<td>17 mm</td>
<td>100 kg</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>A135</td>
<td>M10</td>
<td>17 mm</td>
<td>150 kg</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>A140</td>
<td>M12</td>
<td>21 mm</td>
<td>250 kg</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 30: Swivel lifting eyes

Two ring nuts are required for safer lifting of the cartridge group, which are not included in the ABB Turbo Systems scope of delivery.

<table>
<thead>
<tr>
<th>Ring nuts to be used (VRM)</th>
<th>Product</th>
<th>Thread</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A130</td>
<td>M16</td>
</tr>
<tr>
<td></td>
<td>A135</td>
<td>M16</td>
</tr>
<tr>
<td></td>
<td>A140</td>
<td>M16</td>
</tr>
</tbody>
</table>

Table 31: Ring nuts to be used
8.2 Weights of individual parts

The specified weights of the individual parts or assemblies are rounded-up standard values.

<table>
<thead>
<tr>
<th>Designation</th>
<th>A130 [kg]</th>
<th>A135 [kg]</th>
<th>A140 [kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Filter silencer</td>
<td>19</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>02 Radial air suction branch</td>
<td>6</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>03 Axial air suction branch</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>04 Compressor casing</td>
<td>24</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>05 Wall insert</td>
<td>6</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>06 Diffuser</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>07 Cartridge group</td>
<td>40</td>
<td>60</td>
<td>110</td>
</tr>
<tr>
<td>08 Nozzle ring</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>09 Burst ring</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>10 Turbine casing *</td>
<td>45</td>
<td>65</td>
<td>120</td>
</tr>
<tr>
<td>11 Gas outlet flange</td>
<td>7</td>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td>12 Gas outlet casing *</td>
<td>30</td>
<td>35</td>
<td>65</td>
</tr>
</tbody>
</table>

Table 32: Weights of assemblies

* including burst protection
8.3 Removing air inlets

▶ Mark the casing position for assembly.

1. Attach lifting gear to the filter silencer (81000) or air suction branch (82000).
2. Loosen and remove V-clamp (72020).
3. Remove filter silencer (81000) or air suction branch (82000), set it down properly in an appropriate place and secure it.
4. Remove and dispose of the O-ring (81010 / 82010).
8.4 Removing the gas outlet casing

Mark the casing position for assembly.

1. Attach lifting gear to the gas outlet casing (61001).
2. Loosen and remove nuts (51009).
3. If present: Loosen the support (61301) from the bracket.
4. Remove the gas outlet casing (61001), set it down properly in an appropriate place and secure it.
5. Remove and dispose of the gasket (61002).

Fig. 28: Removing the gas outlet casing
8.5 Removing the gas outlet flange

Depending on the way of fixing the gas outlet flange, the appropriate Working Instruction has to be consulted (pressing off using 3 or 6 press-off screws).

If the following Working Instructions are not observed, this can lead to cracks in the gas outlet casing.

The following variants are possible:

- Pressing off using 3 press-off screws.
- Pressing off using 6 press-off screws.
- Mark the casing position for assembly.

Gas outlet flange with 3 press-off screws

---

**CAUTION**

Cracks in the gas outlet casing

Non-observance of the action steps described can lead to inadmissible cracks on the gas outlet flange.

- Observe the maximum tightening torques when pressing off.
- Follow the action steps described.

---

Only dismantle the gas outlet flange if this is necessary for service work.

- If necessary: Treat the centering seat with rust remover through the press-off threads and the clearance holes.
- Mark the casing position for assembly.

<table>
<thead>
<tr>
<th>Product</th>
<th>Press-off screws to be used (strength 8.8)*</th>
<th>Tightening torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>A130</td>
<td>3 x M 8 x 20</td>
<td>≤ 20 Nm</td>
</tr>
<tr>
<td>A135</td>
<td>3 x M10 x 25</td>
<td>≤ 40 Nm</td>
</tr>
<tr>
<td>A140</td>
<td>3 x M12 x 30</td>
<td>≤ 65 Nm</td>
</tr>
</tbody>
</table>

Table 33: 3 press-off screws

*not included in the ABB Turbo Systems scope of delivery.

1. Press off and remove the gas outlet flange (57002) with screws (01) according to the table. If it is not possible to press off the gas outlet flange with the maximum tightening torque, contact an ABB Turbo Systems Service Station.

2. If present: Remove the C-ring (57003).
8 Dismantling and fitting / 8.5 Removing the gas outlet flange

Gas outlet flange with 6 press-off screws

⚠️ CAUTION

Cracks in the gas outlet casing
Non-observance of the action steps described can lead to inadmissible cracks on the gas outlet flange.
▶ Observe the maximum tightening torques when pressing off.
▶ Follow the action steps described.

Only dismantle the gas outlet flange if this is necessary for service work.
▶ If necessary: Treat the centering seat with rust remover through the press-off threads and the clearance holes.
▶ Mark the casing position for assembly.

Fig. 29: Removing the gas outlet flange

<table>
<thead>
<tr>
<th>Product</th>
<th>Press-off screws to be used (strength 8.8) *</th>
<th>Tightening torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>A130</td>
<td>6x M6</td>
<td>≤ 10 Nm</td>
</tr>
<tr>
<td>A135</td>
<td>6x M8</td>
<td>≤ 20 Nm</td>
</tr>
<tr>
<td>A140</td>
<td>6x M10</td>
<td>≤ 40 Nm</td>
</tr>
</tbody>
</table>

Table 34: 6 press-off screws – gas outlet flange

* not included in the ABB Turbo Systems scope of delivery.

1. Evenly press off and remove the gas outlet flange (57002) with screws (01) according to the table. If it is not possible to press off the gas outlet flange with the maximum tightening torque, contact an ABB Turbo Systems Service Station.

2. If present: Remove the C-ring (57003).
8.6 Removing the compressor casing

Removing the compressor casing

Mark the casing position for assembly.

1. Loosen screws (72011) and remove together with fastening strips (72012).
2. Attach swivel lifting eye (S) to the compressor casing and the lifting gear.
3. Remove the compressor casing (72000) and turn it 180°.
4. Remove and dispose of the O-ring (42012).
5. Loosen screws (79041) and remove from the compressor casing (72000) with fixing discs (79040) and diffuser (79000).

If the compressor casing cannot be loosened, it can be pressed off against the turbine casing using the press-off tool (90042) (see chapter Pressing off the casing →68).
Dismantling the wall insert

1. Knock the wall insert (77000) out of the compressor casing (72000) with a plastic tip hammer.
2. Attach swivel lifting eye (S) to the compressor casing (72000) and the lifting gear.
3. Lift up the compressor casing (72000).
4. Remove and dispose of the O-ring (77005).

Fig. 31: Dismantling the wall insert
8.7 Pressing off the casing

CAUTION

Axial force of the press-off tool

Using the press-off tool (90042), a high level of axial force can be generated. If the casing is pressed off with too much force on one side, the rotor can be damaged.

- Use the tool on both sides in alternation and make sure not to press off too hard on either side.

Fig. 32: Press off the casing
8.8 Removing the cartridge group

If present: Remove the insulation sheets (01, 02, 03).

Mark the casing position for assembly.

Do not remove oil orifice (if present)

To limit the oil flow rate through the bearing casing during operation (engine under load) to the admissible values, an oil orifice is mandatory at the oil inlet of the bearing casing if the oil inlet pressure is > 3 bar (overpressure).

If an oil orifice is fitted in the oil inlet of the bearing casing, it must not be removed.

---

Fig. 33: Removing insulation sheets

Fig. 34: Oil orifice

01 Bearing casing
02 Oil orifice
03 Circlip
1. Treat threads of studs (51006) with penetrating oil and leave to take effect.

2. Loosen nuts (51007) and remove Verbus Ripp® washers (51003) together with the fastening strips (51002).

3. Insert screws from service support into cartridge group.

4. Secure ring nuts (VRM) onto the screws with washers.

5. Secure the lifting gear to the ring nuts and suspension eye as shown.

6. Remove the cartridge group vertically from the turbine casing.

7. Turn the cartridge group into the horizontal rotor axis.

If the cartridge group cannot be loosened, the press-off tool (90042) can be used (see chapter Pressing off the casing →68).
8.9 Removing the nozzle ring

1. If present: Remove the metal C-ring (51105).
2. Position the fastening strips (51002) in place.
3. Pull out the nozzle ring (56001) with the two extraction devices (90070) and the service support base (90012).
4. Remove the lamellar sealing ring (56005).
5. Remove the burst ring (57210).

Fig. 37: Removing the nozzle ring

(option)
51105
90012
56001
90070
56005
51002
51000
57210
8.10 Installing the cartridge group on the service support

1. Remove ring nuts (VRM).
2. Remove service support screws.
3. Fit service support (90012) according to the illustration.
4. Insert the cartridge group.
5. Fit the nuts.

Fig. 38: Installing the cartridge group on the service support
8.11 Axial clearance A and radial clearance B

- Measure and record clearances A and B after the removal and before the installation of the cartridge group.
- Attach the dial indicator and align it for the respective clearance as per the illustration.

![Fig. 39: Measuring clearance A and B](image)

<table>
<thead>
<tr>
<th>Product</th>
<th>A [mm]</th>
<th>B [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A130</td>
<td>0.08 ... 0.16</td>
<td>0.47 ... 1.00</td>
</tr>
<tr>
<td>A135</td>
<td>0.10 ... 0.18</td>
<td>0.58 ... 1.16</td>
</tr>
<tr>
<td>A140</td>
<td>0.12 ... 0.21</td>
<td>0.70 ... 1.37</td>
</tr>
</tbody>
</table>

Table 35: Permissible clearances A and B

1. Move the rotor to and fro up to the stop. In order to obtain a correct measurement, elevate the turbine a little.
2. Measure clearance A and compare it with the permissible values in the table.
3. Raise the compressor and push the turbine down at the same time.
4. Raise the turbine and push the compressor down at the same time.
5. Measure clearance B and compare it with the permissible values in the table.

⚠️ CAUTION

Clearances outside the tolerance

Serious damage to engines or property can be caused by clearances outside the tolerance and excessively worn parts.

- Have the components assessed and, if necessary, replaced by an ABB Turbocharging Service Station.
8.12 Nozzle ring compression PD

For the nozzle ring (56001) to be fixed during operation, it must be clamped between the heat shield (42400) and the turbine casing (51000).

1. Measure dimensions A, B, and S on cleaned surfaces.
2. Calculate compression (PD).

> If the calculated value (PD) lies outside the specified range, contact an ABB Turbocharging Service Station.

<table>
<thead>
<tr>
<th>Product</th>
<th>Compression PD [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A130</td>
<td>-0.15 ... 0.15</td>
</tr>
<tr>
<td>A135</td>
<td>-0.16 ... 0.16</td>
</tr>
<tr>
<td>A140</td>
<td>-0.16 ... 0.16</td>
</tr>
</tbody>
</table>

Table 36: Permitted nozzle ring compression PD

Fig. 40: Nozzle ring compression PD
8.13 Installing nozzle ring

*) Variant A1 or A2, depending on the nozzle ring version.

1. Fit the lamellar sealing ring (56005) in the correct slot (see detail A1/A2). When doing this, pay attention to correct winding of the lamellar sealing ring (see detail B).

2. Secure the lamellar sealing ring (56005) with adhesive tape (01).

3. Place the burst ring (57210) in the turbine casing.

4. Insert the nozzle ring (56001) (with the cams facing downwards) into the turbine casing as far as it will go. Align the cams on the nozzle ring with the recesses of the turbine casing (51000). Do not remove the adhesive tape (01).

5. If present: Fit the metal C-ring (51105).
The end position of the nozzle ring (56001) in the turbine casing (51000) can be checked via dimension H.

Fig. 42: Measuring the end position of the nozzle ring

<table>
<thead>
<tr>
<th>Product</th>
<th>Minimum dimension H [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A130-H</td>
<td>11.00</td>
</tr>
<tr>
<td>A135-H</td>
<td>13.50</td>
</tr>
<tr>
<td>A140-H</td>
<td>16.50</td>
</tr>
</tbody>
</table>

Table 37: End position of the nozzle ring, control dimension H

1. Measure dimension H as shown in the illustration and compare it with the minimum dimension H in the table.

### 8.14 Installing the cartridge group

#### Lifting the cartridge group and rotating it by 90°

Fig. 43: Lifting the cartridge group and rotating it by 90°

1. Loosen and remove nuts.
2. Lift the cartridge group out of the service support (90012).
3. Insert the screws of the service support from above and fit ring nuts (VRM) with washers.
4. Attach lifting gear to the ring nuts (VRM).
5. Lift cartridge group at the side of the ring nuts (VRM) and turn it into a vertical position.
Installing the cartridge group

1. Coat the threads of the studs (51006) with high-temperature grease.
2. Align the casing position of the cartridge group with the marking.
3. Lower the cartridge group into the turbine casing.
4. Remove ring nuts and screws.
5. Install the fastening strips (51002) with Verbus Ripp® discs (51003) and hexagon nuts (51007).
6. Tighten the hexagon nuts (51007).

Table 38: Tightening torque (51007)

<table>
<thead>
<tr>
<th>Part number</th>
<th>A130</th>
<th>A135</th>
<th>A140</th>
</tr>
</thead>
<tbody>
<tr>
<td>51007</td>
<td>M8</td>
<td>M10</td>
<td>M12</td>
</tr>
<tr>
<td></td>
<td>25 Nm</td>
<td>45 Nm</td>
<td>75 Nm</td>
</tr>
</tbody>
</table>
8.15 Installing the compressor casing

Fitting the wall insert and the diffuser

1. Always replace the O-ring (77005) (see section Spare parts).
2. Install the wall insert (77000) in the compressor casing.
3. Secure the diffuser (79000) with fixing discs (79040) and screws (79041).

Table 39: Tightening torque (79041)

<table>
<thead>
<tr>
<th>Part number</th>
<th>A130</th>
<th>A135</th>
<th>A140</th>
</tr>
</thead>
<tbody>
<tr>
<td>79041</td>
<td>M6 8 Nm</td>
<td>M6 8 Nm</td>
<td>M6 8 Nm</td>
</tr>
</tbody>
</table>

Fig. 45: Fitting the wall insert and the diffuser
Installing the compressor casing

Fig. 46: Installing the compressor casing

<table>
<thead>
<tr>
<th>Part number</th>
<th>A130</th>
<th>A135</th>
<th>A140</th>
</tr>
</thead>
<tbody>
<tr>
<td>72011</td>
<td>M8</td>
<td>M10</td>
<td>M12</td>
</tr>
<tr>
<td></td>
<td>35 Nm</td>
<td>70 Nm</td>
<td>105 Nm</td>
</tr>
</tbody>
</table>

Table 40: Tightening torque (72011)

1. Fit a new, high temperature-resisting O-ring (42012, red or green) (see chapter **Required customer spare part set (97070) → 89**).
2. Thoroughly clean the fastening strips (72012) before assembly.
3. Attach swivel lifting eyes (01) to the compressor casing (72000) and lifting gear.
4. Install the compressor casing (72000).
5. Install the fastening strips (72012) with screws (72011).
8.16 Radial clearances N and R

![Diagram of radial clearances]

Fig. 47: Measuring clearances N and R

\[
N = \frac{N_1 + N_2}{2}
\]

\[
R = \frac{R_1 + R_2}{2}
\]

Table 41: Permissible clearances N and R

<table>
<thead>
<tr>
<th>Product</th>
<th>N [mm]</th>
<th>R [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A130</td>
<td>0.26 ... 0.60</td>
<td>0.45 ... 0.70</td>
</tr>
<tr>
<td>A135</td>
<td>0.34 ... 0.70</td>
<td>0.51 ... 0.85</td>
</tr>
<tr>
<td>A140</td>
<td>0.45 ... 0.90</td>
<td>0.64 ... 1.00</td>
</tr>
</tbody>
</table>

1. Push the feeler gauges (01) into the gap such that there is no clearance. The upper direction (N1) and lower direction (N2) must be covered simultaneously.

2. Calculate clearance N and compare it with the permissible values in the table.

3. Push the feeler gauges (01) into the gap such that there is no clearance. The upper direction (R2) and lower direction (R1) must be covered simultaneously.

4. Calculate clearance R and compare it with the permissible values in the table.

**CAUTION**

Clearances outside the tolerance

Serious damage to engines or property can be caused by clearances outside the tolerance and excessively worn parts.

- Have the components assessed and, if necessary, replaced by an ABB Turbocharging Service Station.
8.17 Installing air inlets

Fig. 48: Installing the air inlets

<table>
<thead>
<tr>
<th>Part number</th>
<th>A130</th>
<th>A135</th>
<th>A140</th>
</tr>
</thead>
<tbody>
<tr>
<td>72020</td>
<td>M12</td>
<td>M12</td>
<td>M12</td>
</tr>
<tr>
<td></td>
<td>60 Nm</td>
<td>60 Nm</td>
<td>60 Nm</td>
</tr>
</tbody>
</table>

Table 42: Tightening torque (72020)

1. Secure lifting gear to filter silencer (81000).
2. Fit a new O-ring (81010) to the filter silencer (81000) or a new O-ring (82010) to the air suction branch (82000).
3. Fit the filter silencer (81000) or air suction branch (82000) with the V-clamp (72020).
4. Observe the tightening torque.
8.18 Installing the gas outlet flange

1. If present: Insert the metal C-ring (57003) into the turbine casing (51000) and secure with high-vacuum grease.
2. Install the gas outlet flange (57002) in the turbine casing.
3. Measure radial clearance (R) (see chapter Radial clearances N and R).

8.19 Installing the gas outlet casing

1. Insert a new gasket (61002) into the gas outlet casing (61001).
2. Coat the threads of the studs (51008) with high-temperature grease.
3. Attach the lifting gear to the gas outlet casing (61001) and position the gas outlet casing in the correct position on the turbine casing (51000).
4. If present: Fit the support (61301).

---

Table 43: Tightening torque (51009)

<table>
<thead>
<tr>
<th>Part number</th>
<th>A130</th>
<th>A135</th>
<th>A140</th>
</tr>
</thead>
<tbody>
<tr>
<td>51009</td>
<td>M8</td>
<td>M10</td>
<td>M12</td>
</tr>
<tr>
<td></td>
<td>20 Nm</td>
<td>40 Nm</td>
<td>65 Nm</td>
</tr>
</tbody>
</table>

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5. Fit the hexagon nuts (51009). Observe the tightening torque.

### 8.20 Table of tightening torques

**Fig. 51: Tightening torques**

The following tightening torques must be observed for the designated screw fittings:

<table>
<thead>
<tr>
<th>Position</th>
<th>Part number</th>
<th>A130</th>
<th>A135</th>
<th>A140</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>72020</td>
<td>M12</td>
<td>60 Nm</td>
<td>M12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>04</td>
<td>79041</td>
<td>M6</td>
<td>8 Nm</td>
<td>M6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08</td>
<td>51007</td>
<td>M8</td>
<td>25 Nm</td>
<td>M10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>09</td>
<td>51009</td>
<td>M8</td>
<td>20 Nm</td>
<td>M10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>72011</td>
<td>M8</td>
<td>35 Nm</td>
<td>M10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>86505</td>
<td>M12 x 1.5</td>
<td>15 Nm</td>
<td>M12 x 1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>51101 / 51103 / 51104 / 61201</td>
<td>M8</td>
<td>20 Nm</td>
<td>M8</td>
</tr>
</tbody>
</table>

Table 44: Tightening torques of the screw fittings
9 Taking out of operation at short notice

9.1 Possible emergency repairs

⚠️ WARNING

Danger of fire and explosion due to lubricating oil leaks

Leaking oil may ignite on hot surfaces. This can result in serious injuries to personnel or fatal accidents.

- Cordon off danger area.
- Raise the alarm and, depending on the situation, stop the engine.
- Seal the oil leak.
- Soak up oil and dispose of in an environmentally compatible manner.

Wear safety gloves to protect against thermal hazards.

⚠️ CAUTION

Directives for taking out of operation

Serious damage to engine or property can be caused by non-compliance with the directives for blanking the turbocharger off the engine.

- Follow the directives of the enginebuilder.

If the engine has to be brought back into operation again as quickly as possible in the event of a turbocharger defect, the following emergency repair options exist:

- If present: Installing the replacement turbocharger →85.
- If present: Installing the replacement cartridge group →85.

- Observe the following sections in connection with the emergency repairs mentioned.
9.2 Installing the replacement turbocharger

To enable you to quickly put an engine back into operation after a turbocharger has sustained damage, ABB Turbo Systems recommends having a replacement turbocharger or appropriate spare parts available in storage. The defective turbocharger can be removed and the replacement turbocharger installed within a short period of time.

- Remove defective turbocharger (see chapter Removing and Installing → 8).
- Install replacement turbocharger (see chapter Removing and Installing → 8).
- Send the defective turbocharger to an ABB Turbocharging Service Station for inspection and repair.

9.3 Installing the replacement cartridge group

**WARNING**

Incorrect handling of a cartridge group

Incorrect handling of a cartridge group can damage the turbocharger and cause injuries to persons.

- Have repairs to the cartridge group carried out by an ABB Turbocharging Service Station only.

To enable you to quickly put an engine back into operation after a turbocharger has sustained damage, ABB Turbo Systems recommends having a replacement cartridge group available in storage. The defective cartridge group can be removed and the replacement cartridge group installed within a short period of time. A replacement cartridge group is ready for use immediately and includes the complete bearing casing with bearing and a balanced rotor.

The repair of a cartridge group requires special tools and the expertise of an ABB Turbocharging Service Station. The rotating parts rotate extremely fast, and are sensitive to unbalance.

- Remove defective cartridge group (see chapter Dismantling and fitting → 58).
- Install replacement cartridge group (see chapter Dismantling and fitting → 58).
- Send the defective cartridge group to an ABB Turbocharging Service Station for inspection and repair.
10 Mothballing the turbocharger

10.1 Taking the engine out of operation for up to 12 months

State of the engine lubricating oil

The turbocharger normally remains attached to the engine. The measures to be taken for mothballing the turbocharger depend on the state of the lubricating oil. No measures are required under the following conditions:

- Acid number (TAN) < 2 mg KOH/g
- The engine lubricating oil is replaced by a preservative oil and circulated with the pre-lubrication pump before the engine is taken out of operation. Residues of old engine oil are flushed away in this way and the bearing parts are largely protected against corrosion.

Preparations for mothballing

**WARNING**

Handling operating materials and supplies

Swallowing or inhaling vapours of operating materials and supplies or contact with them may be harmful to health.

- Do not breathe in these substances and avoid contact with the skin.
- Ensure proper ventilation.
- Observe the information in the material safety data sheet for the operating materials and supplies.
- Wear personal protective equipment (PPE) according to the material safety data sheet.
- Comply with local legislation.

Wear safety goggles.

Wear safety gloves to protect against chemical hazards.

Wear a respiratory mask to protect against gases.

If the acid number (TAN) is greater than 2 mg KOH/g, the following mothballing measures are necessary after taking the engine out of operation:

- Dismantle the turbocharger.
- The rotor and bearing parts must be dismantled and subsequently refitted by an ABB Turbocharging Service Station.
- Clean all parts.
10 Mothballing the turbocharger / 10.2 Taking the engine out of operation for more than 12 months

- Coat plain surfaces of steel and cast parts with anticorrosive oil.
- Fit turbocharger completely.

**Rotation of the rotor in the stack draught**
If the rotor turns as a result of the stack draught:
- Install a blind flange between the outlet flange of the compressor casing and the charge air duct.

### 10.2 Taking the engine out of operation for more than 12 months

If the engine is taken out of operation, the following variants are possible with regard to the turbocharger:
- Turbocharger remains attached to the engine
- The casings of the turbocharger remain attached to the engine, the rotor and bearing parts are dismantled by an ABB Turbocharging Service Station and stored separately
- The turbocharger is completely removed, either as a whole unit or in individual parts

For the measures always necessary for preparing the turbocharger parts for mothballing, see section Taking the engine out of operation for up to 12 months, subsection Preparations for mothballing.

If the turbocharger remains attached to the engine, see section Taking the engine out of operation for up to 12 months →86, subsection Rotor turning in stack draught.

If the complete turbocharger is removed or the turbocharger is assembled again from the individual parts:
- Seal all openings of the turbocharger with paraffin paper and wooden lids.

Only dry rooms with 40 ... 70 % atmospheric humidity, in which no water condensation can form, are suitable as storage locations.

**State of the mothballed turbocharger**
- Check the turbocharger parts annually for corrosion.
- If there are signs of rust: Thoroughly clean parts and renew corrosion protection.
11 Disposing of turbocharger components

**WARNING**

Handling damaged thermal insulation

Damaged thermal insulation can lead to dust exposure. The glass fibres can cause mechanical irritation of the eyes, skin, and respiratory tracts.

- Avoid the formation of dust.
- Vacuum up dust with a suitable vacuum cleaner.
- Wear a respiratory mask to protect against dusts (P1 or P2 mask).
- Wear work gloves made of leather.

- Wear safety goggles.
- Wear a respiratory mask to protect against dusts.
- Wear safety gloves to protect against mechanical hazards.

Disposal must be environmentally compatible, professional, and in compliance with locally applicable regulations.

The turbocharger consists largely of metal (cast iron materials, steel, nickel-steel alloys, aluminium and bearing brass).

Further components are: Non-metallic materials (filter components of felt and polyethylene), lubricants (engine oil), electronic parts (speed sensor and associated components), and thermal insulation.

- Dispose of metals as scrap metal for recycling.
- Dispose of non-metallic materials as waste.
- Dispose of residues of lubricants as waste oil.
- Dispose of electronic components as electronic waste.
- Dispose of thermal insulation as hazardous waste.
12 Spare parts

12.1 Ordering spare parts

CAUTION

Spare part storage
All spare parts that were ordered together with the turbocharger must be kept intact and ready for use.
- Carefully clean any rusted parts and grease them.

Please quote the following data when making queries and ordering spare parts:
- Turbocharger type
- Serial number of the turbocharger
- Designation and part number

Spare parts can be ordered from any ABB Turbocharging Service Station.
- If different model variants are not taken into account in this document, contact an ABB Turbocharging Service Station.
- Dispose of placed and unusable parts in an environmentally-friendly and professional manner in accordance with the local regulations.
- Dispose of the packaging of new parts in an environmentally-friendly and professional manner in accordance with the local regulations.

12.2 Required customer spare part set (97070)

For the operations described in the Operation Manual, the customer spare part set (97070) is required. These parts are only available in the complete set.

<table>
<thead>
<tr>
<th>Part number</th>
<th>Designation</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>42012</td>
<td>O-ring (high-temperature resisting, colour: red or green)</td>
<td>1</td>
</tr>
<tr>
<td>61002 *</td>
<td>Gasket</td>
<td>1</td>
</tr>
<tr>
<td>77005</td>
<td>O-ring</td>
<td>1</td>
</tr>
<tr>
<td>79041</td>
<td>Counter-sunk screw</td>
<td>2</td>
</tr>
<tr>
<td>81010/ 82010</td>
<td>O-ring</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 45: Customer spare part set 97070

* This gasket can only be installed when a gas outlet casing from ABB Turbo Systems is used.
12.3 View of turbocharger with part numbers

Fig. 52: Overview of part numbers

(……) only available in customer spare part set (97070).
<table>
<thead>
<tr>
<th>Part number</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>10900</td>
<td>Cartridge group</td>
</tr>
<tr>
<td>42008</td>
<td>Socket screw</td>
</tr>
<tr>
<td>42012</td>
<td>O-ring (high-temperature resisting, colour: red or green)</td>
</tr>
<tr>
<td>42201*</td>
<td>Clamping nut</td>
</tr>
<tr>
<td>51000</td>
<td>Turbine casing</td>
</tr>
<tr>
<td>51002</td>
<td>Fastening strip</td>
</tr>
<tr>
<td>51105*</td>
<td>Metal C-ring</td>
</tr>
<tr>
<td>51500</td>
<td>Burst protection</td>
</tr>
<tr>
<td>56001</td>
<td>Nozzle ring</td>
</tr>
<tr>
<td>56005</td>
<td>Lamellar sealing ring</td>
</tr>
<tr>
<td>57002</td>
<td>Gas outlet flange</td>
</tr>
<tr>
<td>57003*</td>
<td>Metal C-ring</td>
</tr>
<tr>
<td>57210</td>
<td>Burst ring</td>
</tr>
<tr>
<td>61001</td>
<td>Gas outlet casing</td>
</tr>
<tr>
<td>61002</td>
<td>Gasket</td>
</tr>
<tr>
<td>61200</td>
<td>Burst protection</td>
</tr>
<tr>
<td>61205</td>
<td>Protective grid</td>
</tr>
<tr>
<td>61301*</td>
<td>Support profile</td>
</tr>
<tr>
<td>72000</td>
<td>Compressor casing</td>
</tr>
<tr>
<td>72011</td>
<td>Hexagon-head screw</td>
</tr>
<tr>
<td>72012</td>
<td>Fastening strip</td>
</tr>
<tr>
<td>72020</td>
<td>V-clamp</td>
</tr>
<tr>
<td>77000</td>
<td>Wall insert</td>
</tr>
<tr>
<td>77005</td>
<td>O-ring</td>
</tr>
<tr>
<td>79000</td>
<td>Diffuser</td>
</tr>
<tr>
<td>79041</td>
<td>Counter-sunk screw</td>
</tr>
<tr>
<td>81000</td>
<td>Filter silencer</td>
</tr>
<tr>
<td>81010</td>
<td>O-ring</td>
</tr>
<tr>
<td>82000</td>
<td>Air suction branch</td>
</tr>
<tr>
<td>82010</td>
<td>O-ring</td>
</tr>
<tr>
<td>86505*</td>
<td>Speed sensor</td>
</tr>
<tr>
<td>86515*</td>
<td>Cable connector</td>
</tr>
<tr>
<td>86526*</td>
<td>F/I converter</td>
</tr>
<tr>
<td>86528*</td>
<td>Tachometer</td>
</tr>
</tbody>
</table>

Table 46: Spare parts list

* Depending on the specification of the turbocharger
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