



**TCR**

# **Project Guide**

Exhaust Gas Turbocharger

Engineering the Future – since 1758.

**MAN Diesel & Turbo**



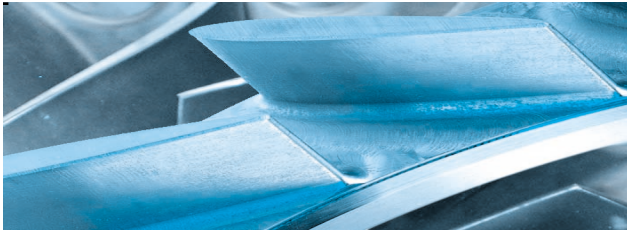




# Project Guide

## Exhaust Gas Turbocharger TCR Series

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Low Noise Levels  
Long Service Life of Wear Parts  
High Power/Load Ratio  
Extended Application Range  
Compact Design  
Easy Maintenance  
Simple Installation  
Safe Operation  
Low Weight

## Turbine

- New CFD-optimized components guarantee reliability and increased efficiency: Rotor, nozzle ring as well as inlet and outlet casing
- Constant and pulse pressure turbocharging
- Mix-flow turbine design
- Compact gas-admission casing
- Optimized gas outlet diffuser

## Bearings

- High-grade thrust bearings for low mechanical losses
- Optimized shaft diameter for maximum efficiency
- Compact design of bearings for optimized damping characteristics

## Compressor

- Optimized compressor wheel, diffuser and compressor casing
- Extended pressure ratio and flow rate
- Internal Flow Recirculation (IRC) for extended surge margins
- New compressor wheel fixation for easy servicing

## Maintenance

- Long inspection intervals
- Reduced number of components

## Long Service Life of Wear Parts

- Floating radial bearings
- Thrust bearings
- Nozzle ring
- Compressor wheel

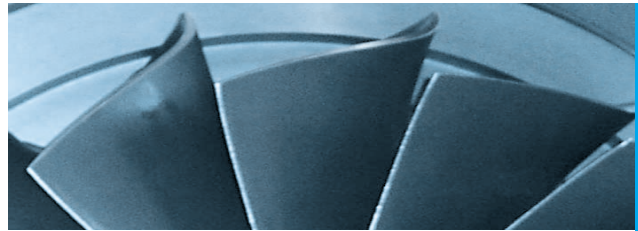
## Casing Design for Easy Assembly

- Uncooled casings
- Lubrication via engine oil-lubrication system
- Integrated oil pipe system
- No sealing air system

## Safety

- Containment-proven exhaust gas turbocharger

## General



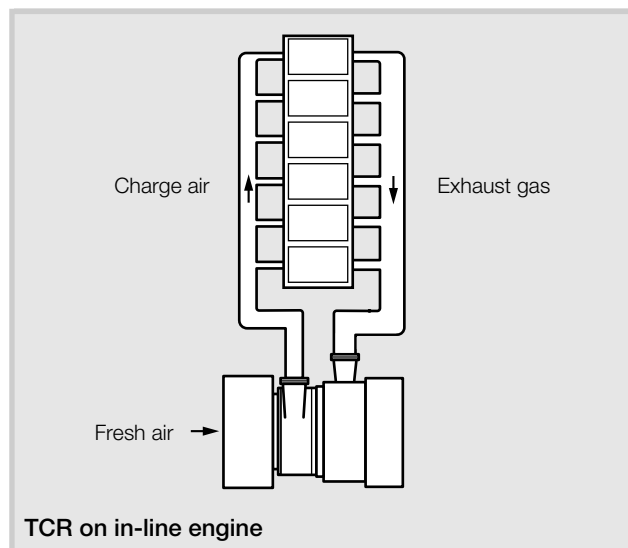
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### Characteristics of the TCR Series Exhaust Gas Turbocharger

Economic operation of modern engines without exhaust gas turbochargers is inconceivable. MAN Diesel turbochargers are equally tried and tested with marine main engines, auxiliary engines and in stationary systems under the most various operating conditions. Reliability, easy maintenance and long inspection intervals have been confirmed through-out decades of experience.

**Exhaust gas turbochargers of the TCR Series can be used with two-stroke and four-stroke engines with constant and pulse pressure turbocharging and engine outputs from 450 kW to 6 700 kW.**

With the new TCR Series, not only clear increases in efficiency, but also substantial improvements in reliability and service life are introduced.



The modular design of the TCR Series allows for optimal adaptation of the turbochargers to the conditions for both four-stroke as well as two-stroke engines.

### Engine Types and Operating Range

MAN Diesel turbochargers of the TCR Series are designed for HFO/MDO engines, dual fuel and gas engines.

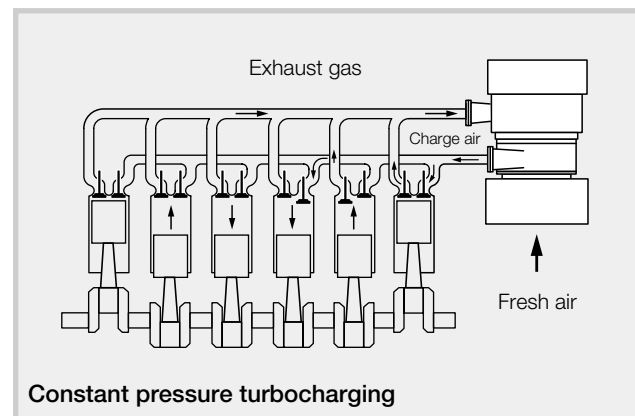
They can be operated on propulsion engines (diesel-mechanic and diesel-electric), on genset auxiliary engines, in stationary systems as well as on traction engines.

### Principles of Exhaust Gas Turbocharging

The exhaust gas turbochargers of the TCR Series are intended for constant and pulse pressure turbocharging.

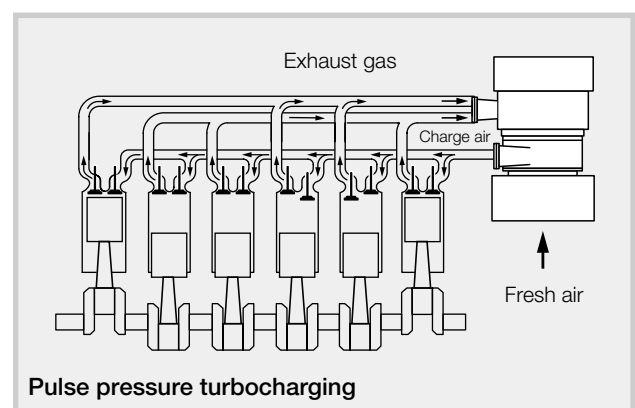
#### Constant pressure turbocharging:

With constant pressure turbocharging, the engine exhaust gases flow into a common exhaust manifold, are accumulated there and flow with minor pressure fluctuations to the exhaust turbine.



#### Pulse pressure turbocharging:

With pulse pressure turbocharging, the engine exhaust gases of the individual cylinders are conducted together to several narrow exhaust gas pipes and transmit the outlet pressure pulses of the cylinders into the multi-socket gas-admission casing.





## Type Plate

The type plate is attached on the pressure socket of the compressor casing. An additional type plate is located on the silencer or on the air intake casing:

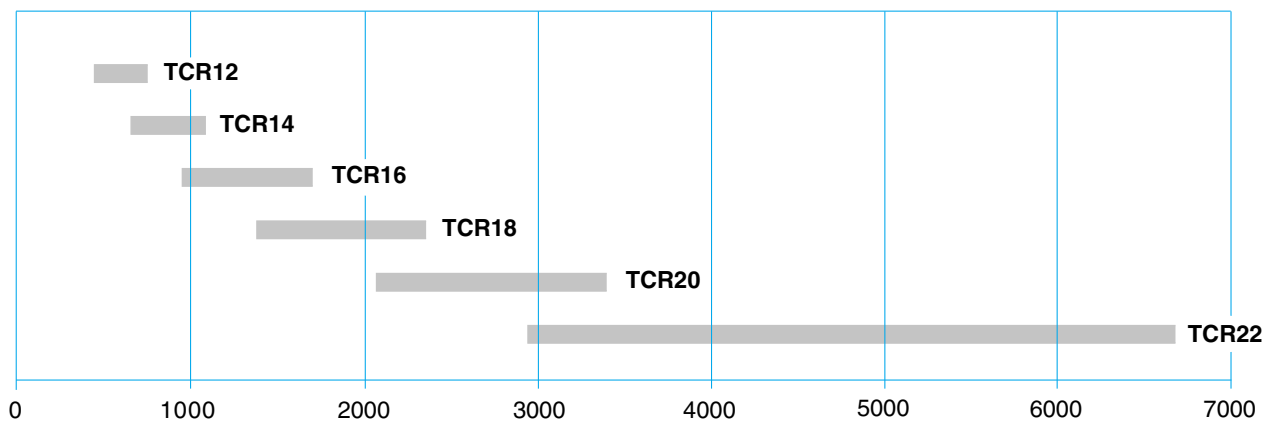
<b>Exhaust gas turbocharger</b>	
type <input type="text"/>	W/No. <input type="text"/>
max <input type="text"/> 1/min	t <sub>max</sub> <input type="text"/> ° <input type="text"/>
type-tested <input type="text"/> year <input type="text"/>	

The type plate contains the following information:

- Turbocharger type,
- Works number (serial number),
- Max. allowable rotor speed,
- Max. allowable turbine inlet temperature,
- Unit of temperature for the turbine inlet temperature,
- Date of the type test,
- Year of ex-works delivery.

## Application Ranges of the TCR Series

The state-of-the-art exhaust gas turbochargers designed and manufactured by MAN Diesel can be used in a very wide range for the charging of diesel and gas engines per TC:



Engine output per exhaust gas turbocharger in kW

Currently, the turbocharger types TCR14, TCR16, TCR18, TCR20 and TCR22 are available.

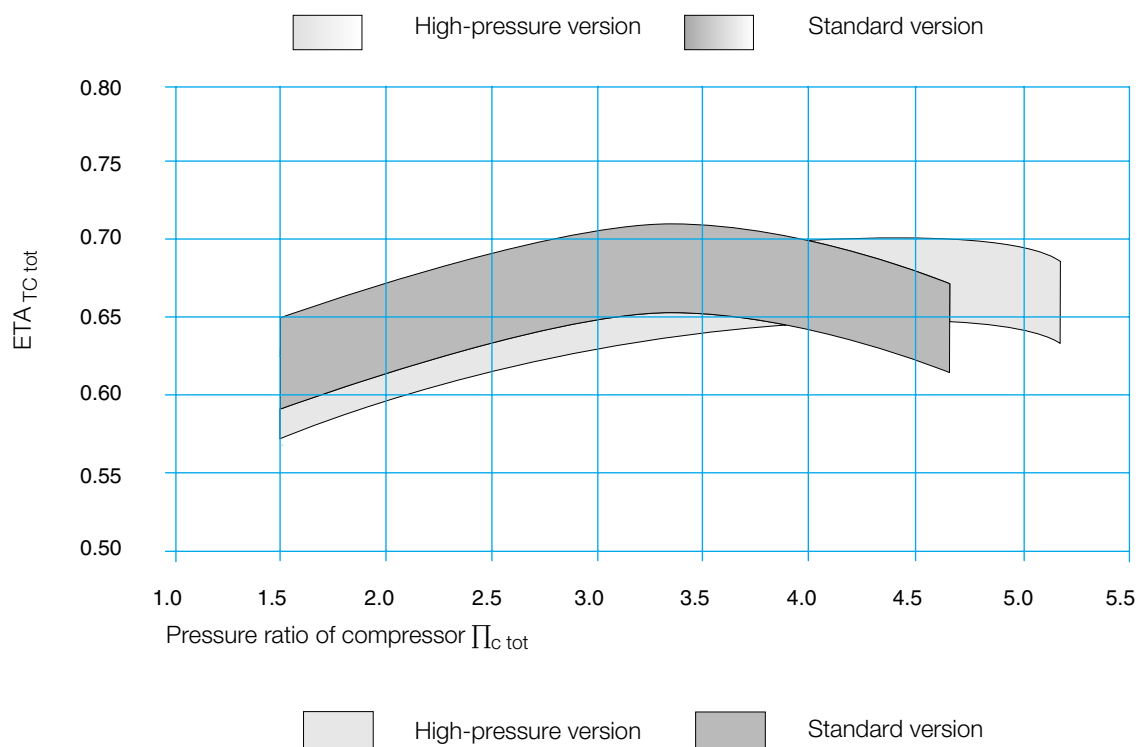
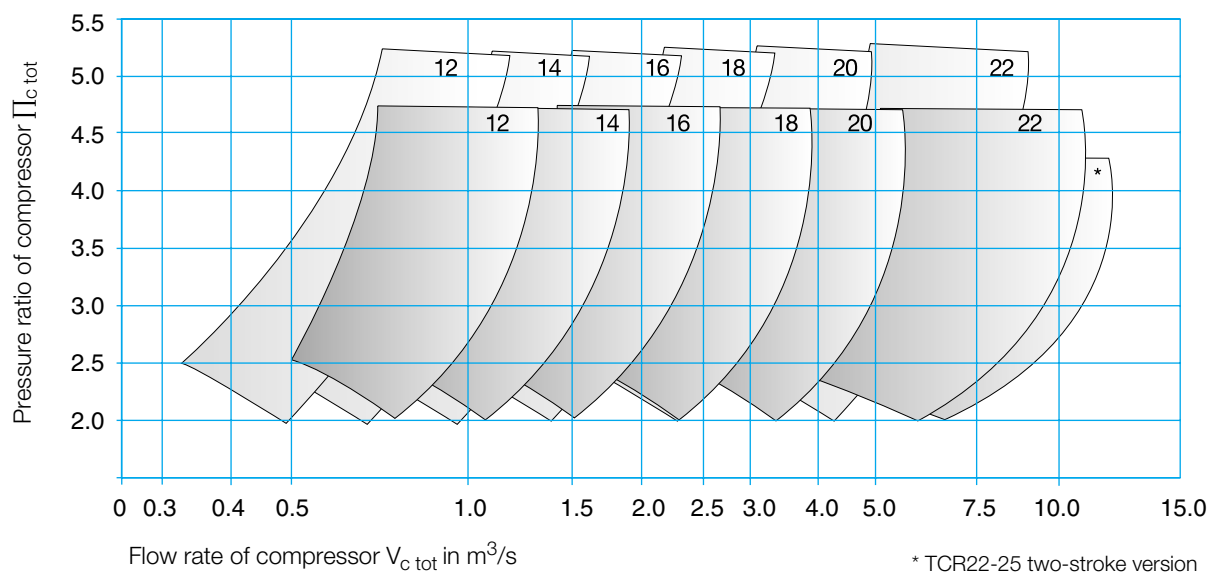
Introduction date of the TCR12 on request.

## Performance Characteristics

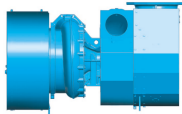
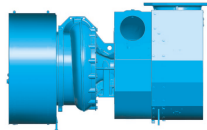
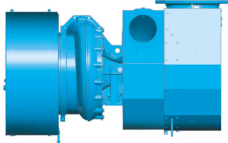
The following operating lines are distinguished:

- Generator curve (constant engine speed),
- Standard propeller curve (variable engine speed),
- Propeller curve at reduced engine speed (high torque),
- Combinator curve (combination of generator and propeller curve),
- as well as vehicle engine curve.

Regardless of the engine's application purpose, a safety margin of all possible operating points to the surge line of the compressor is always required. This is ensured by the respective dimensioning of the compressor.

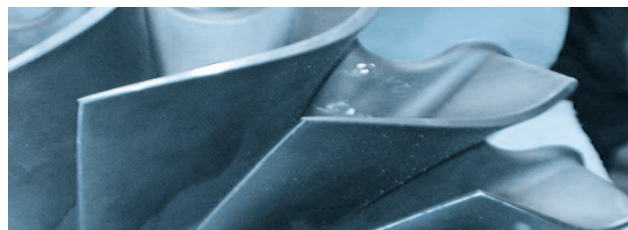


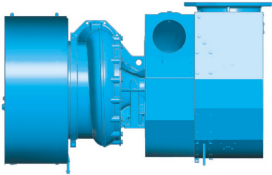
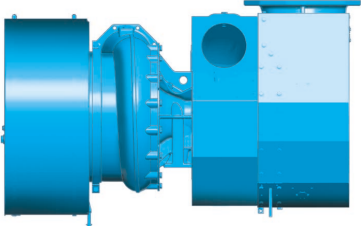
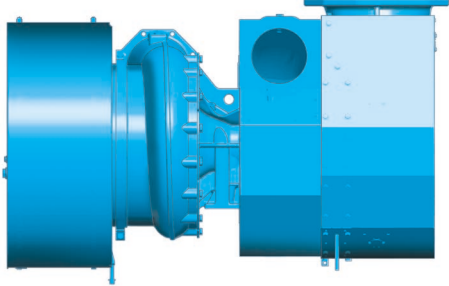
## Overview of Series

Type	TCR12	TCR14	TCR16
			
Technical Data			
Max. engine output per exhaust gas turbocharger Four-stroke engine ( $l_e \approx 7$ kg/kWh) in kW Two-stroke engine ( $l_e \approx 8$ kg/kWh) in kW	760	1 100	1 600
Max. flow rate in m <sup>3</sup> /s	1.26	1.84	2.67
Total pressure ratio Standard version up to High-pressure version up to	4.7 5.2	4.7 5.2	4.7 5.2
Max. allowable rotor speed in rpm	71 300	59 100	49 100
Max. allowable turbine inlet temperature in °C <sup>1)</sup>	650	650	650
Weight as shown	100	165	260

1) Higher temperature on request at MAN Diesel

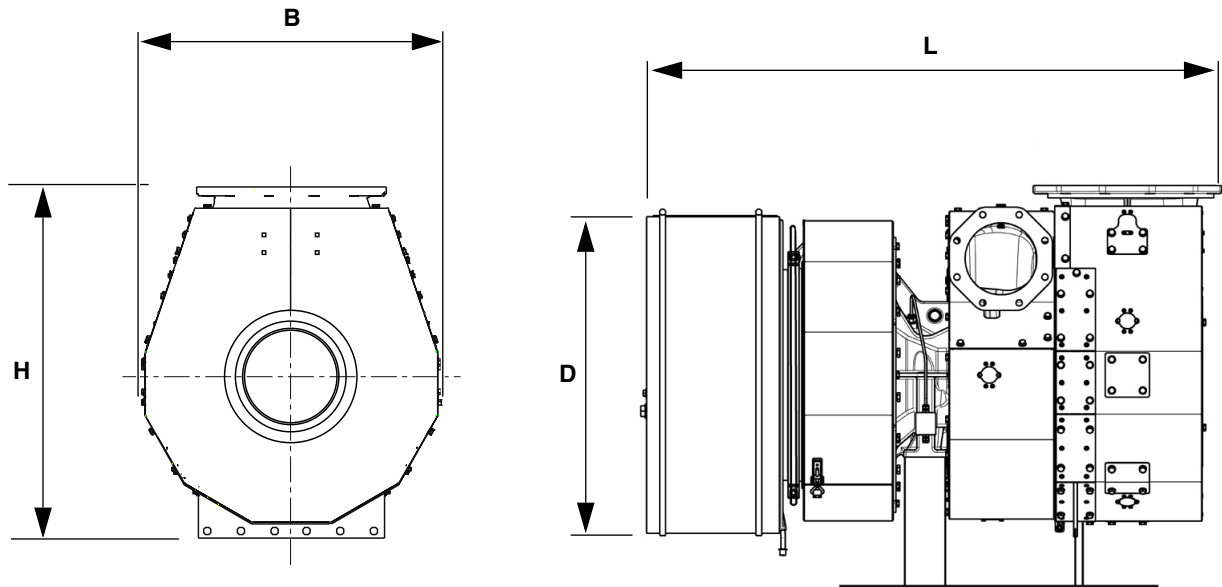


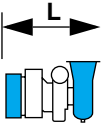
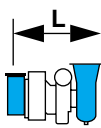
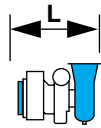


TCR18	TCR20	TCR22	TCR22-25 Two-stroke version
			
<p>2 350 2 050</p>	<p>3 400 3 000</p>	<p>6 700 5 900</p>	<p>6 400</p>
<p>3.92</p>	<p>5.69</p>	<p>11.18</p>	<p>12.19</p>
<p>4.7 5.2</p>	<p>4.7 5.2</p>	<p>4.7 5.2</p>	<p>4.2</p>
<p>40 500</p>	<p>33 600</p>	<p>24 300</p>	<p>23 000</p>
<p>650</p>	<p>650</p>	<p>650</p>	<p>650</p>
<p>415</p>	<p>720</p>	<p>1 550</p>	



## Dimensions and Weights



Type				H in mm	B in mm	D in mm
	L <sup>1)</sup> in mm	L <sup>2)</sup> in mm	L <sup>3)</sup> in mm			
TCR14	904	963	734	530	453	490
TCR16	1 092	1 238	887	658	555	590
TCR18	1 308	1 400	1 066	792	661	714
TCR20	1 580	1 713	1 307	953	777	854
TCR22	2 042	2 234	1 691	1 244	1 023	1 104

- 1) With silencer
- 2) With air intake casing
- 3) With air intake pipe



## Weights of the Assemblies

Assemblies	TCR14	TCR16	TCR18	TCR20	TCR22
Gas outlet casing	38 kg	57 kg	86 kg	144 kg	325 kg
Gas-admission casing	24 kg	38 kg	59 kg	102 kg	233 kg
Cartridge	30 kg	50 kg	89 kg	152 kg	337 kg
Compressor wheel	2 kg	3 kg	6 kg	10 kg	22 kg
Rotor, complete	7 kg	12 kg	23 kg	39 kg	87 kg
Bearing casing	23 kg	38 kg	66 kg	113 kg	250 kg
Compressor casing	29 kg	43 kg	68 kg	132 kg	277 kg
Insert					
Compressor side	8 kg	13 kg	17 kg	35 kg	75 kg
Turbine side	3 kg	4 kg	7 kg	13 kg	30 kg
Silencer	14 kg	27 kg	45 kg	76 kg	156 kg
Air intake casing	18 kg	22 kg	38 kg	64 kg	139 kg
Air intake pipe	11 kg	14 kg	24 kg	42 kg	90 kg
Total weight <sup>1)</sup> (approx. value)	165 kg	260 kg	415 kg	720 kg	1 550 kg

1) Exhaust gas turbocharger with silencer and gas outlet casing



## Casing Positions

For the best possible adaptation to the engine, certain casing assemblies of the exhaust gas turbocharger can be adjusted continuously by up to 360° relative to the vertical position.

Compressor casing	Bearing casing	Gas-admission casing
0° - 360°	0°	0° - 360°
	Further positions upon consultation with MAN Diesel	
continuously adjustable		continuously adjustable
Air intake casing	Gas outlet casing	
0° - 360°	from -90° to +90°	
continuously adjustable	continuously adjustable	

**Note**

All casing positions viewed from the turbine side.

## Design

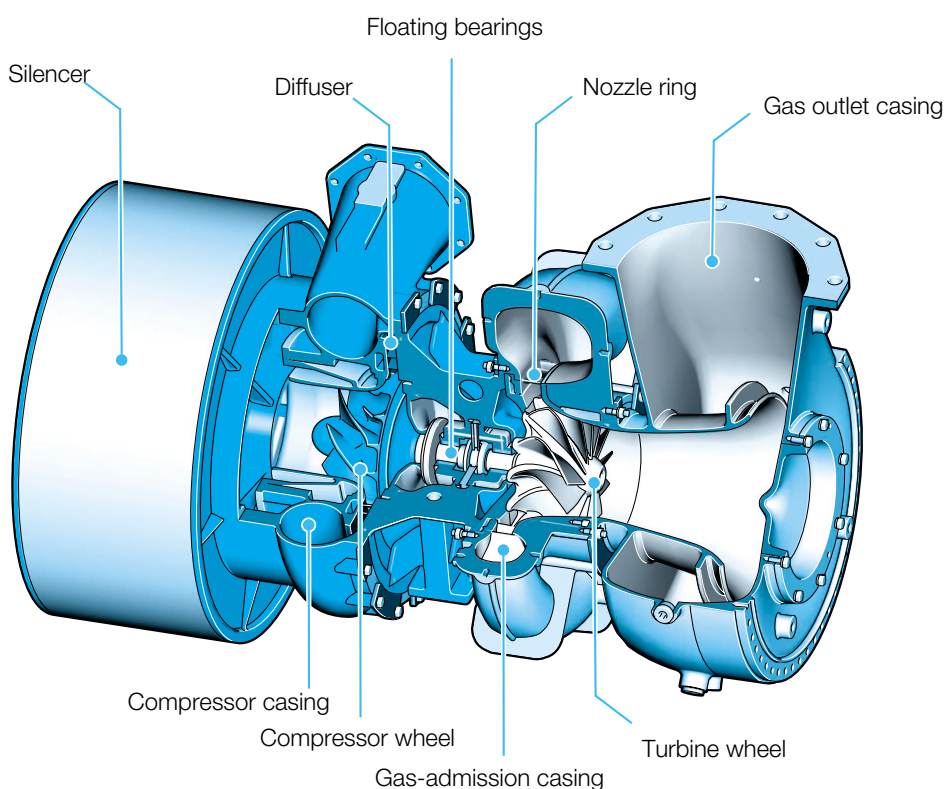


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### Characteristics of the Assemblies

The following view indicates the advanced design principle of the TCR Series:

- High efficiency
- Uncooled casings
- Silencer
- Optional: Internal Flow Recirculation (IRC)
- Easy-to-service, high efficiency compressor wheel
- Floating bearings
- Integrated lubricating oil pipe
- Profiled turbine nozzle ring with long service life
- Standard flanges on gas outlet casing and air intake casing
- Easy inspection through large maintenance hatch



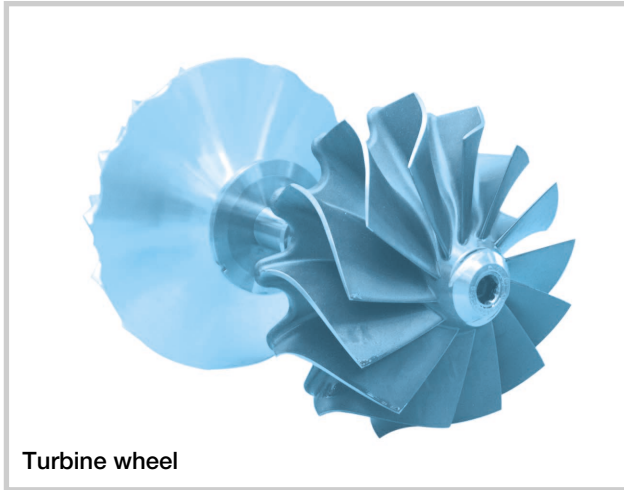
The development of flow parts is carried out based on modern CFD calculation programs. Simulation of the complete turbine and compressor stage allows for realistic calculation of the operating performance and efficiency of the turbocharger.

This enables a more compact design of many components as well as significantly improved adaptation to the engine operating curve.



## Turbine Wheel

The turbine wheel, which is precision casted, consists of a high temperature nickel-based alloy and is connected to the rotor shaft by means of friction welding. CFD simulations, FEM calculations, as well as extensive operational testing with test-bed load measurement ensure maximum reliability.

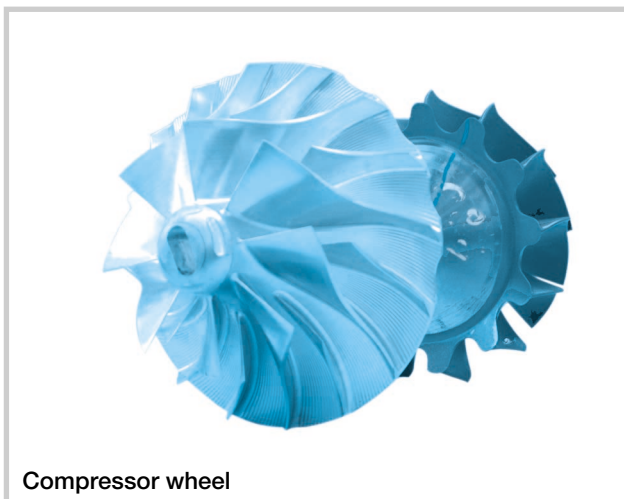


The turbine is very well accessible for inspections and cleaning.

## Compressor Wheel

The highly stressed compressor wheel is milled from a forged aluminum block. It builds up the charge pressure and supplies the engine with the necessary amount of air.

The compressor wheel and the turbine are seated together on the rotor shaft.



## Internal Bearings

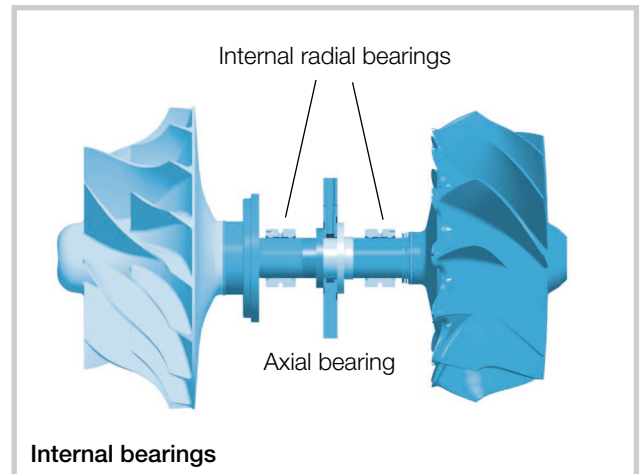
For 70 years MAN Diesel has been using plain bearings in turbochargers with great success. The huge experience resulting has been turned into a bearing concept with high longevity.

The TCR Series combines tried and tested aspects of the axial and radial bearing concept of the NR Series with new detail solutions.

## Bearings

The rotor shaft runs in plain bearings which enable precise centering of the rotor shaft. The centrally arranged thrust bearing handles the axial guidance and the axial thrust.

These bearings have ideal properties under extreme high axial and radial forces and ensure long service life. The high damping effect of the oil film make them insensitive to vibrations and imbalance.



Characteristics of the bearing concept:

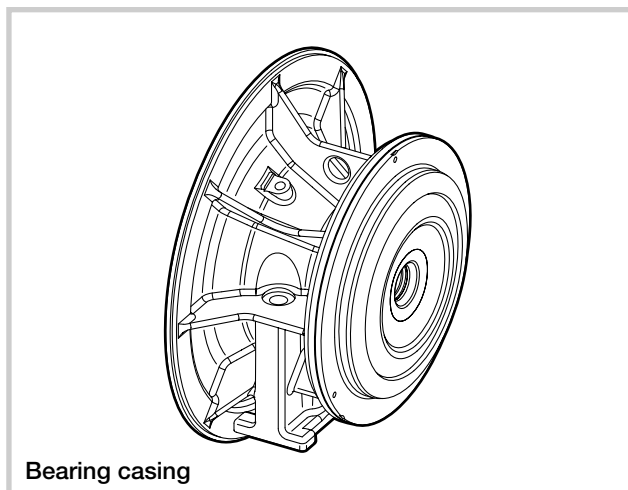
- Floating bearings,
- Compact bearing concept with center thrust bearing,
- Shaft sealing with piston rings and no sealing air.

Easy assembly and disassembly of the bearings is ensured through housing of the radial bearings in the bearing bodies.

## Bearing Casing

The bearing casing is manufactured of cast iron with spheroid graphite. It contains the distribution ducts for the lube oil which is also used for cooling of the casing.

For special applications, e.g., for gas engines with high exhaust gas temperatures, water-cooled bearing casings can be provided.



Bearing casing

## Diffuser

The diffuser raw part is manufactured of cast iron with spheroid graphite, from which the vane profile is then milled.

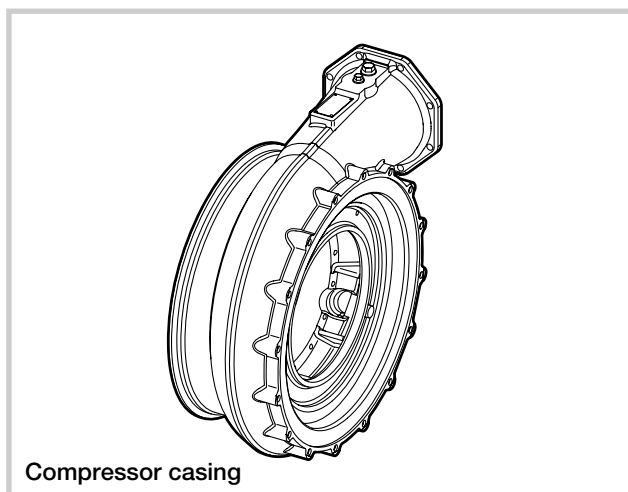


Diffuser

Optimal adaptation of the compressor map to the engine takes place by changing the diffuser cross-section (see Page 10-3, Chapter Matching Procedure). This provides for optimal conversion of the speed component in pressure after the compressor wheel.

## Compressor Casing

The compressor casing is manufactured of cast iron with spheroid graphite. The standard design is with single outlet. It is fastened to the bearing casing with clamping claws.



Compressor casing

The casing position is adjusted continuously (see Table on Page 2-5).

The newly calculated flow cross-sections and the large outlet surfaces ensure effective conversion of the kinetic energy into pressure.

For special applications the compressor casing can be sound-insulated.



## Silencer with Air Filter

Exhaust gas turbochargers for marine engines, as a standard, are equipped with silencers that are surrounded by a filter mat.

Silencer characteristics:

- High turbocharger efficiency due to low pressure loss, especially at high air-flow,
- Effective sound level reduction,
- Low air-flow velocity at the silencer intake,
- Integrated cleaning device for compressor.

The completely new developed silencer casing dampens the sound immission to less than 105 dB(A).

Air filter mat characteristics:

- The effective filtration widely keeps the compressor, diffuser and charge-air cooler free from dirt particles,
- Easy replacement and installation,
- In case filter particles are drawn in, there is no danger of damage to any leading edges of the compressor,
- Cleaning of the air filter mat is required only every 250 operating hours (approx.).



The plastic air filter mat is resistant to temperatures of up to 100 °C, short-term even to 120 °C. The relative humidity can be 100%. The behavior in fire is self-extinguishing.

The filter mats can be fully regenerated. For this, rinse with warm water from inside to outside, vacuum or blow out with compressed air. If necessary, mild detergents can be added to the water. Avoid heavy mechanical stress such as wringing out or applying a hard water jet.

Technical data according to ASHRAE (DIN 24 185):

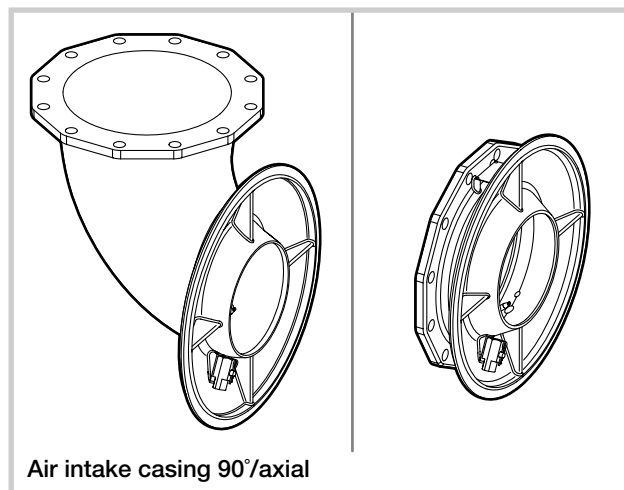
Average separation content .....	83%
Efficiency .....	< 20%
Quality class (filtration class) .....	EU3
Dust-absorption capacity .....	520 g/m <sup>3</sup>
Pressure loss.....	200 Pa (20 mm water column)

## Air Intake Casing

The air intake casing is used during operation without air filter. It achieves constant distribution of pressure and velocity at the pressure intake owing to the optimized flow ducts.

The air intake casing can be adjusted continuously from 0° to 360° relative to the bearing casing (see Table on Page 2-5).

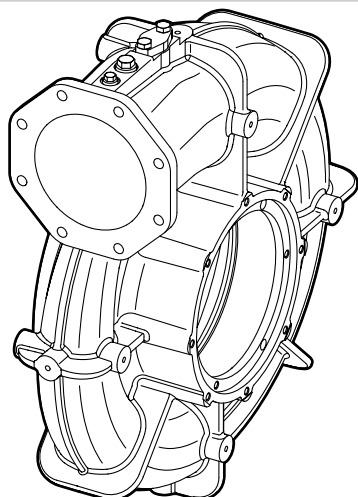
The air intake casing is available in the 90° as well as in the axial version:





## Gas-Admission Casing

The gas-admission casing is manufactured from of silicide-molybdenum alloyed cast iron with spheroid graphite. The un-cooled casing is heat-insulated with a covering.



Gas-admission casing

The gas-admission casing is fastened to the bearing casing with clamping claws and can be adjusted continuously (see Table on Page 2-5).

Optimized flow cross-sections keep the loss of flow at a low level. For pulse pressure turbocharging, the gas-admission casing can be provided with several gas-intake connections.

## Turbine Nozzle Ring

The cast turbine nozzle ring with profiled vanes largely contributes to the excellent turbine efficiency of the TCR Series.

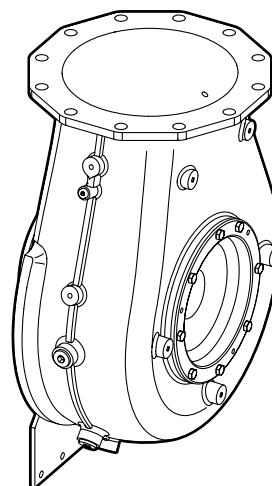


Turbine nozzle ring

Optimum adaptation of the turbocharger to the engine is achieved through nozzle-ring variants with different cross sections. Turbine nozzle rings are manufactured from an extremely resistant material which ensures long service life.

## Gas Outlet Casing

The gas outlet casing is manufactured from cast iron with spheroidal graphite. The casing is uncooled and is heat-insulated with a covering.

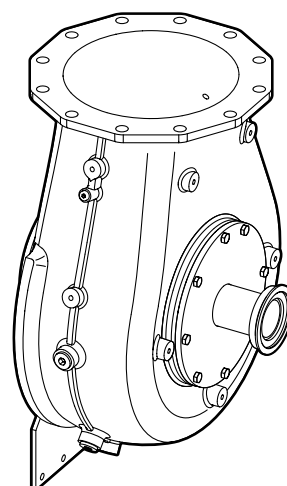


Gas outlet casing

An optimized, high-volume and very effective gas outlet diffuser is integrated in the gas outlet casing. It can be adjusted continuously from  $-90^\circ$  to  $+90^\circ$  relative to the bearing casing (see Table on Page 2-5).

### Waste Gate

The gas outlet casing can be supplied with a waste gate connection:



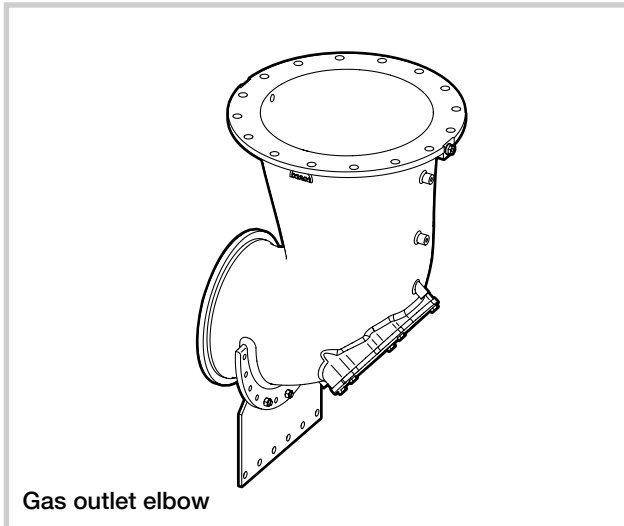
Gas outlet casing with waste gate

The waste gate enables the exhaust gas to be bypassed in order to avoid the maximal turbocharger speed from being exceeded. The optimized waste-gate connection, which is in line with the turbocharger axis, allows for easy engine-side mounting.



## Gas Outlet Elbow

Exhaust gas turbochargers of the TCR Series can also be supplied with a gas outlet elbow.



The gas outlet elbow is manufactured from cast iron with spheroidal graphite. As a result, the reduced space requirement and the lower weight are an advantage for assembly.

## Containment Safety

With modern diesel engines, turbochargers are one of the components that are subject to the highest loads. The high speeds of turbocharger rotors lead to high centrifugal forces and high component temperatures at the same time.

All assemblies of a MAN Diesel turbocharger are designed to provide optimal burst protection. Extensive calculations and operational testing ensure maximum safety.

MAN Diesel turbochargers comply with the required containment safety according to the regulations of the classification societies so that particles cannot be expelled in case of damage.

## Loads on Connections and Flanges

All exhaust gas turbocharger casing flanges, with the exception of the turbine outlet, may be subject only to loads by the effected gas forces. The maximum values are to be observed under consideration of exterior forces and torque.

This necessitates the use of compensators directly at the turbine inlet, at the turbine outlet as well as after the compressor.

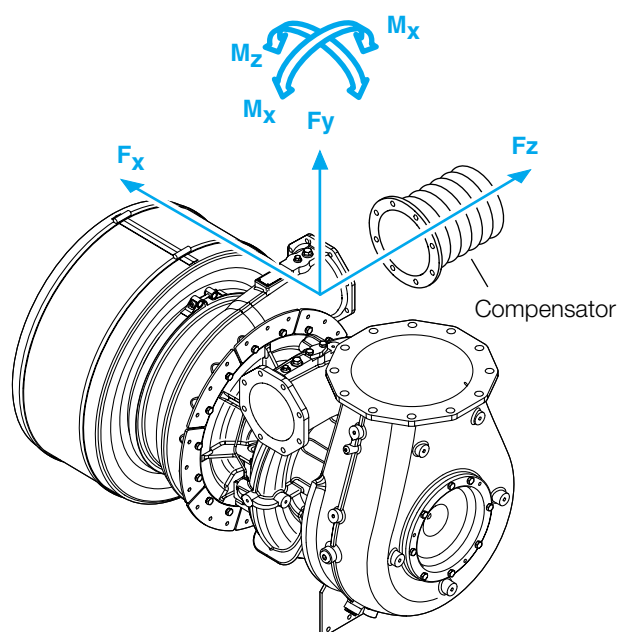
The compensators are to be pre-loaded in such a manner that thermal expansion of the pipes and casing do not effect forces or torque in addition to the air or gas forces.

The mentioned parameters for the connections apply for **radial and axial** air intake casings.

- Forces and torques according to API Standard 617,
- Direction of effect transferred according to MAN Diesel Standard,
- Minimized anticipated loads as far as possible,
- Parameters include forces of masses and compensators.

## Connections of the Charge Air Pipes

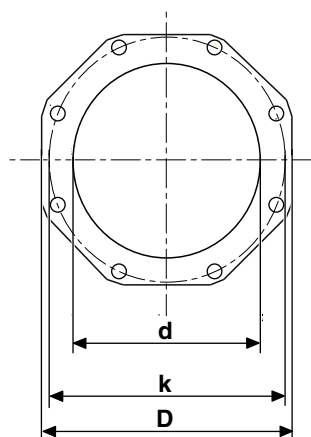
Type	$F_x$ in N	$F_y$ in N	$F_z$ in N	$M_x$ in Nm	$M_z$ in Nm
TCR14	1 900	3 900	3 900	2 900	1 400
TCR16	2 300	4 600	4 600	3 500	1 700
TCR18	2 800	5 700	5 700	4 300	2 100
TCR20	3 400	6 900	6 900	5 200	2 600
TCR22	3 900	7 900	7 900	6 000	3 000



Maximum loads

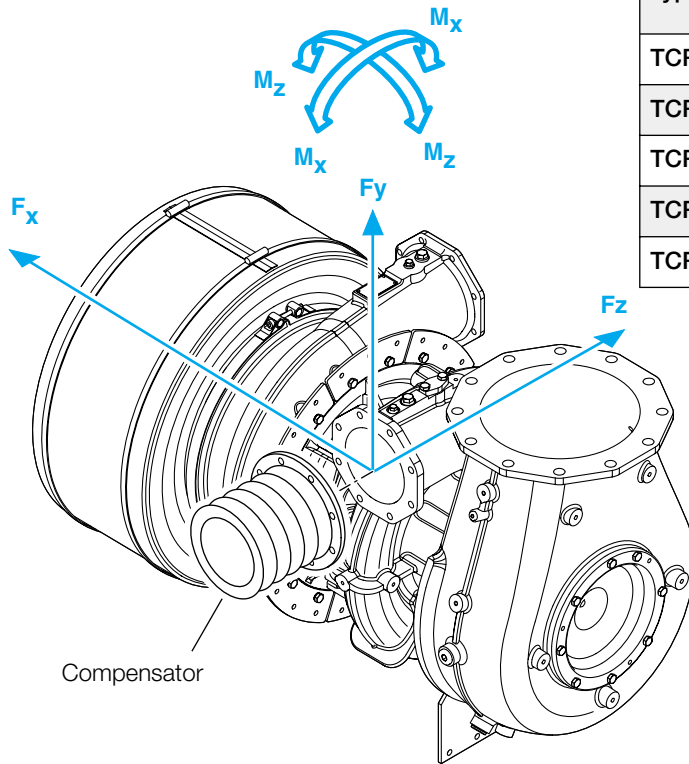
- Compensator fastened directly to the turbocharger flange

Type	D in mm	d in mm	k in mm	Bolts
TCR14	150	121	167	4
TCR16	180	145	200	4
TCR18	231	176	220	8
TCR20	280	212	265	8
TCR22	370	277	350	8



Compressor casing connection

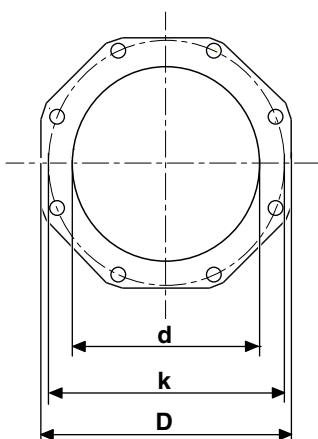
## Connection of the Exhaust Gas Pipe (Engine Side)



Type	$F_x$ in N	$F_y$ in N	$F_z$ in N	$M_x$ in Nm	$M_z$ in Nm
TCR14	1 700	3 500	3 500	2 700	1 300
TCR16	2 100	4 300	4 300	3 200	1 600
TCR18	2 600	5 200	5 200	3 900	1 900
TCR20	3 100	6 300	6 300	4 700	2 300
TCR22	3 800	7 700	7 700	5 800	2 900

### Maximum loads

- Compensator fastened directly to the turbocharger flange

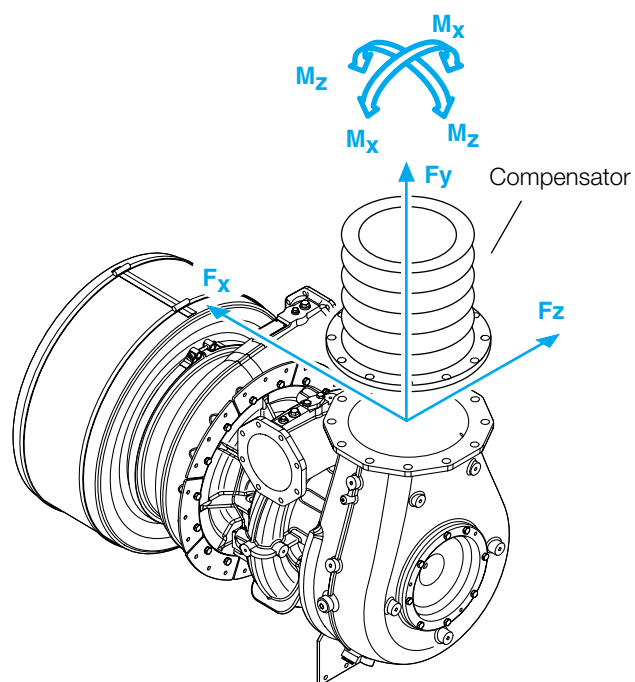


Type	D in mm	d in mm	k in mm	Bolts
TCR14	150	111	164	4
TCR16	180	134	195	4
TCR18	233	162	215	8
TCR20	275	195	260	8
TCR22	360	255	340	8

### Connection of gas-admission casing

## Connection of the Exhaust Gas Pipe (System Side)

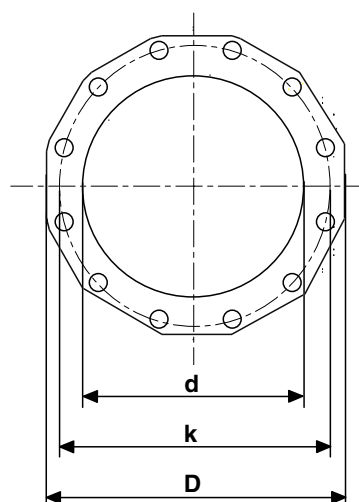
Type	$F_x$ in N	$F_y$ in N	$F_z$ in N	$M_x$ in Nm	$M_z$ in Nm
TCR14	3 400	6 800	6 800	5 200	2 600
TCR16	3 800	7 700	7 700	5 800	2 900
TCR18	4 100	8 300	8 300	6 300	3 100
TCR20	4 400	8 900	8 900	6 800	3 400
TCR22	5 000	10 200	10 200	7 700	3 800



### Maximum loads

- Compensator fastened directly to the casing flange
- Flange connection according to DIN 86044

Type	D in mm	d in mm	k in mm	Bolts
TCR14	296	212	280	8
TCR16	357	256	335	12
TCR18	425	310	395	12
TCR20	540	373	495	16
TCR22	703	487	650	20



Connection of gas outlet casing



## Allowable Inclinations

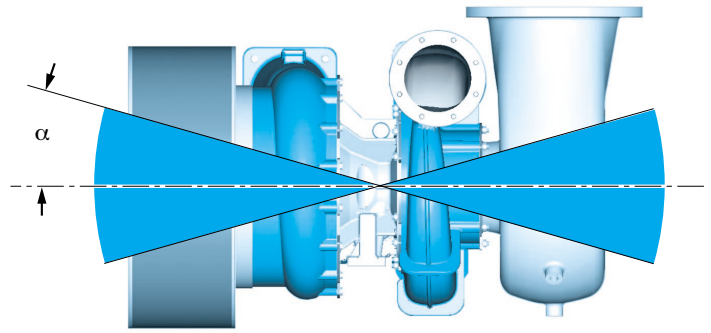
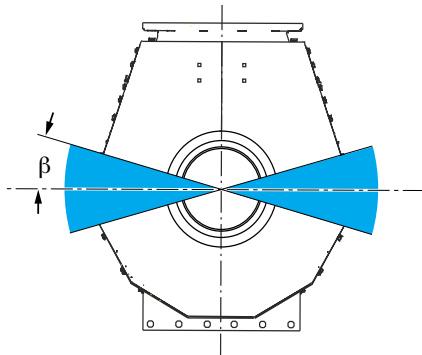
The exhaust gas turbochargers of the TCR Series require horizontal assembly with respect to the axis of the running equipment.

For operation in ships, however, where the installation position is crosswise to the longitudinal axis, inclination angles occur that can influence the operating ability of the exhaust gas turbocharger.

The following inclination angles can be handled by the exhaust gas turbocharger without problems.

With the installation position in longitudinal direction of the ship, these limit values are not reached even under unfavorable exterior conditions.

For certain individual cases, larger inclination angles are also possible. When required, please contact MAN Diesel SE in Augsburg.



Inclination	Continuous	Short-term
$\alpha$	$\pm 15^\circ$	$\pm 22.5^\circ$
$\beta$	$\pm 10^\circ$	$\pm 10^\circ$

## Allowable Vibration Accelerations

During engine operation, the exhaust gas turbocharger is subject to stress through vibrations that are actuated by the engine **(A)** and the exhaust gas turbocharger **(B)** itself.

The excitations starting from the engine lie within the low-frequency range.

The resulting vibrations of the turbocharger structure stress the possibly mounted silencer and connecting elements between casing parts and turbocharger feet.

The bearing load resulting from the engine excitation is negligible, as the rotors of the MAN Diesel exhaust gas turbocharger run in plain bearings.

Vibrations actuated from the exhaust gas turbocharger itself are generated by forces of imbalance that are transmitted via the bearing onto the casings. The relevant frequency is in the high-frequency range.

The vibrations resulting from the imbalance forces do not influence the structure of the exhaust gas turbocharger casing, but serve as an indicator for the balance condition of the rotor and thus for the running behavior.

Imbalances occurring during operation can be caused through irregular dirt deposits, damaged vanes of the compressor and/or turbine wheel or residual imbalance.

When erratic running of the turbocharger is observed during operation, the condition can be improved in most cases by cleaning of the compressor (see Page 6-1) and the turbine (see Page 6-1 ff.).

If the running behavior is still not satisfactory after repeated cleaning, the rotor is to be inspected and a balance check is to be carried out. The maximum allowable vibration acceleration for both of the mentioned excitation types are listed in the following.

### A: Frequency range 3 - 300 Hz,

excitation degree caused through engine

	Allowable Vibration Acceleration <b>①</b>
TCR14 - 16	2.0 g effective
TCR18 - 22	1.8 g effective

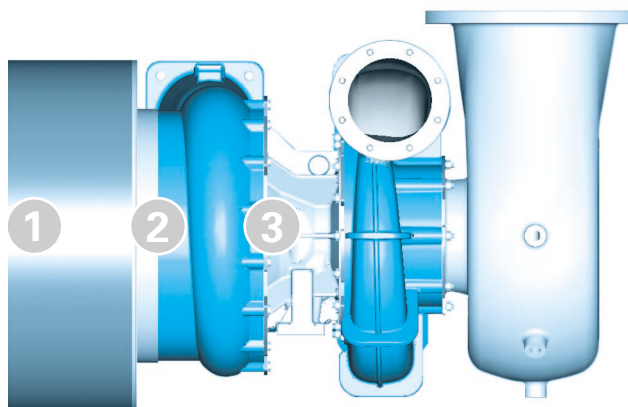
	Allowable Vibration Acceleration <b>②</b>
TCR14 - 16	1.8 g effective
TCR18 - 22	1.4 g effective

### B: Frequency range 300 - 3100 Hz,

actuated through the first harmonic oscillation of the rotor speed; individual share.

	Allowable Vibration Acceleration <b>③</b>
TCR14 - 16	0.8 g Amplitude
TCR18 - 22	0.8 g Amplitude

## Measuring Points for Vibration Acceleration



**(1)** At the front plate of the silencer

**(2)** At the flange of the compressor casing/silencer

**(3)** At the flange of the compressor casing/bearing casing, vertical to the turbocharger axis

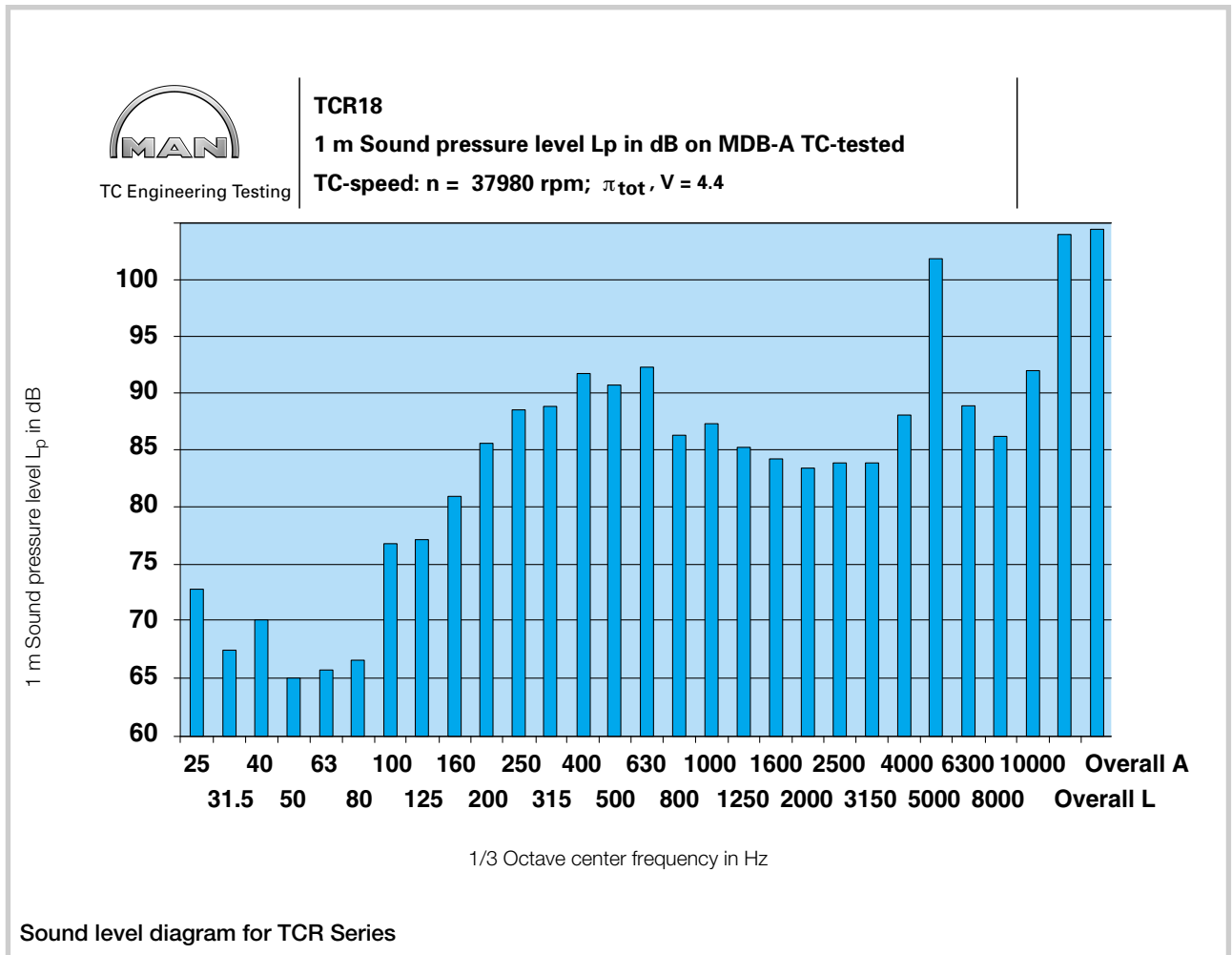


## Sound Level Diagram

A completely new developed silencer was designed for the TCR exhaust gas turbocharger. Together with the insulations at the gas outlet casing, gas-admission casing and compressor casing of the turbocharger, sound immission values of below 105 dB (A) can be achieved on the engine.

In the example, the sound level diagram is shown for the TCR 18 exhaust gas turbocharger, equipped with silencer and air filter. The third octave spectrum of the dampened air-intake sound was measured.

Sound pressure level in dB; speed:  $n = 37\,980$  rpm.





## Systems

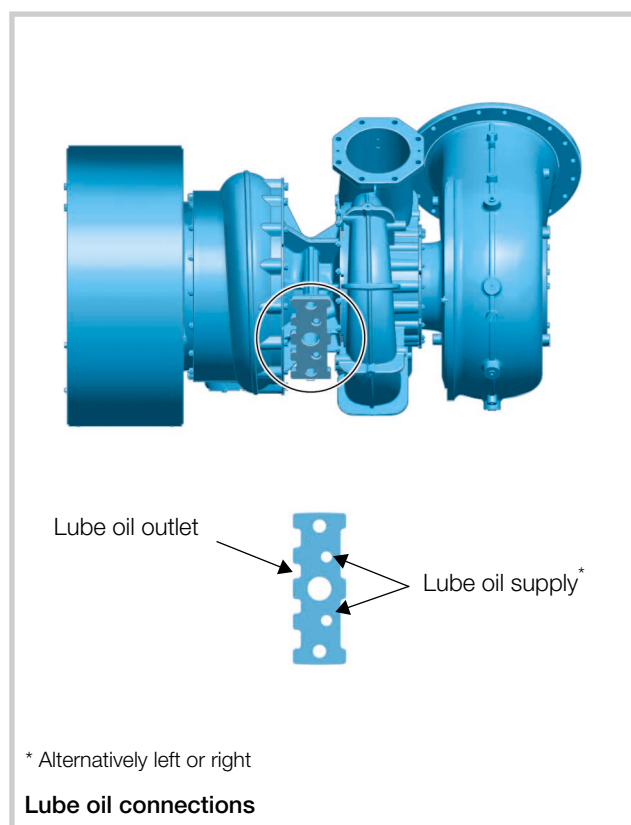


### Lube Oil System

The lube oil is conducted from the lube oil system of the engine to the exhaust gas turbocharger.

### Lube Oil Connections

The exhaust gas turbocharger has two connections for lube oil supply at the bottom of the bearing casing. The connection not needed is to be plugged in the area of the turbocharger bracket.



The oil pressure is adjusted with an orifice. Alternatively, the provided orifice can also be mounted in the turbocharger bracket on the engine side.

#### Note

Ensure that only one orifice is mounted in the lube oil supply of the turbocharger.

The connection for lube oil discharge is located between the two supply connections. The measuring point for the lube oil pressure is located at the top of the bearing casing.

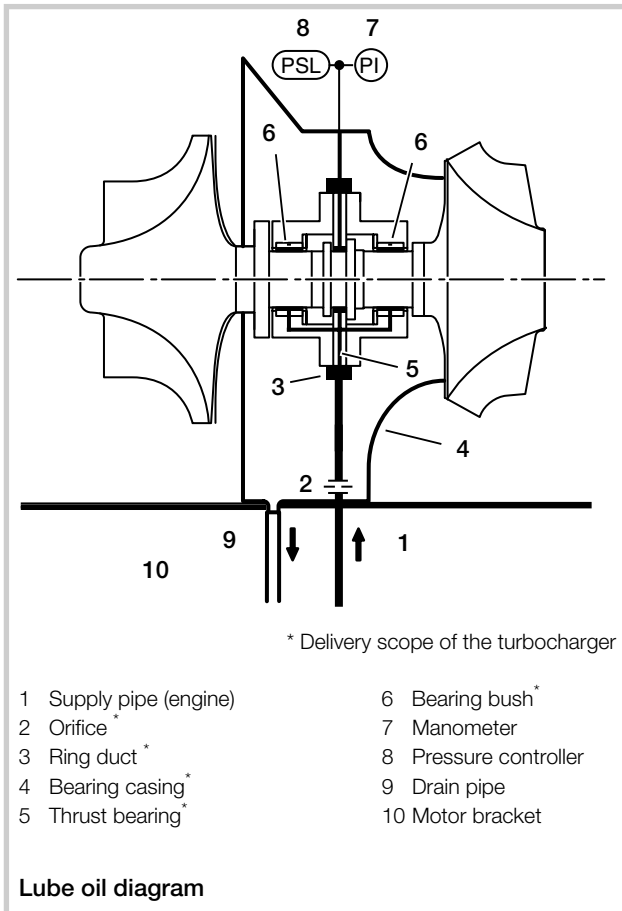
Type	Inner diameter of lube oil supply in mm	Inner diameter of lube oil outlet in mm
TCR14	22	32
TCR16	22	37
TCR18	22	45
TCR20	22	54
TCR22	32	70

### Function of the Lube Oil System

Lubrication and cooling of the highly stressed bearing points in the exhaust gas turbocharger is effected through a lube oil system which is integrated in the bearing casing of the turbocharger.

The lube oil is conducted from the lube oil system (Lube oil diagram, see Page 4-2) of the engine via the supply pipe (1) to the lube oil system of the turbocharger. The orifice (2) mounted in the oil supply reduces the oil pressure to the required value. The lube oil is conducted to the radial and axial lubrication gaps of the turbocharger via the ring duct (3) and the bores in the bearings. A connection for the manometer (7) and/or the pressure controller (8) for controlling/monitoring of the lube oil pressure is located on the top of the bearing casing (4).

The oil flows back into the engine's lube oil system via the drain pipe (9).



### Lube Oil Discharge

The drain pipe is to be installed with the maximum possible slope, sufficiently dimensioned and free of resistance and back-ups.

- For ship systems the inclination of the drain pipe must be at least 5° in excess of the largest possible slope of the ship,
- For stationary systems the drain pipe must have an inclination of at least 5°.

**Upon request, planning data can also be supplied for self-sufficient lube oil supply of the exhaust gas turbocharger, independent from the engine lubrication circuit. For more details please contact MAN Diesel in Augsburg directly.**



**E-Mail:**  
**Turbochargers@de.manbw.com**

### Venting

Up to 0.2% of the intake air escapes with the lubrication oil through the drain pipe via the bearing casing. This air volume can lead to an inadmissible high increase of the prevailing pressure in the crankcase.

To avoid this, the oil discharge must be vented. This must occur via a larger space/cavity that permits settling of the oil. The two possibilities are either via separate venting in the oil discharge or through sufficiently dimensioned crankcase venting. The cross section of the venting pipe should correspond with that of the oil drain pipe.

### Note

*For two-stroke engines, a bracket with integrated venting possibility can be supplied optionally from MAN Diesel.*

### Shaft Sealing

The oil chamber is sealed with piston rings on the turbine and compressor side. For this reason, TCR exhaust gas turbochargers do not require sealing air and can be pre-lubricated beyond limitation.

The robust piston-ring sealing ensures ease of servicing.

### Lube Oil Flow Rate

The flow rate of the lube oil depends on the viscosity (SAE class) and the temperature of the oil. The bearings are dimensioned to be operated with commercially available SAE 30 or SAE 40 engine oil. This enables direct linking of the lube oil supply to the lube oil circuit of the engine. High-alkaline cylinder oils are not suitable for the lubrication of the turbocharger bearings.

Lube Oil Characteristics	Parameter
Viscosity	SAE 30 or SAE 40
Lube oil inlet temperature (min.)	40 °C
Lube oil inlet temperature (max.)	75 °C

The following Table applies for SAE 30 at 60 °C:

Type	Flow Rate at 2.2 bar in m <sup>3</sup> /h	Flow Rate at 1.3 bar in m <sup>3</sup> /h	Discharged Heat in kW
TCR14	0.9	0.6	7
TCR16	1.2	0.9	9
TCR18	1.9	1.3	11
TCR20	2.6	1.8	14
TCR22	4.4	3.0	21

## Lube Oil Pressure of the Exhaust Gas Turbocharger

The required lube oil pressure of the turbocharger is adjusted by means of an orifice in the lube oil supply. Upon initial starting of operation, the oil pressure is set and checked at the measuring point connection (at the top of the bearing casing) (see Page 4-1).

The lube oil pressure is to be set in such a manner that a pressure of 1.3 - 2.2 bar is given at this location under full load of the engine with the lube oil at operating temperature.

The following parameters apply for the monitoring of the lube oil pressure:

- The alarm value is to be set at 1.0 bar for a pressure drop of the lube oil pressure,
- The limit value for load reduction to half load is at 0.8 bar,
- At 0.6 bar, the engine is to be stopped immediately.

When starting the engine and during the warm-up phase of the engine with still cool lube oil, a short-term higher lube oil pressure is permitted.

For differences in elevation between the pressure-measuring point and the center of the exhaust gas turbocharger, it is imperative to take the value of 0.1 bar per 1 meter of level difference into account.

Example:

If the manometer or the pressure controller is situated three meters below, then the manometer must indicate a value increased by 0.3 bar or the pressure controller must be set 0.3 bar higher than the required operating pressure.

The required lube oil pressure is adjusted by means of a throttle device in the supply line.

The indication of the active alarm and the reaction through the engine control must occur at the same time. Therefore, the engine control must at least correspond with category 3 according to DIN EN 954-1.

## Pre-lubrication

Before starting the engine, the bearing points of the exhaust gas turbocharger must be pre-lubricated. This takes place automatically together with the pre-lubrication of the engine, as the lube oil system of the turbocharger is connected to the lube oil system of the engine. Depending on the engine system, pre-lubrication occurs directly before starting.

### Pre-lubrication before starting:

Duration < 10 minutes with an oil pressure of 1.3 - 2.2 bar.

### Continuous pre-lubrication:

With an oil pressure of 0.3 to 0.6 bar.

## Post Lubrication

After an engine shut-down, the bearings of the turbocharger must be post lubricated for cooling purposes with a lube oil pressure of 0.3 to 0.6 bar (reference height: center axis of the exhaust gas turbocharger) for a period of 10 to 30 minutes.

## Oil Pressures

Measuring Location	Limit Value in bar
Lube oil pressure during operation (40 - 75 °C)	1.3 - 2.2
Max. lube oil pressure in cold condition	< 6
Continuous pre-lubrication	0.3 - 0.6
Post lubrication, 10 to 30 minutes	0.3 - 0.6

Alarm Points	
Alarm	1.0
Direct load reduction of the engine (slow down)	0.8
Engine stop (shut down)	0.6



## Filtration of Lube Oil

Additional lube oil filters are not necessary; the nowadays usual filtration for heavy fuel oil operation is sufficient, as far as the pass-through size of particles < 0.05 mm. Furthermore, it is assumed that the engine lube oil is continuously maintained by separation and is not enriched with residual matter exceeding 0.02 mm and water.

Before the first starting of operation or after extended maintenance, the pipes between engine filter and exhaust gas turbocharger are to be thoroughly pickled, cleaned and flushed. Clean oil increases the service life of the plain bearings.

## Taking an Oil Sample

In order to receive a representative oil sample, the following requirements are to be met:

- Take oil sample only while the engine is running,
- Take oil sample in front of the exhaust gas turbocharger and always at the same location,
- Fill sample bottle only to 90%,
- Provide for a special sample removal cock.

## Evaluation of the Lube Oil Condition

For exhaust gas turbochargers that are supplied with oil via the engine lube oil circuit, the assessment criteria of the engine manufacturer primarily apply for the evaluation of the lube oil condition.

For exhaust gas turbochargers with their own lube oil system, regular checks of the lube oil condition are to be carried through. For routine inspections of the lube oil condition, the parameters in the Table below are sufficient.

The mentioned limit values are empirical field values with orientation of the engine requirements toward the lubricating oil. In order to reach long storage service life, these limit values must not be exceeded.

A binding statement on the further usability of the oil can only be derived from a full analysis where the values are to be determined according to standardized testing methods.

Oil Parameters for Routine Inspections	Limit Value
Viscosity	± one viscosity class
Water content (% in weight)	< 0.2 (short-term to 0.5)
Total contamination in (% in weight)	≤ 2.0

## Changing the Oil

An oil change is required when the chemical/physical parameters of the oil filling have changed in such a manner that the lubricating, cleaning and neutralizing properties are no longer sufficient. In this, the limit values mentioned in the Table as well as a drop test can serve only as a reference.

## Quality Requirements



### Fuels

The quality of the fuel with which the engine is operated affects the composition of the exhaust gas that flows through the turbocharger. Impurities in the fuel can lead to residue in the exhaust gas which can effect the turbocharger in an abrasive or corrosive manner.

#### Marine Diesel Oil (MDO)

Marine Diesel Oil (MDO) is also known as diesel fuel oil, diesel oil, bunker diesel oil or marine diesel fuel.

MDO is offered exclusively for shipping as a heavy distillate (ISO-F-DMB) or as a mixture of distillate and low quantities of residual oil (ISO-F-DMC). The term “blended MDO” is common for the dark brown to black colored mixture. MDO is produced from crude oil and must be free of organic acids.

The usability of the fuel depends on the design of the engine and the cleaning device as well as if the characteristics mentioned below, which are based on the condition at the time of supply, are observed.

The characteristics determined were based on ISO 8217-1996 and CIMAC-2003. The characteristics refer to the mentioned testing methods.

	Testing Method	Parameter	
		DMB	DMC
Specification ISO-F		DMB	DMC
Density at 15°C in kg/m <sup>3</sup>	ISO 3675	0.900	0.920
Kinematical viscosity at 40°C in mm <sup>2</sup> /s=cSt	ISO 3104	< 11	< 14
Pour Point Winter quality in °C Summer quality in °C	ISO 3016	< 0 < 6	< 0 < 6
Flash point (Pensky Martens) in °C	ISO 2719	> 60	> 60

	Testing Method	Parameter	
		DMB	DMC
ISO-F Specification		DMB	DMC
Total sediment content (% in weight)	ISO CD 10307	0.10	0.10
Water content in Vol. %	ISO 8733	< 0.3	< 0.3
Sulphur content (% in weight)	ISO 8754	< 2.0	< 2.0
Ash content (% in weight)	ISO 6245	< 0.01	< 0.05
Coke residue (MCR) (% in weight)	ISO CD 10370	> 0.3	< 2.5
Cetane number	ISO 5165	> 40	> 40
Copper strip test	ISO 2160	< 1	< 1
Vanadium content in mg/kg	DIN 51790 T2	0	< 100
Aluminum and silicon content in mg/kg	ISO CD 10478	0	< 25
Visual check		1)	—

1) At room temperatures and with good lighting, the fuel should be clear and appear transparent.

Other Specifications British Standard BS MA 100-1987	Parameter	
	Class M2	Class M3
ASTM D 975	2D	4D
ASTM D397	No. 2	No. 4

Mixing fuels can lead to a reduction of quality. This can result in combustion with a higher degree of residuals which can cause heavy contamination of the turbocharger. Extreme contamination can damage the turbocharger.



**Therefore the following points are to be observed:**

In loading plants and during transportation, MDO is treated as residual oil. Mixing with, e.g., high-viscous fuel oil or interfuel remaining in a bunker vessel is possible and can lead to a considerable reduction in quality.

Different bunker batches of blended MDO (ISO-F DMC) can be incompatible and therefore should not be mixed. For this reason, the respective fuel tank should be emptied to the greatest possible extent before a new batch is filled in.

Ocean water in the fuel aides corrosion in the turbocharger and leads to high-residual combustion. Solid foreign matter increases the mechanical wear in the nozzle ring and the turbine of the turbocharger.

**Therefore the following is to be observed:**

If blended MDO (ISO-F DMC) is primarily being used, we recommend installing a centrifugal separator in front of the fuel filter. This widely separates solids particles (sand, rust catalyst residue, catfines) and water so that the cleaning intervals for the filter inserts can also be prolonged.

**Operating data:**

- Separator admission 65% with reference to the rated flow rate capacity,
- Separation temperature 40 -50 °C.

**Heavy Fuel Oil (HFO)**

MAN Diesel turbochargers can be operated on engines that run on crude-oil based heavy fuel oil (HFO), when the engine and the processing system are designed accordingly.

The fuels used must meet the fuel specifications.

The respective limit values that are to be met are listed in the fuel specifications. The limit values that influence the engine operation are to be specified when ordering fuel, e.g., in the bunker or charter clause.

Adding motor oil (waste oil), mineral-oil-foreign materials (e.g. coal oil) and remainders from refining or other processes (e.g. solvent) is prohibited!

This ban is specifically to be pointed out in the fuel order, as it is not yet part of the standard fuel specifications.

Such additions lead to combustion with high residue and increased wear and corrosion on components of the turbocharger. Adding motor oil (waste/old oil) is particularly critical as the lube oil additives cause emulsions to form and keep debris, water and catalyst particles finely distributed in poise. This impedes or prevents the required fuel cleaning.

The heavy fuel oils ISO F-RMK 35/45/55, with a maximum density of 1010 kg/m<sup>3</sup>, can be used only when respectively modern separators are available.

Thorough processing of heavy fuel oil is required for trouble-

free engine operation.

**The following points are to be observed for this:**

- Heavily abrasive inorganic, solid foreign substances (catfines, rust, sand) must be separated to the greatest possible extent.
- With an aluminum content >10 mg/kg, the abrasive wear in the turbocharger increases heavily.
- Use only separators of the latest generation which are fully effective over a large density range without any adjustment, and separate water with an HFO density of 1.01 g/ml at 15 °C. The cleaning effect is monitored by the separator itself.
- The HFO purification is to be designed in such a manner that the characteristics in the Table are reached:

Parameter	Particle Size in µm	Quantity
Inorganic solid foreign particles (including catfines)	< 5	< 20 mg/kg <sup>1)</sup>
Water	—	< 0.2 Vol.%

1) AlSi content < 15 mg/kg

- With unfavorable vanadium-sodium ratio, the melting temperature of the HFO ash drops to the range of the exhaust valve temperature, which causes hot corrosion. By pre-cleaning the HFO in the settling tank and in the centrifugal separators, the water and thus the water-soluble sodium compounds can be removed to the largest extent. With a sodium content exceeding 100 mg/kg, increasing salt deposits in the turbine are to be expected. This jeopardizes the turbocharger operation (among other things by pumping of the turbocharger). When using PTG the sodium content must be limited to 50 mg/kg. Under certain conditions, hot corrosion can be avoided with a fuel additive that increases the melting temperature of the HFO ash.
- Heavy fuel oils with a high ash content in form of foreign substances, e.g., sand, rust catfines, increase the mechanical wear in the turbocharger. Heavy fuel oils from catalytic cracking plants can contain catfines. These are generally aluminum silicate, which effects high wear in the turbocharger. The determined aluminum content multiplied by 5-8 (depending on catalyst composition) approximately amounts to the content of catalyst material in the HFO.



## Fuel Specification Heavy Fuel Oil (HFO)

Fuel Specification							
CIMAC 2003	A30	B30/ C10	D80	E/F 180	G/H3/ K50	—	H/K700
BS MA-100		M4	M5	M7	8/9	M8/—	M9/—
ISO F-RM	A10	B/C10	D15	E/F25	G/H35	H/K45	H/K55
System-relevant Parameters							
Viscosity (at 50 °C) <sup>1)</sup> in mm <sup>2</sup> /s=in cSt	40	40	80	180	380	500	700
Viscosity (at 100 °C) <sup>1)</sup> in mm <sup>2</sup> /s=in cSt	10	10	15	25	35	45	55
Density (at 15 °C) <sup>1)</sup> in g/ml	0.975	0.981	0.985	0.991/1.010			
Flash point <sup>2)</sup> in °C	60	60	60	60	60	60	60
Pour point							
Summer <sup>1)</sup> in °C	6	24	30	30	30	30	30
Winter <sup>2)</sup> in °C	0	24	30	30	30	30	30
Engine-relevant Parameters							
Carbon residue <sup>1)</sup> (Conradson) (% in weight)	10	10/14	14	15/20	18/22	22	22
Sulfur <sup>1)</sup> (% in weight)	3.5	3.5	4	5	5	5	5
Ash <sup>1)</sup> (% in weight)	0.10	0.10	0.10	0.15	0.15	0.20	0.20
Vanadium <sup>1)</sup> in mg/kg	150	150/ 300	350	200/ 500	300/ 600	600	600
Water <sup>1)</sup> in Vol. %	0.5	0.5	0.8	1	1	1	1
Sediment <sup>1)</sup> (potential) (% in weight)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Supplementary Parameters							
Aluminum and silicium <sup>1)</sup> in mg/kg	80						
Asphaltenes <sup>1)</sup> (% in weight)	2/3 of the carbon residue (Conradson)						
Sodium <sup>1)</sup> in mg/kg	Sodium < 1/3 vanadium, sodium < 100						
Cetane number of the fluid mixing component: min. 35							
Fuel to be free of mineral-oil-foreign additives such as coal oil or vegetable oil. Free of creosote and lubricating oil (waste oil)							

1) maximum

2) minimum



## Lubricating Oil and Additives

Commonly, doped oils (HD oils) are used for gas oil and diesel-oil operation (MGO/MDEO), whereas semi-alkaline lubricating oils are used for heavy fuel oil operation (HFO).

The base oil must meet the following limit values, particularly concerning the aging stability:

Properties	Testing Method	Parameter
Structure	—	Preferably paraffin-based
Behavior in cold, still fluid in °C	ASTM-D2500	-15
Flash point according to Cleveland in °C	ASTM-D92	> 200
Ash content (oxide ash) (% in weight)	ASTM-D482	< 0.02
Carbon residue according to Conradson (% in weight)	ASTM-D189	< 0.05
Aging tendency after 100 h of heating (to 135 °C)	MAN aging apparatus	—
n-heptane insoluble (% in weight)	ASTM-D4055 or DIN 51592	< 0.2
Evaporation loss (% in weight)	—	< 2
Spot test (filter paper)	MAN-Test	Visual check <sup>1)</sup>

1) Sample must not show precipitation/parting of resinous and asphaltic aging

Additives must be dissolved in oil and structured in such a manner that as little as possible ash results upon combustion. The ash must have a soft structure. Otherwise, increased formation of residue in the bearing casing of the turbocharger must be taken into account. Hard additive ash enables increased mechanical wear.

Additives may not aid a clogging of the filter inserts, neither in active nor in processed condition.

### Lubrication Oil Additives

We strongly advise to refrain from subsequent addition of additives to the lube oil or mixing different lube oil brands, as this can interfere with the function of the additive package matched for itself and for the base oil. The addition of addi-

tives or the mixing of different lube oil brands also annuls the responsibility of the lube oil supplier company for the lube oil.

## Intake Air

The quality as well as the condition of the intake air has a decisive influence on the performance of the turbocharger. Not only is the atmospheric condition of great importance, but also the degree of solid and gaseous impurities.

Mineral dust particles in the intake air have a wear-increasing effect, whereas chemical/gaseous ingredients increase corrosion.

For this reason, effective cleaning of the intake air and regular maintenance/cleaning of the silencer air filter mat is required.

### Intake Air Characteristics

The particle size in the intake air must not exceed 5 µm after the silencer/air intake casing or ahead of the compressor inlet. The following maximum particle concentrations in the intake air may not be exceeded:

Properties/Characteristics	Concentration in mg/Nm <sup>3</sup> 1)
Dust (sand, cement, CaO, Al <sub>2</sub> O <sub>3</sub> etc.)	5
Chlorine	1.5
Sulphur dioxide (SO <sub>2</sub> )	1.25
Hydrogen sulphide (H <sub>2</sub> S)	15

1) Standard cubic meter in Nm<sup>3</sup>

When dimensioning the intake air system, pay attention not to exceed a total pressure loss (filter, silencer, piping) of 20 mbar.

Exception:

A pressure loss higher than 20 mbar has been taken into consideration for the layout (e.g. gas addition for gas engines).



## Auxiliary Equipment



### Cleaning Equipment

	Wet Cleaning		Dry Cleaning, Turbine
	Turbine	Compressor	
Heavy Fuel Oil operation	x	x	x
Marine diesel oil/gas oil operation	x <sup>1)</sup>	x	x

1) Depends on fuel ingredients such as vanadium, sodium and nickel

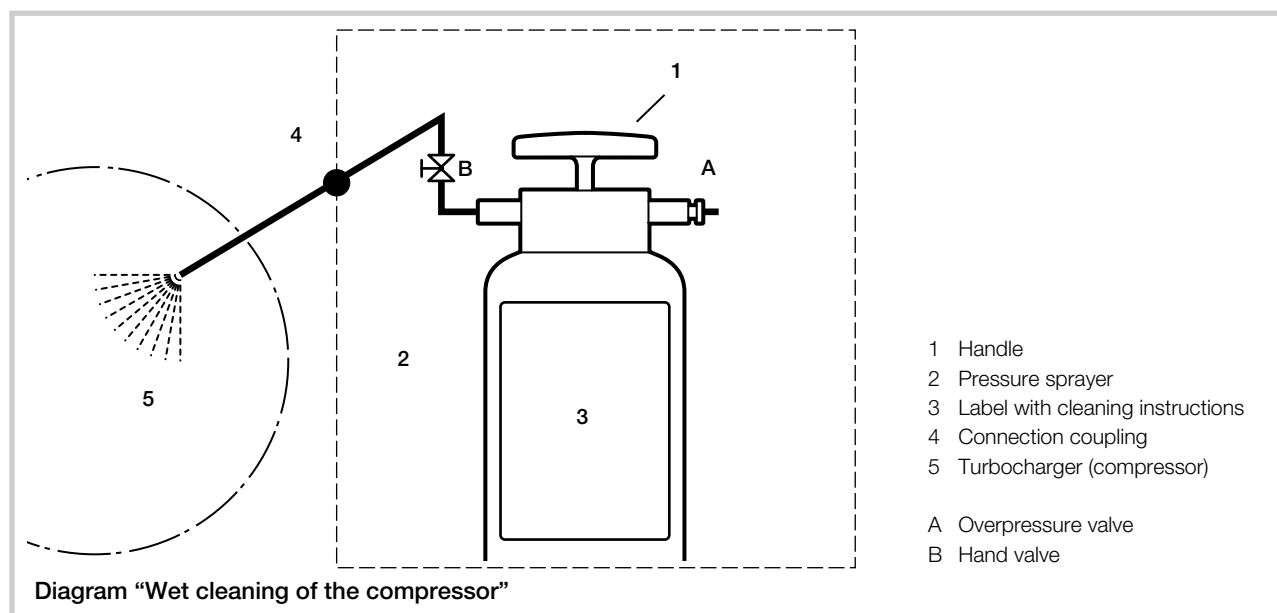
### Compressor Cleaning

During operation, deposits and oily debris films increasingly form on the vanes of the compressor wheel and the diffuser. This contamination reduces the efficiency of the compressor.

Therefore, we recommend carrying out the compressor cleaning every 100 to 200 operating hours. For this, cleaning equipment with a pressure sprayer is provided by MAN Diesel:

- Cleaning of the compressor is carried out with water during operation at full load,
- Cleaning is to be performed only with fresh water; do not use ocean water, chemical additives or detergents,
- Blow washing water in for approx. 30 seconds,
- The cleaning intervals for the compressor should be determined depending on the contamination degree of the respective system.

The compressor cleaning equipment is connected at the silencer/air intake casing or at the corresponding connection coupling.



### Turbine Cleaning

From the initial starting of operation on, the exhaust gas turbochargers of engines in heavy fuel oil operation, marine diesel oil operation and gas oil operation must be cleaned in regular intervals in order to remove combustion residue from the blades of the turbine wheel and the turbine nozzle ring.

Otherwise such deposits can impair the operating data or even lead to heavy vibrations of the turbine blades.



The following two cleaning procedures are possible:

- Turbine wet cleaning,
- Turbine dry cleaning.

Both cleaning procedures can be applied to the same exhaust gas turbocharger, whereby the advantages of both cleaning procedures complement one another.

Observe the cleaning instructions on the instruction plate of the exhaust gas turbocharger and in the operating manual.

### Wet Cleaning of the Turbine

Wet cleaning of the turbine is carried out during operation at strongly reduced engine load in order to avoid overstressing of the turbine materials (thermal shock):

Type	Max. Exhaust Gas Temperature before the Turbine in °C	Max. Turbocharger Speed in rpm
TCR14	≤ 320	≤ 26 000
TCR16	≤ 320	≤ 22 000
TCR18	≤ 320	≤ 18 000
TCR20	≤ 320	≤ 15 000
TCR22	≤ 320	≤ 12 000

The cleaning frequency depends on the type of fuel and on the operating mode; we recommend carrying out turbine wet

cleaning every 150 operating hours:

- Use fresh water without any chemical additives whatsoever,
- The washing duration for interval cleaning is: 10 x 0.5 minutes washing and drying for 1 minute each time.

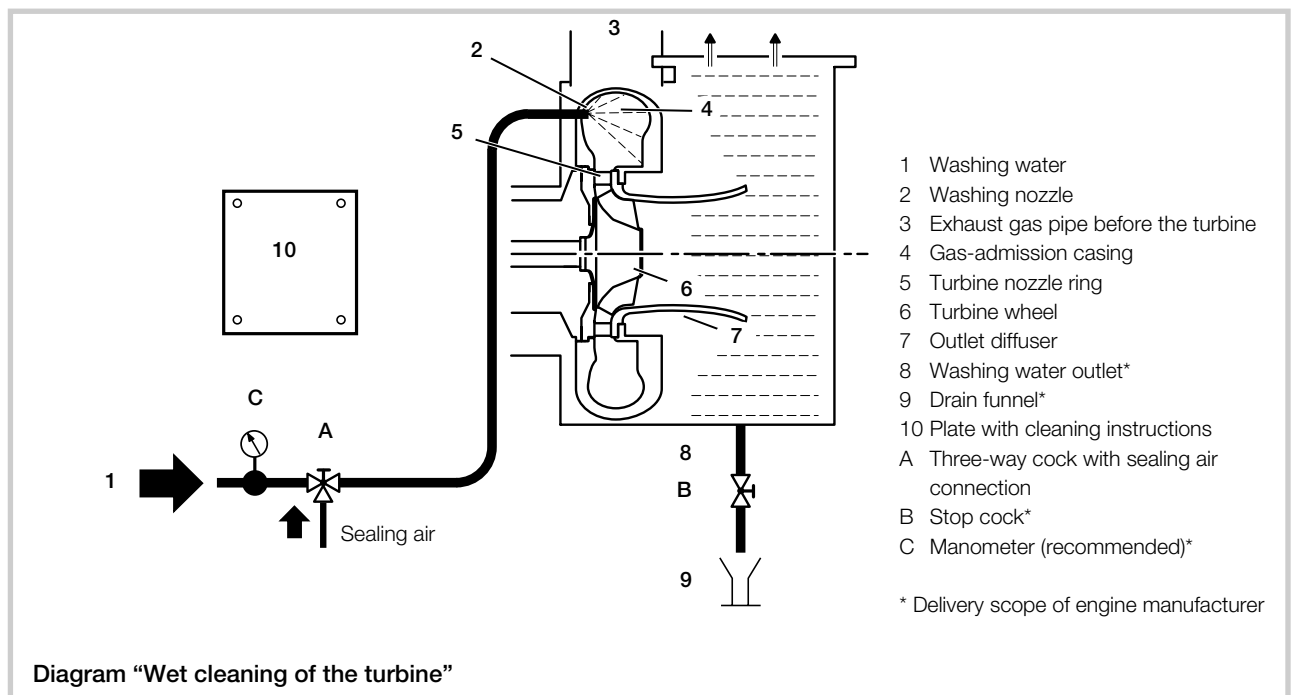
The washing water (1) flows through the three-way cock (A) (water pressure approx. 2 bar) into the gas-admission casing (4). The washing nozzle (2) sprays the water in the exhaust gas pipe before the turbine (3). The droplets of the washing water bounce against the turbine nozzle (5) ring and the turbine (6) where they wear off contamination. The washing water collects in the gas outlet casing. A large portion of the washing water evaporates in the gas outlet diffuser (7) due to the high flow velocity and is emitted outside via the flue flange as steam. The portion of washing water that does not evaporate drains through the washing water outlet (8) and the stop cock (B). The washing water is conducted to a sediment tank via the drain funnel (9) and collected there.

The sealing air prevents clogging or rusting through of the piping. For this, a minor quantity of the air after the charge air cooler is used and continuously flows through the respective piping system.

The sealing-air flow rate required for the turbine cleaning is 0.1 - 0.3% of the compressor flow rate.

#### Advantages of turbine wet cleaning:

Better cleaning effect and thus longer cleaning intervals.



## Dry Cleaning of the Turbine

In addition to wet cleaning of the turbine, dry cleaning of the turbine can also be performed.

Dry cleaning of the turbine is carried out during operation at 75% - 100% operating load of the engine.

Shorter cleaning intervals must be observed in regard to wet cleaning of the turbine, otherwise more intense deposits will not be removed.

It is recommended to perform the cleaning with granulates every one to two days. When using HFO that produces heavy coverings, the cleaning interval should be increased to twice daily.

Depending on the type of funnel, particles of soot can escape during the cleaning procedure. Special consideration should be taken for passenger ships.

The granulate tank is fitted with an opening for filling, a compressed-air supply pipe and a pipe leading to the gas-admission casing.

Type	Granulate Quantity <sup>1)</sup> in l
TCR14	0.1
TCR16	0.2
TCR18	0.2
TCR20	0.3
TCR22	0.5

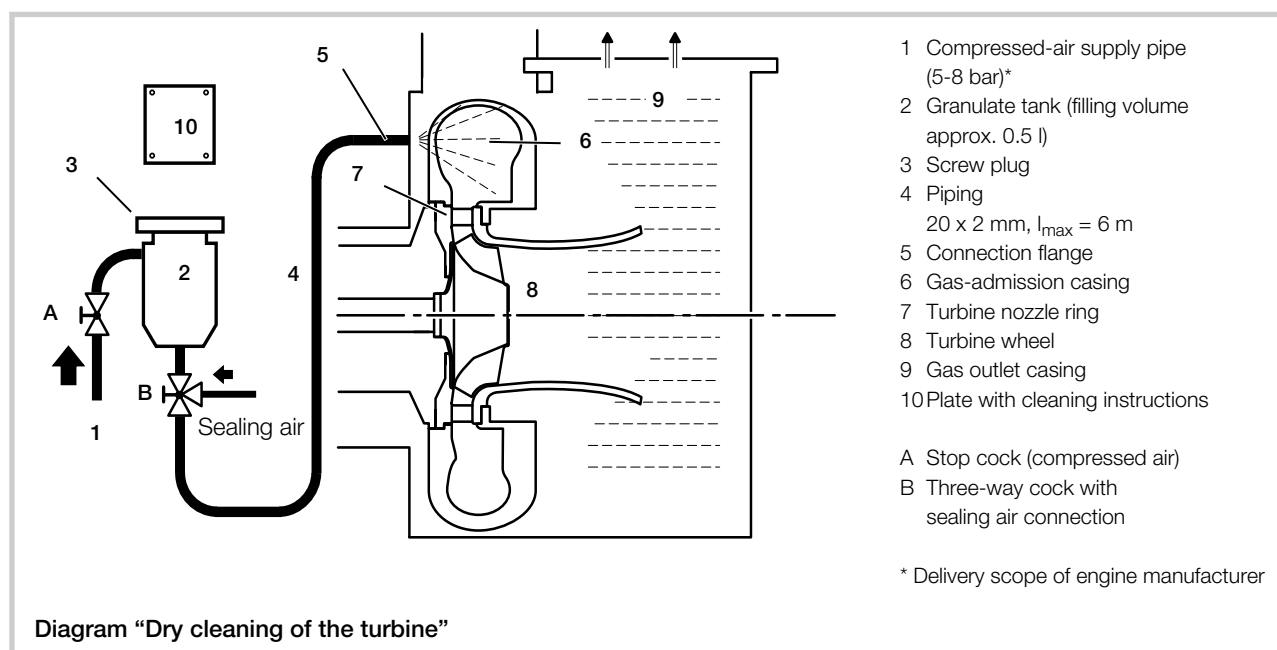
1) Granulate consisting of nut shells or activated carbon (soft) with a particle size of 1.0 mm (max. 1.5 mm)

The compressed-air supply pipe and the further piping are both shut with a cock. The granulate tank is filled with cleaning granulate and shut tight.

The stop cock (A) of the compressed-air supply (1) is opened and compressed air flows into the granulate tank (2). Afterwards the cock (B) of the pipe leading to the gas-admission casing (6) is opened. The compressed air blows the granulate out of the granulate tank into the gas-admission casing. There, the exhaust gas flow transports the granulate to the turbine wheel (8). The granulate particles bounce against the turbine nozzle ring (7) and the turbine wheel (8), and in this manner remove deposits and contamination.

The exhaust flow forwards the granulate and the dirt particles out of the system.

- The granulate tank must be fastened at a suitable location and must not be positioned more than 1 m below the connection flange,
- The piping must not be longer than 6 m and must be supported against vibrations. Unhindered flow must be ensured,
- Maximum operating temperature of the stop cock (exhaust gas):  $\leq 200\text{ }^{\circ}\text{C}$ ,
- The piping should have as few bows as possible with large bend radius,
- The connection flange have to be attached on the exhaust gas pipe. The max. distance between injection point and gas-admission casing is the inlet diameter of the gas-admission casing d.





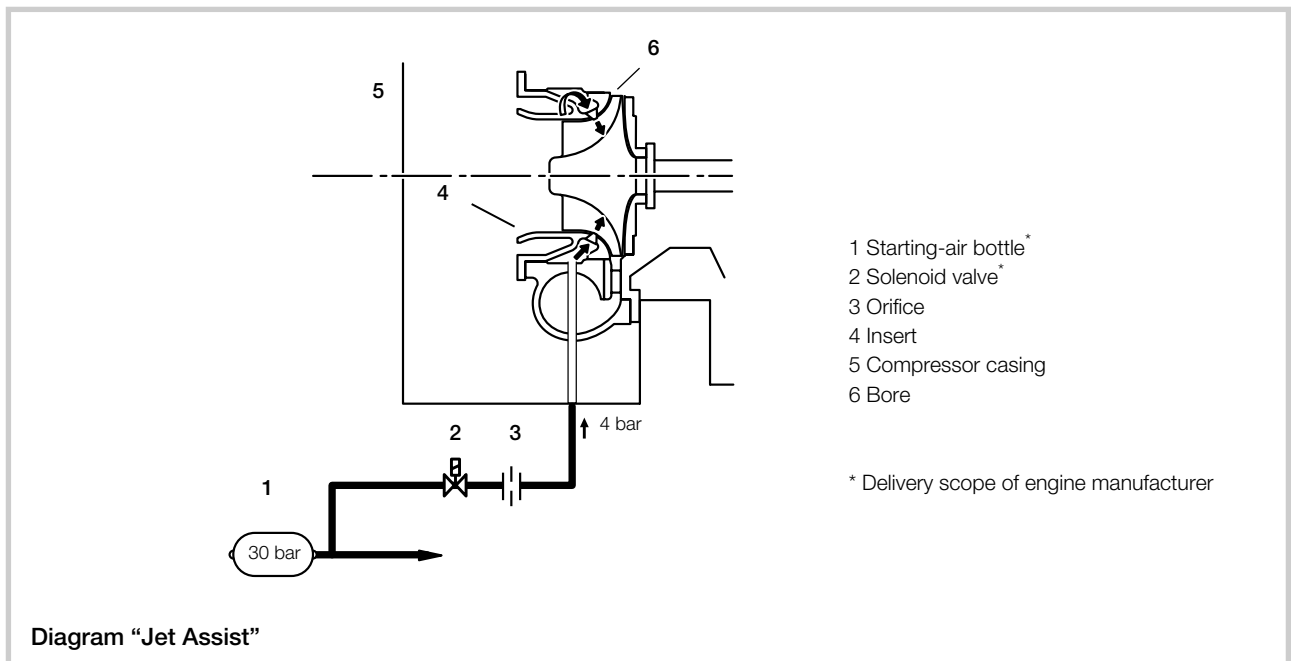
## Jet Assist

The “Jet Assist” acceleration system is used when special requirements are made towards swift and possibly soot-free acceleration, and/or towards the load applications of the engine.

In case of a sudden load increase, the Jet Assist system accelerates the rotor within an extreme short period by supplying auxiliary compressed air, which is conducted onto the compressor wheel through several nozzles in the compressor insert.

## Jet Assist Connections

Type	Jet Assist Air Pressure 4 bar
	Inner Diameter of the Connection Pipe in mm
TCR14	20
TCR16	20
TCR18	40
TCR20	40
TCR22	50



## Connection Sizes for Pipes and Piping

### Connections for Turbine Dry Cleaning

Type	Compressed-air Connection in mm
TCR14	10 x 1.5
TCR16	10 x 1.5
TCR18	12 x 1.5
TCR20	12 x 1.5
TCR22	12 x 1.5

### Connections for Turbine Wet Cleaning

Water supply: 16 x 2 mm

Drain-water connection: G 3/4"

### Sealing-air Connection for Turbine Cleaning

Dry cleaning: 6 x 1 mm

Wet cleaning: 10 x 1 mm

**2D connection drawings and 3D CAD models can be supplied on request.**

**If required, please directly contact MAN Diesel in Augsburg.**

**E-mail:  
 turbochargers@de.manbw.com**



## Engine-Room Planning



7

Provide for hoisting rails with a traversable crane trolley in axial direction above the exhaust gas turbocharger in which a lifting tackle with the respective minimum carrying capacity for lifting is inserted, so that, e.g., maintenance can be carried out.

### Disassembly Dimensions for the Assemblies

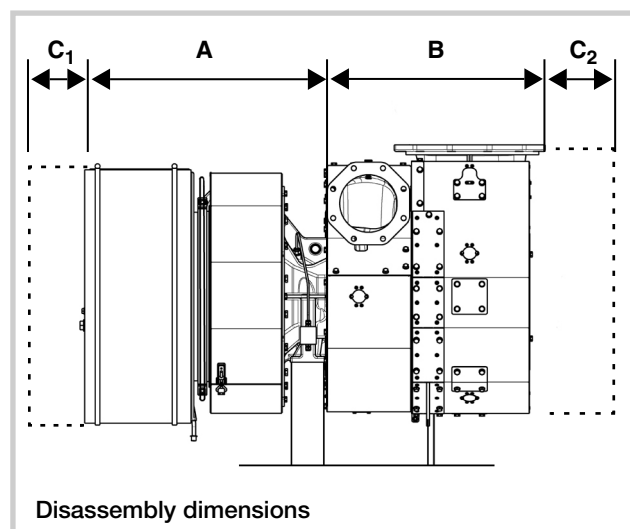
The disassembly dimensions  $C_1$  (compressor side) and  $C_2$  (turbine side) shown in the graphic are required to disconnect and remove assemblies from the exhaust gas turbocharger:

We recommend planning additional 300 to 400 mm as working space.

It must be ensured that the silencer and gas outlet casing can be removed and placed down either to the bottom, the top or to the side, so that the exhaust gas turbocharger is accessible for additional servicing.

Pipes are not to be installed in these free spaces.

The following Tables list the disassembly dimensions for turbochargers with air intake casing/air intake pipe and gas outlet elbow:



#### Turbocharger with air intake casing

Type	A in mm	B in mm	$C_{1min}$ in mm	$C_{2min}$ in mm
TCR14	505	480	100	120
TCR16	685	545	120	120
TCR18	735	655	120	120
TCR20	895	780	130	130
TCR22	1 055	1 000	150	150

The following Table lists the disassembly dimensions for the turbocharger with silencer and gas outlet casing:

Type	A in mm	B in mm	$C_{1min}$ in mm	$C_{2min}$ in mm
TCR14	445	460	100	300
TCR16	535	585	120	400
TCR18	645	700	120	400
TCR20	750	870	130	400
TCR22	880	1 130	150	400

#### Turbocharger with air intake pipe

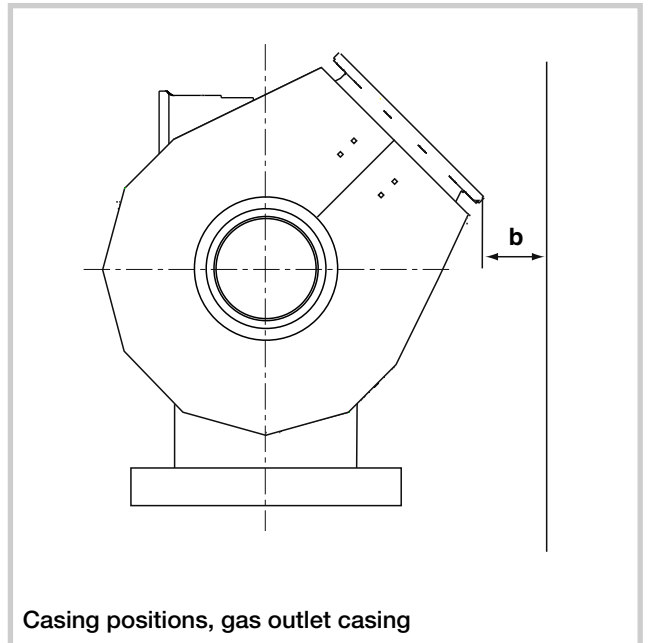
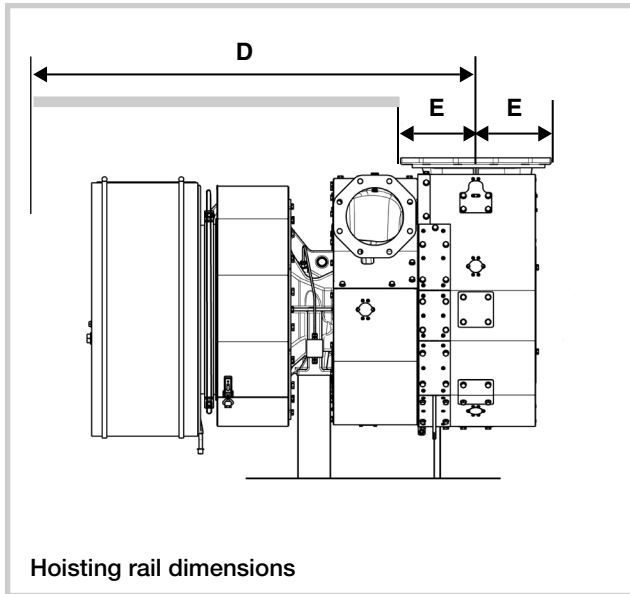
Type	A in mm	B in mm	$C_{1min}$ in mm	$C_{2min}$ in mm
TCR 14	275	480	100	120
TCR 16	330	545	120	120
TCR 18	400	655	120	120
TCR 20	490	780	130	130
TCR 22	530	1 000	150	150

The minimum clearance of the silencer to a bulkhead or deck should not be less than 100 mm.

Between the hoisting rails above the gas outlet casing and manifold, sufficient space must be provided for the exhaust gas system (make sure to observe the maximal possible dimension E).

## Casing Positions

The gas outlet casing can be delivered assembled in various angle positions (also see Table on Page 2-5):



Type	$D_{\min}^{1)}$ in mm	$D_{\min}^{2)}$ in mm	$D_{\min}^{3)}$ in mm	E in mm
TCR14	880	940	710	150
TCR16	1 035	1 180	830	180
TCR18	1 220	1 315	980	215
TCR20	1 430	1 575	1 170	270
TCR22	1 845	2 020	1 495	355

- 1) with silencer
- 2) with air intake casing
- 3) with air intake pipe

### Note

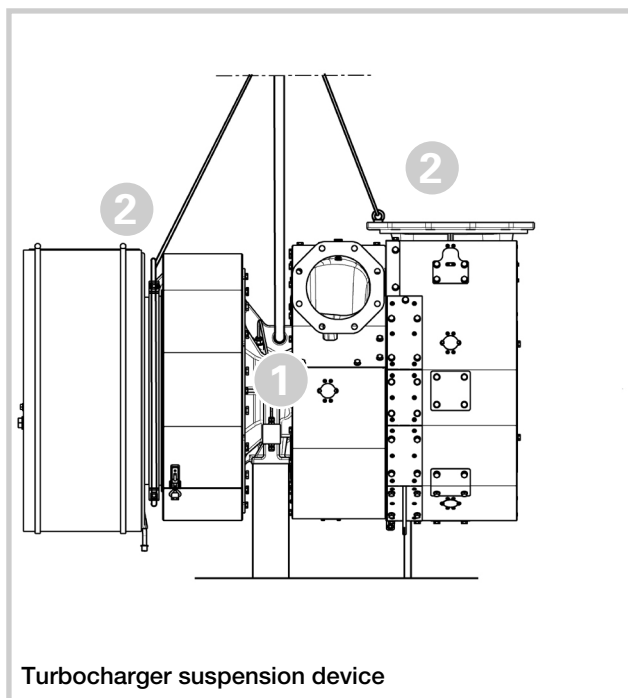
Weights of the assemblies, see Page 2-4.

For these cases, provide for sufficient clearance b between the flange/exhaust gas system and the engine-room walls!

### Note

If required, please enquire about the flange clearances relative to the angle position at MAN Diesel in Augsburg.

## Turbocharger Suspension Device



Turbocharger suspension device

The fastening point (1) of the endless sling for lifting the turbocharger is at the bearing casing; the auxiliary ropes (2) of the lifting tackle are to be fastened between silencer/air intake casing and compressor casing or gas outlet casing.

Type	Weight in kg	Minimal Carrying Capacity of the endless Sling in kN
TCR14	165	4
TCR16	260	6
TCR18	415	10
TCR20	720	15
TCR22	1 550	35

## Exhaust Gas System

Exhaust-gas resistance has a very large influence on the fuel consumption and the thermal load for the engine.

The pipe diameter depends on:

- the exhaust-gas volume,
- the length and arrangement of the pipe.

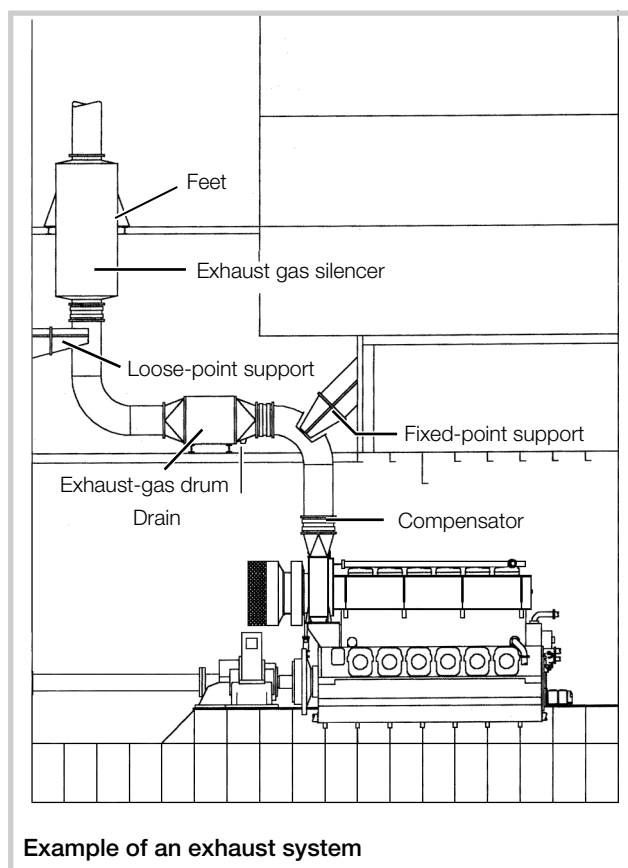
Sharp bends result in very high resistance and are therefore to be avoided. Where this is not possible, use pipe bends with blade grids.

### Note

The **total resistance** of the exhaust gas system must not exceed **30 mbar**.

The **exhaust-gas velocity** in the pipe must not exceed **40 m/s**.

*Exception: A higher pressure loss has been taken into consideration for the layout (e.g. underwater exhaust gas system)*



Example of an exhaust system



## Exhaust Gas System - Installation

The following points are to be observed when installing the exhaust gas system:

- The exhaust pipes of more than one engine may not be conducted together,
- The exhaust pipes must be able to expand. For this purpose, expansion pieces are installed between the fixed-point supports which are attached at suitable locations. A sturdy fixed-point support is to be provided for directly above the compensator, as far as this is possible, in order to keep forces away from the exhaust gas turbocharger that result from the weight, the thermal expansion or the sideward axis displacement of the exhaust pipe. To keep the sound transmission in other parts of the vessel as low as possible, the exhaust pipes should be fastened flexible or supported with the use of damping elements.
- Continuously opened drainages are to be provided for back-flowing condensate and possible drum-leakage water.

### Installation of Flexible Pipes

Apart from the engine movements caused by rough seas or swell in vertical, axial and transverse direction, the largest motion amplitudes of an elastically supported engine occur in transverse direction while starting and shutting down the engine.

For reasons of improved motion absorption, we therefore recommend the installation of the pipes in axial or vertical direction, and not in transverse direction to the engine.

For straight installation, the clearance of the flanges to each other is to be selected in such a manner that the hose can sag. It must not be subject to tensile stress during operation.

For installation with 90° bend, the radii indicated in our drawing are minimum required radii, and must not be fallen below. Hoses may not be installed twisted, which is why the loose flanges on the hoses are designed rotatable.

For screwed connections, the hexagon on the hose is to be counter-held with a wrench when tightening the nut.

#### Note

*Observe the manufacturers' instructions!*

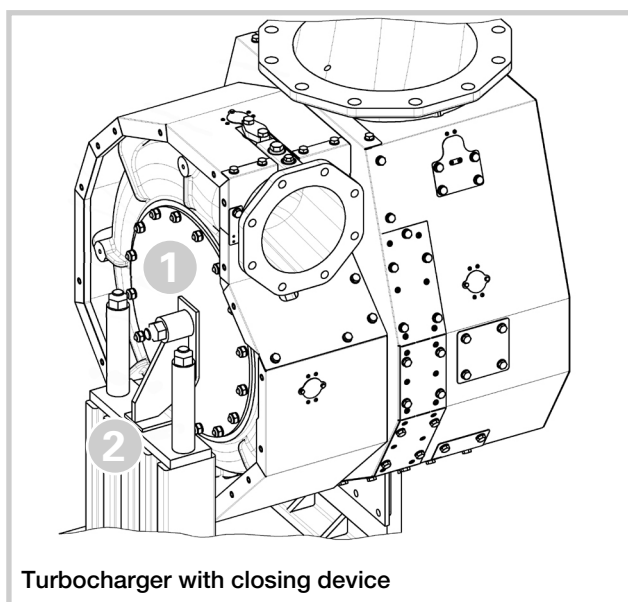


## Emergency Operation in Case of Failure of an Exhaust Gas Turbocharger



Exhaust gas turbochargers are highly stressed turbo machines. As with engines, malfunctions can occur despite careful operations management.

If damage occurs to a turbocharger that cannot be corrected immediately, emergency operation is possible. For this, the cartridge is removed and the gas-admission casing is closed.



### Emergency Measure

In order to close the gas-admission casing, the silencer/air intake casing and the compressor casing must be removed first. The cartridge (bearing casing with turbine rotor) and the turbine nozzle ring are removed.

Afterwards, the gas-admission casing is closed with the closing cover (1). The foot (2) is used to secure the casing and seal off the lube oil supply and discharge.

In emergency operation, the turbocharger exhaust side is still flow through.

### Auxiliary Device

For the turbocharger (delivery scope optional):

- Closing cover and foot for closing off the gas-admission casing and sealing off the lube oil supply and discharge.

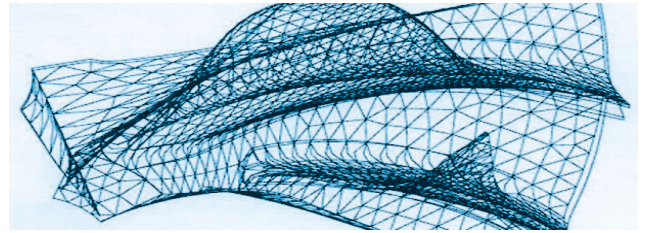
### Achievable Outputs

The following criteria limit the achievable engine load at emergency operation:

- Maximum exhaust gas temperature after cylinders,
- Maximum exhaust gas temperature before the turbocharger,
- Maximum permitted speed of the still operative turbochargers (for engines with several turbochargers),
- Smoke number of exhaust gas.

### Personnel and Time Requirements

Emergency Measure	Qualified Mechanic	Assistant
	Required Time in h	Required Time in h
Mounting of the closing device	2.6	2.6



### Layout Calculation

A layout calculation in accordance with the experience of MAN Diesel on the basis of ISO conditions (25 °C/1000 mbar) enables safe engine operation at inlet air temperatures between 5 °C and 45 °C.

For operation in arctic climate (< +5 °C), a blow-off valve is to be provided for after the compressor in order to exclude exceeding charge air pressure and danger of surging.

The maximum speed of the rotor mentioned on the type plate of the exhaust gas turbocharger is a constant value, regardless of the respective ambient temperature.

#### Note

*At a given engine output, the pressure ratio of the compressor increases with decreasing inlet air temperature and decreases with increasing temperature.*

### Efficiency of the Exhaust Gas Turbocharger

The efficiency is an important criteria for the evaluation of the turbocharger.

The following formula shows how the efficiency of the turbocharger can be calculated. The specific thermal value “ $c_p$ ” and the isentropic exponent “ $\kappa$ ” are temperature-dependent. The values for the exhaust gas “ $\kappa_G$ ” and “ $c_{pG}$ ” are also influenced by the gas composition.

$$\eta_{TC} = \frac{T_1}{T_3} \frac{\dot{m}_L}{\dot{m}_G} \frac{c_{pL}}{c_{pG}} \frac{\left[ \left( \frac{p_2}{p_1} \right)^{\frac{\kappa_L - 1}{\kappa_L}} - 1 \right]}{\left[ 1 - \left( \frac{p_4}{p_3} \right)^{\frac{\kappa_G - 1}{\kappa_G}} \right]}$$

- $T_1$  = Compressor inlet temperature in K
- $T_3$  = Turbine inlet temperature in K
- $\dot{m}_L$  = Air flow in kg/s
- $\dot{m}_G$  = Exhaust gas mass flow (air and fuel in kg/s)
- $c_{pL}$  = Specific heat (air in J/kg.K)
- $c_{pG}$  = Specific heat (exhaust gas in J/kg.K)
- $p_1$  = Air inlet pressure in bar
- $p_2$  = Charge-air pressure in bar
- $p_3$  = Turbine inlet pressure in bar
- $p_4$  = Turbine outlet pressure in bar
- $\kappa_L$  = Isentropic exponent (air)
- $\kappa_G$  = Isentropic exponent (exhaust gas)
- $\eta_{TC}$  = Turbocharger efficiency
- $p_2/p_1$  = Pressure ratio of compressor
- $p_3/p_4$  = Pressure ration of turbine



## Definition of the Efficiency

MAN Diesel exhaust gas turbochargers are used by various engine manufacturers within and beyond the MAN Diesel Group. Traditionally, various efficiency definitions are customary for exhaust gas turbochargers.

### Turbocharger Definition

The total efficiency is one of the most common characteristics for the thermodynamic properties of a turbocharger. The total pressures directly before and after the compressor and before the turbine as well as the total temperatures are to be put into the equation. The flow velocity in the turbine outlet casing is not taken into account as no further usage of the dynamic pressure is given; as a result, the static exhaust gas turbine outlet pressure is applied and not the total pressure.

### Engine Definition

The engine definition defines the turbocharging efficiency of the engine. Contrary to the turbocharger definition,  $p_2$  is assigned to the pressure in the air pipe ahead of cylinder plus the cooler-pressure drop. The pressure in the exhaust gas pipe after cylinder is assigned to  $p_3$ .

### Please note:

As various losses of the supercharger system are taken into account for the engine definition, this efficiency is always lower than the efficiency according to the turbocharger definition, despite the same thermodynamic capacity of the exhaust gas turbocharger.

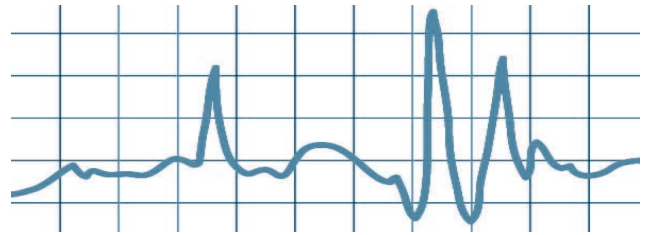
The efficiencies are calculated with the help of measured operating values. In order to receive a meaningful comparison between exhaust gas turbochargers of varying specifications, sizes, designs and makes, it is always necessary to mention the definition used for the calculation of the efficiency.

When a pressure or temperature value in the definition is unknown, then it is not possible to determine the efficiency of exhaust gas turbochargers.

The following Table lists the main differences of the two definitions for calculation of the total efficiency of an exhaust gas turbocharger:

Pressure Values for the Efficiency Definition of Exhaust Gas Turbochargers		
	Turbocharger Definition	Engine Definition
Pressure: $p_2$	Total compressor outlet pressure	Pressure of the air pipe plus cooler-pressure drop
Pressure: $p_3$	Total turbine inlet pressure	Pressure in the exhaust gas pipe

## Speed Measurement, Adjustment, Checks



### Speed Measurement

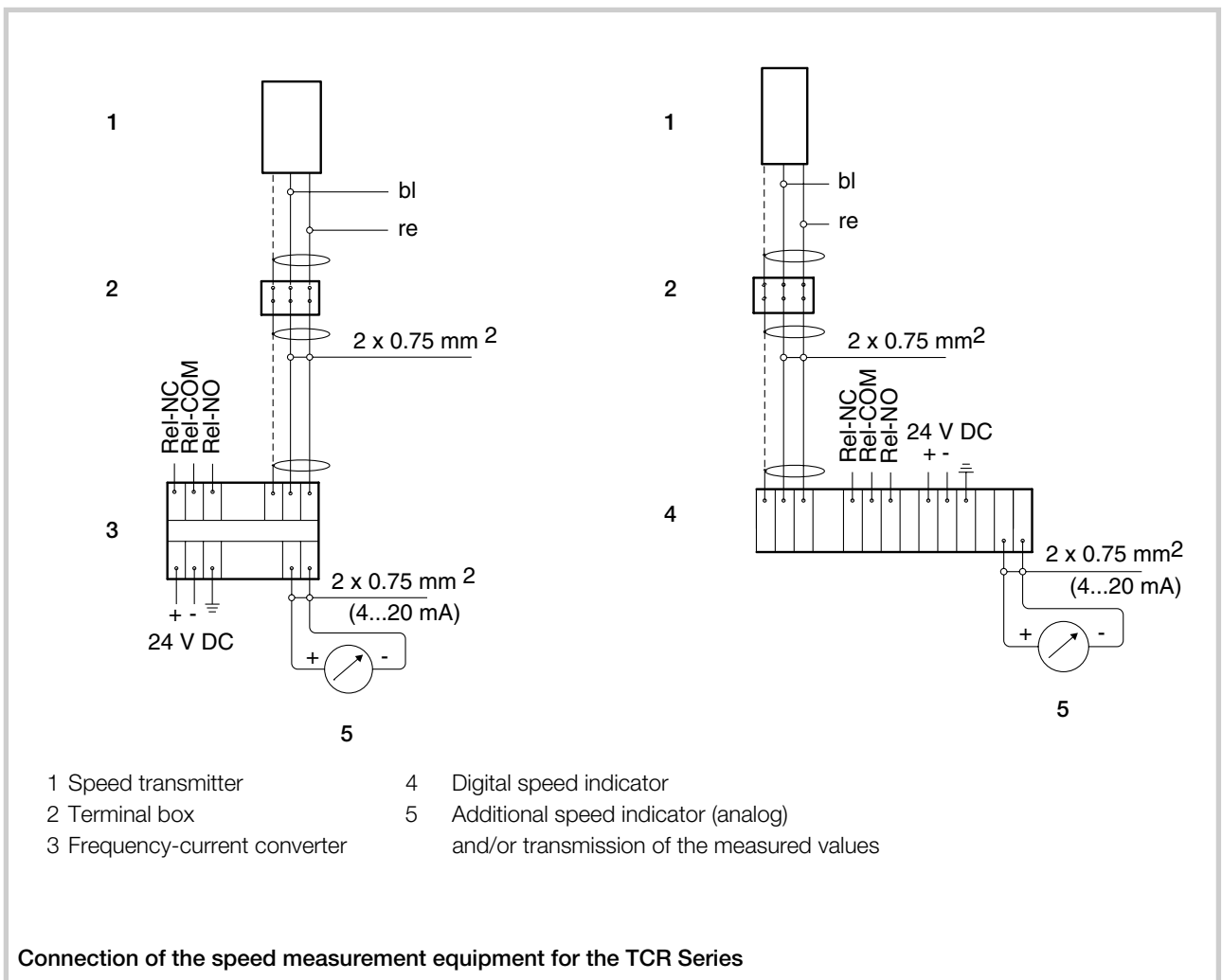
For all exhaust gas turbochargers of the TCR Series, MAN Diesel supplies a speed transmitter for measuring of the rotor speed as standard.

The speed transmitter is positioned in the bearing casing and delivers speed impulses. The alternating impulses are conducted via a 2-wire cable to the terminal box on the compressor casing.

From the terminal box, the impulse signal is conducted on to a frequency-current converter or to a digital speed indicator (both optional).

The signal can additionally be indicated on a suitable analog measuring instrument. Transmission of the measured values is possible with both types of speed measurement equipment.

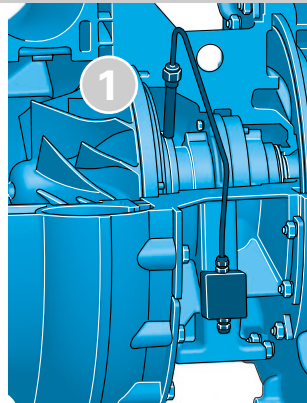
MAN Diesel supplies the measuring instrument and the transmission system for the measured values on request.



## Description of Components

### Speed Transmitter

The speed transmitter (1) is screwed radial into the bearing casing. A retaining ring with two grooves on the circumference is seated on the rotor shaft to generate the speed impulses.



**Speed transmitter**

The speed transmitter is screwed in with a gap clearance of approx. 1 mm to the retaining ring and secured.

### Read-out devices

The read-out devices can be located in the switch cabinet or housed in the operating cabinet.

A speed transmitter with terminal box is part of the MAN Diesel delivery scope. The following measuring transformers can be connected:

- Frequency-current converter,
- Digital tachometer with speed indicator.

When using a frequency-current converter or a digital tachometer, the number of grooves on the retaining ring (number of impulses per revolution), the maximum rotor speed as well as the alarm points must be taken into account when programming the equipment.

When using original MAN Diesel components this adjustment is factor-set.

### Note

*Speed detection and speed indication must be exactly in tune with each other! It is therefore recommended to have the detection and indication system supplied completely through MAN Diesel.*

### Analog speed indication/transmission of measured values

Both types of speed measurement equipment have a power output (4-20 mA) for connection of an additional analog speed measurement device and/or the measured value transmission.

## Measurement of the Air Volume

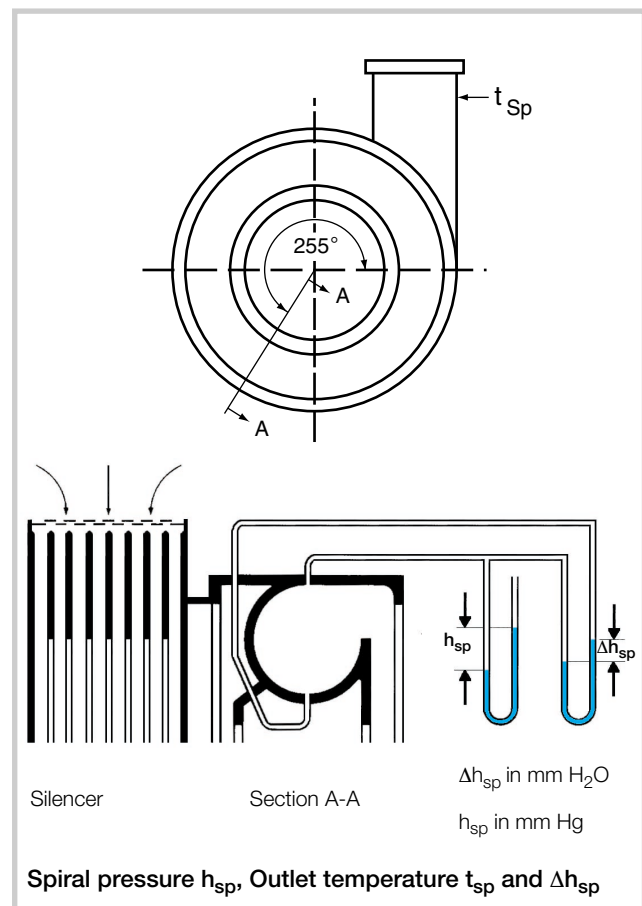
The measurement of the air volume is carried out via calibration of the compressor casing.

The measuring method is based on the theory of gas flow in manifolds: The pressure difference between inner and outer wall is correlated to the second power of the flow velocity.

The compressor casing is comparable to a manifold of variable cross-section area. At a certain, through numerous tests determined cross section, the static pressure difference  $\Delta h_{sp}$ , is measured at two opposing wall locations.

As during the testing of the TCR turbocharger both  $\Delta h_{sp}$  as well as the air volume can be measured in the usual manner (with orifice) at the burner rig, a calibration curve can be derived.

For the subsequent engine testing, this curve easily enables to determine the air volume when  $\Delta h_{sp}$ , the spiral pressure  $h_{sp}$  and the outlet temperature  $t_{sp}$  are measured:



This calibration curve is not transferable to other turbochargers, even if the size and specification are the same.

The accuracy of this method is approx.  $\pm 1\%$ . For diffuser flow areas other than the calibration curve has been derived for, correction factors are used. In order to ensure reliable



measurement, all measuring hoses, extensions, threads, etc. must be absolutely airtight (check by spraying on a soap solution).

## Matching Procedure

Each newly specified exhaust gas turbocharger for a new application is matched by MAN Diesel so that:

- It is optimized with the best possible flow cross-sections for the operating conditions of the engine,
- A sufficient surge margin is ensured across the complete operating range.

Therefore, it is customary that different variants of nozzle rings and diffusers (matching parts) are provided for matching purposes.

## Matching Steps

- Test run of the engine with the exhaust gas turbocharger in the "Condition of delivery",
- If the air pressure (as required by the engine manufacturer) before cylinder is too low or too high in the design point, the nozzle ring must be exchanged,

**The following applies for the air pressure before cylinder:** In order to reach a higher air pressure, a smaller nozzle ring must be used. To reach a lower air pressure, a larger nozzle ring must be used.

- At the same time the surge margin must be checked.

**The following applies for the surge margin:** When the surge margin is less than required, a smaller diffuser must be used (in rare cases even a smaller compressor wheel). The part-load range must also be checked for a sufficient surge margin.

## Surge Stability Check

"Surging" describes the unstable operation of a compressor when the air flow of an engine operating point becomes too low for the given pressure ratio.

In this case, the air flow stalls and air from the subsequent pipe system flows through the compressor in the opposite direction.

After the sudden decrease of pressure, the air flow starts again in the normal direction until the surge procedure is repeated.

In this process, the compressor wheel is highly stressed so that continuous surging can lead to damage.

The air intake section of the engine system is to be dimensioned in such a manner that pressure blasts of at least 1 bar overpressure can be withstood.

**One of the following methods can be applied:**

### Four-stroke engines:

- Reduce engine speed with constant fuel admission; a speed reduction of at least 15% should be possible without the occurrence of surging,
- Increase the charge air temperature at constant power output; a temperature increase of at least 50 °C above the air temperature at the compressor inlet should be possible without the occurrence of surging.

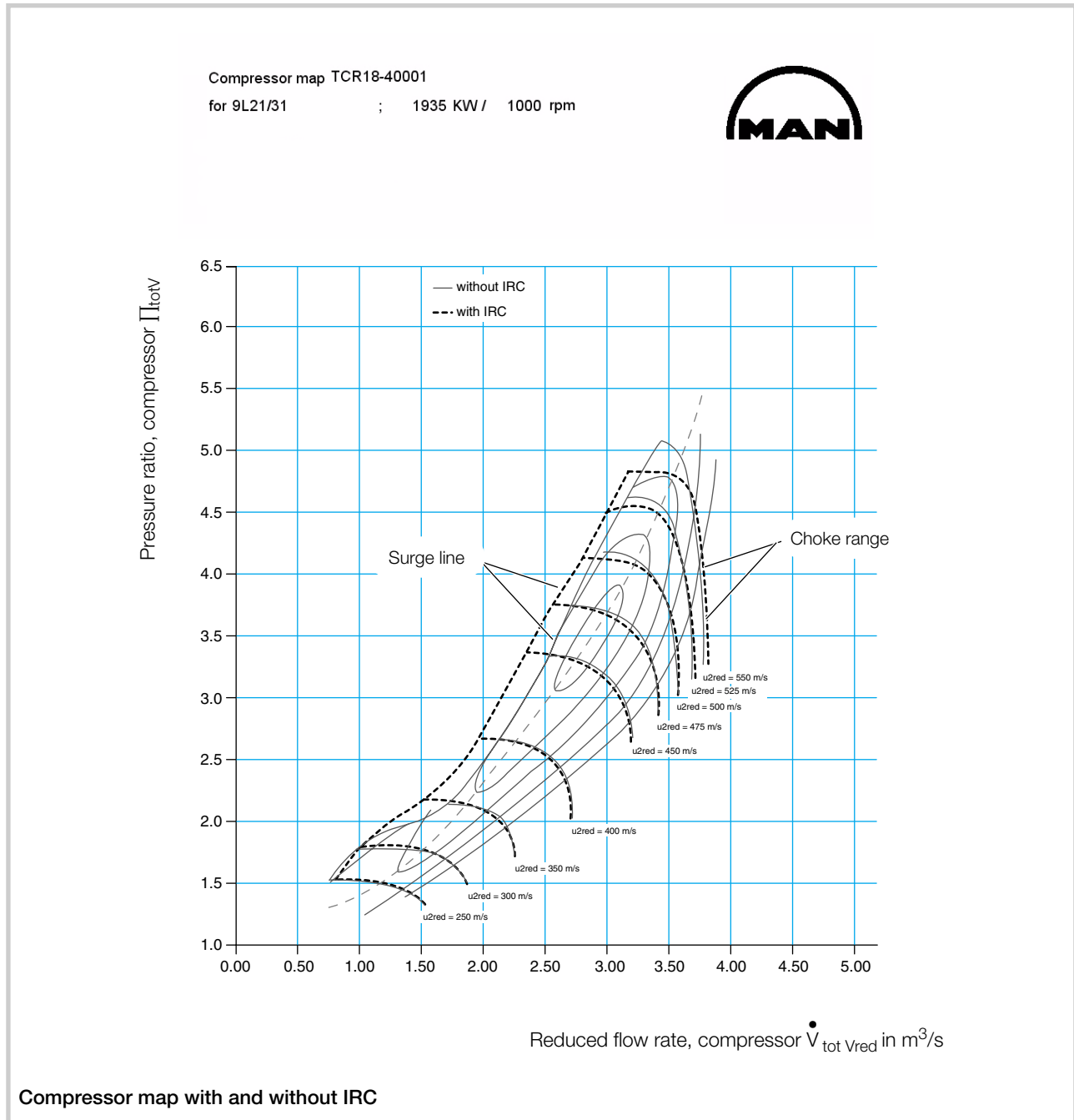
### Two-stroke engines:

- Run the engine at 100% load,
- Reduce the load suddenly to 75%. If no surging occurs repeat the procedure, but this time reduce the load from 100% to 50%; if not more than one surge blast occurs, the stability above 50% load is good,
- Run the engine at part load and a scavenging air pressure of > 0.6 bar overpressure so that the auxiliary blowers no longer run. Pull the fuel pump of one cylinder suddenly to zero, and repeat this measure with other cylinders. If surging occurs in not more than one case, the stability is sufficient.

## Characteristic Map Diagram

As a basic for the matching of each newly specified exhaust gas turbocharger, the corresponding compressor map as well as the turbine characteristics are provided through MAN Diesel.

### Compressor Map



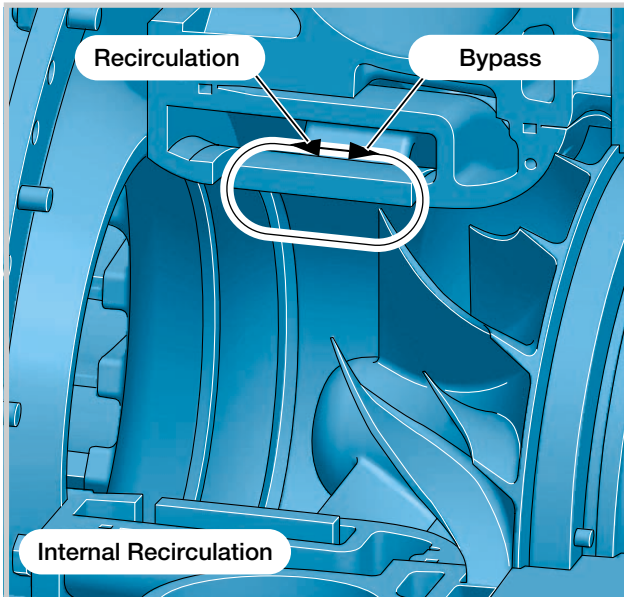
Based on the characteristic parameters 'Pressure ratio' and 'Air volume flow rate', all operating points can be plotted along the operating line reduced for elimination of influences of different intake conditions. Together with other parameter curves such as speeds and efficiencies, they provide information on the performance of the compressor. The distance of the operating line to the surge limit can be increased by means of the compressor-internal measure IRC (Internal Recirculation).

### Internal Recirculation (IRC)

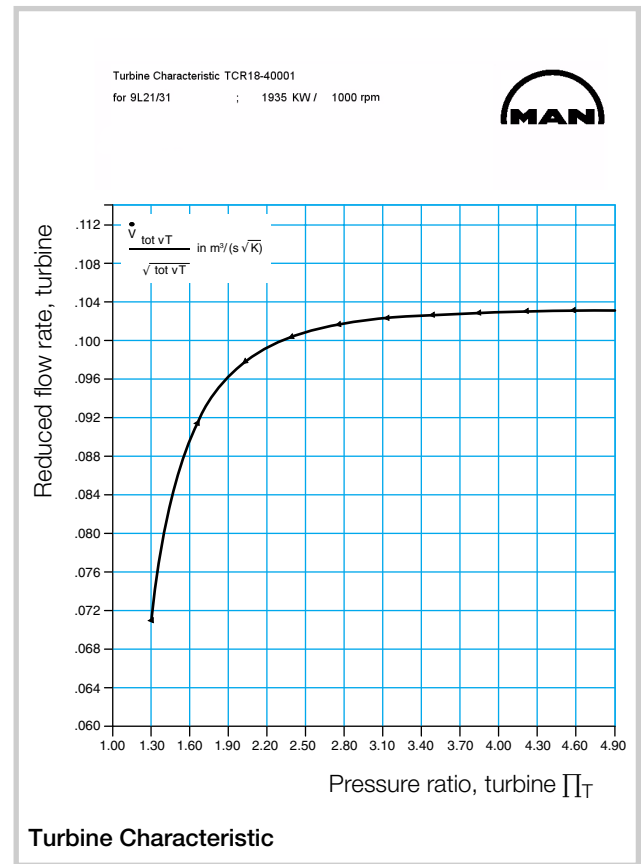
The compressor map width usable for an engine operating line is increased using IRC through the following effects:

- Increase of the surge limit margin at low and medium pressure ratio,
- Extension of the choke limit at high pressure ratio.

This means that at low and medium pressure ratio, the minimal flow rate required for stable compressor operation is reduced through an additional neutral portion of the air flow. This is effected through recirculation of the air flow around the inlet area of the compressor wheel blades (see figure below). In the opposite flow direction and with high pressure ratio, however, the maximal flow rate is increased owing to an additional portion of air flow that bypasses the inlet area.



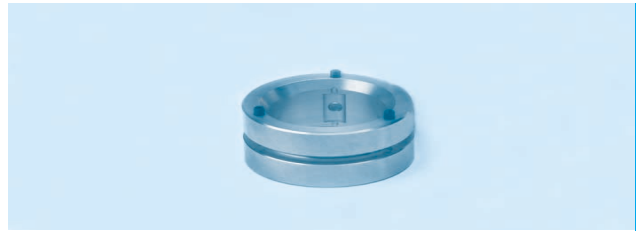
### Turbine Characteristic



Based on the characteristic parameters 'Pressure ratio' and 'Exhaust gas volume flow rate', the respectively given exhaust gas volume and also the air volume - through subtraction of the fuel quantity - can be calculated back from the known plotted operation characteristic curve (clearly assigned to a turbine geometry), reduced for elimination of influences different ambient conditions. This serves as an alternative, when no calibration of the compressor casing is given for direct measurement of the air volume.



## Quality Assurance



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An integrated quality and environmental management system is established at MAN Diesel which is certified according to ISO 9001 since 1991 and to ISO 14001 since 2001. This affords our customers the confidence that MAN Diesel turbochargers meet customer expectations to complete satisfaction, from development over production to dispatching.





Germanischer Lloyd  
Certification



# CERTIFICATE

The Germanischer Lloyd Certification GmbH, 20459 Hamburg,  
herewith certifies that the company



**MAN B&W Diesel AG**  
Stadtbachstraße 1, D-86224 Augsburg

has established and maintains an Environmental Management System relevant for  
**Development, design, production, installation and servicing of  
Diesel engines and turbochargers for ships and power plants in Augsburg  
as well as casting of nodular cast iron and grey cast iron components.**

Germanischer Lloyd Certification GmbH has audited the company. Evidence was provided  
that the Environmental Management System fulfills the requirements of the following standard:

**DIN EN ISO 14001**  
edition: 10/1996

The validity of this certificate is subject to the company applying and maintaining its  
Environmental Management System in accordance with the standard indicated. This will be  
monitored by Germanischer Lloyd Certification GmbH.

Validity extended until May 29, 2007

Hamburg, May 25, 2004

Certificate No. **EM-2307 HH**



*R. Westphal*  
(R. Westphal)

*J. Rogge*  
(J. Rogge)

## Description of the Quality Criteria

### Standards, Provisions and Regulations

Exhaust gas turbochargers of the MAN Diesel TCR Series meet the regulations of the guideline 98/37/EG (Machine Guideline).

The following national and international standards were applied upon development and production:

- DIN EN 292-1 - Security of Machines; Basic Terms, General Design Guidelines; Part 1: Basic Terminology, Methodology
- DIN EN 292-2- Security of Machines; Basic Terms, General Design Guidelines; Part 2: Technical Guidelines and Specifications
- DIN EN 1050 - Security of Machines; Guidelines for Risk Assessment
- DIN EN 62079 - Creating Manuals; Outline, Contents and Representation
- DIN 7168 - General Tolerances; Length and Angle Measures, Form and Position; not for new constructions
- DIN 6784 - Workpiece Edges
- DIN EN ISO 1302 - Geometric Product Specification (GPS) - Indication of the Surface Condition in the Technical Product Documentation
- Q11.09004-8500 - Turbocharger Quality Guidelines (List of the applied MAN Diesel Works Standards for turbochargers).

### Acceptance by international Classification Associations

- Each turbocharger type of the TCR Series receives a type acceptance which includes the following: A drawing check, an examination of the regulation conformity, the type test run at the burner rig with maximum speed and exhaust temperature.
- In addition to this, each individual turbocharger can be ordered and delivered with acceptance and IMO Certificate upon request.
- As the first of its series, the TCR18 turbocharger is certified by the following international acceptance companies: ABS (American Bureau of Shipping), BV (Bureau Veritas), DNV (Det norske Veritas Classifikation A.S.), GL (Germanischer Lloyd), LR (Lloyd's Register of Shipping).

### Compressor Wheel

- The die-forged blanks will be crack- and ultrasonic-tested before milling.
- Each compressor-wheel blank carries a test ring on which the strength values will be checked.
- After milling and pre-machining, all compressor wheels will be balanced and spin-tested at speeds far above the maximum allowable operating speeds.

- Measuring of bores and wheel exterior to ensure that all dimensions are still within tolerance.
- Crack testing by penetration method.
- All finishing performed according to specifications.
- Checking/measuring of all machined surfaces and diameters.
- Re-balancing of finish-machined compressor wheels.

### Turbine Wheel

- The pre-machined precision cast turbine undergoes a crack detection test prior to welding to the shaft.
- Renewed crack detection test of the friction-weld seam after friction welding with the shaft.
- Turbine rotors are balanced and spin-tested at speeds far above the maximum allowable operating speeds.
- Finishing according to specifications.
- Checking/measuring of all machined surfaces and diameters.
- Re-balancing of the finish-machined turbine rotor.

### Service Life Periods

The following data is based on empirical values of MAN Diesel that have been manufactured with identical materials and manufacturing procedures.

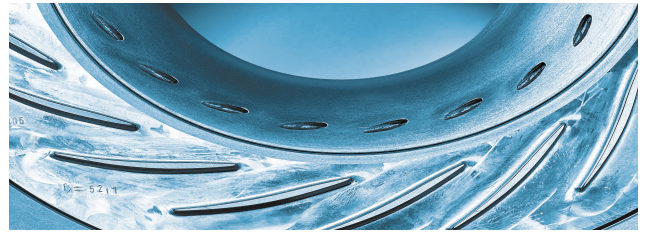
The mentioned service life periods are reference values that apply under normal operating conditions. They can be considerably reduced due to e.g., insufficient maintenance, frequent "blackouts" or use of low-quality fuel and lube oil.

	Operating Hours
Plain bearings	up to 30 000
Nozzle ring	up to 30 000
Turbine rotor	up to 60 000
Compressor wheel	up to 60 000 <sup>1)</sup>
Casing	no limitation

1) Depends on:

- The intake air temperature,
  - the charge pressure,
  - the load profile of the engine,
- and may fall shorter in case of unfavorable values.

# 12 Maintenance and Checking



When carrying out maintenance and inspection work, it is usually sufficient to remove only partial subassemblies of the exhaust gas turbocharger. Only for mayor overhauls, it can be required to remove the complete exhaust gas turbocharger.

When primary components are repaired or for major overhauls, it is recommended to protocol the condition of the individual assemblies.

Components with traces of wear or damage that particularly influence the strength and smooth running of rotating parts must be replaced against original spare parts or be repaired by an authorized repair shop or the manufacturer.

For shipping, pack and protect components against corrosion so that they remain intact during transportation.

## Maintenance

### Turbocharger on the Four-stroke Engine

Inspection intervals (during operation) in h	24	150	250	3 000	12 000	18 000
Check turbocharger for abnormal noise and vibrations	X					
Check turbocharger and system pipes for leakages (charge air, exhaust gas, lube oil)	X					
Check all fastening screws, casing bolts and piping connections for tight seating.			X <sup>1)</sup>	X		

1) Inspection of new or overhauled components required (once, at the operating hours listed)

Maintenance intervals (during operation) in h	24	150	250	3 000	12 000	18 000
Dry cleaning <sup>1)</sup> of the turbine	X <sup>2)</sup>					
Wet cleaning <sup>1)</sup> of the turbine		X <sup>2)</sup>				
Cleaning of compressor (during operation)		X <sup>2)</sup>				
Cleaning of air filter <sup>1)</sup>			X <sup>2)</sup>			

1) if given

2) or more frequently, if required

Maintenance intervals (combined with an engine maintenance) in h	24	150	250	3 000	12 000	18 000
Major overhaul every 12 000 ... 18 000 operating hours: Remove, clean and check all components of the turbocharger! Inspect gap upon assembly!					X	



### Turbocharger on the Two-stroke Engine

Inspection intervals (during operation) in h	24	150	250	3 000	24 000	30 000
Check turbocharger for abnormal noise and vibrations	X					
Check turbocharger and system pipes for leakages (charge air, exhaust gas, lube oil)	X					
Check all fastening screws, casing bolts and piping connections for tight seating.			X <sup>1)</sup>	X		

1) Inspection of new or overhauled components required (once, at the operating hours listed)

Maintenance intervals (during operation) in h	24	150	250	3 000	24 000	30 000
Dry cleaning <sup>1)</sup> of the turbine	X <sup>2)</sup>					
Wet cleaning <sup>1)</sup> of the turbine		X <sup>2)</sup>				
Cleaning of compressor (during operation)		X <sup>2)</sup>				
Cleaning of air filter <sup>1)</sup>			X <sup>2)</sup>			

1) if given

2) or more frequently, if required

Maintenance intervals (combined with an engine maintenance) in h	24	150	250	3 000	24 000	30 000
Major overhaul every 24 000 ... 30 000 operating hours: Remove, clean and check all components of the turbocharger! Inspect gap upon assembly!					X	



## Personnel and Time Requirements

### Cleaning Work:

	Qualified Mechanic	Assistant
	Required Time in h	Required Time in h
Turbine:		
Dry cleaning	0.3	—
Wet cleaning	0.6	—
Compressor	0.3	—
Air filter	0.4	—

### Removing and Refitting the Turbocharger:

The mounting time for removing and refitting of the turbocharger includes the connection of the charge air and exhaust gas pipes, Jet Assist, turbine cleaning, compressor cleaning, draining of dirt/condensate, lube oil pressure/temperature, speed measurement and misc. special connections.

	Qualified Mechanic	Assistant
	Required Time	Required Time
Turbocharger to engine	approx. 4.5 h	1.0 h

### Inspection of Bearings and Piston Rings:

To inspect the thrust bearing, the bearing bushes, the turbine rotor, the retaining ring and the piston rings, the following components must be removed or dismantled:

- Silencer and air intake casing,
- Insert on compressor side,
- Compressor casing,
- Cartridge.

For a complete inspection of the bearings, the piston rings and the rotor, approx. 7.6 man hours are estimated:

	Qualified Mechanic	Assistant
	Required Time in h	Required Time in h
Silencer/air intake casing	0.4	0.4
Insert	0.4	—
Covering of compressor casing	0.6	—
Compressor casing	0.6	—
Cartridge	0.6	0.6
Bearings and piston rings	4.0	—
Total hours	6.6	1.0

### Inspection Periods for Major Overhaul:

Together with an engine maintenance, the turbocharger is subject to a major overhaul every 12 000 to 18 000 operating hours (operation with four-stroke engines) or every 24 000 to 30 000 operating hours (operation on two-stroke engines). Here, all components of the turbocharger must be cleaned and checked, and the gaps and clearances must be inspected for dimensional accuracy.

**Approx. 15 man hours are estimated for the major overhaul of a TCR turbocharger.**



## Service Addresses

The current global MAN Diesel service address list can be obtained from:

Turbocharger Service Office  
 Phone.: +49 821-322-1198  
 Fax: +49 821-322-3998  
 E-mail: tc-service-augsburg@de.manbw.com

## Transport

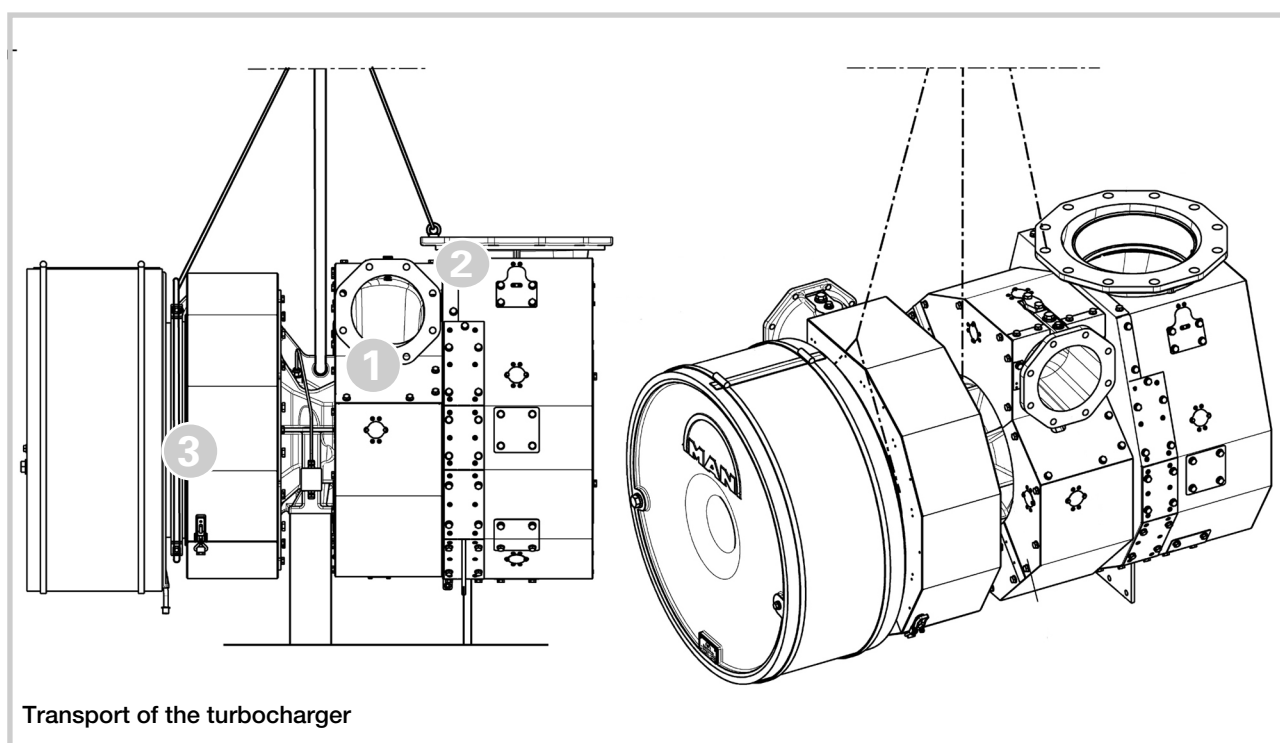


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The illustration shows the fixing points for transport of the complete exhaust gas turbocharger.

Fixing point (1) for fixation of the endless sling of the lifting

tackle is located on the bearing casing. Equalization ropes are fastened on the gas outlet casing (2) as well as between silencer/air intake casing and compressor casing (3).



### Note

For attachment of the lifting tackle to the bearing casing, use only the endless slings intended for this purpose. Ensure not to damage fixing point (1) in the bearing casing!

## Preservation Treatment and Packing

### Corrosion Protection

The corrosion protection includes preservation and packing of the turbocharger in accordance with the transport and storage conditions to be expected.

Corrosion protection criteria are

- the required duration,
- the transport conditions (land carriage, air or sea freight),
- the climatic conditions during the transport,
- the storage at the place of destination.

Preservation is carried out already upon assembly of the exhaust gas turbocharger.

In this, fitted surfaces (with the exception of tapered seats of the compressor wheel) are treated with anti-corrosion oil, e.g.: Fuchs Anticorit 1, Valvoline Tectil, Teco 6 SAE 30, Esso Rust Ban 335 or Cyclesso 400, Shell Ensis Oil L.

The rotor as well as the interior surfaces of the casings are treated with anti-corrosion agents with low flow properties, e.g.: Fuchs Anticorit 6120-42 E or Anticorit 15 N, Esso Rust Ban 391 or with moisture-displacing properties, e.g.: Fuchs Anticorit 6120-42 DFV, Valvoline Tectyl 511 M or Tectyl 472.

When using these operating-media-consistent agents, removal of the preservation agent prior to starting operation is not required.

Machined exterior surfaces are treated with anti-corrosion agents such as: Fuchs Anticorit BW 336, Valvoline Tectyl 846, Esso Rust Ban 397. These agents must be removed with diesel fuel or petroleum upon assembly prior to starting operation.

After preservation, all openings on the exhaust gas turbocharger are sealed air-tight as far as this is possible.



### Increased Corrosion Protection

Increased corrosion protection is achieved (e.g. for overseas, tropics, subtropics) when before closing the openings, vapor-phase corrosion agent (e.g. Branorol 32-5) is sprayed into the gas-intake connection, gas-discharge connection and air-discharge connection at a ratio of 300 cm<sup>3</sup> per 1 m<sup>3</sup> interior space, or when drying agent (bag or block form) is attached to the interior sides of the closing covers.

In such cases, the drying agents must be removed upon assembly prior to starting operation of the exhaust gas turbocharger and the casing must thoroughly be blown through with compressed air, otherwise toxic fumes can be set free when being heated up.

### Packing

The packing must meet the required degree of corrosion protection and the conditions for transport and storage.

### Seaworthy Packing

For oversea shipping and/or extended storage in tropical or subtropical areas, it can be required to additionally shrink-wrap the exhaust gas turbocharger in an aluminum-plastic compound foil, including a sufficient amount of desiccant bags and moisture indicators within the packing crate.

**Instructions on the control measures to be carried out for corrosion protection or post preservation will be supplied or can be requested, as can be detailed instructions on corrosion protection.**



**E-mail: [tc-service-augsburg@de.manbw.com](mailto:tc-service-augsburg@de.manbw.com)**



# Training and Documentation

## Training Programs

- For engineers and qualified mechanics
    - Servicing the turbocharger,
    - Theoretical and practical training.
  - Courses for groups are available on request
- For more information on our training programs, please directly contact MAN Diesel SE in Augsburg:  
tc-service-augsburg@de.manbw.com.

With the delivery of an exhaust gas turbocharger, our customers receive comprehensive technical documentation consisting of:

- Operating Manual
- Working Instructions (Work Cards)
- Spare Parts Catalog
- Reserve Parts List and Tool List
- Certificates
- Records

The technical documentation can also be supplied electronically on request.

## Technical Documentation

**Work Card: Assembly and Maintenance**

3.3.7 Cartridge

**Requirement**  
Maintenance work is due/required. Begin from the compressor side.

**Brief Description**  
Removal and refitting of cartridge.

Number	Qualification	Hours	Work Sequences
1	Qualified Mechanic	0,5	1 and 2

**Personnel and Time Requirement**

Quantity	Designation	Number	Status
3	Forcing-off bolts	596.018	Optional

**Tools Appliances**

**Required Spare Parts**

**Corresponding Chapters Work Card**

**Weights**

**Fig. 3-13** Removal and refitting of the cartridge

**Starting Condition**  
Silencer or air intake casing, insert on compressor side and covering of compressor casing (if provided) removed.

**Work Sequence 1**  
**Removal of the Cartridge**

1. Disconnect the connection for speed measuring, if available.
2. Remove the face-side covering from the gas-admission casing (501.001).
3. Hang the cartridge (599.000) to the lifting tackle with the rope and shackles. Carefully tension the rope.
4. Unscrew the hexagon nuts (501.008), remove lock washer pairs (501.007) and clamping cleats (501.005).
5. Uniformly force off the cartridge at 3 locations of the circumference using the forcing-off tools (596.018 and 596.019); remove cartridge in axial direction and place it down on wooden support.

**Important!**  
*Do not damage the blades of the compressor or turbine wheel. When removing the cartridge, pay attention to the turbine nozzle ring (513.001).*

Version 10/2004 - TCR18 - C2 Working Instructions 3-34

**List of tools (X11.596 00-0219) --- OPTION**

S.1 List of tools (X11.596 00-0219)

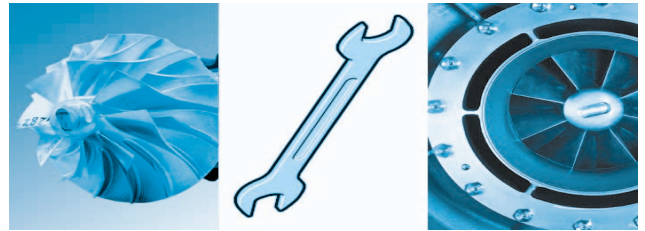
Order No.	Designation	Sketch	[mm]	Quantity
596.001	Hexagon pin		L = 60	1
544.063 or 545.063			0.294 kg	
596.002	Retainer		L = 275	1

**Compressor casing (546.01)**

Version 10/2004 - TCR18 - C3 Spare Parts Catalog 3-27

**Examples for Work Card and Spare Parts Catalog**

# 16 Ordering of Spare Parts

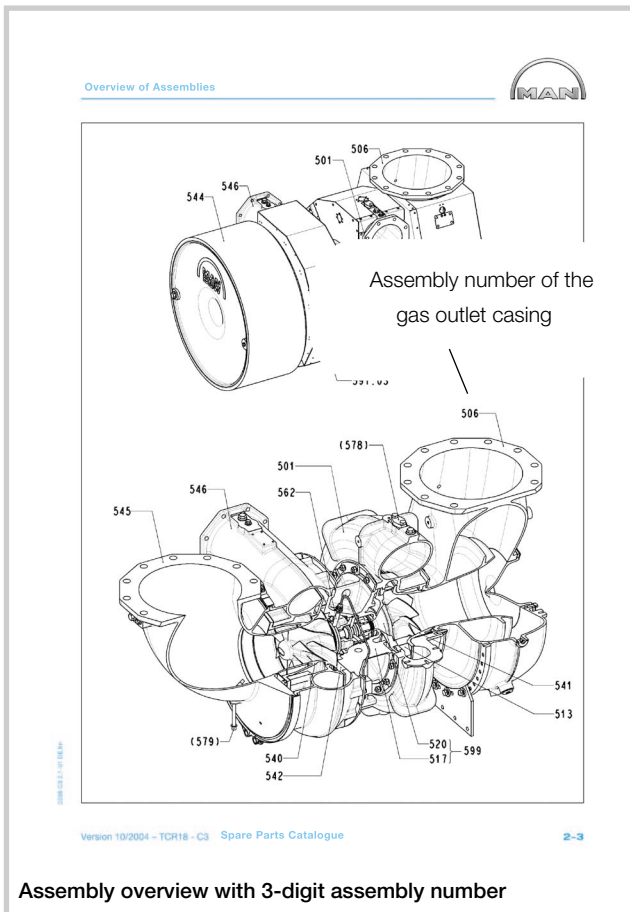


Maintenance and repair work can only be carried out properly when the required spare parts and reserve parts are available.

## Spare Parts

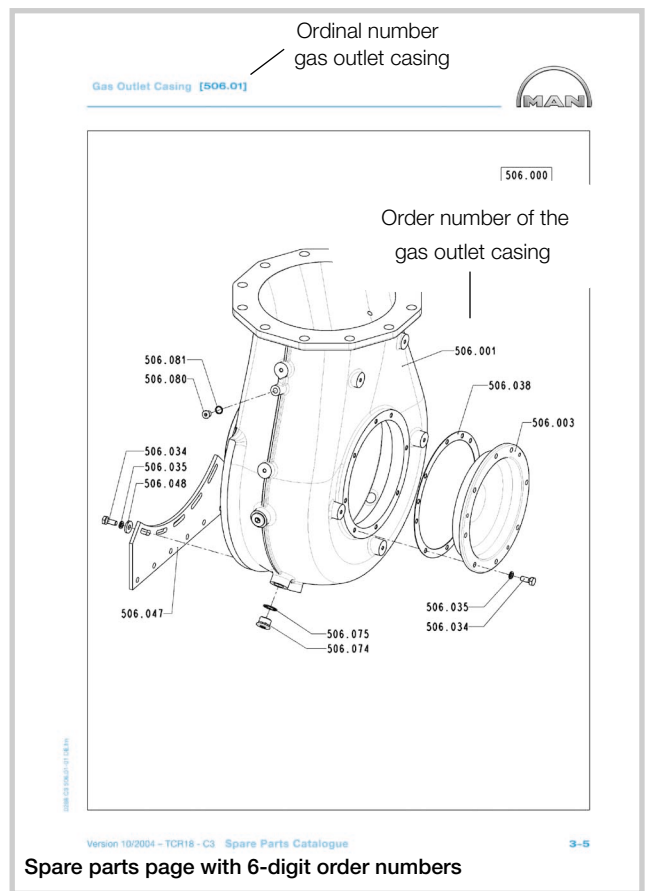
The spare parts catalog is part of the operating manual. It comprises all primary components of the turbocharger.

The pages of the spare parts catalog are organized according to the subassembly system of the turbocharger. Most subassemblies can be determined with help of the Overview of Subassemblies, in front of the spare parts catalog.



Assembly overview with 3-digit assembly number

The **ordinal number** consisting of the 3-digit assembly number and a 2-digit version number, is located at the top of the spare parts pages:



Spare parts page with 6-digit order numbers

The **order number** consists of a 3-digit assembly number and a 3-digit position number. Assembly and position number are divided by a dot.

Examples:

Assembly number:

506 (gas outlet casing)

Order number:

506.001 (gas outlet casing)

506.038 (gasket)



## Reserve Parts and Tools

For each turbocharger a set of reserve parts and tools can be ordered optionally. Reserve parts and tools are each packed in a box. The contents in the boxes are itemized in lists.

The assemblies number for reserve parts is 595 for tools 596. For reordering, the same guidelines apply as for the spare parts.

## Ordering

Please direct your order to:

MAN Diesel SE  
86224 Augsburg

Phone: +49 8 21-322-1198

Fax: +49 8 21-322-3998

E-mail: [tc-service-augsburg@de.manbw.com](mailto:tc-service-augsburg@de.manbw.com)

To avoid questions and confusion, the following information are required upon ordering:

1. Type of exhaust gas turbocharger
2. Works number of the exhaust gas turbocharger (type plate)
3. Order number of the component
4. Quantity
5. Shipping address.

# 17 Tools

For each turbocharger a set of tools can be ordered optionally.

A set of tools consists of assembling/disassembling devices, suspension devices, holding devices and equipment for emergency operation.

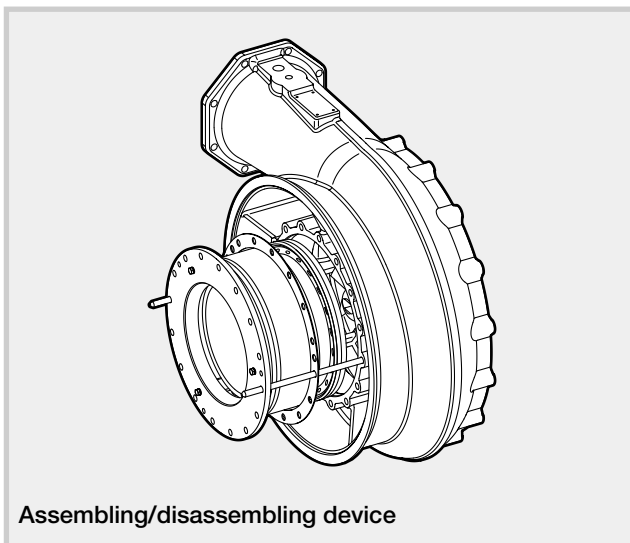
These tools ensure that damage can not occur to the turbocharger in the course of maintenance and repair work, and that the work can be carried out swiftly and effectively.

The tools are packed in a box. The contents of the box is itemized in the enclosed list.

## Assembling/Disassembling Devices

Components that can not be removed and installed by simply loosening the screw connections are removed and installed with guide rods, forcing-off devices or holding devices. These are:

- Cartridge
- Bearing bodies
- Insert
- Turbine wheel.

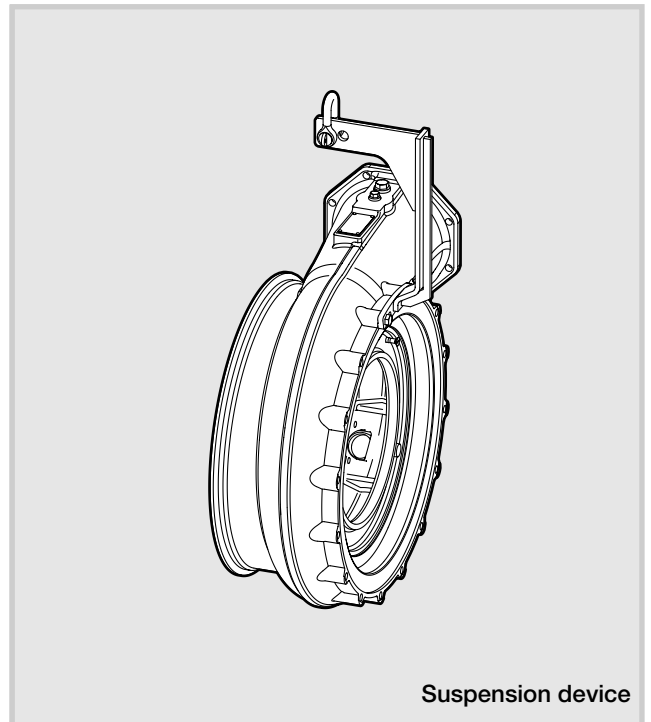


## Suspension Devices

In most cases, standard suspension devices such as shackles and lifting eye bolts are used. These are fastened in the threads or in special bores of the components.

Some heavy components are moved away from the turbocharger by means of specially designed suspension devices:

- Gas-admission casing
- Compressor casing

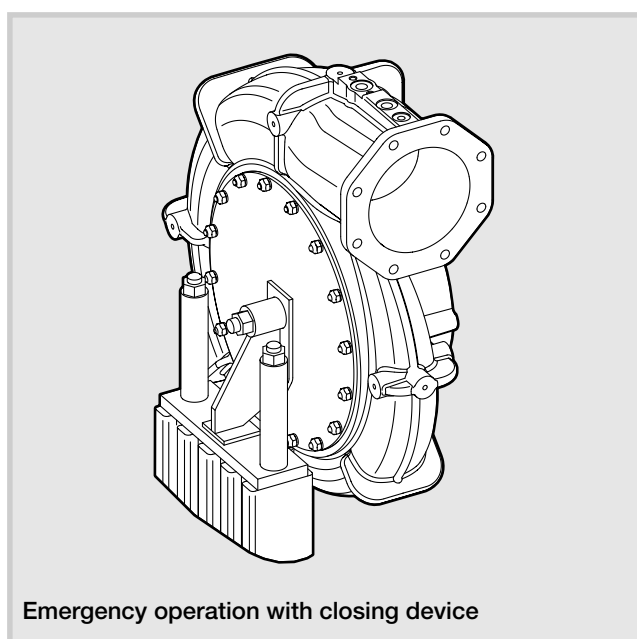


## Emergency Operation

For emergency operation in case of a turbocharger failure, a closing device is provided for the gas-admission casing.

In emergency operation, the gas-admission casing as well as the lube oil supply and discharge are closed and sealed off with this closing device.

The cartridge is removed for this.



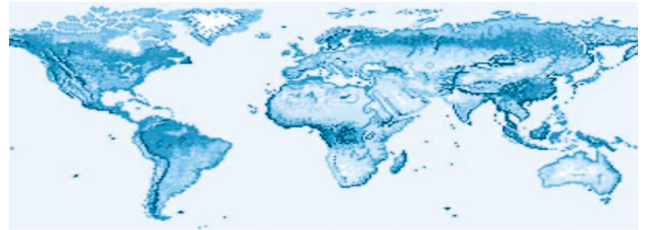
## General

The assemblies number for tools 596. For reordering, the same guidelines apply as for the spare parts and reserve parts.

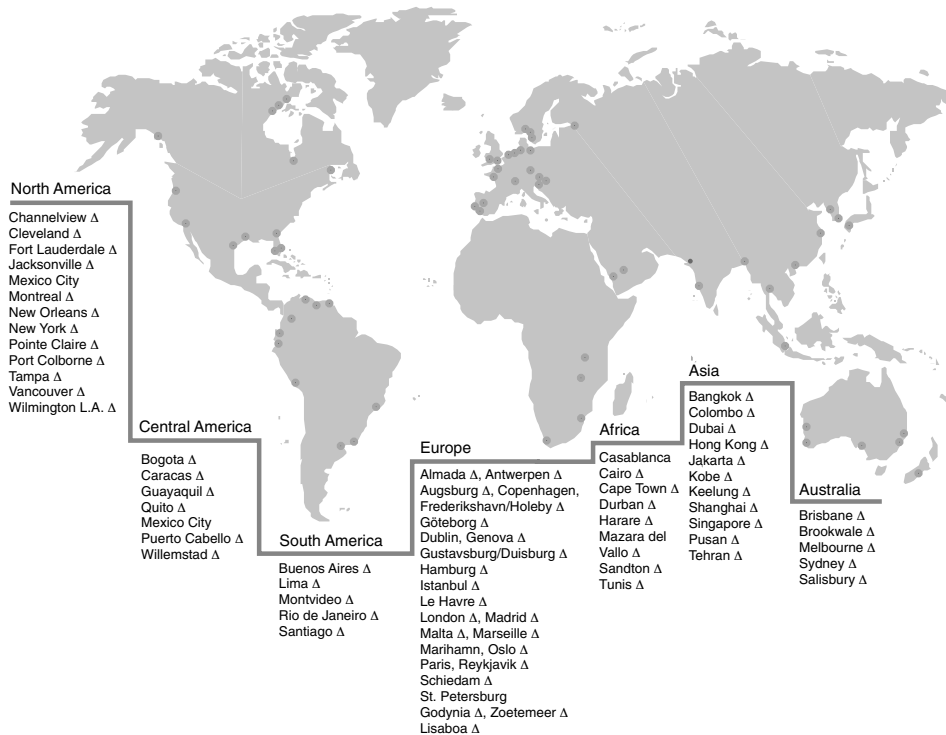


# 18

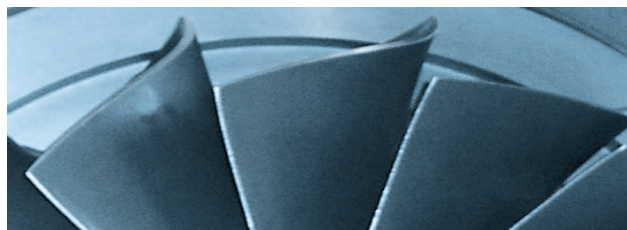
## Worldwide Turbocharger Service



- Augsburg Works  
MAN Diesel SE  
86224 Augsburg  
Phone: +49 821-322-0  
Fax: +49 821-322-33 82
- Hamburg Works  
MAN Diesel SE  
Service Center, Hamburg Works  
Rossweg 6  
20457 Hamburg  
Germany  
Phone: +49 40-7409-0  
Fax: +49 40-7409-104
- MAN Diesel Singapore Pte. Ltd.  
29 Tuas Avenue 2  
Singapore 639460  
Phone: +65 6349-1600  
Fax: +65 6862-1409  
Fax: +65 6861-8590 (Service)
- Authorized Repair Shops (ARS)  
Qualified repair shops with MAN Diesel trained service engineers.
- Agents  
Independent companies with close contact to MAN Diesel.
- Over 150 service bases worldwide.
- Swift supply of high-grade OEM spare parts.
- 24 hour around-the-clock service.
- Fast, reliable and competent assistance from experienced, highly-skilled service engineers and qualified mechanics.
- Centralized, computer-controlled spare parts stock in Augsburg.



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