VTA
Project Guide

Variable turbine area for TCA turbocharger

Engineering the Future – since 1758.

MAN Diesel & Turbo

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Variable Turbine Area (VTA)

Application Ranges for the Variable Turbine Area

The VTA was designed for applications on super-charged large-bore diesel engines with varying load profiles. Due to its adjustability, the VTA efficiently adapts to a wide range of engine operation.

Method of Operation

A fresh-air supply is necessary to meet the requirements of modern large-bore diesel engines. A specifically efficient method is by using a variable turbine area, abbreviated VTA. It changes the pressure level in the engine by adapting the tightest flown-through nozzle-ring cross-section. The flown-through surface is changed by adjusting the guide vanes of the turbine nozzle ring.

When the flown-through cross-section is reduced by adjusting the guide vanes, the speed of the inlet flow to the turbine wheel is increased. This increases the turbocharger speed, which leads to an increase of the compressor-side charge pressure.

VTA for TCA Turbochargers

The VTA technology is available for all sizes of the TCA series and can be employed both for two-stroke and four-stroke engines. The use of a variable turbine area can significantly improve diesel as well as gas engine applications.

Engine performance is optimized to customer requirements through adapted control programs.

See table Overview – VTA Application Ranges.

Application	Method of Operation	Effect
Two-stroke diesel engine	▪ Scavenge-air pressure at part load is increased by closing the VTA:	▪ In part load, either
	Economy Mode (Mode 1.)	
	Ignition-pressure increase for reduction of the SFOC [3]	reduced fuel consumption (NOx increased) or
	Emission Mode (Mode 2.)	
	Ignition pressure is held constant by means of delayed injection ▪ Correction of ambient-temperature influences on scavenge pressure ▪ Closing upon acceleration ▪ Compensation of extracted-gas flows (e.g. for power-turbine applications, see „Power Turbine“ line) ▪ Systems with EGR [4]: Maintaining the scavenge-air pressure at a constant level upon changes of the EGR rate 3) Specific fuel oil consumption 4) Exhaust gas recirculation	Reduced NOx emissions (Fuel consumption lightly increased in comparison to **Mode 1.**). In conjunction with variable injection technology and when accordingly optimized, the VTA enables reduced fuel consumption and a flexible change between **Mode 1**. und **Mode 2.** ▪ Slight consumption increase at full load ▪ Shifting of the auxiliary blower's shut-off point to lower outputs ▪ Elimination of a bypass for correction of scavenge pressure at extremely low intake temperatures („Arctic conditions“) ▪ Improved load-application performance ▪ Additional improvement of the part-load behavior in terms of reduced engine load, due to shifting of the efficiency maximum. ▪ Exhaust-gas temperatures reduced at part load **NOTE!** In sole „Economy Mode“ (**Mode 1.**), the VTA layout must be adapted to the NOx limit values.
Four-stroke diesel engine	▪ VTA closes at part load ▪ Correction of ambient-temperature influences on charge pressure ▪ Closing upon acceleration ▪ Compensation of extracted-gas flows (e.g. for power-turbine applications, see „Power Turbine“ line) ▪ Systems with EGR [4]: Maintaining the charging air pressure at a constant level upon changes of the EGR rate ▪ HAM [5] applications: Increase of the water content at part load. 4) Exhaust gas recirculation 5) Humid air motor	▪ Reduced fuel consumption at part load ▪ Increase of the NOx emissions ⇨ To within the limit values or constant cycle values, with appropriate thermodynamic optimization (similar to two-stroke) ▪ Reduction of the exhaust-gas temperature at part load ▪ Elimination of blow-off valves ▪ Improved load-application behavior ▪ Reduction of soot emissions at low-load operation and load application ▪ Additional improvement of the part-load behavior in terms of reduced engine load, due to shifting of the efficiency maximum.

Application	Method of Operation		Effect
Gas engine	▪ VTA opens at part load ▪ Correction of ambient-temperature influences on charge pressure ▪ Closing on load application to prevent mixture from being over-rich ▪ Variation of the charge pressure to adapt to changing gas qualities		▪ Reduced fuel consumption due to increased charging efficiency when compared with blow-off valves or throttle ▪ Elimination of blow-off valves/throttle
Dual-fuel engine	See gas or diesel engine		See gas or diesel engine
Test engine	▪ Adaptation of the charging air pressure to changed engine parameters		▪ Elimination of conversions ▪ Continuous setting possibility of the charging air pressure
Power turbine	1.	**VTA only on power turbine**	
	▪ „Closing“ of the VTA for throttling of the power-turbine output		▪ Increase of the charging efficiency at given power-turbine output when compared to power-turbine control via control flaps owing to the elimination of pressure losses
	2.	**VTA on each turbocharger and power turbine**	
	▪ „Closing“ of all VTAs with constant surface factor (resulting in a constant bypass ratio) ▪ At full load: „Closing“ of the power turbine's VTA for throttling of the power-turbine output, „Opening“ of the turbocharger VTAs for limitation of the charge pressure. ▪ At part load: „Closing“ of the VTA for throttling of the power-turbine output according to 1.		▪ Increased power-turbine output and reduced SFOC by increasing of the scavenge-air pressure (see „Two-stroke engine“ line) and exhaust gas pressure ▪ Increase of the charging efficiency at given power-turbine output when compared to power-turbine control via bypass ▪ Increase of the charging efficiency at given power-turbine output – see 1.
System technology	▪ Compensation of flow rate variations ▪ Closing during a starting procedure		▪ Elimination of pressure losses caused by control flaps

Table 1: Overview – VTA Application Ranges

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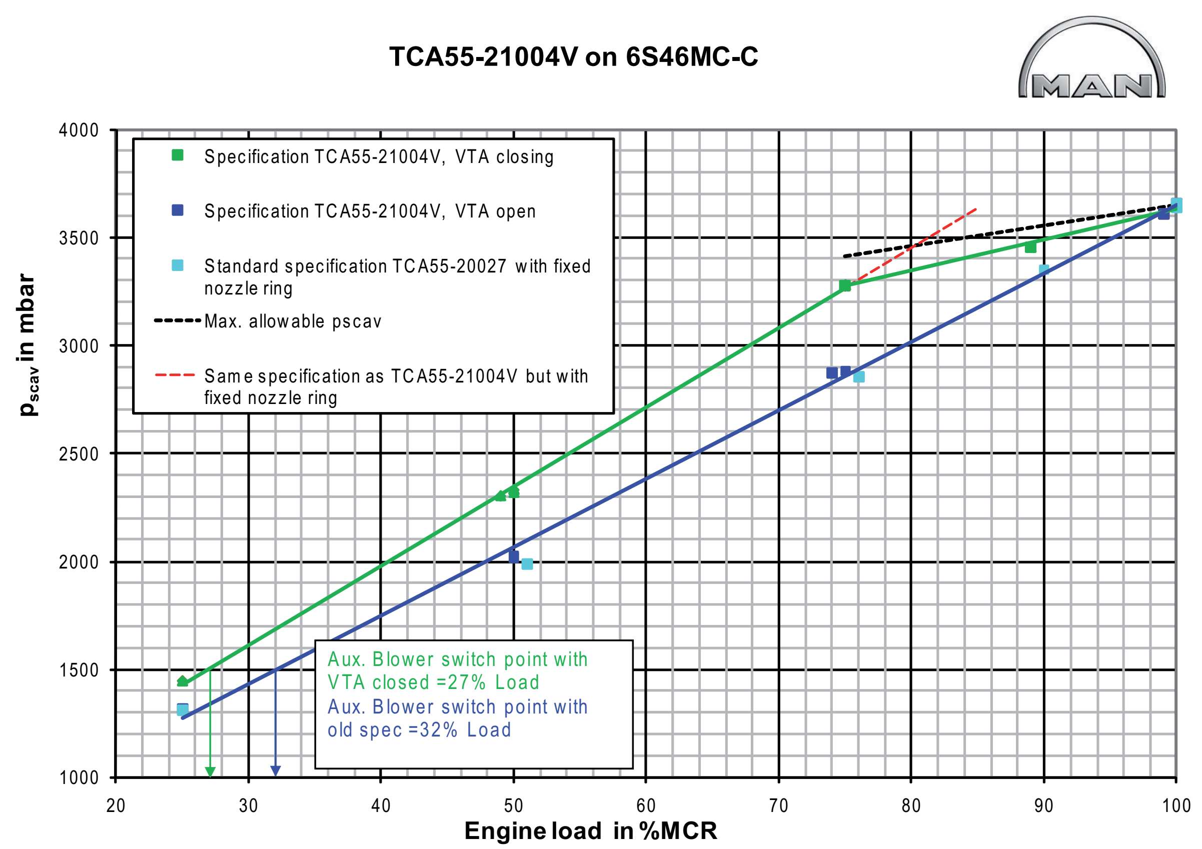
Application Examples

VTA on a two-stroke diesel engine



p_{scav} *Scavenge air pressure*
MCR *Maximum Continuous Rating*

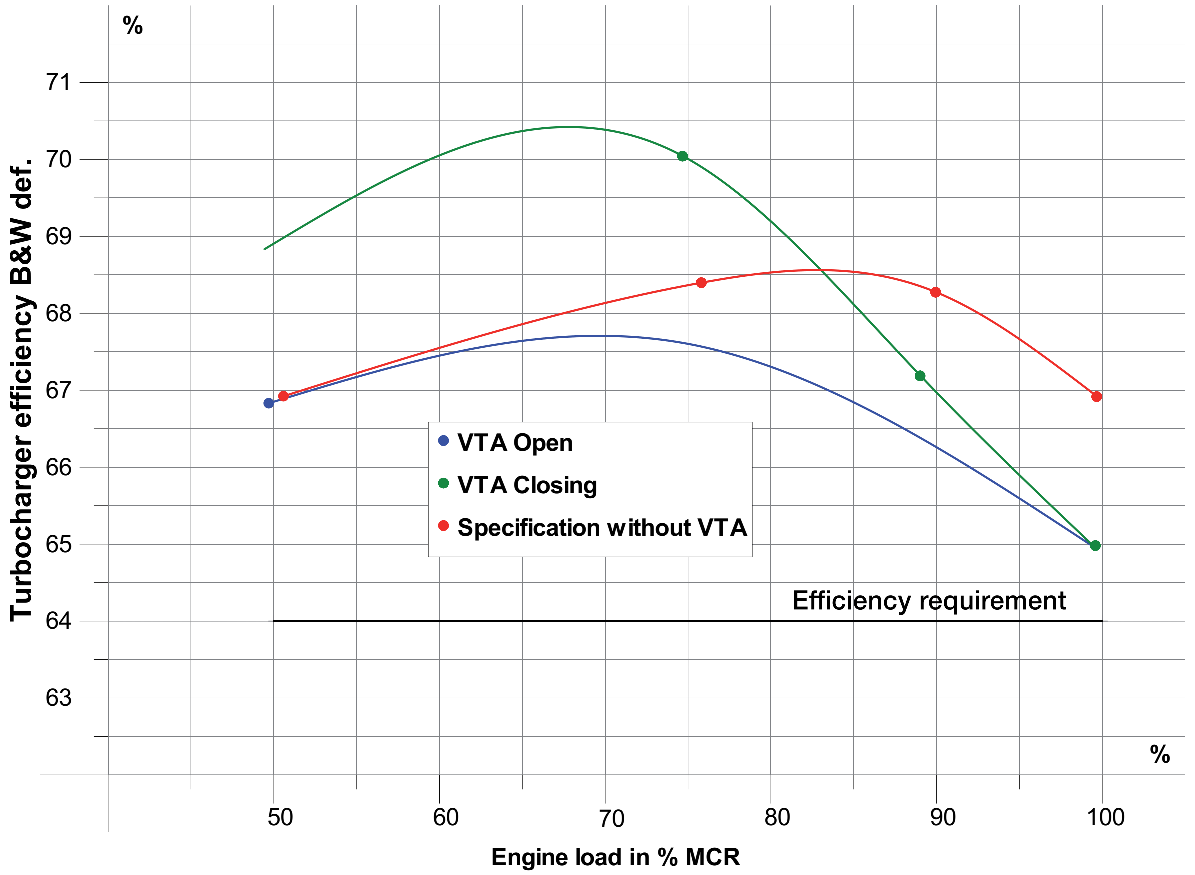
Figure 1: Increase of the scavenge-air pressure with TCA55-21V on 6S46MC-C

MAN two-stroke diesel engine 6S46MC-C with TCA55-21V turbocharger

The Fig. Increase of the scavenge-air pressure with TCA55-21V on 6S46MC-C shows the operation method of the VTA on the 6S46MC-C engine.

The green curve indicates the scavenge-air pressure that builds up when the VTA is closed towards part load („VTA closing"). In comparison to this, the scavenge-air pressures for the VTA test specification TCA55-21004V, with still open nozzle ring for part load („VTA open" – dark-blue curve), as well as the starting specification TCA55-20027 with rigid nozzle ring (light-blue dots) are shown.

As no device for variation of the injection timing is being offered for this engine, an increase of the ignition pressure at part load can only be achieved via the scavenge-air pressure. In case a specification with a smaller, rigid nozzle ring would be selected, a reduction of the maximal available output would be required in order not to exceed the maximal value for the ignition pressure within the load range of approx. 80-100% MCR. This can be prevented by opening the VTA from 75% MCR on.



MCR Maximum Continuous Rating

Figure 2: Turbocharger efficiencies with TCA55-21V on 6S46MC-C engine

The Fig. Turbocharger efficiencies with TCA55-21V on 6S46MC-C engine shows the efficiency characteristic of the VTA layout with the previous, full-load optimized specification. A clear increase of the efficiencies below 85% MCR can be seen for the closing nozzle ring.

In this case, the margin to the layout efficiency requirement has been used to extensively optimize the part load performance. Therefore the difference between the specification with and without VTA is extremely positive at part load as well as negative at full load – but still fulfilling all requirements.

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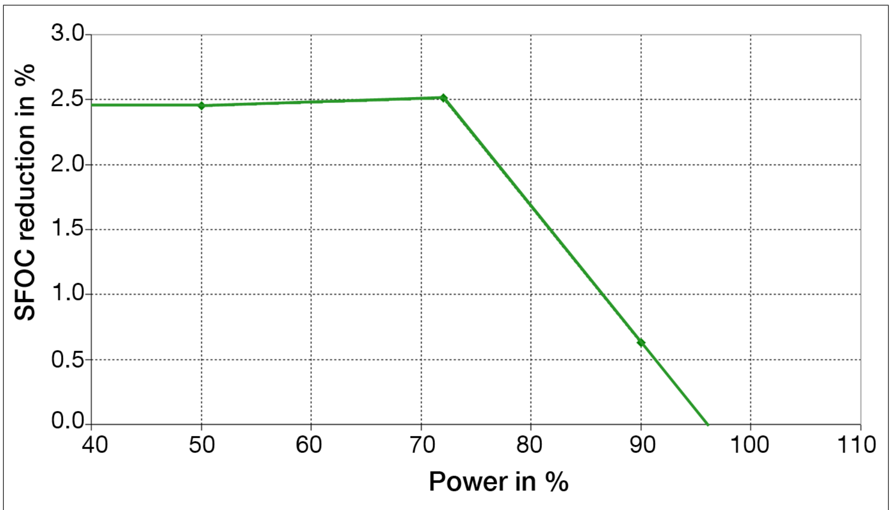
Variable Turbine Area (VTA)

VTA Project Guide TCA

Fuel Consumption Savings



SFOC Specific Fuel Oil Consumption

Figure 3: Reduction of fuel consumption with TCA55-21V on 6S46MC-C engine

The Fig. Reduction of fuel consumption with TCA55-21V on 6S46MC-C engine shows the fuel consumption savings measured during the maiden voyage while closing the VTA toward part load. In accordance with previous trends, the scavenge-pressure increase results in a reduction of fuel consumption of approx. 1 g/kWh per 100 mbar; in the example shown, the savings result to 4 g/kWh at 75% MCR.

Fuel Consumption Savings for MAN Two-stroke Diesel Engines

The following table shows the fuel consumption savings to be expected for MC, MC-C, ME-C and ME-B engines with VTA technology, which can be represented with different approaches. In this, the turbocharger layout can be varied depending on whether greater fuel consumption savings in the low load range („Low load optimized“), or also in the mid-range („Standard layout“) are desired. Interim solutions (e.g. 1 g/kWh at 75%, 3 g/kWh each at 25 and 50%) are also possible.

	Engine Load	**75%**	**50%**	**25%**
SFOC savings g/kWh	Standard lay-out	2	2	2
SFOC savings g/kWh	Low load optimized	0	4	4

Table 2: Fuel consumption savings to be expected for MC, MC-C, ME-B engines with VTA technology

VTA on a Four-stroke Gas Engine

Gas operation of the dual-fuel engine 7L51/60DF engine with TCA55-41V turbocharger

For stable and knock-free combustion, gas engines require a limited gas/air ratio, which is achieved through regulation of the charge pressure. When the load falls below 50%, a significant reduction of the charge pressure is

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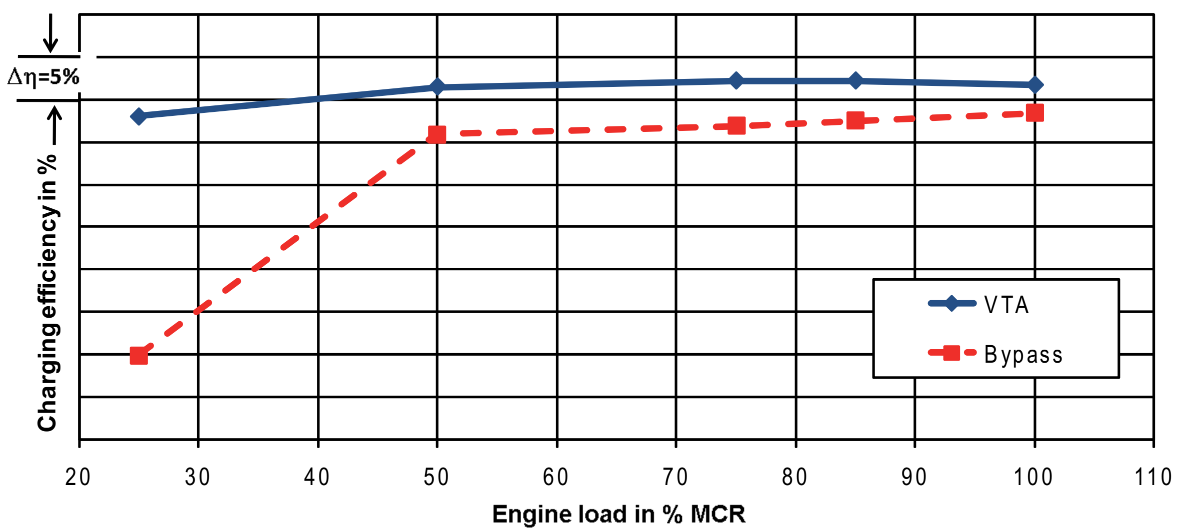
required. Furthermore, a control reserve must be provided for in the 50-100% MCR load range for load applications and high intake temperatures. For rigid geometry, this can be realized by blowing-off during operation under normal conditions or part load with significant losses of the charging efficiency, or efficiently by opening the VTA position. Add to this that with open VTA position at part load, a more efficient layout can be achieved in comparison with a rigid turbine nozzle ring.

Increase of the Charging Efficiency

The resulting increase of the charging efficiency with VTA when compared with the bypass concept is shown in the Fig. Improvement of the charge efficiency with a TCA55-41V on an 7L51/60DF engine.



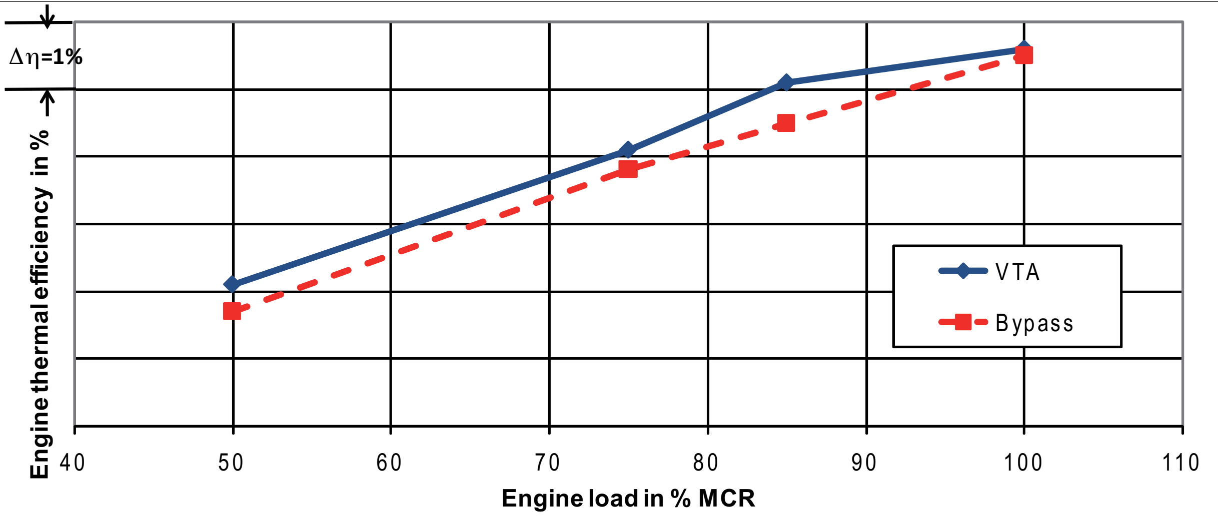
MCR Maximum Continuous Rating

Figure 4: Improvement of the charging efficiency with a TCA55-41V on an 7L51/60DF engine

Thermal Efficiency

For a gas engine primarily operated in the 50 – 100% load range, the result is an improvement potential of approx. 0.5% percentage points of the engine's thermal efficiency.

See Fig. Improvement of the thermal efficiency with a TCA55-41V on an 7L51/60DF engine.



MCR Maximum Continuous Rating

Figure 5: Improvement of the thermal efficiency with a TCA55-41V on an 7L51/60DF engine

Overview of Series

VTA on the TCA Turbocharger

Activate 3D

Fly-around

Actuator

VTA

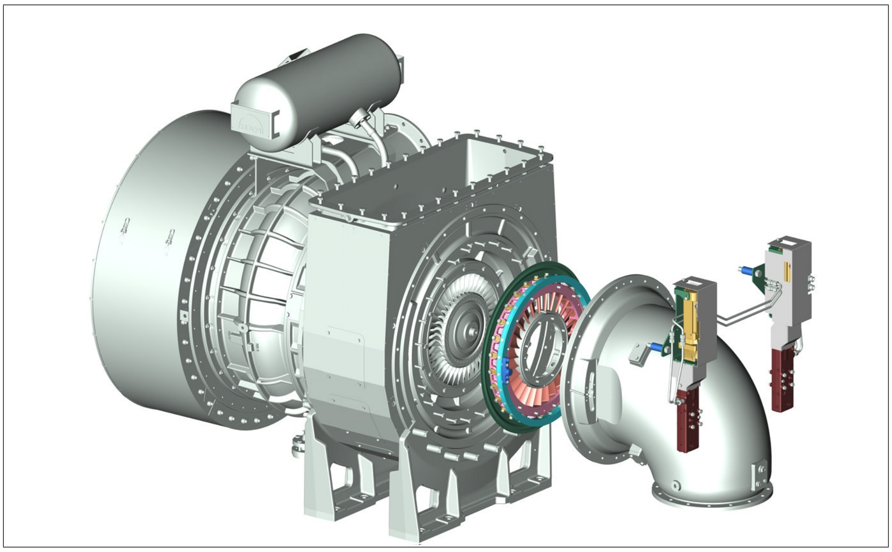


Figure 1: TCA turbocharger with variable turbine area

Dimensions

Overall Dimensions

The use of a variable turbine area does not change the dimensions of the turbocharger.

Overall dimensions of TCA turbochargers:
see Project Guide „TCA Turbochargers“.

Control Cabinet

For the variable turbine area, an additional control cabinet or switch box is necessary for accomodation of the VTA control system, depending on the engine system.

Description of the required components for the VTA control system:
See chapter [4] – Systems/ .

Dimensions and set-up of the required control cabinets:
See chapter [5] – Engine-room Planning.

Weights

Assembly		**Turbocharger**			
Number	**Designation**	**TCA55**	**TCA66**	**TCA77**	**TCA88**
510	Variable turbine area	78 kg	131 kg	220 kg	361 kg
511	Adjusting device	40 kg	40 kg	56 kg	56 kg
549	Inflation air pipe	2 kg	2 kg	3 kg	3 kg
–	m+[1)]	100 kg	110 kg	140 kg	190 kg
1) m+ = Weight increase of a TCA turbocharger with VTA compared to a TCA turbocharger of the same series without VTA					

Table 1: Weights of individual VTA components

Tip! The VTA can generally be implemented in all TCA turbocharger types and sizes.

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For weight information on VTA components of non-listed TCA turbochargers, please contact our technical sales department.
E-mail: turbochargers@mandiesel.com

Casing Positions

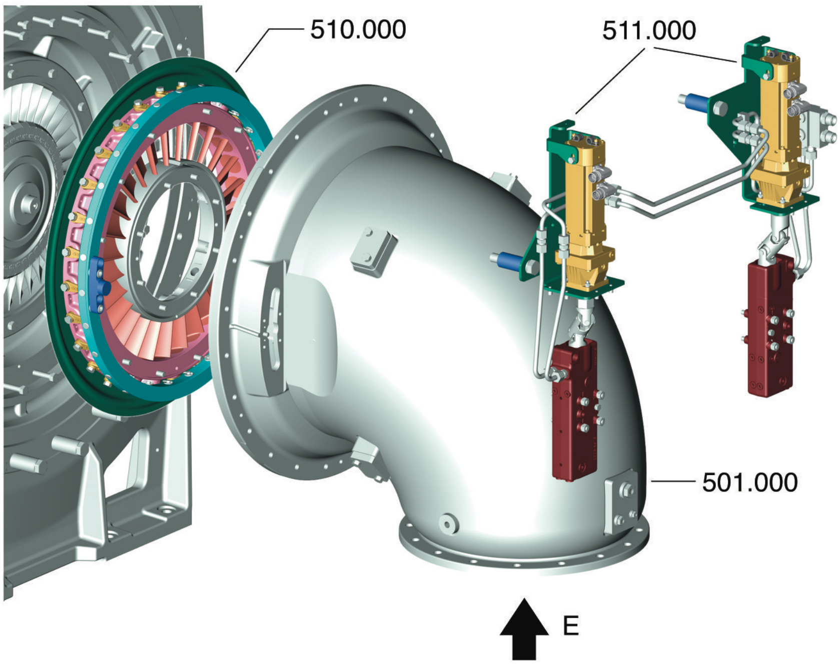
By using the variable turbine area, there are no restrictions in terms of the turnability of individual turbocharger casings of TCA turbochargers.

Tip! Possible casing positions for TCA turbochargers: see Project Guide „TCA Turbochargers“.

Mounting Position of the Adjusting Device

The adjusting device for the turbine nozzle ring is firmly mounted to the gas-admission casing and cannot be turned separately.

The servomotors of the adjusting device generally face towards the exhaust gas pipe – see Fig. 90° gas-admission casing with VTA adjusting device.



501.000 Gas-admission casing E Exhaust-gas inlet
510.000 Variable turbine area
511.000 Adjusting device

Figure 2: 90° gas-admission casing with VTA adjusting device

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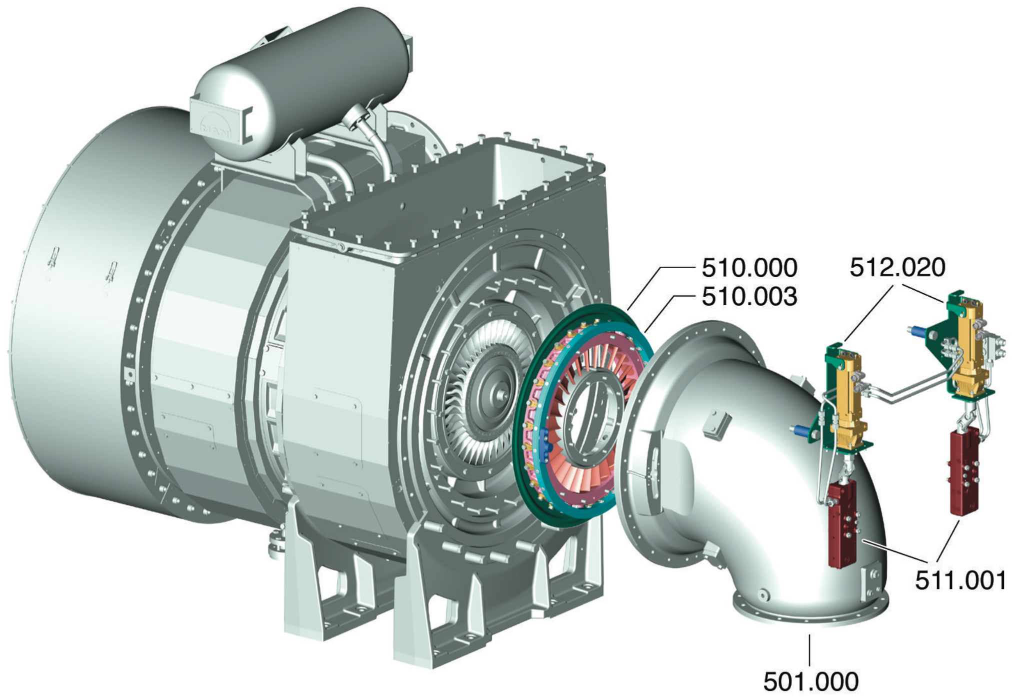
Design

Characteristics of the Assemblies



501.000 Gas-admission casing
510.000 Variable turbine area
510.003 Setting ring
511.001 Spindle drive
512.020 Servomotor

Figure 1: TCA turbocharger with variable turbine area (VTA)

Assembly 510

Variable Turbine Area

To benefit from the advantages of the low vibrations and the excellent flow characteristic, the cast turbine guide vanes of the variable turbine area (510.000) have the same profile as the rigid nozzle ring.

Assembly 511

Adjusting Device

The main components of the adjusting device are the two spindle drives (511.001), which convert the rotating motion of the servomotors (512.020) into a linear motion for adjustment of the VTA.

Operation Method of the Adjusting Device

Servomotors (512.020)

The variable turbine area is driven via two servomotors, which are mounted to the adjusting device. The speed of the motor is reduced and the torque is increased via a planetary gearing. A universal joint transmits the torque from the servomotor to the spindle drive. One spindle drive is provided for each servomotor.

Spindle Drive (511.001)

Each spindle drive has a shaft that is axially supported in needle bearings. The shaft rotation occurs via torque initiation. The rotating motion of the spindle shaft is converted into a translatory motion via a groove nut.

Setting Ring (510,003)

The motion of the nuts of both servo-drives is transmitted onto the driving features fastened on the setting ring, which then transfer the setting ring into a rotating motion.

Adjustable Turbine Guide Vanes

Setting levers -one for each turbine guide vane-, which are supported in the setting ring, are uniformly distributed around the circumference. The setting levers are positively locked with the turbine guide vanes, which are supported in the outer guide ring. The torque transmitted from the setting ring onto the levers initiates the rotating motion of the turbine guide vanes.

NOTE! For displacement of the turbine nozzle ring, it is required to operate the two parallel driven servomotors in opposite rotational direction.

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Systems

VTA Control (VCS)

Various control-system variants are available in order to cover all application ranges.

For a detailed list of the components required for this:
See chapter [9] – Delivery Scope/ Delivery Scope VTA and Equipment.

Definitions

VTA	Variable Turbine Area
VCS	VTA Control System
MPC	Multi Purpose Controller
MOP	Main Operating Panel
SACS	Scavenging Air Control Software
ECS	Engine Control System

VTA on the MC/ MC-C Two-stroke Engine

For this application, the following parameters (among others) are necessary for displacement of the VTA:

- Filling of fuel index transmitter or regulator
- Scavenge-air pressure

These parameters are processed in the multiprocessor (MPC) of the VTA control system (VCS). The MPC provides the VTA control system with signals with which the VTA is moved.

The following parameters issued:

- Slow Down
- Warnings for the safety system

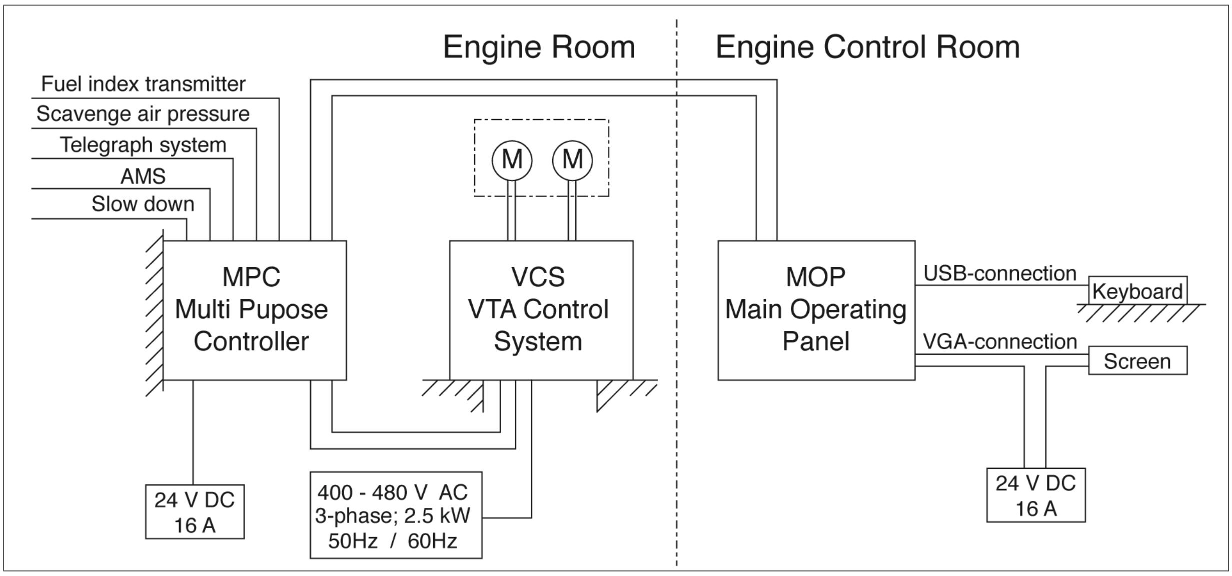

Figure 1: Wiring diagram – VTA control system (VCS) for MC/ MC-C two-stroke engine

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VTA on the ME/ ME-C/ ME-B Two-stroke Engine

In this variant, the MPC responsible for the VTA control system (VCS) is electronically integrated in the engine control system (ECS) and controlled by it.

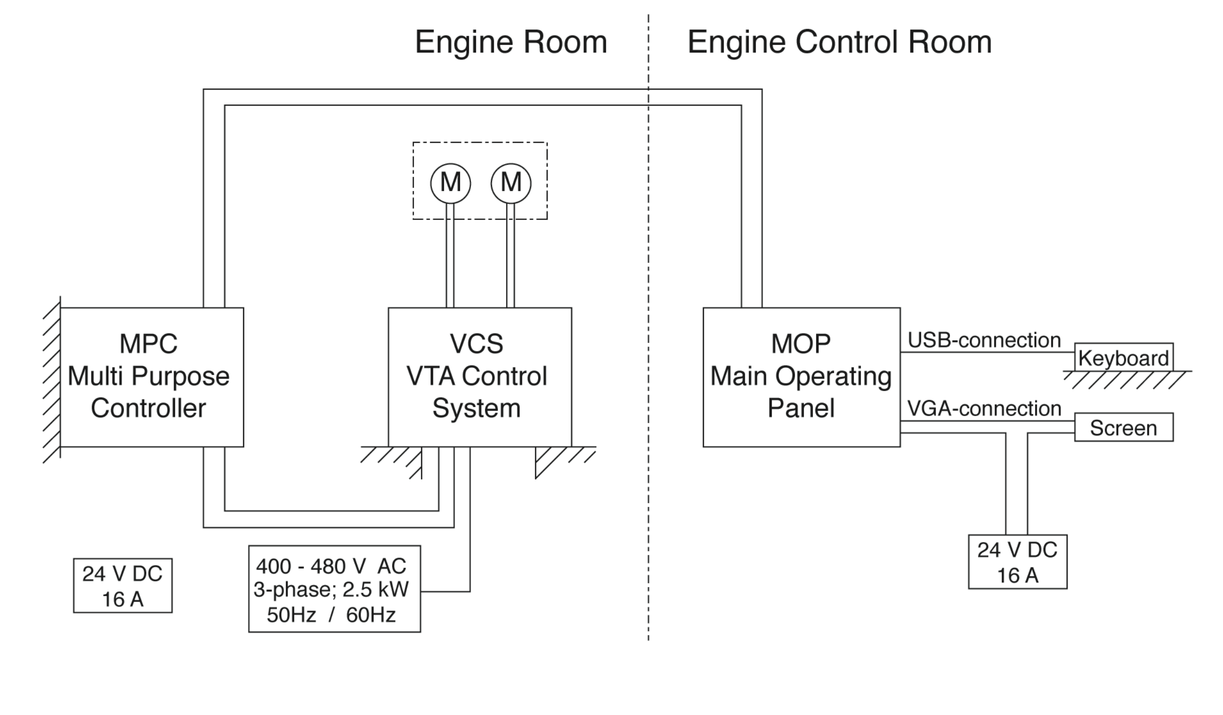

Figure 2: Wiring diagram – VTA control system (VCS) for ME/ ME-C/ ME-B two-stroke engine

VTA on the MAN Diesel Four-stroke Engine

For this variant, the VTA control system is completely integrated into the engine control system. Engine and turbocharger are supplied as a ready-for-use unit.

Stand-alone

The stand-alone version can operate independent from other control systems. Here, only different system parameters are scanned, according to which the VTA is adjusted via default parameter sets.

In this, the following parameters can, for example, be used:

- Analog signal for position
- Turbocharger speed
- Fuel index
- Charging air pressure

NOTE! The VTA control system for the „Stand-alone" variant must be adapted from case to case to the system subject to charging. The parameter sets for the moving logic are know-how of the engine manufacturer, and are read in to the control system via USB interface or CD.

See schematic sketch Wiring diagram – VTA control (VCS) for stand-alone variant.

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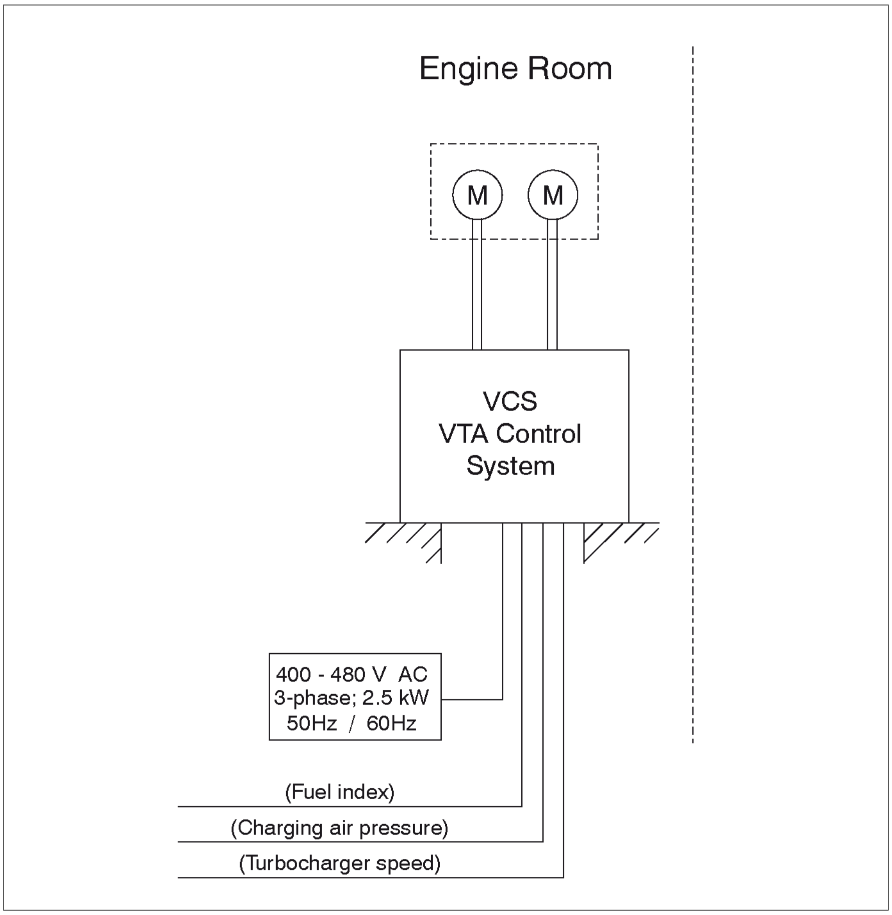

Figure 3: Schematic sketch – VTA control (VCS) for Stand-alone variant

Cooling Water System

The cooling water system is used for cooling of the adjusting device's spindle drives.

Method of Operation

The non-insulated areas of the gas-admission casing for mounting of the spindle drives are completely covered off by the spindle drives. As a result, the complete thermal radiation of the gas-admission casing is taken up by the spindle drives.

The cooling water is conducted via different ducts through the complete spindle drives, where it absorbs dissipates the heat.

Water Quality

The cooling water must generally be taken from the high-temperature range of the engine cooling water circuit (HT).

Connections, Pipes

Threaded sockets are provided for connection of the cooling water on the turbocharger side. These are intended as interface to the delivery scope of the engine manufacturer.

The threaded sockets for the cooling water system are firmly connected to the adjusting device and the gas-admission casing. The adjusting device with the therein integrated cooling water system does not limit the turnability of the gas-admission casing.
See chapter [2] – Overview of Series / Casing Positions.

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Turbocharger	Outside Diameter (D) for Connection Pipe in mm	Thread Size (T) of the Threaded Socket
TCA55	16	M22 x 1.5
TCA66	16	M22 x 1.5
TCA77	20	M27 x 2
TCA88	20	M27 x 2

Table 1: Pipe connection for cooling water pipe

IMPORTANT! The pipes from the cooling water source to the described turbocharger interface are to be provided by the engine manufacturer.

Pressures, Flow Rates and Temperatures

The temperatures and pressures in the following table apply for the connection to the adjusting device:

Turbocharger	Minimum Pressure at the Intake in	Minimum Pressure Difference between Intake and Outlet in	Required Cooling Water Flow Rate in	Minimum Temperature at the Intake in	Maximum Temperature at the Intake in
	bar	bar	l/h	°C	°C
TCA55	1.3	0.3	430	40	120
TCA66	1.3	0.3	430	40	120
TCA77	1.3	0.3	430	40	120
TCA88	1.3	0.3	430	40	120

Table 2: Technical data of the cooling water

Monitoring

The cooling water temperature at the adjusting device is not explicitly monitored!

Inflation Air

Operation Method of the Inflation Air System IAS (Inflation Air System)

The inflation air system is used for sealing off the VTA.
The inflation air prevents exhaust gas from entering below the inner guide ring.

By pressurizing the inner guide ring with inflation air, the radial gap between the inner guide ring and the guide vane is minimized even under varying thermal conditions, and maximum efficiency is achieved.

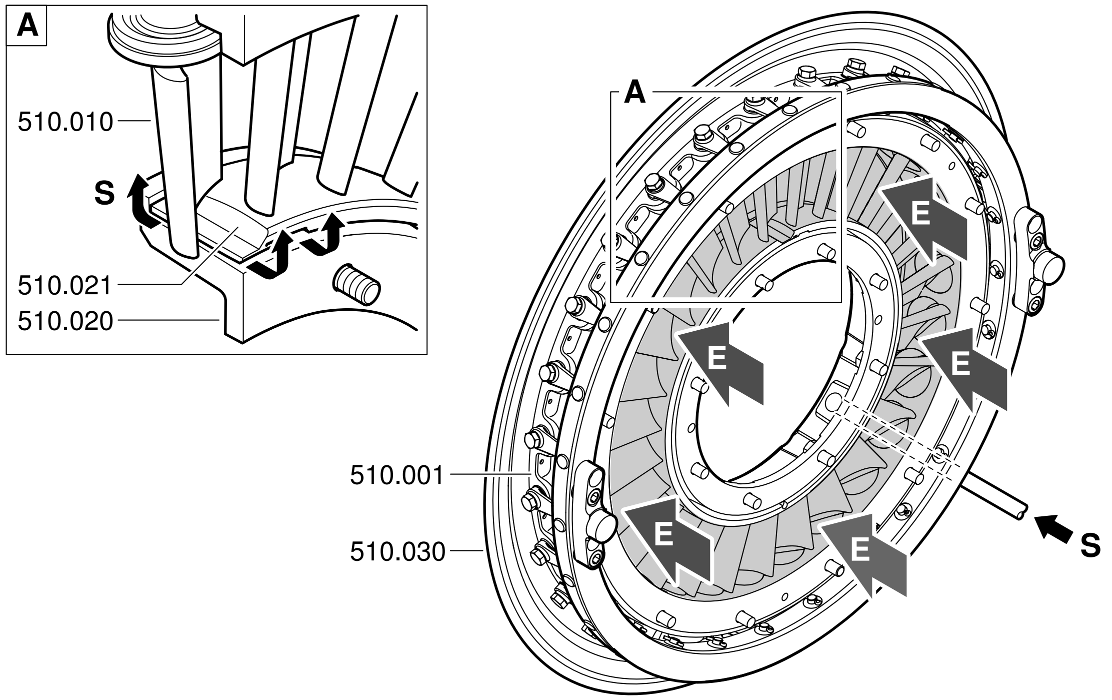
See Fig. VTA Inflation Air System.

Air Source

Air can be used from the charge air pipe or from an external compressor.

Pressures

The pressure at the inflation air pipe must be greater than the exhaust gas pressure ahead of the turbine.



510.001 Guide ring, outer 510.021 Guide ring, inner E Exhaust gas
510.010 Turbine guide vane 510.030 Sealing cover S Inflation air
510.020 Retaining ring

Figure 4: VTA inflation air system

Inflation Air Pipe Connection

A pipe for connecting the inflation air on the turbocharger side is provided. This is intended as interface to the delivery scope of the engine manufacturer.

The pipe is firmly connected with the gas-admission casing. The inflation air, however, does not limit the turnability of the gas-admission casing.

see Fig. VTA inflation air pipe on the TCA turbocharger

Turbocharger	Outside Diameter for Connection Pipe	Wall Thickness of Pipe	Resulting Flow Cross-section
	mm	mm	mm²
TCA55	16	2	113
TCA66	16	2	113
TCA77	20	2	201
TCA88	20	2	201

Table 3: Pipe connection for the inflation air system

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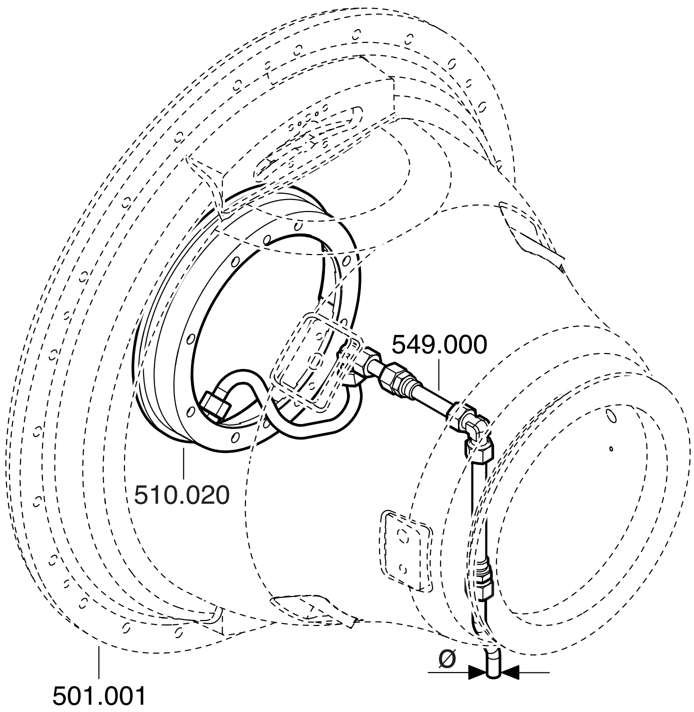

501.001 Gas-admission casing
510.020 Holding ring
549.000 Inflation air pipe, compl.

Figure 5: VTA inflation air pipe on the TCA Turbocharger

Engine-room Planning

Equipment

Certain specifications apply for the set-up of the components for operation of a variable turbine area.
See chapter[9] – Delivery Scope/ Delivery Scope VTA and Equipment.

VTA Control System (VCS)

Control Cabinet

The control cabinet for the VTA control system is designed for installation in engine rooms. The control cabinet is to be mounted on the floor.

The control cabinet must be installed at a location suitable for inspections.

In case of control cabinet installation to a wall, the wall to switch cabinet clearance must be at least 100 mm in order to enable air convection. Additionally, the control cabinet should be provided with fresh air via the engine-room ventilation.

The ambient temperature for operation must be at least 0 °C and must not exceed +55 °C. The relative humidity must not exceed 96 %. The control cabinet must not be subjected to a max. vibration of 0.7 g.

IMPORTANT! The control cabinet must not be set up on the engine gallery when the gallery is connected directly to the engine.

Figure 1: Control Cabinet – VTA control system (VCS)

Dimensions in mm			
Control Cabinet	**Width**	**Height**	**Depth**
VTA Control System (VCS)	800	1300	500

Table 1: Main dimensions, control cabinet – VTA control system (VCS)

Multi Purpose Controller (MPC)

The switch box for the engine control is designed for installation in the engine room. The switch box shall be installed to a wall, preferably in the vicinity to other switch boxes for the engine control.

Figure 2: Switch box for wall installation – MPC

Tip! The switch box must be accessible for inspections.

Dimensions in mm		
Switch box	**Width**	**Height**
Multi Purpose Controller (MPC)	400	500

Table 2: Main dimensions of the switch box – Multi Purpose Controller (MPC)

Main Operating Panel (MOP)

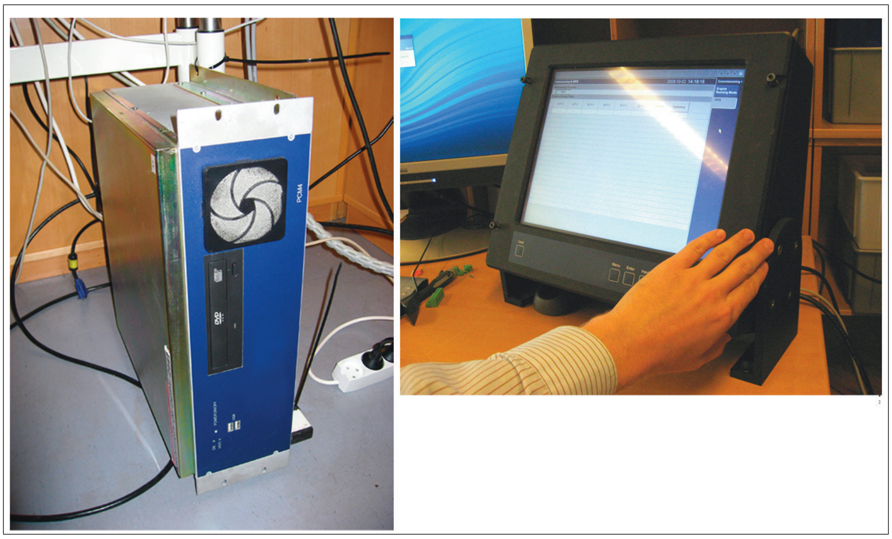

Figure 3: Main Operating Panel (MOP) – Desktop computer

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The main operating panel (MPO) consists of a 15“ monitor, a computer and a keyboard. Computer, keyboard and monitor are designed for installation in engine control room.

Personal Computer (PC)

Clearance to other peripheral equipment

To ensure sufficient air convection, the PC must be installed with a **clearance of 50 mm** from the face sides and the lid to the next component.

Clearance to the wall

Throughout the complete area behind the PC, a **150 mm clearance** to the next component is required to accommodate the plug connectors and cables.

To enable proper extending of the CD-ROM/DVD drive, a minimum clearance of 200 mm are required in front of the PC.

Monitor

With the supplied console, the monitor can either be mounted on a table or to a wall.

Keyboard

The keyboard is not affixed and can be placed on a table. The cable length is 1.6 m.

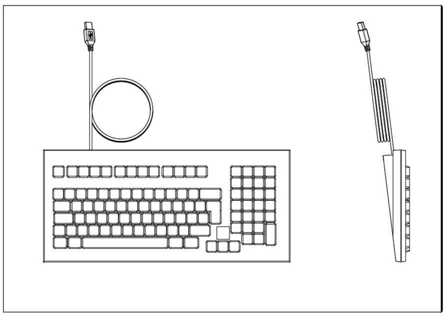

Figure 4: Keyboard for PC

Cabling

Electromagnetic Compatibility

All connection cables of the individual components necessary for VTA operation must be installed according to the rules for electromagnetic compatibility. Control and power cables must be installed in separate cable ducts.

Connection Cables

The cable length between the servomotor (turbocharger) and the frequency converter (VTA control cabinet) must not exceed **50 m (max.)**. The cable may not be extended.

The bending radii of the cables may not fall below the cable diameter of **6 mm**.

Shielding

All sensors must be cabled using shielded cables. The shielding must be connected with a terminal element. The section where the shielding is removed from the cable is to be kept as short as possible.

Grounding of the Control Cabinet

The control cabinet must be connected to ground via the vessel or via the customer's equipotential bonding conductor.

Connection Terminals

The control cabinet is equipped with spring connection terminals. The complete cabling to external systems should be carried out without the use of wire end ferrules.

Operation

Putting into Operation

The variable turbine area is supplied according to its specification. Minimal and maximal surfaces (nozzle-ring cross-sections) are factory-specified by means of mechanical stops/limits.

VTA on a Two-stroke Engine

The variable turbine areais supplied with the maximal possible surface set. After connecting the servomotors to the control cabinet and switching on the power supply, the system is ready-for-operation.

VTA on a Four-stroke Engine

Upon integration of the VTA control system into the engine control system, calibration of the adjusting device (reference run) is necessary. For this, a special function in the VTA control system is available, which is carried out at the factory.

NOTE! During engine operation, the turbine nozzle ring is displaced automatically through the programmed VTA control system.

VTA – Adjustment Ranges and Adjustment Speeds

Turbocharger	TCA55	TCA66	TCA77	TCA88
Speed of cross-section area change (mean value) in cm^2/sec	29.6	34.4	NOS	NOS
Duration for adjusting the maximal possible adjustment range1) in sec	11.5	14	NOS	NOS
1) The actual adjustment range depends on the respective turbocharger layout				

Table 1: VTA turbine nozzle ring – Adjustment ranges and adjustment speeds

Example:
VTA on a 6S46MC-C engine

Engine 6S46MC-C	Turbocharger TCA55
Ratio of AD_{max} / AD_{min} 2)	1.2
Duration for adjusting the specified adjustment range in sec	2.5
2) Flow Cross-section turbine nozzle ring	

Table 2: Adjustment values of a VTA turbine nozzle ring on a 6S46MC-C engine

Emergency Operation on Failure of the VTA Adjusting Device

The objective of emergency operation is to bring the turbocharger into a safe operating condition by means of VTA, to ensure engine operation in case of an electronic or mechanical defect.

Mechanical Defect

The main criterion for automatic shut-off of the VTA is the torque at the two servomotors. Owing to the continuous torque monitoring, a developing mechanical defect can be recognized at an early stage, and can be prevented by switching off the VTA ahead of time.

In this case, the VTA will automatically be set to a safe condition. Also, an error signal is supplied to the engine control system.

Tip! For information on achievable engine power in emergency operation, please contact the engine manufacturer.

Defects on the Electronics

In case of failure of the electronic control system of the VTA, the variable turbine area can be manually set to a condition safe for operation.

Measures

- In case the voltage supply of the VTA control system is still available, the electrical brakes built into the servomotors are still activated. These need to be deactivated by flipping a switch in the control cabinet of the VTA control system.
- Should the VTA control system no longer be provided with voltage, the brakes cannot be deactivated. In this case, the servomotors have to be dismounted.
- The turbine nozzle ring can then be manually moved. This is done by turning the universal joints, which transmit the torque of the servomotors onto the spindle drives, until the spindle drives have moved to the mechanical stops. In this position, the turbine nozzle ring is open and in a safe operating condition.

NOTE! The operating range that can be run depends on the application and specification, and must be clarified with the engine manufacturer.

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Maintenance and Checking

Introductory Remarks

The control system of the VTA is designed in such a manner that maintenance and checking work are necessary only upon request of the system.

Tip! The maintenance intervals for the VTA correspond with those of a turbocharger with rigid nozzle ring.

Cleaning the Variable Turbine Area

Cleaning the variable turbine area with the cleaning devices (option) mounted to the turbocharger does not differ from cleaning a turbocharger with rigid nozzle ring.

See Operating Manual of the turbocharger.

Movable Components

To avoid seizing of the movable VTA components, these are automatically cleaned in periodic intervals during operation of the turbocharger.

In the process, the turbine nozzle ring moves its turbine guide vanes program-controlled in a part-load range specifically defined for the engine system. After this cleaning procedure, the initial flow cross-section is reset again. In this manner, possibly existing deposits are effectively removed from the components.

IMPORTANT! The profile of the cleaning procedure to be specified depends on the engine application and the fuel being used for the system, and requires matching between the engine manufacturer and MAN Diesel.

Maintenance of the Adjusting Device

Spindle Drives

For each scheduled maintenance on the turbine side of the turbocharger, the spindle drives must be lubricated with special grease upon assembly.

Inspection of the Pipe Systems

Daily checking (visual) of the cooling-water and inflation air pipes for leaks.

Electronic Equipment

According to the maintenance specification for the component.

Tip! Also see the enclosed operating manual of the manufacturer.

Matching

Matching Procedure

The matching procedure of a turbocharger with VTA differs as follows from that of a turbocharger without VTA.

Tip! Also see the „TCA Turbocharger“ Project Guide.

Adjusting the Charging Air Pressure

For operation with VTA, exchanging the nozzle ring is of course not applicable; additionally, the charge pressure can be set continuously variable.

For the matching, it generally applies that a complete VTA movement and control program is to be checked instead of a rigid component.

Examples for such a movement program are:

- Diesel engine: Closing the VTA to part load
- Gas engine: Opening the VTA to part load
- Maintaining constant charging air pressure under changing environmental conditions
- Instationary movement programs for improvement of the transient behavior, e.g. reduction of the soot emission under load applications.

Also see chapter [1] – Table Overview – VTA application ranges.

Movement Program

When creating the movement program, attention is to be paid that all mandatory required VTA positions for this program are within the upper and lower limits of the flow cross-section. These limit values are defined by the mechanical limits of the moving mechanism and the permissible turbine blade loading.

Additionally, the following limits resulting from the application are to be adhered to in the program:

- It must be ensured that a too high charging air pressure does not lead to the maximal ignition pressure being exceeded, especially in the 85%-100% load range.
- The cycle limit values for NO_X emissions must be met.
- For gas engines, the admissible λ window between knocking and instability range is to be taken into account.

IMPORTANT! When matching, it is to be checked that all above mentioned operating points can be run, even under unfavorable ambient conditions (compressor intake temperature, ambient pressure, charging air temperature, fuel composition and exhaust-gas back pressure).

Should the conditions in this regard (e.g. maximal temperatures for gas engines, minimal temperatures for diesel engine) not be adjustable when matching, then a check must be carried out with ISO correction factors or via process calculation.

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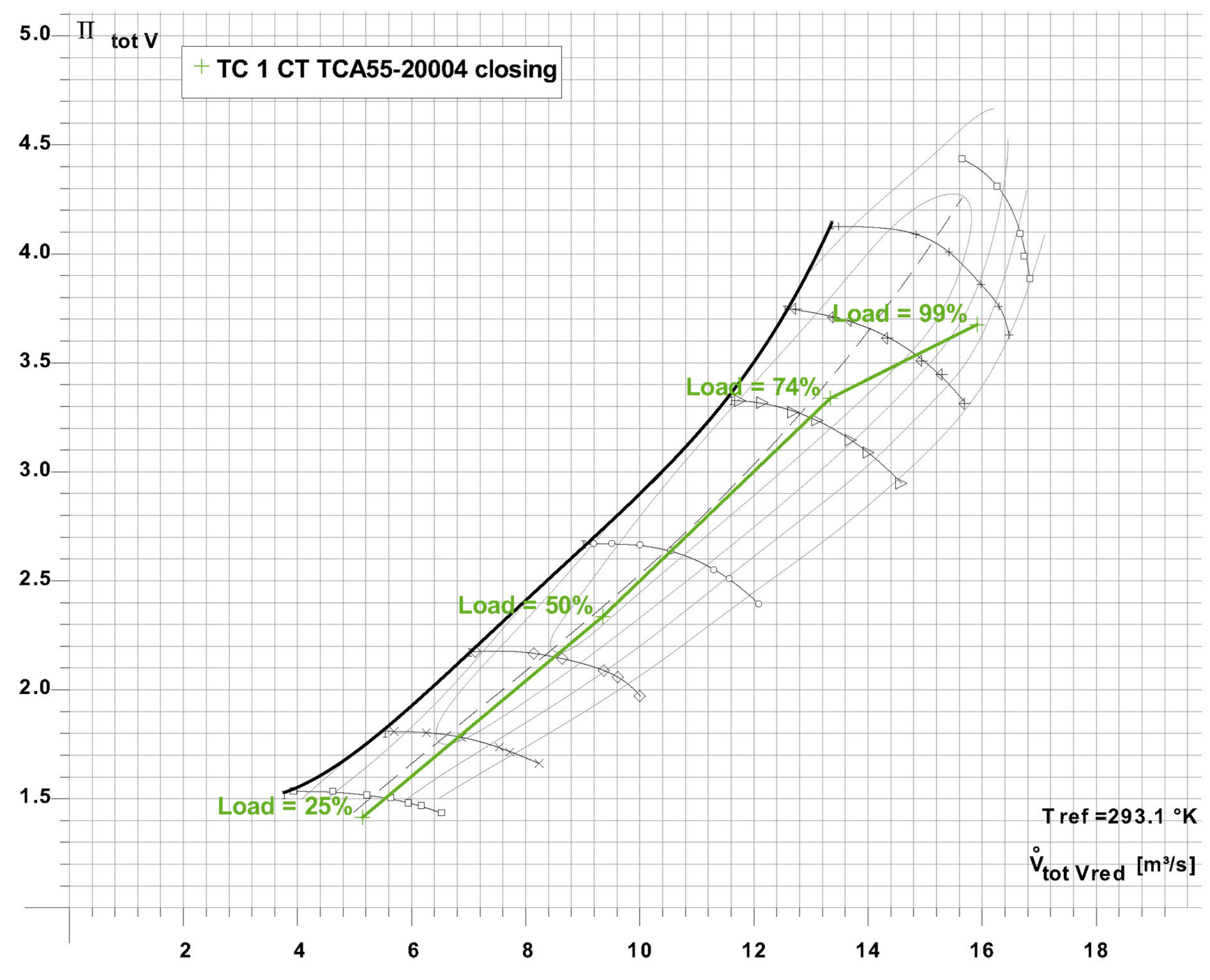
Surge Tests

For two-stroke applications in particular, the operating curve shifts toward the surge line by closing the VTA – see Fig. Operating curve, two-stroke engine with VTA closing towards part load.

Therefore, attention is to be paid that surge tests, as far as possible, are carried out in closed condition according to the later movement program.

Therefore, the following procedure is required for the load shedding test of the two-stroke engine:

1. Load reduction from 75% to 25% within 10 seconds for checking the surge stability in closed condition of the VTA, whereby the maximal ignition pressure must not be exceeded.
2. Load reduction from 100% to 50% according to standard procedure, yet with activated movement program. Here, the result strongly depends on the control algorithm and the adjustment speed of the VTA.



$\Pi_{tot\ V}$ *Compressor pressure ratio*

$\dot{V}_{tot\ Vred}$ *Volumetric flow rate*

Figure 1: Operating curve, two-stroke engine with VTA closing toward part load

Delivery Scope

Delivery Scope, VTA and Equipment

Depending on the application, the equipment requirements as well as the delivery scope for the variable turbine area can vary. The following tables list the components included in the MAN Diesel delivery scope and the components to be provide by the customer.

Definitions to tables 1 to 3

VTA	Variable Turbine Area
VCS	VTA Control System
MPC	Multi Purpose Controller
MOP	Main Operating Panel
SACS	Scavenging Air Control Software
ECS	Engine Control System

Hardware

VTA	Two-stroke Diesel Engine		Four-stroke Diesel Engine	Stand-alone
Delivery Scope Hardware	**MC MC-C**	**ME ME-C ME-B**		
Variable turbine area	●	●	●	●
Adjusting device	●	●	●	●
Inflation air system	●	●	●	●
Supply line to the inflation air system	EB	EB	EB	EB
Cooling water system	●	●	●	●
Supply and removal pipe to cooling water system	EB	EB	EB	EB
Servomotors	●	●	●	●
VCS	●	●	●	●
MPC	●	EB	●	●
PC (MOP)	●	(●)	●	●
Monitor with holding fixture (MOP)	●	(●)	●	●
Keyboard (MOP)	●	(●)	●	●
Fuel-admission indication sensor	●	EB	EB	EB
Sensor for scavenge-air pressure/ charging air pressure	●	EB	EB	EB
● (●) EB	Delivery scope of MAN Diesel Component of ECS and already given Delivery scope of the engine manufacturer			

Table 1: Delivery scope, hardware

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Software

VTA	Two-stroke Engine		Four-stroke Engine	Stand-alone
Delivery Scope Software	**MC MC-C**	**ME ME-C ME-B**		
Software for checking the scavenge-air pressure (SACS) for MPC and MOP	Part of the engine / plant specification		-	-
VTA control software for frequency converter in VCS	●	●	●	●
●	Delivery scope of MAN Diesel			

Table 2: Delivery Scope Software

Cable Sets

VTA	Two-stroke Diesel Engine		Four-stroke Diesel Engine	Stand-alone
Delivery Scope Hardware	**MC MC-C**	**ME ME-C ME-B**		
Connection cable: Servomotors - VCS	●	●	●	●
Connection cable: MPC – VCS	YA	YA	-	-
Connection cable: MOP – keyboard (USB)	●	(●)	-	-
Connection cable: MOP – screen (VGA)	●	(●)	-	-
Connection cable: Sensor for scavenge-air pressure/ charging air pressure - MPC	EB	-	-	YA
Connection cable: Remote fuel sensor – MPC	EB	-	-	YA
Connection cable: MPC – MOP	YA	YA	-	-
Power cable VCS	YA	YA	YA	YA
Power cable MPC	YA	●	-	-
Power cable PC (MOP)	YA	(●)	-	-
Power cable Screen (MOP)	YA	(●)	-	-
● (●) EB YA	Delivery scope of MAN Diesel Component of ECS and already given Delivery scope of the engine manufacturer Shipyard			

Table 3: Delivery Scope Cable Sets

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Retrofit – Worldwide Turbocharger Service

Retrofitting a Variable Turbine Area

Retrofit

The VTA can be integrated in all TCA turbochargers.

Please contact our technical service:
MAN Diesel I PrimeServ Turbocharger

MAN Diesel I PrimeServ

Turbocharger Service			
Address		**Telephone/Fax/E-mail/Web**	
Retrofit	**MAN Diesel SE** PrimeServ Turbocharger Service Aftersales Turbocharger Retrofit (ATR) 86224 Augsburg GERMANY	Phone Fax E-mail Web	+49 821-322-4273 +49 821-322-3998 mailto:primeserv-tc-retrofit@mandiesel.com http://www.mandiesel.com/primeserv
Spare Parts	**MAN Diesel SE** PrimeServ Turbocharger Service 86224 Augsburg GERMANY	E-mail Web	mailto:primeserv-tc-retrofit@mandiesel.com http://www.mandiesel.com/primeserv
Technical Information	**MAN Diesel SE** Turbocharger 86224 Augsburg GERMANY	Phone Fax E-mail Web	+49 821-322-1345 +49 821-322-3299 mailto:turbochargers@mandiesel.com http://www.mandiesel.com/turbocharger

Worldwide Turbocharger Service

Internet

MAN Diesel Service Addresses as well as authorized Service Partners (ASP) can be found on the Internet under:

http://www.mandiesel.com/primeserv

PrimeServ Worldwide

A pamphlet of the Worldwide Service Addresses can be obtained at:

Turbocharger Service (Secretariat)	
Phone Fax E-mail	+49 821-322-1198 +49 821-322-3998 mailto:primeserv-tc-commercial@mandiesel.com

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