

# Exhaust Gas Turbochargers

Programme 2011

Engineering the Future – since 1758.

**MAN Diesel & Turbo**





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# Turbocharger Applications

## Turbochargers type TCR, NR, TCA and NA

- Straightforward design
- Uncooled gas casings
- In-board plain bearing arrangement
- Lubrication by engine lube oil system
- High availability, reliability, durability
- High efficiency
- Easy maintenance and servicing
- Long lifetimes of components
- Long intervals between overhauls

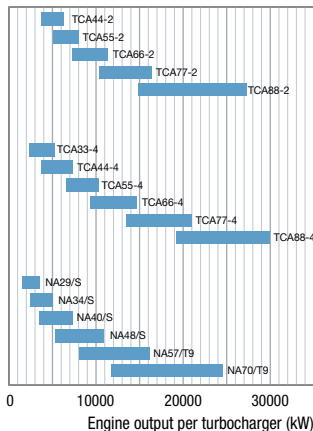
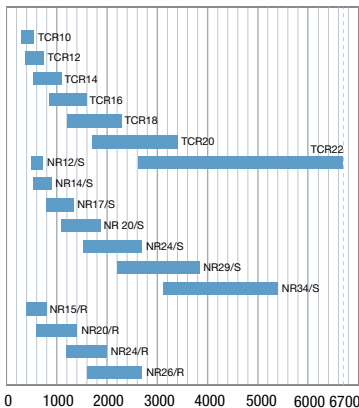
## Applications for

- Propulsion engines
- Generating engines
- Traction engines
- Suitable for HFO, MDO and gas engines

## Special equipment

- Tailormade solutions
- Power turbines
- Turbo compound systems
- Variable Turbine Area (VTA)

## MAN Diesel & Turbo TCR, NR, TCA and NA turbocharger programme



# The TCR Series



# The TCR Series

## Benefits

- Ultimate performance
- Easy maintenance
- Increased lifetime of wear parts
- Simple installation
- Extended application range
- High power density, low weight and compact design
- Containment proven

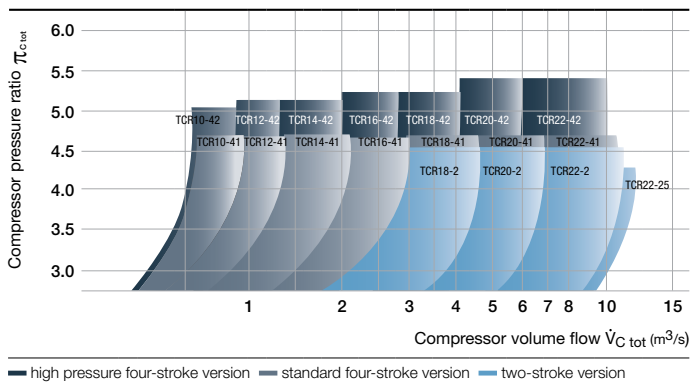
## Features

- Overall completely new design

## Turbine

- New CFD optimised profiled rotor blades, nozzle ring, inlet and outlet casing for increased efficiency
- Constant and pulse pressure turbocharging
- Optional variable nozzle ring

## MAN Turbocharger application ranges TCR



## Bearings

- High performance plain bearings for minimised mechanical losses
- Optimised shaft diameter for increased efficiency
- Compact plain bearing concept for best rotor dynamic performance

## Compressor

- New CFD optimised compressor wheel, diffuser ring and compressor volute for increased efficiency
- Extended pressure ratio and specific volume flow
- Internal flow recirculation for extended surge margin (option)
- New compressor wheel fixation for easy servicing

## Easy maintenance

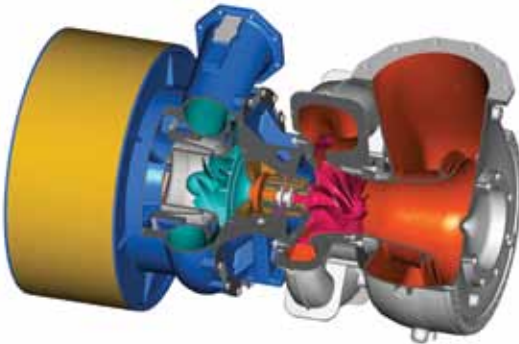
- Extended inspection intervals
- Easy access to compressor wheel
- Reduced number of parts

## Smart design for convenient installation

- Uncooled casings
- Lubrication by engine lube oil system
- Integrated oil inlet and oil drain for pipeless design
- No sealing air required

## Others

- Compliance with present and future engine standards and environmental legal restraints
- Containment proven
- Low moment of inertia for best dynamic behaviour



# The TCR Series

## Technical data

Turbine type	Radial flow turbine
Max. permissible temperature	700°C
Pressure ratio	up to 5.4
Suitable for HFO, MDO, Gas	

## Turbocharger programme

Turbocharger type	Max. supercharged engine output (kW)		Max. permissible speed (rpm)	Mass (kg)
	2-stroke le* = 8 kg/kWh	4-stroke le* = 6.5 kg/kWh		
TCR10	-	550	85,000	40
TCR12	-	800	70,900	100
TCR14	-	1,200	58,700	135
TCR16	-	1,750	48,800	205
TCR18	2,400	2,600	40,300	350
TCR20	3,500	3,800	33,400	600
TCR22	6,200	6,500	25,600	1,400

\* Specific air consumption



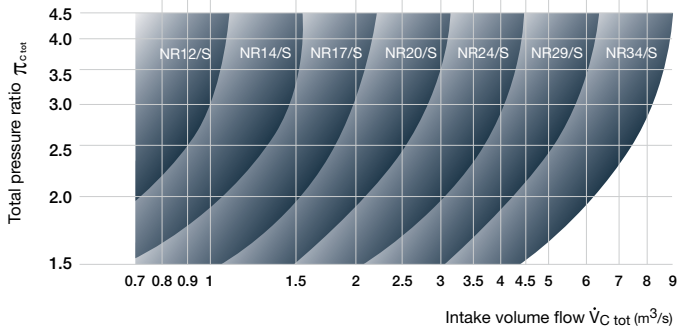
# The NR/S Series

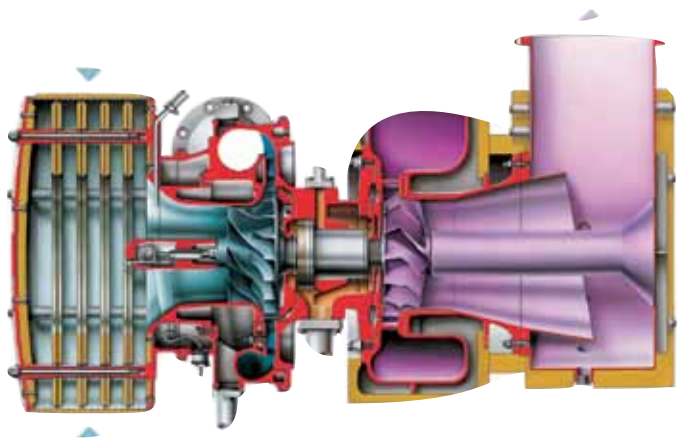
# The NR/S Series

## Features

- Compact in dimensions, simple in design, trouble free, long service life, easy to operate, HFO compatible up to IF-700
- In-board bearings lubricated by the engine's lube oil system:
  - compressor side: axial thrust bearing and radial floating bush;
  - turbine side: floating bearing bush; lifetime of bearings more than 25,000 hours
- Totally water-free design
- Optimised flow components
- Extended range of application
- Pressure ratio of up to 4.5
- High efficiency level
- Ample margin to cope with future diesel technology requirements

## MAN Turbocharger application ranges NR/S





# The NR/S Series

## Technical data

Turbine type	Radial flow turbine
Max. permissible temperature	650°C (opt. 720°C)
Pressure ratio	up to 4.5
Suitable for HFO, MDO, Gas	

## Turbocharger programme

Turbocharger type	Max. supercharged engine output (kW) le* = 7 kg/kWh	Max. permissible speed (rpm)	Mass (kg)
NR12/S	670	75,000	155
NR14/S	950	64,000	190
NR17/S	1,350	52,600	260
NR20/S	1,870	44,700	350
NR24/S	2,690	37,300	505
NR29/S	3,820	31,300	780
NR34/S	5,400	26,300	1,450

## Overall dimensions

Turbocharger type	Length (mm)	Width (mm)	Height (mm)
NR12/S	855	400	430
NR14/S	655	400	420
NR17/S	1,030	700	640
NR20/S	1,162	714	676
NR24/S	1,468	745	835
NR29/S	1,778	930	1,026
NR34/S	1,881	1,102	1,121

\* Specific air consumption

# The NR/R Series

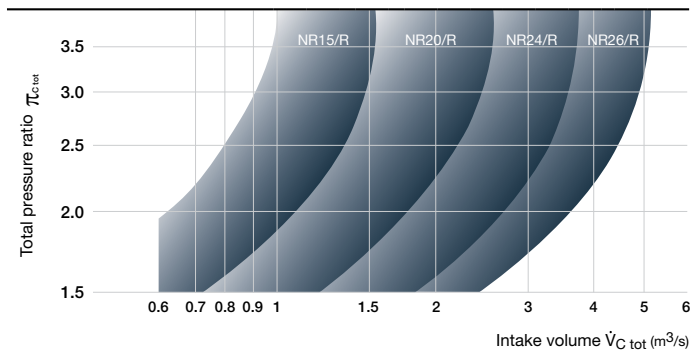


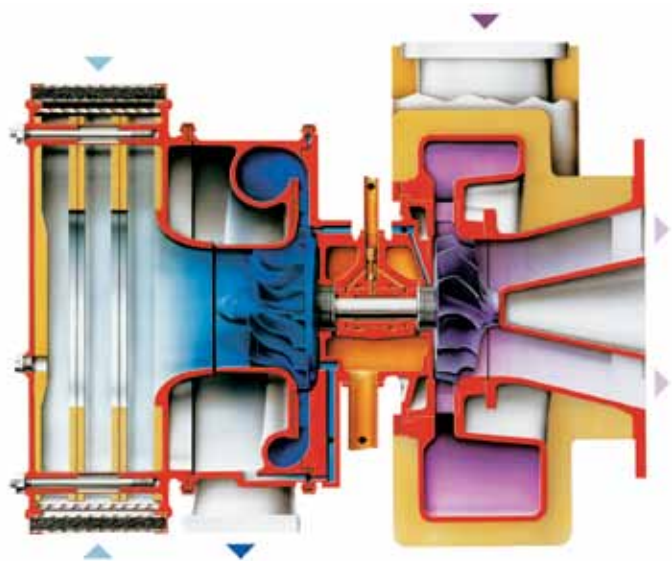
# The NR/R Series

## Features

- Compact in dimensions, simple in design, trouble free, long service life, easy to operate, HFO compatible up to IF-700
- Totally water-free design
- In-board floating bearing arrangement lubricated by the engine's lube oil system; lifetime of bearings more than 25,000 hours
- More than 30,000 units delivered worldwide for diesel engines of various applications and makes
- High efficiency over a wide operating range, resulting in low fuel consumption and lower gas temperatures; pressure ratio of up to 4.0

## MAN Turbocharger application ranges NR/R





# The NR/R Series

## Technical data

Turbine type	Radial flow turbine
Max. permissible temperature	650°C
Pressure ratio	up to 4.0
Suitable for HFO, MDO, Gas	

## Turbocharger programme

Turbocharger type	Max. supercharged engine output (kW) $l_e^* = 8 \text{ kg/kWh}$	Max. permissible speed (rpm)	Mass (kg)
NR15/R	800	57,000	200
NR20/R	1,400	44,000	400
NR24/R	2,000	36,000	550
NR26/R	2,700	31,500	800

## Overall dimensions

Turbocharger type	Length (mm)	Width (mm)	Height (mm)
NR15/R	714 – 722	500 – 520	520 – 670
NR20/R	899 – 957	660 – 690	705 – 730
NR24/R	860 – 1,110	695 – 765	735 – 740
NR26/R	1,023 – 1,308	800 – 820	780 – 850

\* Specific air consumption

# The TCA Series



# The TCA Series

## Turbine

- Newly developed, wide-chord turbine blades without damping wire for increased efficiencies
- New turbine nozzle ring
- New optimised turbine outlet diffusor
- New optimised turbine inlet casing
- Variable Turbine Area – VTA (option)

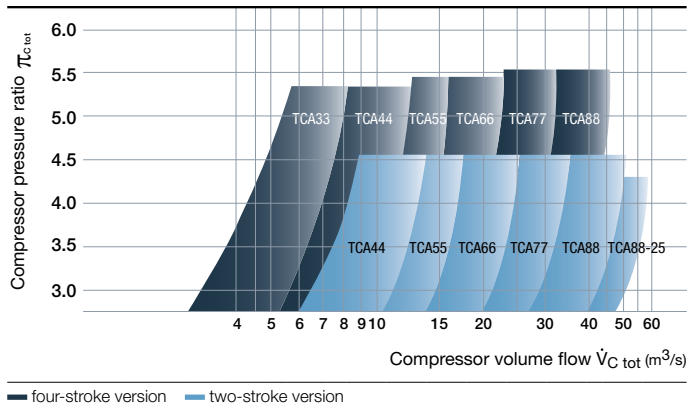
## Bearings

- Reduced shaft diameter for minimised mechanical losses
- High performance bearings for minimised mechanical losses
- Journal bearings for optimised damping behaviour

## Compressor

- Newly developed compressor wheel with reduced noise emission, increased efficiency and optimisation to the engines' operating line
- New compressor diffuser vanes
- Newly developed compressor volute
- Internal Recirculation – IRC (option)

## MAN Turbocharger application ranges TCA



### Easy maintenance

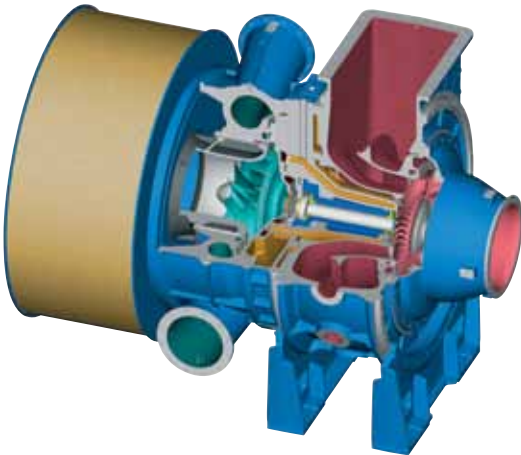
- Thrust bearing inspection without shaft removal
- Compressor wheel change with basic tooling and without dismantling of compressor casing
- Easy replacement of turbine blades

### Extended lifetime of wear parts like

- Floating journal bearings
- Floating thrust bearing disk
- Cast nozzle rings
- Turbine blades
- Compressor wheel
- Optional titanium compressor wheel

### Smart design for simple installation

- Uncooled casing
- Lubrication by engine lube oil system
- Integrated oil piping and oil venting system
- Integrated sealing air supply
- Reduced number of parts
- Integrated burst protection



# The TCA Series

## Technical data

Turbine type	Axial flow turbine
Max. permissible temperature	500°C 2-stroke / 650°C 4-stroke
Pressure ratio	up to 5.5
Suitable for HFO, MDO, Gas	

## Turbocharger programme

Turbocharger type	Max. supercharged engine output (kW)		Max. permissible speed (rpm)	Mass (kg)
	2-stroke le* = 9 kg/kWh	4-stroke le* = 6.5 kg/kWh		
TCA33	-	5,300	27,800	1,140
TCA44	6,200	7,900	22,700	1,970
TCA55	8,000	10,400	20,000	3,290
TCA66	11,600	14,800	16,900	5,510
TCA77	16,600	20,900	14,200	9,250
TCA88	27,200	29,800	12,000	15,790

\* Specific air consumption

## Overall dimensions

Turbocharger type	Length (mm)	Width (mm)	Height (mm)
TCA33	1,735	895	966
TCA44	2,084	1,075	1,160
TCA55	2,472	1,275	1,377
TCA66	2,937	1,515	1,636
TCA77	3,490	1,800	1,944
TCA88	4,144	2,138	2,309

# The NA/S/T9 Series

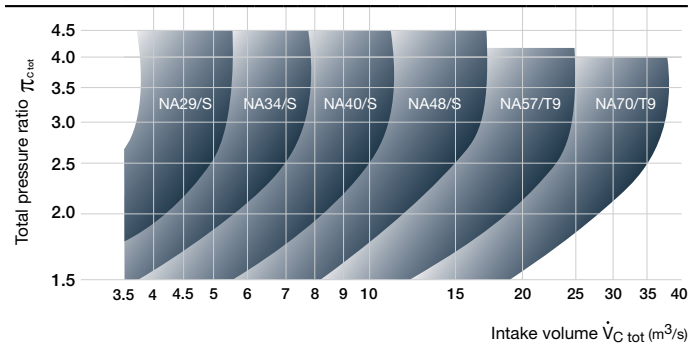


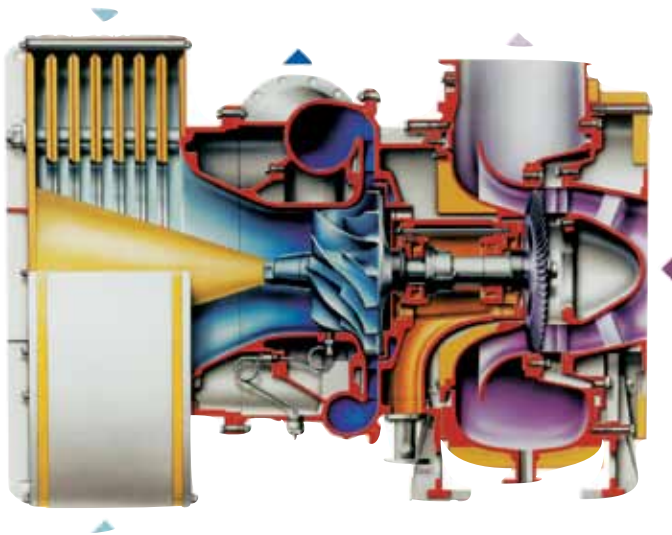
# The NA/S/T9 Series

## Features

- In-board arrangement of plain bearings, lubricated by the engines' lube oil supply system; lifetime of bearings more than 25,000 hours
- One-part compressor wheel milled out of high-strength aluminium alloy. The continuously backward bent blades lead to stable characteristics at a high efficiency level up to pressure ratios of 4.5 for NA/S (up to 4.2 for NA/T9)
- Enlarged turbine blades made of high-quality material with improved blading efficiency
- All casings of the NA/S turbochargers of "waterless" design  
The bearing casings of NA57/T9 and NA70/T9 are water-cooled
- No corrosion of turbine casings with heavy fuel oil operation
- Excellent acceleration behaviour due to a low moment of inertia of the rotor
- Profiled nozzle ring
- Simple maintenance and long service life

## MAN Turbocharger application ranges NA/S/T9





# The NA/S/T9 Series

## Technical data

Turbine type	Axial flow turbine
Max. permissible temperature	650°C
Pressure ratio	up to 4.5
Suitable for HFO, MDO, Gas	

## Turbocharger programme

Turbocharger type	Max. supercharged engine output (kW) le* = 8 kg/kWh	Max. permissible speed (rpm)	Mass (kg)
NA29/S	3,600	31,300	1,050
NA34/S	5,100	26,300	1,350
NA40/S	7,300	22,400	2,200
NA48/S	11,000	18,600	3,700
NA57/T9*	16,100	15,000	5,100
NA70/T9**	24,500	12,000	9,800

## Overall dimensions

Turbocharger type	Length (mm)	Width (mm)	Height (mm)
NA29/S	1,023 – 1,308	890	920
NA34/S	1,268 – 1,990	950	1,355 – 1,440
NA40/S	1,435 – 2,286	1,130	1,540 – 1,630
NA48/S	1,807 – 2,709	1,322	1,759 – 1,879
NA57/T9**	1,994 – 2,879	1,537	2,033 – 2,133
NA70/T9***	2,502 – 3,547	1,920	2,550

\* Specific air consumption

\*\* Pressure ratio up to 4.2

\*\*\* Pressure ratio up to 4.0

# The (TCS-) PTG Power Turbine Series

A close-up, black and white photograph of several turbine blades, likely from a gas turbine engine. The blades are arranged in a radial pattern, with their leading edges pointing towards the center. The lighting creates strong highlights and shadows, emphasizing the curved, aerodynamic shape of the blades. The background is a soft, out-of-focus grey.

# The (TCS-) PTG Power Turbine Series

## Exhaust gas turbine

- Newly developed high efficiency turbine
- New turbine nozzle ring with extended lifetime
- Bearing arrangement with long lifetime
- Axial: based on most modern TCA series
- Radial: based on most modern TCR series

## Gearbox

- High efficiency high speed gearbox reducing turbine speed to generator speed

## Couplings

- Gearbox to generator: high flexible coupling

## Generator

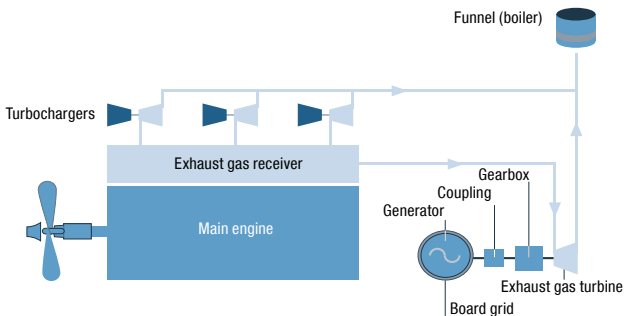
- Synchronous generator suited to marine applications
- Asynchronous generator suited to stationary applications

## Exhaust gas system

- Control valves for power turbine operating range
- Fast acting emergency valves for emergency shutdown
- Control and safety equipment

## Optional: Variable Turbine Area (VTA) for exhaust gas turbine

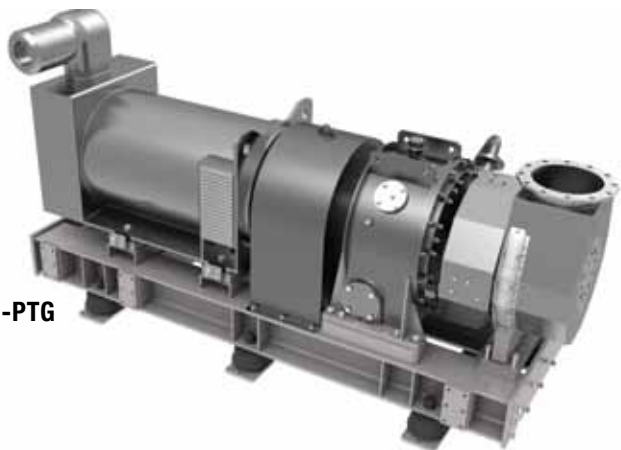
- Increasing efficiency and flexibility of operation



**PTG**



**TCS-PTG**



# The (TCS-) PTG Power Turbine Series

## Technical data

Turbine type	Radial or axial
Max. permissible temperature	550°C
Output shaft speed	1,800 rpm (1,500 rpm)
Suitable for HFO, MDO, Gas	

## Power turbine programme

### Radial flow turbine

	Max. output (kW)	Max. flow rate (kg/s)	Speed (PT 1/min)
	$\pi_r = 3.6$	Temperature before turbine 450°C	
(TCS-) PTG18	960	6.7	34,000
(TCS-) PTG20	1,400	9.7	28,000
(TCS-) PTG22	2,420	16.6	21,000

### Axial flow turbine

(TCS-) PTG55	3,650	23.2	16,000
(TCS-) PTG66	5,140	32.7	13,500

# The Variable Turbine Area (VTA)



## The Variable Turbine Area (VTA)

The VTA system consists of a nozzle ring equipped with adjustable vanes which optionally replace the fixed-vane nozzle rings in MAN Diesel & Turbo's standard TCA and TCR turbochargers.

By altering the pitch of the adjustable vanes, the pressure of the exhaust gases on the turbine is regulated and thus the volume of charge air can be precisely matched to the quantity of injected fuel at all points in an engines load and speed range. The result is reduced specific fuel consumption, reduced emissions HC and CO<sub>2</sub> and improved engine response.

### Benefits

- Up to 5g/kWh lower fuel consumption
- Lower soot and smoke emission
- Lower CO<sub>2</sub> emissions
- Lower particle emissions
- Suitable for TCA and TCR turbochargers
- Retrofit packages
- Short payback time
- VTA cuts fuel consumption and reduces emissions



## The Variable Turbine Area (VTA)

The tables below summarise the optimisation possibilities available with MAN B&W type engines. All SFOC figures are relative to the SFOC at 100% load for a standard  $L_1$  engine.

SFOC optimised load range	Tuning methods	SFOC change (g/kWh)				
		35%	50%	65%	80%	100%
High load (85–100%)	Standard $L_1$ engine	3.5	–1	–3.5	–3.5	0
Part load (50–85%)	VTA	0.5	–4	–6.5	–4.5	0.5
Low load (25–70%)	VTA	–1.5	–6	–8.5	–3.5	0.5

Table 1: Optimisation possibilities – ME/ME-C engines, SMCR =  $L_1$

SFOC optimised load range	Tuning methods	SFOC change (g/kWh)				
		35%	50%	65%	80%	100%
High load (85–100%)	Standard $L_1$ engine	4	0	–2.5	–3	0
Part load (50–85%)	VTA	2	–2	–4.5	–4	2
Low load (25–70%)	VTA	1	–3	–5.5	–3	1

Table 2: Optimisation possibilities – MC/MC-C/ME-B engines, SMCR =  $L_1$

For a specific  $L_1$  engine, the SFOC profile can be found directly from the above tables. For example, an S70ME-C8.2 running at 65% load with an  $L_1$  SFOC of 169 g/kWh and optimised for part load with VTA tuning has a consumption of 169 –6.5 g/kWh = 162.5 g/kWh.

The above tuning methods are also available for derated engines with different SMCR.

Only high-load optimisation is possible for engines with conventional efficiency turbochargers.

The methods and options mentioned will be explained in the following.

# The Variable Turbine Area (VTA)

## Fuel savings with MAN B&W low speed propulsion engines

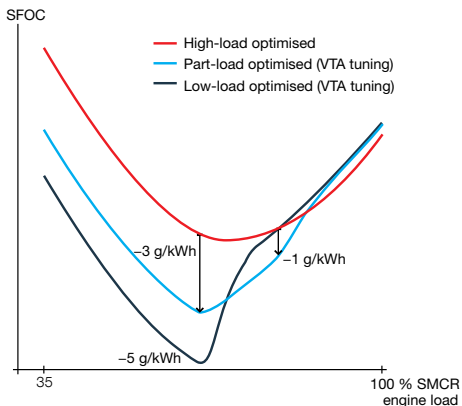


Fig. 1: ME/ME-C engines

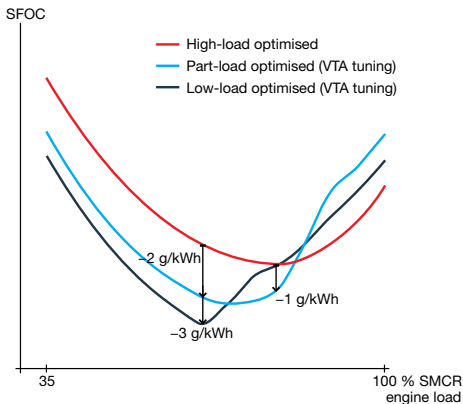
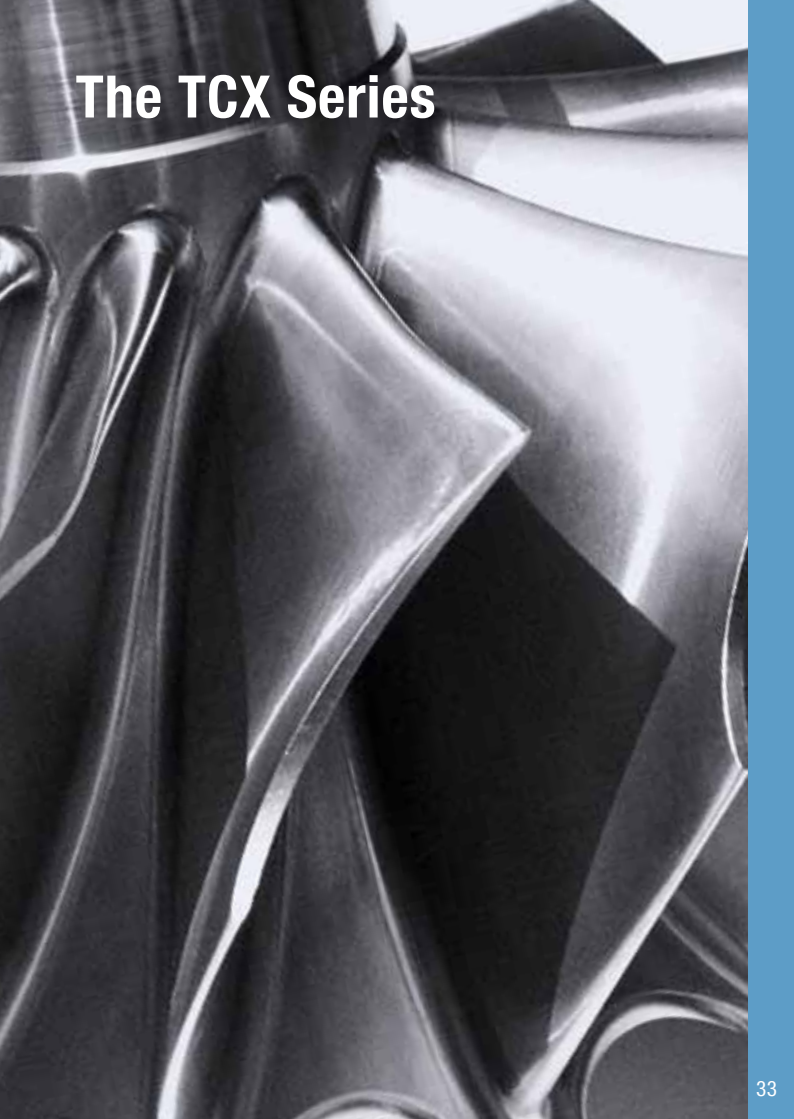


Fig. 2: MC/MC-C/ME-B engines



# The TCX Series

# MAN Diesel & Turbo Introduces Two-Stage Turbocharging with New TCX Generation

## **TCX features compact architecture and low-pressure ratio-optimised flow components**

Development of the next generation of large-bore diesel engines has the reduction of exhaust emissions as a primary target. Reducing engine emissions through internal measures is achieved by increasing the mean effective pressure. This requires high charge-air pressures but cannot be achieved through single-stage turbocharging. However, two-stage turbocharging enables the charge-air pressure to be increased substantially while simultaneously reducing exhaust emissions, despite the increased specific engine output. MAN Diesel & Turbo is now ready to bring two-stage turbocharging to the market with the introduction of its TCX generation.

In comparison to single-stage turbochargers, the TCX series incorporates characteristic features especially suited for lower-pressure ratios per stage:

- Optimised component characteristics at low-pressure ratios
- The use of pressure-ratio reduction for the benefit of air capacity increase
- The use of pressure-ratio reduction for the benefit of dynamic behaviour
- Compactness in order to minimise additional space (and weight) requirements for the two-stage turbocharger system including intercoolers
- Matching of compressor and turbine capacities to accommodate low-pressure ratios
- Wider application ranges per turbocharger size





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