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MAN PrimeServ – a service brand of MAN Diesel & Turbo

T/C-Retrofit

Aspire to higher performance

MAN | PrimeServ

Aspire to Higher Performance

Exhaust gas turbochargers decisively influence the performance of diesel engines, increasing their performance by as much as 300% compared to naturally aspirated engines. To deliver optimum performance, modern engines require high efficiency, state-of-the-art turbocharging.

Retrofitting an existing engine with the latest MAN Diesel & Turbo turbocharger technology is an effective method of extending its useful life while also improving its performance, economics and environmental impact.

A turbocharger retrofit can achieve the following benefits

- Improved spare part availability
- Improved engine output and supercharging
- Improved matching of engine performance to the required operating profile
- Easier maintenance and longer TBOs
- Reduced specific fuel oil consumption
- Reduced exhaust emissions (particulate matter, NO_x, CO_2)

MAN Diesel & Turbo offers turbocharger retrofits for diesel and gas engines from all manufacturers.

Rapid, reliable T/C-retrofit services

- Replacing existing turbochargers with the latest MAN turbocharger
- Rematching existing turbochargers
- Upgrading turbochargers to VTA technology
- Modifying turbochargers to meet Tier II and III emission standards
- Installing jet assist systems, where compressed air from an external source is used to aid compressor wheel acceleration
- Fitting dedicated turbocharger lubrication systems
- Implementing PTG thermal efficiency systems for existing engines

Reasons for Retrofit

Improved spare part availability

Engine 12V40/54 A | 2 x NA34/K replaced by 2 x NR26/R

Whether due to wear, damage or simply the expiry of expected life, most components require replacement at some time.

As turbocharging technology advances, the availability of spare parts for obsolete and obsolescent turbochargers decreases while their price increases. The production cycles of critical parts like rotors and casings become longer, translating into extended delivery times or extended stocking of emergency reserves by the operator. Extended payback periods result.

By contrast, retrofitting new turbochargers can be faster than procuring spares for older types, guarantees ready availability of spares for the new equipment and can be more cost effective in the long run.

A retrofit turbocharger provides

- Reduction or avoidance of engine downtime
- Reduced costs
- Full manufacturer's warranty on the new turbocharger
- Improved overall engine performance
- Secure long term supply of spare parts
- Faster spare part procurement
- Cheaper spare parts
- Longer TBOs

Reasons for Retrofit

Improved engine output and supercharging

Restoring your engine's design rating

Current situation: Low charge air pressure or / and too high exhaust gas temperatures

Exhaust gas temperatures increase over time due to wear and ageing of the turbocharger or of other engine and system components. Certain temperature levels may lead to engine load limitations.

Solution: Retrofit

- Higher turbocharger efficiency
- Increased air-flow rate
- Lower exhaust gas temperatures
- Implementation of basics of modern engine calculations
- Restoring or increasing nominal charge air pressure, as requested

Engine response (load acceptance / acceleration)

Current situation: Poor engine response at load changes

Worn turbochargers with low efficiency react slowly to load imposition, causing heavy smoke emissions and rapid fouling of gas affected parts.

Solution: Retrofit

- Improved turbocharger efficiency
- State-of-the-art rotor with lower inertia
- Potential for implementation of special features like jet assist or variable turbine area system (VTA)
  - Jet assist: compressed air is blown onto the compressor wheel to increase compressor acceleration and hence charge air pressure
  - VTA consists of a nozzle ring with variable pitch vanes to control gas pressure at the turbine: during part load engine operation – e.g. manoeuvring – nozzle ring area is reduced to give higher rotor speed and increased charge air pressure
- Better engine start-up behaviour

Compressor surge margin

Current situation: Increased back pressure / surging

- Modification or fouling of the existing exhaust gas path, leading to higher exhaust gas back pressure
- Changed engine operating requirements: e.g. dredging mode or higher torque propeller may require an increase in surge margin

Solution: Retrofit

- Turbocharger with closely adapted performance characteristics
- Appropriate surge margin
- Extended engine operating envelope to cover the new load profile
- Additional benefits
  - Higher turbocharger efficiency
  - Higher air-flow rate
  - Lower exhaust gas temperatures

Engine 18V40/54 | 2 x VTR 401 replaced by 2 x NA34/S

Reasons for Retrofit

Improved matching of engine performance to the required operating profile

Engine 9L32/36 | 1 x NA40/T replaced by 1 x NA34/S

New engines are closely adapted to the load profile of the intended application. The engine-turbocharger combination is matched accordingly.

The engine profile may change over the years due to

- Power uprating for increased engine load (e.g. higher vessel speed, higher generator output)
- Power derating (e.g. limitations with generator or foundation structure)
- Propulsion plant modifications (e.g. FPP to CCP)
- Modifications (extension)
- Trade/charter changes
- Fuel type change (Liquid to gas)

Operating profile changes may make existing turbocharger performance unsuitable and impair engine performance. Turbocharger retrofit or re-matching of the turbocharger to the engine is often required.

Current situation:

Changed demands resulting from different engine operating profile.

Solution: Retrofit

New, specially-adapted turbochargers enable the engine to fulfil its new demands via

- Modified air-flow rate
- Adapted charge-air pressure
- Extended surge margin
- Increased turbocharger efficiency
- Special features, i.e. Jet assist, VTA

Reasons for Retrofit

Easier maintenance and longer TBOs

Maintenance should be performed according to maker's recommendations. Scheduled major overhauls may take up to 2 days or more.

Current Situation:

Old turbocharger generations have shorter TBOs and have higher maintenance requirements in terms of manpower and spare parts.

Solution: Retrofit

The time between overhauls can be extended by

- Cleaner combustion at a corresponding exhaust gas temperature level
- Use of high efficiency retrofit turbocharger with enginespecific matching
- Reducing tendency to deposit build-up on gas conducting components
- New design features
- Improved bearing arrangement
- Uncooled casings
- Cleaning equipment (wet and dry cleaning procedures)
- Components with higher wear resistance

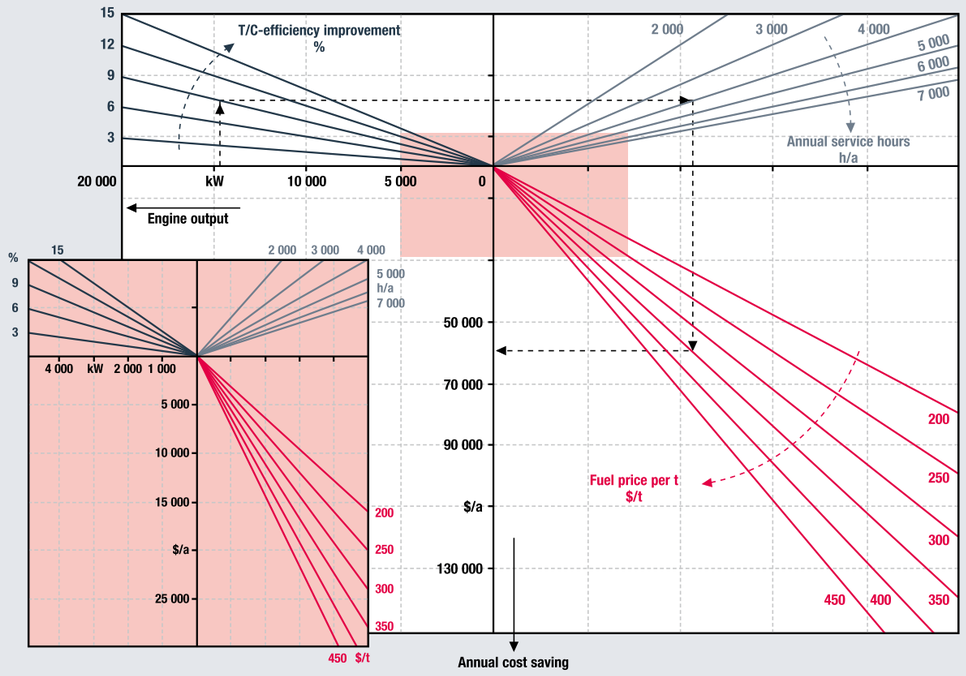
Maintenance work can be reduced via

- Maintenance-friendly access to main components
- Inspection cover on the turbine side
- Reduction of assembly / disassembly time via improved compressor wheel fixation
- Restoration of the turbocharger to as-new condition

Reasons for Retrofit

Reduced specific fuel oil consumption

Annual cost saving diagram



Example: Achieving a potential 9 percent improvement in t/c efficiency by retrofitting a 19,000 kW-engine operating 4,000 hours a year at full load would help to save approx. 58,000 $/year, based on a fuel price of 350 $ per ton.

Higher turbocharger efficiency leads to improved overall engine efficiency. Thus, turbocharger retrofit is always accompanied by a reduction in SFOC. This considerably shortens payback times.

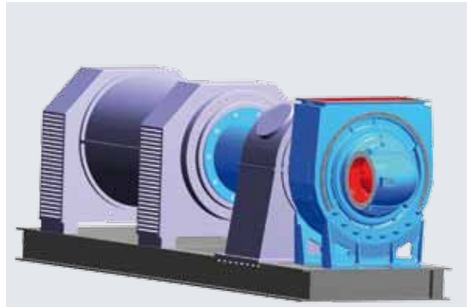
If only improvements in SFOC are taken into account, turbocharger retrofitting may only be worthwhile where a very large difference in efficiency exists between the old and new turbochargers. For this reason, turbocharger retrofitting should always be assessed on the basis of all the potential benefits.

Problem:

Spiralling operating costs due to high fuel consumption at times of increasing fuel prices.

Solution: Retrofit

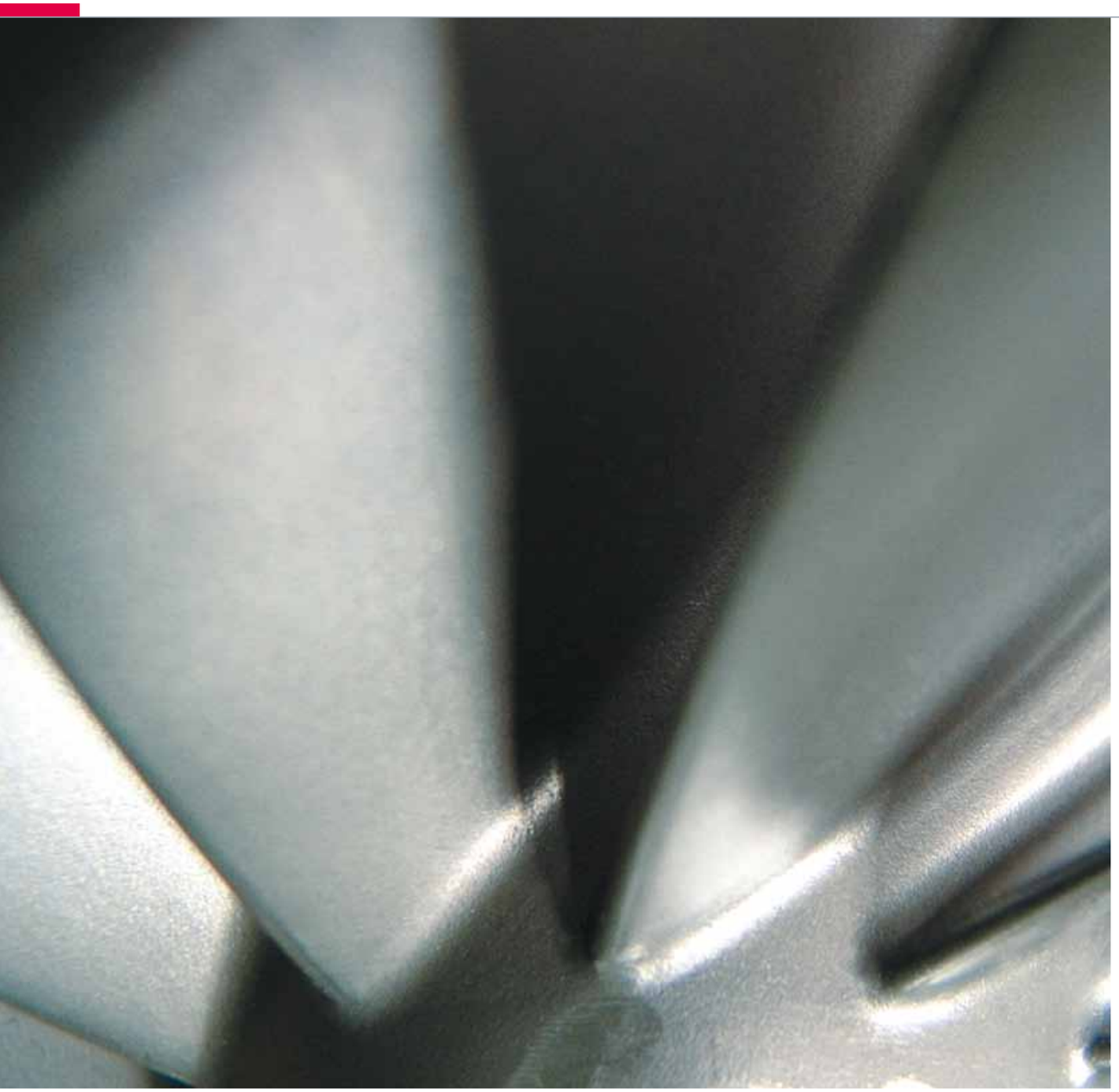
- Enhanced turbocharger efficiency
- Improved combustion
- Application of the VTA system
- Option: Implementation of the MAN Diesel & Turbo TCS (Turbo Compound System) for increased thermal efficiency
- Reduction of SFOC



Turbo Compound System

Reasons for Retrofit

Reduced exhaust emissions



Valid with unbroken seal only

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Not to be used on board

NOx Compliance Report
(acc. to NOx Technical Code)

MAN

Engine Group Certification
Engine Group: L48BI

Parent Engine: 6L 48/60B
Engine no: 1 130 413

EMISSION CERTIFICATION
Approval No. Date
6 4 3 9 0 - 0 7 HH 2007 - 08 - 17
Germanischer Lloyd
Head Office Hamburg

GL Approval no.: .....
Approval date: .....

MAN Diesel SE
Augsburg, June 2007

Technical File (IAPP)

Engine exhaust emissions are a major issue and will become an increasingly critical factor as emissions regulations tighten. International legislation is often exceeded by stricter national regulations governing the maximum permissible emissions from combustion engines. For example, particulate (e.g. soot) emissions are subject to strict limitations in Alaska and NO_x is strictly regulated in the Baltic.

Particulate emissions are critical because they are readily detectable by regulating authorities and are a health hazard. Competent authorities are thus empowered to prohibit vessels from navigating certain routes.

On passenger ships – especially luxury cruise liners – particle deposits can adversely affect the cruise operator's customer image.

Problem:

Heavy soot emissions due to low turbocharging efficiency.

Solution: Retrofit

A new turbocharger with higher efficiency provides more charge air to the engine, especially during rapid load changes due to its better acceleration. The result is more efficient combustion and reduced particulate emissions.

Optional special features:

- Jet assist
- VTA system

Retrofit Procedures – How to Retrofit?

Customers may send retrofit enquiries direct to the Retrofit Service Team at MAN Diesel & Turbo in Augsburg, Germany or approach their local authorised service provider. The enquiry should include specific data about the engine and turbocharger as well as essential background information to determine the specific engine profile.

On request, MAN Diesel & Turbo can send a specialist to carry out an investigation of the decisive factors relating to the feasibility of the retrofit (engine operating values, turbocharger attachment, installation conditions, cooling, controls, transportation) on board or on site.

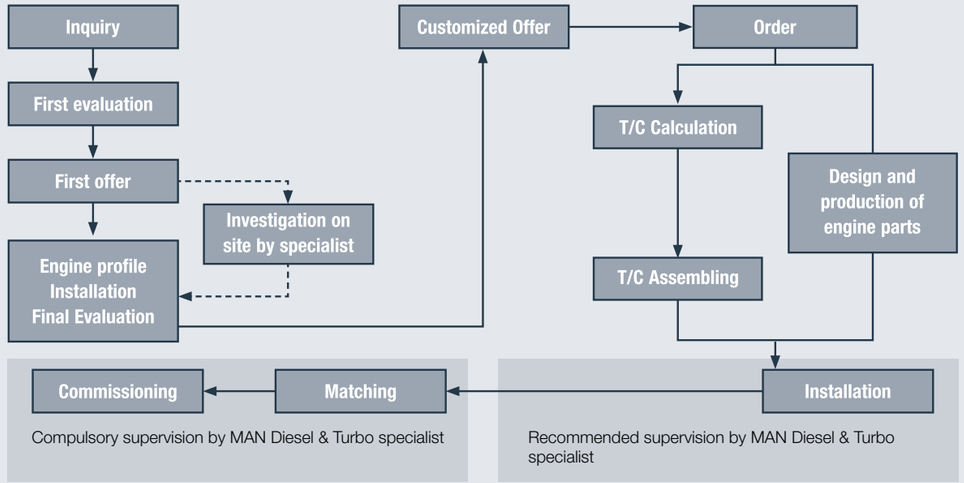
Offers are then individually prepared using customer-specific data. The standard delivery time for new turbochargers is 4 months from date of order. Fast-track delivery is possible on request in urgent cases.

For new applications retrofit turbochargers are tested at our burner test-rig to obtain comparative values for better evaluation of subsequent trial results.

Classifications are made according to customer's demands and technical files issued for ship applications. MAN Diesel & Turbo will assist with certification procedures.

Although MAN Diesel & Turbo is able to supply turnkey retrofit solutions worldwide, installation work can be carried out either by the operator's own personnel, the shipyard, a qualified workshop, by MAN Diesel & Turbo's own experts or in suitable combinations of personnel. Conversions are executed using a comprehensive MAN Diesel & Turbo retrofit package or custom-designed parts made on site according to our recommendations for turbocharger attachment. The desired solution depends on the complexity of the installation and the targeted cost-effectiveness of the retrofit.

Engine 18V40/54 | 2 x VTR 401 replaced by 2 x NA34/S



Retrofit procedure

Supervision of installation by a MAN Diesel & Turbo retrofit specialist is always recommended and is compulsory for the commissioning phase.

During the test run, the specialist completes turbocharger matching on site to ensure satisfactory engine operation with the retrofitted turbocharger. Post-retrofit operating values are recorded and documented.

To achieve the full benefit of the retrofit, the engine itself should be in good condition. Thus, we recommend retrofit shortly after overhaul of the related engine systems (combustion chamber parts, fuel injection system, charge air cooler, exhaust gas boiler, etc.).

The engine downtime required for conversion depends on the complexity of the retrofit project, the location and installation circumstances of the engine and other circumstances.

The warranty period for the retrofit turbocharger starts after commissioning.

Conclusion

Engine 6S50MC | 1 x NA48/T replaced by 1 x TCA55

Turbocharger retrofitting modernises your engine, prolonging its effective life and improving both its economic viability and its environmental compatibility – likewise, extending the useful life of your vessel or power plant.

Although engine operators often focus on just one major problem, MAN Diesel & Turbo turbocharger retrofits address the full range of issues that can be resolved by the application of a brand-new, high efficiency turbocharger.

As a result, the full range of savings and improvements should be taken into account, when assessing the viability of an MAN Diesel & Turbo turbocharger retrofit.

As a leading manufacturer of diesel engines and turbochargers, MAN Diesel & Turbo is pleased to offer you our full support in your retrofit decision, from individual consultation to application-specific proposals and final commissioning of the completed turbocharger retrofit.