



# V28/33D Series Engines

For offshore patrol vessels

Engineering the Future – since 1758.

**MAN Diesel & Turbo**





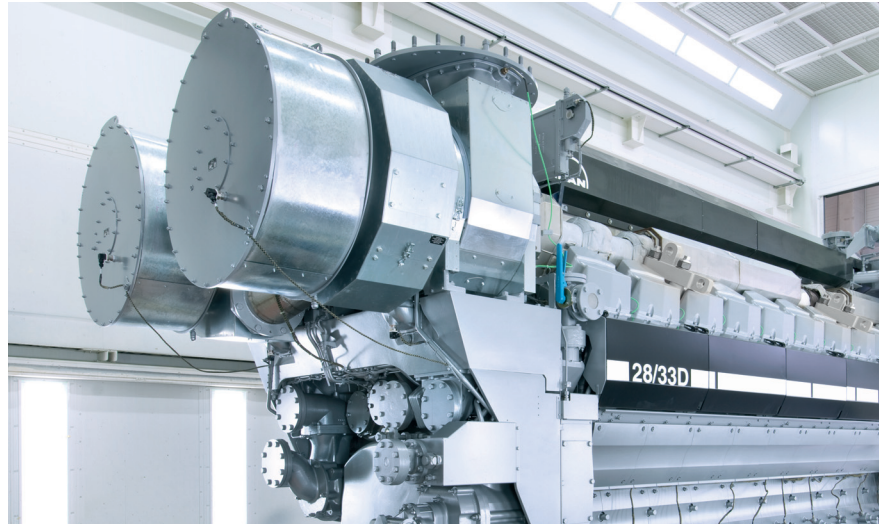
# Introduction

## V28/33D: Perfect for naval propulsion

Our deep knowledge of naval propulsion requirements – earned from extensive experience with high and medium speed engine applications for geared propeller or waterjet and diesel-electric installations – has benefited the latest addition to MAN Diesel & Turbo's (MDT) marine engine programme: The V28/33D series, the most versatile member of an extensive range addressing the propulsive and genset drive demands of diverse naval tonnage.

Our previous naval engine references covering more than 2,600 engines with a combined output exceeding 8,900 MW are in naval service in more than 1,000 corvettes, frigates, destroyers, submarines, aircraft carriers, offshore patrol vessels and various logistical support ships in over 60 navies and coast guards.

From this experience, brought forward from MAN, Pielstick and Ruston engine designs and service experience, we have developed a family of V28/33D, V28/33D STC and V28/33D GenSet engines. This new engine range delivers power outputs up to 10,000 kW from V12, V16 and V20-cylinder models while meeting the strictest specifications for noise, vibration, shock, and exhaust emissions as well as thermal and visual signatures. The resultant robust newly-refined 280 mm-bore V28/33D engine design sets new standards and is approved by all major classification societies. The engine's performance, economy and reliability have been further proven in demanding commercial installations as a propulsion plant in large high speed monohull and catamaran ROPAX ferries. The V28/33D engine family combines



20V28/33D

the highest unitary displacement in its class (20.32 litres per cylinder) within one of the most compact dimensional envelopes. Low weight and compactness simplify engine installation and foster optimised machinery room layouts, while high fuel economy, reliability and ease of operation and maintenance contribute to the lowest life-cycle and total ownership costs on the market.

Excellent power-to-weight and power-to-installation space ratios make the engine equally well suited to fast monohull and multi-hull vessels, offshore patrol vessels with either single or twin engine-gear-propeller systems or corvettes, frigates and destroyers with combined propulsion plant configurations (such as CODAD, CODOG and CODAG) or as prime movers for diesel-electric propulsion systems.

Low weight with robustness, compactness, quietness and long operating time between maintenance are especially valued in engines specified for offshore patrol vessels. Whether mechanical or

electric propulsion is selected, V28/33D engines offer an optimum combination of high power and rapid engine response, long endurance, economical and low-signature operation during extended cruising and patrolling missions.

The highest power density in the engine speed class results in rated outputs of 5,460 kW, 7,280 kW and 9,100 kW at 1,000 rpm respectively from the V12, V16 and V20-cylinder versions of the standard V28/33D model. For naval applications these ratings rise to 6,000 kW, 8,000 kW and 10,000 kW at 1,032 rpm (equating to an output of 500 kW per cylinder).

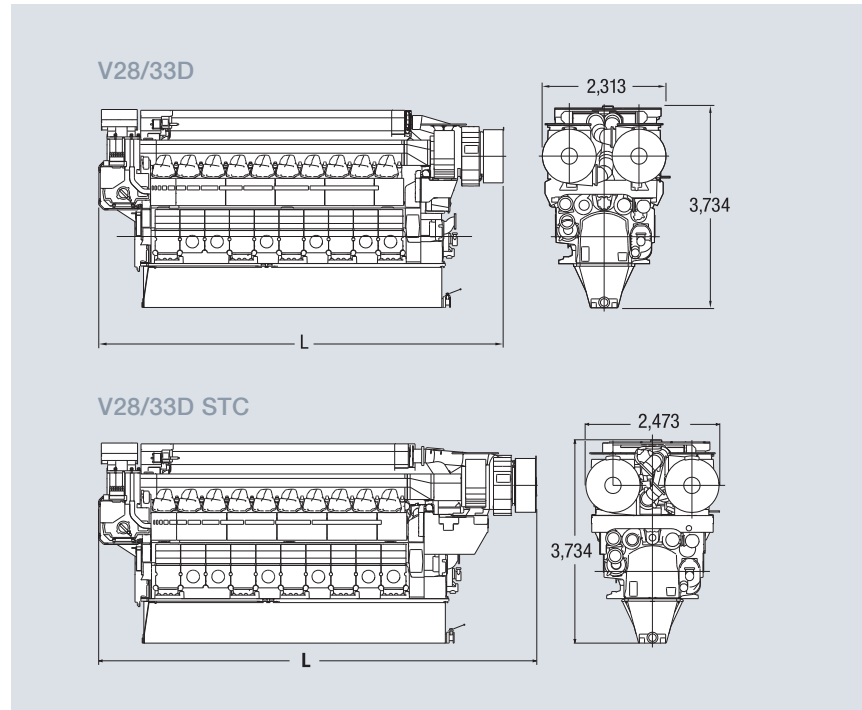
The V28/33 series engines join and complement MDT's extensive medium speed engine portfolio for naval propulsion and genset drive applications covers power outputs from 1,290 kW to 21,600 kW with advanced 210 mm, 270 mm, 280 mm, 320 mm and 480 mm-bore designs running at nominal speeds from 500 rpm to 1,000 rpm.

# Engine Specifications

## MAN V28/33D data

Bore, mm	280
Stroke, mm	330
Cylinders	V12, 16, 20
Power output, kW	5,460 (6,000), 7,280 (8,000), 9,100 (10,000)
Output /cylinder, kW	455 (500)
Speed, rpm	1,000 (1,032)
Mean effective pressure, bar	26.9 (28.6)
Mean piston speed, m/s	11 (11.35)
Specific fuel consumption, g/kWh @ 100% load	191 (193)*

\* with all ancillary drives & engine driven pumps included



## V-engine V28/33D

	Cyl. No.	Rated power output – ICFN* (kW)	Speed (rpm)	L (mm)	Dry mass **(t)
12V28/33D Ferry	12	5,460	1,000	5,713	31.9
Navy		6,000	1,032		
16V28/33D Ferry	16	7,280	1,000	6,633	39.9
Navy		8,000	1,032		
20V28/33D Ferry	20	9,100	1,000	7,543	48.0
Navy		10,000	1,032		

## V-engine V28/33D STC

	Cyl. No.	Rated power output – ICFN* (kW)	Speed (rpm)	L (mm)	Dry mass **(t)
12V28/33D STC Ferry	12	5,460	1,000	6,207	33.6
Navy		6,000	1,032		
16V28/33D STC Ferry	16	7,280	1,000	7,127	41.6
Navy		8,000	1,032		
20V28/33D STC Ferry	20	9,100	1,000	8,047	49.5
Navy		10,000	1,032		

For multi engine arrangement only. Weight and performance parameters refer to engine with turning wheel, TC silencer, attached pumps, oil filters and lube oil cooler.

\* ICFN: I = Power to ISO 3046; C = Continuous power output; F = Fuel stop power; N = Net Power

\*\* Tolerance: 5%

## Simplicity and functionality

In conceiving the 280 mm-bore/330 mm-stroke V28/33D engine, a simple and functional design was sought using the minimum number of components and pursuing maximum commonality between the models of different cylinder numbers. The following main development goals were defined:

- High reliability
- Low fuel consumption
- Low operating costs
- High operating efficiency at low and high powers
- Low acoustic and thermal signature characteristics
- Capable of extended operation at low loads without white smoke or maintenance impact
- Optimum power-to-weight and power-to-size ratios
- Ease of installation and maintenance

These characteristics are particularly suitable for offshore patrol vessels.

## Engine design – brief overview

Component and system refinements have benefited the original V28/33D design, the latest features including the MDT-developed engine-mounted SaCoS<sub>one</sub> safety and control system and a new MAN TCA33 axial-turbine turbocharger model.

A high structural strength underwrites high shock resistance and low thermal and mechanical distortion, promoting low component wear and a long service life at the lowest possible maintenance costs. Minimised engine interfaces and optimised installation and maintenance procedures simplify shipyard work and ease servicing onboard.

A 52-degree V-cylinder bank facilitates a centrally mounted intercooler assembly to minimise engine height and ease installation. A detailed analysis of all parts was carried out to achieve the weight and compactness goals, with aluminium alloy materials used where possible. The resulting power-to-weight ratio is less than 4.8 kg/kW.

Multifunctional integrated components contribute to a considerable reduction in the overall number of parts, enhancing maintenance procedures and spares logistics. External piping is minimised by exploiting existing drillings or cast-in passages for fluid transmission – the hollow camshaft, for example, doubles as a main lube oil channel – while pre-wired, modular and encapsulated wiring looms avoid the need for exposed on-engine electrical cables.

Governing and monitoring units are engine mounted to reduce the amount of interconnecting cabling to a remote control panel; and all electrical connections are plug-and-socket type.

Easier installation and commissioning of the engine is addressed by grouping all pumps and standard connections at the engine free end. Direct engine-driven pumps are incorporated for lube oil, fuel oil, fresh water (low and high temperature) and sea water supplies. A lube oil module (duplex filters, cooler and temperature regulator) is also mounted on the engine to simplify installation and reduce piping and total weight.

An advanced electronically-controlled unit pump system enhances control of fuel quantity and injection timing

independent of engine speed, enabling performance, emissions and fuel economy to be optimised for the particular application. NO<sub>x</sub> emissions are lower than 10 g/kWh, and the specific fuel consumption is around 190 g/kWh at 85 per cent maximum power rating.

Expertise in tailoring the engines to the specific application is supported by in-house-developed fuel injection and turbocharging technologies allowing precise matching of output to load profile.

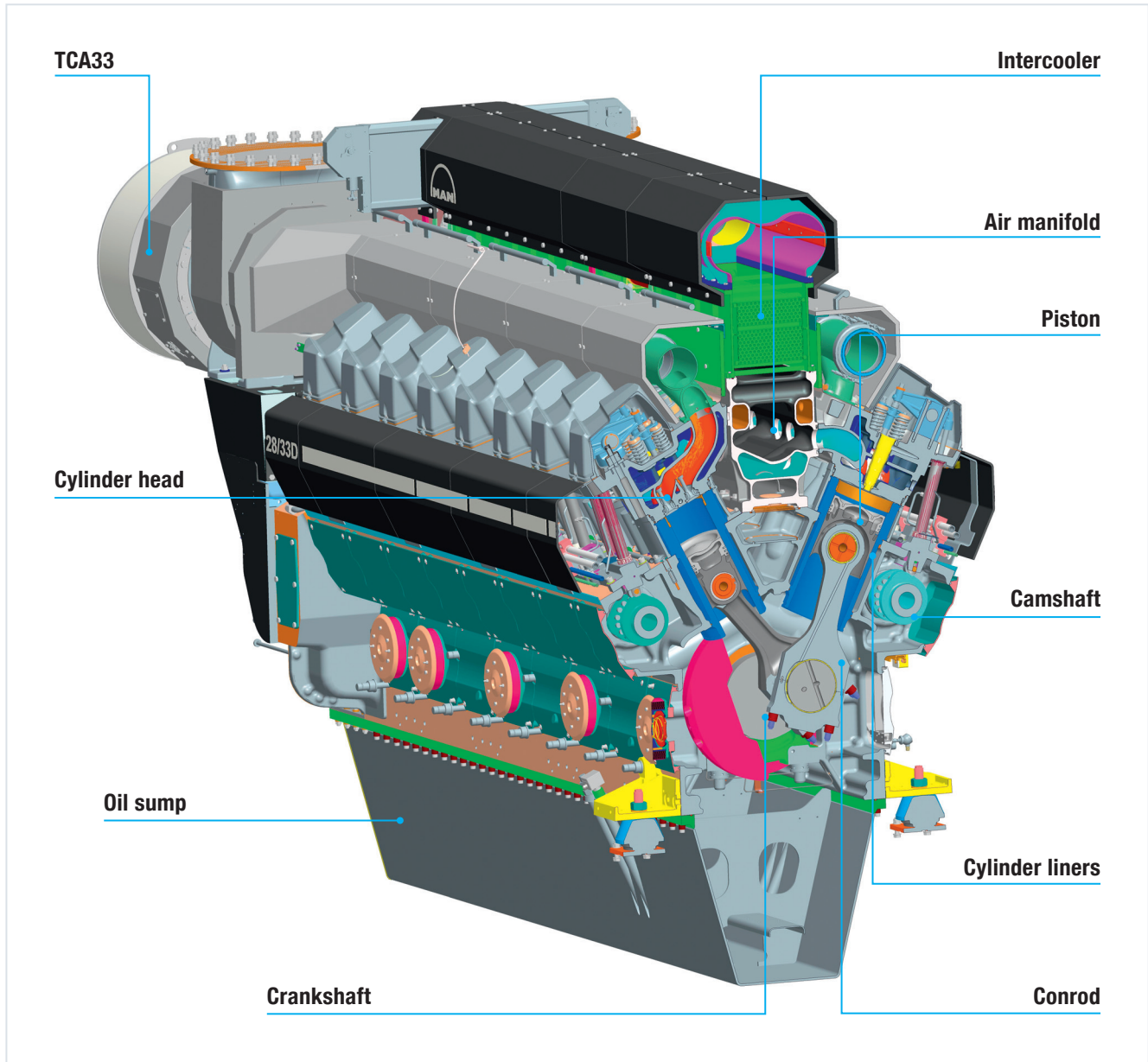
Specialist resources for naval projects include test and simulation facilities to assist in achieving engine shock resistance and thermal and acoustic emissions to the high standards of individual navies and military alliances, such as NATO. Experience in shock attenuation technologies, including the resilient mounting of engines and auxiliary equipment, enables the production of systems capable of withstanding loadings as high as 10 g or more.

A robust engine structure – characteristic of MAN medium speed engine designs – also provides a firm foundation for excellent shock resistance, survivability and high availability as well as for low component wear and long life through low deformation. Modular construction and ease of accessibility foster maintainability and reduce operating and servicing costs.



# V28/33D Components and Systems

Quality counts



## Crankcase

Machined from a spheroidal graphite iron casting and featuring underslung main bearings which are retained by two vertical studs and two cross-bolts per side for overall engine stiffness. The main bearing caps are secured by hydraulically-tensioned studs to ensure maximum integrity of the crankshaft system.

## Oil sump

Designed with increased volume to satisfy demanding inclination requirements; a rolling dynamic of 22 degrees and a pitching static of 5 degrees are allowed, with an additional dynamic of  $\pm 7.5$  degrees as the standard, but this can be further increased.

## Cylinder liners

Individual units machined from a centrifugal-spun grey iron casting and incorporating deep flanges that are cooled by a separate cast-aluminium water jacket enabling a dry crankcase. The liners are secured in position in the crankcase by the cylinder heads, and their running surfaces are plateau honed and finished to improve oil

retention. A cutting ring fitted at the top of the liner prevents the build-up of carbon on the piston crowns and minimises lubricating oil consumption.

### **Crankshaft**

A new strengthened design ensures reduced stresses and improved lubrication via optimised drillings. It is machined from a high tensile NiCrMo continuous grain-flow steel forging and fitted with two bolt-on balance weights per throw. A solid camshaft drive gear is bolted to a flange at the free end that also incorporates a taper to which the vibration damper is fitted. Provision is also made for a power take-off (PTO) shaft to be arranged at the free end with up to 100 per cent capacity.

### **Main and connecting rod bearings**

Generously dimensioned, precision made, extended life, easily replaceable, thin wall, steel-backed aluminum-tin shells.

### **Camshafts**

Of modular design, comprising one cam element and one bearing journal per engine cylinder, assembled through side access doors and mounted on each side of the engine. Large cam base circles are employed together with large bearings to reduce operating stresses. Housed in the crankcase, the two hollow camshafts incorporate the oil supply gallery to the engine and bearings.

### **Camshaft drive**

Located at the free end of the engine and comprising a solid gear bolted to the crankshaft driving a compound idler gear for each cylinder bank, which in turn drive the two camshafts. All gear

spindles are supported both sides of the gear by the crankcase. Lubricating oil, fuel oil and cooling water pumps are also driven from the free end of the crankshaft.

### **Pistons**

A two-piece design with a lightweight body and alloy steel crown, and a three-ring pack comprising two chrome-ceramic compression rings and an oil control ring. The case-hardened gudgeon pin is fully floating and retained by a circlip at each end.

Lubricating oil is fed from the connecting rod through drillings in the gudgeon pin and piston to a cooling chamber in the piston crown. The oil is then discharged through drillings in the underside of the crown back to the sump.

### **Connecting rods**

This improved straight cut design ensures higher reliability, better engine balancing and lower vibrations. It is manufactured from a one-piece alloy steel forging, and the partially grooved lead bronze bearing shell is carried in straight cut big ends with each cap secured by four hydraulically-tensioned studs and nuts. The stepped small end features a steel-backed lead/bronze bush, and all bearing pressures are kept at a minimum.

### **Cylinder heads**

Machined from a spheroidal graphite iron casting with a thick combustion face incorporating coolant drillings. The two inlet and two exhaust valves, the latter with cooled seats, are arranged around the central fuel injector.

Twin inlet ports connect directly to the air manifold, while a single tandem exhaust port exits from the top face for ease of maintenance. Each pair of valves is operated via short pushrods and conventional rockers from the camshaft via followers of the roller bucket tappet type mounted in a separate housing bolted to the crankcase.

### **Auxiliary drives**

Water pumps and lubricating oil pumps with fuel oil pump are all driven from the free end of the engine through the camshaft drive housed in the crankcase.

### **Air manifolds**

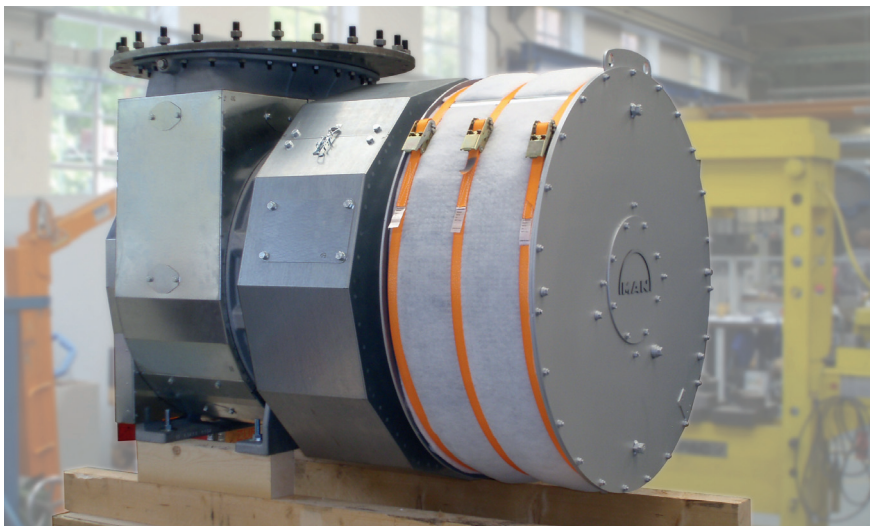
This is a newly designed single-element air manifold of symmetrical design, with a material change to GGG40 (offered as a replacement part for existing engines). It is mounted down the vee of the crankcase, and incorporating passages for the lubricating oil and water systems.

### **Intercooler**

A cylindrical two-stage unit contained in a casing that includes part of the inlet ducting; the assembly is mounted directly on top of the air manifold.

### **Turbocharging**

Twin axial-flow MAN turbochargers, selected for efficiency and reliability, are mounted on a cast iron bracket at the free end of the engine. Developed specifically for the V28/33D engine, the high efficiency TCA33 turbocharger features angled turbine inlet casings designed to match the engine exhaust in terms of interfaces and gas flow optimisation. Each turbocharger uses the same inlet casing, which is simply rephased to the opposite angle.



TCA33

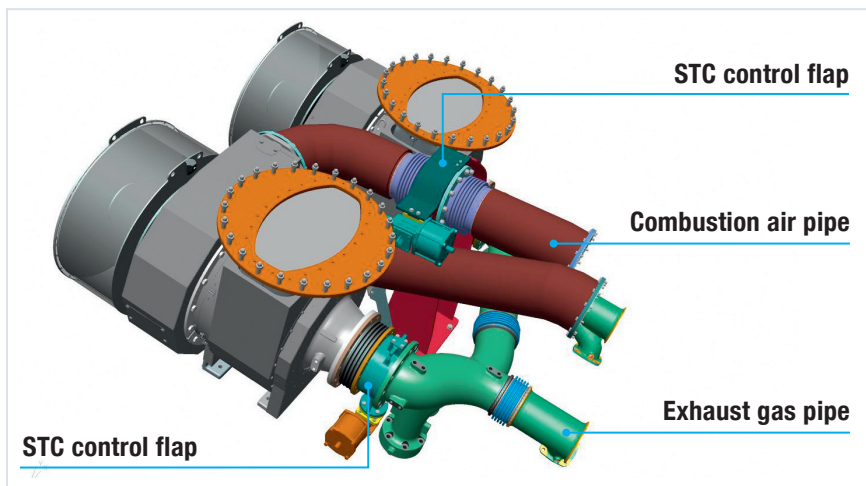
well proven on Pielstick PA6B naval engines, the system incorporates two identical standard MAN TCA33 turbochargers: one alone supplies sufficient charge air in low and medium speed running modes; the second unit cuts in to boost charging at higher speeds.

A digital control system is programmed to automatically switch off one turbocharger at low rpm, increasing the amount of air reaching the combustion chambers.

The low-weight twin TCA33 models are compact and designed for ease of maintenance and extended lifetime. High efficiency at full and part loads from the turbocharging system yields a substantial charge air surplus and thorough combustion without residues. Low thermal stress of the combustion chamber components is another benefit.

A requirement for the engine to fit compact machinery rooms resulted in a new turbine outlet casing design. The rectangular profile of the TCA casing was adjusted to reduce its width and a direct connection provided to the round exhaust system. Detailed analysis and design achieved very low pressure losses in the connection itself and in the downstream exhaust duct.

A single turbocharger frame size covers all cylinder configurations, making interfaces common across the engine range; and installation is standardised without compromising performance and efficiency. Casings are designed to



V28/33D STC system

accept two rotor capacities and a range of compressor wheels and matching components are available to suit different engine powers.

### Sequential turbocharging

A sequentially turbocharged (STC) variant of the upgraded V28/33D engine offers optimised engine-turbocharger matching for high torque at low rpm with reduced fuel consumption, smoke and noise. Based on the configuration

An extended torque envelope yielding economical operating modes and improved engine acceleration characteristics from STC versions are particularly valued for naval propulsion applications. Torque is sufficient to allow ship operation at full propeller pitch (design pitch) at all engine speeds. High torque at low power is particularly useful when towing another vessel.



## Fuel injection

Ideally complementing sequential turbocharging, an advanced microprocessor-managed, solenoid valve-controlled fuel injection system secures flexible and precise control of the injection quantity, rate and timing independent of engine speed.

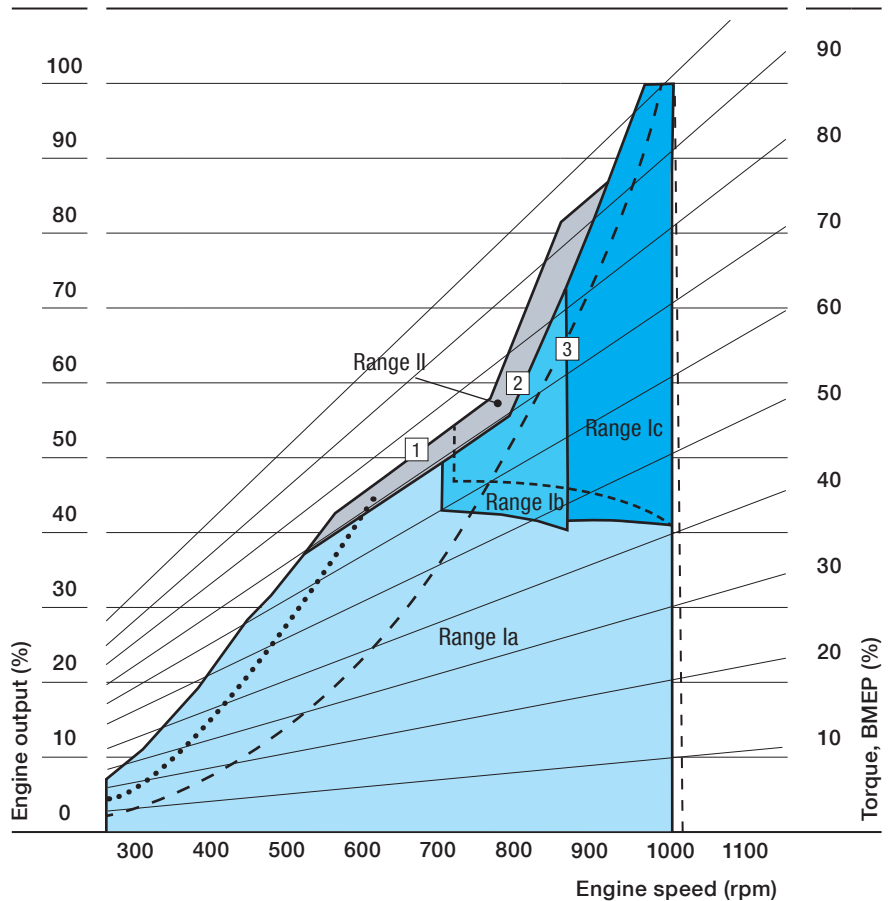
Advanced combustion chamber technology combined with electronically-controlled unit pump injection reduces specific fuel consumption to a very competitive level. Sequential turbocharging reduces SFC further by 10 per cent at powers below 50 per cent, making the V28/33D STC engine the most economical in its class. The large torque envelope of STC engines reduces fuel consumption by optimising the propeller efficiency.

Full authority electronic fuel injection (EFI) technology enables engine performance to be optimised for the specific application, achieving exemplary values for fuel consumption and exhaust emissions over the entire operating map. Electronic control further facilitates convenient integration with overall vessel management and automation systems. In the case of an installation based on two engines driving two propellers, reductions in fuel consumption of up to 9 per cent can be achieved solely from the STC system with the plant operating at constant pitch on the propeller curve.

## Extended low load operation

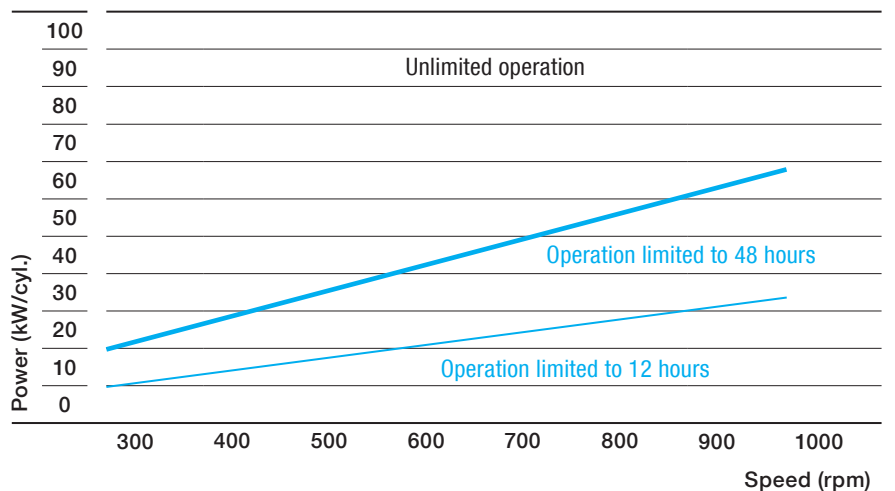
With STC, the V28/33D engine has the capability to operate for extended periods at low load conditions without producing white smoke exhaust emissions or negatively affecting full load performance or maintenance demands.

V28/33D STC operating envelope



1 Load limit Range II 2 Load limit Range I 3 Theoretical propeller curve Range Ia – one TC in operation  
Range Ib – both TC in operation (bypass open, after compressor > before turbine) Range Ic – both TC in operation (bypass closed)

V28/33D STC low load operation



Raise output to 70% load for 20 min after each period of 12/48 hours

**Emissions/smoke and noise signatures**

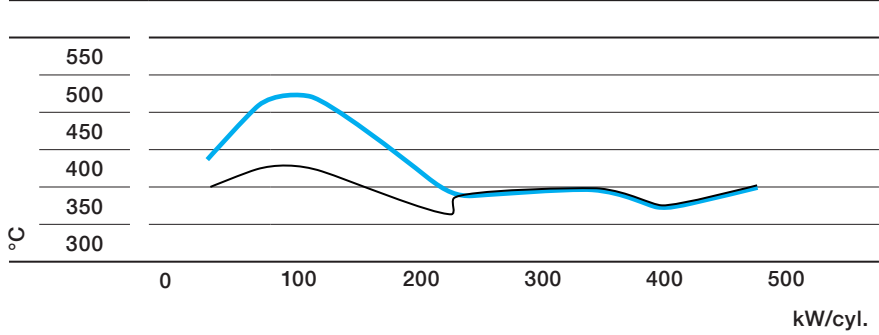
All V28/33D engines are fitted with a package of measures developed to meet IMO Tier II and EPA Tier 2 exhaust gas emission regulations without compromising the engine’s attractive fuel consumption and smoke free emission performance. They focus on: optimised fuel injection system, nozzle tip and injection cam profile, improved combustion chamber, Miller cycling, high-efficiency two-stage charge air cooler, and improved NO<sub>x</sub>/specific fuel oil consumption/soot trade-off.

Additionally, enhanced fuel and air management fosters a low native thermal signature and reduced smoke emissions at part load. Furthermore, the high torque reserves of the STC engine allow operating modes with extremely low noise emissions, including cruising with a CP propeller fixed at its optimum pitch for quiet running while retaining the capability to accelerate rapidly.

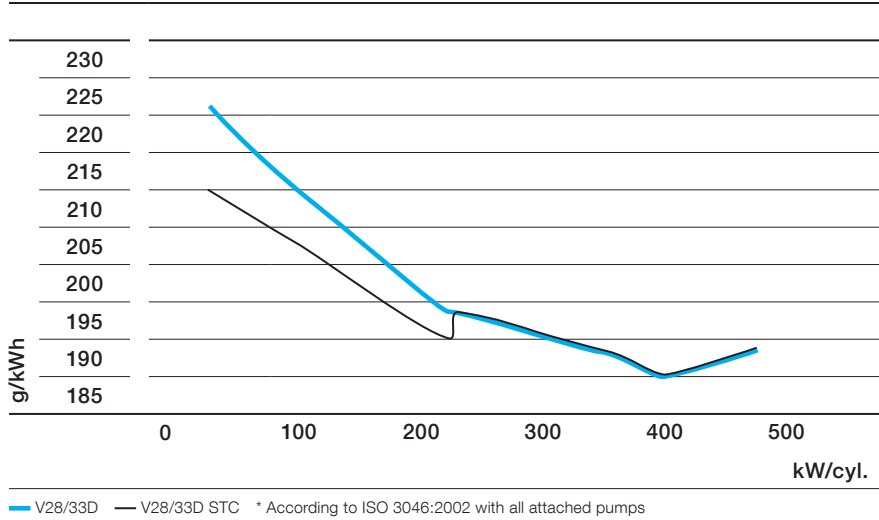
**Safety and control system**

Autonomous in both hardware and software development, MDT designs and refines its own management systems for engine control, monitoring and diagnostics. The V28/33D engine benefits from the latest generation of the group’s proven SaCoS<sub>one</sub> (safety and control on engine) system, which is very compact and mounted on the engine to form one unit with the drive assembly.

**Exhaust gas temperature**



**Specific fuel oil consumption\***



— V28/33D — V28/33D STC \* According to ISO 3046:2002 with all attached pumps

Fostering better safety and security throughout the ship’s life, all the functions of a modern engine management system are incorporated in this single system to offer:

- Integrated self-diagnosis functions
- Maximum reliability and availability
- Simple use and diagnosis
- Quick exchange of plug-in modules
- Trouble-free, time-saving commissioning

Enhanced mapping of all engine control parameters with improved monitoring and diagnostics is secured, including remote online monitoring via telephone or the Internet. A variant of the SaCoS<sub>one</sub> system with two electronic control units offers complete redundancy.

An easy-to-use engine diagnosis system (EDS) covers these work areas: data logging, trend analysis, monitoring, reporting, and maintenance.

# Suitability for Other Applications

## Fighting ships

Although this paper focuses mainly on the V28/33D engines suitability for OPVs, it is clearly suitable in similar or other configurations for corvettes, frigates and destroyers.

Highly dependable power from each propulsion train is vital, whether the plant is based on V28/33D engines alone, in a basic twin engine or CODAD layout, or in combination with gas turbines driving fixed pitch or CP propellers or waterjets via gearing. The lightweight and compact engine is equally at home in diesel-electric propulsion installations, offering a fast starting capability, high dynamic load response and low vibration/structure-borne noise qualities.

Rapid response from low load to full power for optimum ship acceleration is valued in naval propulsion, a quality sharpened in the V28/33D engine by the sequential turbocharging (STC) system.

Military qualifications have been secured in the key areas of noise (air-borne, structure-borne and underwater) and shock resistance (including NATO Stanag, US MIL-901-D, French IT, German BW and British standards).

Acoustic enclosure of the engines achieves significant attenuation of air-borne noise. Single-stage resilient engine mounting is an effective standard solution for addressing structure-borne

noise but a double-stage resilient mounting system with intermediate raft doubles the attenuation efficiency.

A selection of navy-qualified mounts can be offered, including resilient types with high displacement capacities and others with or without displacement limiters for shock or no-shock applications.

Attenuation of ship-radiated underwater noise – main engines, reduction gearboxes and propellers are the major sources – results from running propellers at their optimum pitch, a policy dictating a wide operational zone from the main engine. Separate resilient mountings for the gearbox and engine, both arranged on a common resiliently-mounted raft, curb underwater noise from those sources.

Sequential turbocharging is particularly beneficial with a propulsion plant based on four engines and two propellers when two engines are operated up to 25 per cent of the installed power output. With the V28/33D STC engine running on a double propeller curve, a total reduction in fuel consumption of up to 12 per cent is gained compared with a non-STC engine on a single propeller curve.

The enhanced fuel economy underwrites an extended ship cruising range and a lower engine operating cost (fuel represents approximately 75 per cent of total engine running costs).

## Logistic ships

The need for extended, often arduous, deployment anywhere in the world demands that the propulsion plant of Logistic-Support-Ships deliver the highest availability with maximum operational economy. High performance, robust reliability and low overall running costs additionally make the V28/33D engine an ideal candidate for such a role, whether driving propellers via mechanical or electric transmissions.

A number of the engine's design features contribute to a low specific fuel consumption across the load range, notably sequential turbocharging and electronic fuel injection systems.

# Best Back-up in the Business

## Integrated logistic support

Navies and coast guards demand a high level of support to enhance the operational effectiveness of their fleets, and the high availability of the propulsion plant is of paramount importance.

Comprehensive integrated logistic support (ILS) can be provided by MDT to facilitate sharing of technical data between customers, suppliers, subcontractors and other project participants throughout a ship's lifetime using common neutral data interchange standards with integrated databases.

ILS is pursued through two key steps to achieve the best ratio between operational availability and global cost of system ownership during design and in-service phases:

- A logistic support analysis (LSA) is conducted to study and analyse the reliability/availability/maintainability and testability parameters of a system during the design phase. The aim is to evaluate its capacity to be supported and integrated in the customer environment: the area of deployment; the operating profile of the ship; the specific maintenance policy; and the facilities and capacities onboard and in the shipyard
- Elements of the logistic support: defining the tasks and resources required to progress through the life-cycle of the system with maximum operational availability

## PrimeServ: Keeping ships fighting fit

In supplying naval projects, MDT also commits to supporting vessels to keep propulsion and power generation equipment fully operational for several decades. This task is undertaken by MAN

PrimeServ, our continually developing global after-sales infrastructure. Our PrimeServ organisation deploys an expanding network of the group's own service centres and authorised partners at strategic locations worldwide, offering dedicated products and services on a 24/7 year-round basis.

PrimeServ is primed to meet the special requirements of naval customers with respect to comprehensive documentation, personnel training and local content agreements; and in ensuring long-term engine availability through the supply of guaranteed, full life-cycle replacement parts and the retrofit of new technologies as appropriate.

Commitments include air freighting spares and dispatching specialist assistance at short notice to anywhere in the world, and devising and creating new solutions to replace obsolete assemblies and systems.

Over 100 PrimeServ service stations and authorised service partners in operation all over the world are equipped to:

- Provide prompt OEM-standard service based on experience and feedback from a vast population of engines and associated propulsion plant equipment in the field
- Advise and qualify customers to achieve improved availability and viability over the entire service life of their installations, from start-up to final decommissioning
- Swift and global supply of genuine, quality-assured MDT spare parts – within 24 hours for frequently requested items – and the replacement of obsolescent components, assemblies and systems by new solutions

Spares inventories are optimised and globalised, with stocks at strategic locations more precisely reflecting actual ordering patterns and trends. Spare parts kits incorporate all the parts required for a specific service or repair job, simplifying ordering and ensuring that no components are omitted.

Further support is offered by PrimeServ's engine management concept (EMC) service contracts, which comprise a range of after-sales service and maintenance agreements. Individually tailored contracts can cover both new and existing engines with a choice of 5, 10 or 15-year durations – or the life of the installation – and charging at a fixed monthly rate. Such specialist expertise enables customers to concentrate on their core activity.

An online service helps customers to optimise maintenance schedules via remote engine monitoring, diagnostics and calibration. The resulting condition-based maintenance (CBM) promotes high availability, increases operational safety, shortens downtimes and enhances engine performance.

High-grade product training and regular retraining for naval technicians is available at a growing network of PrimeServ Academies. Both theoretical and practical learning are delivered by specialists supported by a wide range of teaching aids that include computer simulators and an armoury of real engines, systems and sub-systems, assemblies and sub-assemblies.

Courses extend from tuition in basic servicing and repair skills to levels enabling naval technicians to acquire the confidence and qualifications needed to fully take over the operation, maintenance, repair and overhaul of MDT products.



# Summary

With the highest power density in its speed class (1,000 rpm) and outputs up to 10,000 kW, MDT's V28/33D medium speed engine is tailored for the efficient propulsion of offshore patrol vessels, warships and naval support vessels from single- or multi-engined diesel-mechanical or electric installations driving propellers or waterjets.

Experience-balanced ratios between power, compactness and light weight are complemented by a maintainability and reliability ensuring maximum avail-

ability, with quietness accompanied by low acoustic and thermal emissions and high shock resistance.

An impressive operating flexibility over the full load range with high fuel economy and low exhaust gas emissions is enhanced by sequential turbocharging and electronic fuel injection systems. A proven platform for high performance with low life-cycle costs, the engine is supported in the field through life by a dedicated global service and spare parts organisation.

## Annex A – General naval and coast guard references (MAN legacy engines: Paxman, Pielstick, Ruston etc)

Number of ships and type	Engine type	Application
2 Berlin class	2 × 12V32/40	Logistics/Supply Vessel
2 Canberra class	2 × 16V32/40	Amphibious
1 Dokdo class	4 × 16 PC2.5 STC	Amphibious
4 Endurance class	4 × 6RK215	Amphibious
2 Freedom class	2 × 16 PA6 B STC	Littoral Combat Ship
12 Halifax class	1 × 20 PA6	Frigate
2 Horizon class	2 × 12 PA6 B STC	Frigate
1 Juan Carlos I. class	2 × 16V32/40	Amphibious
2 Knud Rasmussen class	2 × 8L27/38	Offshore Patrol Vessel
14 Lewis and Clark class	2 × 9L48/60 + 2 × 8L48/60	Logistics/Supply Vessel
1 Mistral class	3 × 12V32/40	Amphibious
4 Protector class	2 × 12VVP185	Inshore Patrol Vessel
10 San Antonio class	4 × 16 PC2.5 STC	Amphibious
8 Scorpene class	2 × PA4	Submarine
7 SIGMA class	2 × 20 PA6 B STC	Corvette

## Annex B – V28/33D naval reference list

Customer / shipname	Engine type	Application
BAE Systems Australia/HMNZS Otago	2 × 12V28/33D	Offshore Patrol Vessel
BAE Systems Australia/HMNZS Wellington	2 × 12V28/33D	Offshore Patrol Vessel
BAE Systems/TTS Port of Spain	2 × 16V28/33D	Offshore Patrol Vessel
BAE Systems/TTS Scarborough	2 × 16V28/33D	Offshore Patrol Vessel
BAE Systems/TTS San Fernando	2 × 16V28/33D	Offshore Patrol Vessel
Damen Schelde Naval Shipbuilding/HNLMS Holland	2 × 12V28/33D	Offshore Patrol Vessel
Damen Schelde Naval Shipbuilding/HNLMS Zeeland	2 × 12V28/33D	Offshore Patrol Vessel
Damen Schelde Naval Shipbuilding/HNLMS Friesland	2 × 12V28/33D	Offshore Patrol Vessel
Damen Schelde Naval Shipbuilding/HNLMS Groningen	2 × 12V28/33D	Offshore Patrol Vessel

## Annex C – V28/33D commercial reference list

Customer / shipname	Engine type	Application
Fincantieri/Gotlandia II	4 × 20V28/33D	Fast Ferry
Incat/Millennium Tres	4 × 16V28/33D	Fast Ferry
HDW/My A	4 × 20V28/33D	Superyacht
Incat/Natchan Rera	4 × 20V28/33D	Fast Ferry
Incat/Natchan World	4 × 20V28/33D	Fast Ferry
Incat/Norman Arrow	4 × 20V28/33D	Fast Ferry
Incat/NB 067	4 × 20V28/33D	Fast Ferry
Austal/Leonora Christina	4 × 20V28/33D	Fast Ferry



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