Series 396 Engines

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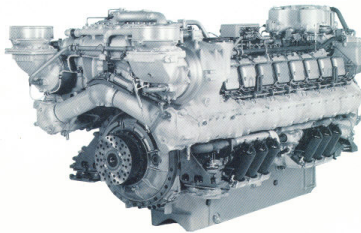
Series 396 Engines

The 396 series includes 8, 12 and 16-cylinder diesels with a cylinder displacement of 3.96 liters and power ratings ranging from 620 to 2,560 kW. These engines belong to the 331/396 engine family of which 11,500 units have already been delivered.

In the 396 power range a variety of design concepts are offered by various engine producers. The spectrum ranges from technically unsophisticated engines, with low power density, to volume-production engines designed initially for vehicular service and subsequently modified for alternative applications.

16V 396 TE04



Technical Data

		8V 396	12V 396	16V 396
No. of cylinders		8	12	16
Vee configuration		90°		
Bore/stroke	mm	165/185		
Displacement, cylinder	liters	3.96		
Displacement, total	liters	31.6	47.5	63.3
Direction of rotation		c.c.w.		
Starting method		electric (air start optional)		

Development of the 396 series, however, was not only aimed at converting technical knowledge to high performance but also took the various application requirements into consideration right from the start.

Use of state-of-the-art computation, simulation and research methods, together with the expertise accrued during more than 75 years of high-speed engine R&D, produced these compact, high-performance diesels which are acknowledged to be world leaders in their field and offer the operator all the benefits of modern engine technology.

Whether short-term maximum-power service, heavy continuous duty or strenuous alternating-load operation, the design and construction of the 396 engines meet all requirements of the four main application areas given below:

- ☐ Marine propulsion
- ☐ Energy supply
- ☐ Railroad applications
- ☐ Heavy vehicle drive

Irrespective of service conditions and duty profile, the basic engine configurations are largely identical. This means:

- ☐ The numbers produced allow the employment of modern CNC machinery, a production method which ensures a high degree of flexibility and consistently high quality.
- ☐ The demands for simple maintenance and servicing can be economically met by parts commonality.
- ☐ Product maturity is guaranteed by utilization of the operational data achieved with all in-service engines.

The basic engines are converted to operational units by the addition of accessory kits which are matched to the specific application. The advantages thus gained are:

- ☐ By combination of only a few components the engines can meet the requirements of a large number of applications.
- ☐ The accessories are developed and tested together with the engines which guarantees functional integrity and reliability.
- ☐ Constructional and technical integration of accessories fulfills the requirements for compactness and maintenance simplicity.

The characteristic properties inherent to the 396 series can be summarized in two groups:

Optimum Performance

- ☐ '396' engines occupy a leading position in power density, i.e. they offer a combination of maximum power, low weight and compactness.
- ☐ Among technically comparable competitors, these engines exhibit a particularly broad performance map by virtue of outstanding MTU technology.

Advanced and Economical Solutions

- ☐ Continued development ensures the latest state of the art in diesel technology.
- ☐ The user receives a maximum of operating economy and reliability for his money.

Series 396 Advantages

Economy

Consistent utilization of technical knowledge and extensive field feedback evaluation contribute significantly to reducing life-cycle costs. Three features are particularly worth mentioning as they are decisive factors for operating economy:

- ☐ Long-proven, application-related maintenance concepts translate into maintenance simplicity and enhanced economy.
- ☐ Preventive maintenance ensures a high degree of operational availability and avoids costly downtime.
- ☐ Low consumption figures throughout the entire operating range. Thus, fuel and oil costs, which constitute a major element of operational expense are kept to a minimum.

Integrated Accessories and Standardized Interfaces

MTU offers ready-to-install power units which incorporate the following features:

- ☐ No need for accessory equipment selection and match-up.
- ☐ Single-source MTU responsibility for the complete plant including peripheral equipment.

Minimum Weight and Compact Dimensions

These two essential traits of an efficient propulsion system provide the following benefits:

- ☐ Reduced transportation, handling and storage costs
- ☐ Simple foundations, reduced machinery space requirements, small installation openings
- ☐ Fulfillment of stringent power, weight and space demands.

Family Design Concept

The 396 family design concept, which involves three engine configurations (8V, 12V, 16V) and two power levels (140 or 160 kW/cylinder), offers the following striking advantages:

- ☐ Interface and parts commonality enables rationalization and systemization in application and installation engineering
- ☐ The employment of differently rated engines from a single family for a complete machinery pool significantly reduces the logistical requirements, from personnel training right through to parts provisioning.

MTU's Scope of Services

Along with the engines and system components, MTU offers a comprehensive package of services which reduce the technical and logistical risks incurred by shipbuilders and packagers, and are the operator's best guarantee of operational availability and plant value retention. The entire scope of services is subdivided into two areas:

Project Management

This covers all activities from the planning phase up to on-site commissioning.

- ☐ Individual consultancy and detailed proposals.
- ☐ Coordination and/or implementation of systems management and systems engineering.
- ☐ Subcontractor supervision and control.
- ☐ Prime contractor responsibility.

Product Support

Comprehensive Product Support is of paramount importance to operational availability and plant upkeep. MTU offers a broad range of services which, apart from maintenance assistance, parts support and documentation, include extensive application engineering, personnel training and workshop planning. Product Support is an essential element in MTU's sales and service activities and is known to meet all the expectations invested in a leading international company.

Technical Description

Series 396 engines are available in three different versions:

- TB 04, external charge air cooling (intercooler in raw water circuit)
- TC 04, internal charge air cooling (intercooler in engine coolant circuit)
- TE 04, internal charge air cooling (intercooler in engine coolant circuit; split-circuit coolant system)

Design Characteristics

- ☐ 4-stroke cycle
- ☐ 90° Vee configuration
- ☐ Direct injection
- ☐ Liquid cooling
- ☐ Exhaust turbocharging
- ☐ Charge air cooling

Description of Major Components

Single-unit grey, or nodular, cast iron crankcase with integrated gearcase at the timing end; light-alloy oil pan; bolted-on flywheel housing with SAE No. 0 flange.

Individual grey cast iron cylinder heads with replaceable valve seat inserts; two inlet and two exhaust valves per cylinder head, all valves provided with "Rotocap" valve rotators; centrally located fuel injectors with oil-tight separation between lube oil and injector chambers.

Forged crankshaft, finished all over and supported in sleeve bearings; bolted-on counterweights; axial alignment by grooved ball bearing; vibration damper as required by torsional vibration computation.

Forged connecting rods, finished all over, angle-split and serrated at the big end; arranged side-by-side on the crankpins to serve two opposing cylinders.

Composite pistons with light-alloy skirt and bolt-on steel crown; internal oil cooling via fixed oil spray nozzles; two compression rings in piston crown, one oil control ring located between crown and skirt; floating piston pin.

Valve actuation by two camshafts arranged in the Vee, roller tappets, pushrods and rocker arms; valve clearance adjustment by adjusting screws located in the rocker arms.

Direct fuel injection with block-type injection pump (16V, 2 pumps) located in the Vee; multi-hole fuel injectors; Cylinder Cutout (if required); gear-type fuel delivery pump; fuel duplex filter.

Redundant electronic MTU governor comprising a microprocessor logic and an electromagnetic actuator.

Forced-feed lube oil system; oil flow from gear-type pump via heat exchanger, fine filter and back-up filter to main oil gallery for distribution to lubrication points and piston cooling oil spray nozzles.

Closed engine coolant system; coolant flow from centrifugal pump to engine coolant jackets; thermostatic control; recooling by engine-mounted heat exchanger or fan cooler; thermostatically controlled hydraulic fan drive possible with fan cooler.

Engine shutdown via solenoid acting on injection pump control rack; additional, independent, engine speed-sensitive emergency shutdown system uses air shut-off flaps to block the engine's air supply.

In addition, the 396 series is distinguished by a variety of attractive technical innovations in turbocharging, fuel injection, combustion and cooling which in view of the advantages offered, are worthy of special mention:

MTU Sequential Turbocharging

Sequential Turbocharging is used, among other applications, for marine propulsion engines facing high power requirements in the lower and medium speed ranges. It incorporates two or three turbochargers with automatic ON/OFF control as a function of engine speed and power requirement and turbocharger maximum efficiency. In addition to increased torque, this system also achieves reduced fuel consumption and lower exhaust temperatures.

VHP Fuel Injection

This very high pressure injection method permits short-duration injection and optimum fuel atomization, and is a requisite to ensuring precise combustion timing for optimization of ignition pressure, fuel consumption and exhaust emissions.

Cylinder Cutout and Charge Transfer

Cylinder Cutout (no fuel injection into selected cylinders) is employed on engines operating under varying speed conditions (low idling speed). The system enhances combustion at idle, thus shortening the warm-up phase and avoiding white smoke from unburned fuel.

Charge Transfer (standard on 12V and 16V 396 TB84/94) is functionally linked up with Cylinder Cutout. With the engine idling, air compressed in the non-firing cylinders is transferred to the firing ones to increase the volume of air available for combustion.

TE Split-Circuit Coolant System

The 396 TE engine features an innovative split-circuit coolant system with a power-dependent subcircuit to cool the combustion air. To achieve this, the coolant flow from the engine is split in two: approximately two thirds proceed through a "high-temperature circuit" and return directly to the engine inlet, while the remainder is fed into a thermostatically controlled "low-temperature circuit". During idling or low-load operation, the thermostat allows heated coolant to bypass the recooler on its way to the intercooler in order to warm-up the combustion air and thus prevent white smoke in the exhaust.

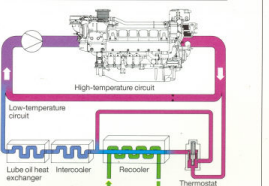
The annular slide valve in the thermostat remains in its initial position until increasing power raises coolant temperature, causing the wax pellet in the thermostat to expand. Gradual closing of the bypass line now directs the coolant stream through the recooler. As a result, coolant entering the intercooler is at a low temperature which, in turn, provides for a high combustion air volume and, consequently, maximum engine power.

After flowing through the intercooler and the oil heat exchanger, "cold" coolant rejoins the uncooled high-temperature circuit, thereby cooling the total volume flow before it reenters the engine.

TE Coolant System, Functional Diagram

The split-circuit coolant system of the 396 TE 04 ensures optimum engine performance throughout the entire power range. At idling speed, the air supply is heated to achieve complete fuel combustion; in the medium range and at full load, conditions are optimized for high power output while thermal stress on engine components is kept low.

Coolant system, functional diagram

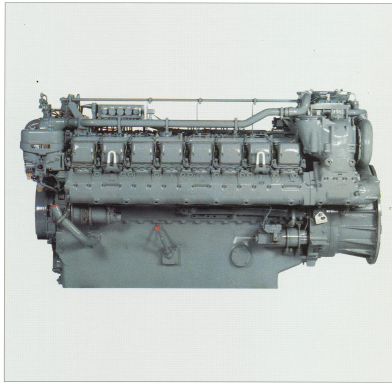


Typical Applications

The accompanying illustrated service examples, though completely unlike, have one thing in common: High demands for operating economy and reliability – and that's why they all feature MTU's compact, high-performance 396 engines.

396

Series 396
Rail Vehicles 590 kW–1840 kW



16V 396 TC

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Power Ratings (kW)

Application Group	2A
Engine Model	UIC Rated Power (Fuel Stop Power) ① 1800 rpm
6V 396 TC14	590
8V 396 TC14	785
12V 396 TC14	1180
16V 396 TC14	1570
8V 396 TB14/TE14	920
12V 396 TB14/TE14	1380
16V 396 TB14/TE14	1840

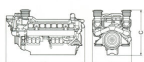
Application Group
2A Rail traction

Rating Definition
① Net brake power per DIN/ISO 3046.

Reference Conditions

Engine model		396 TC	396 TB	396 TE
Intake air temperature	°C	25	25	25
Charge-air coolant temperature	°C	–	55	47
Barometric pressure	mbar	1000	1000	1000
Altitude above sea level	m	100	100	100

Dimensions, Weights



Engine Model	A	B	C	Weight①
	mm	mm	mm	kg
8V396 TE14	2130	1540	1540	2890
12V396 TE14	2600	1540	1700	3900
16V396 TE14	3060	1540	1750	5000
6V396 TC14	1690	1450	1410	2010
8V396 TC14	1830	1490	1410	2520
12V396 TC14	2430	1530	1540	3510
8V396 TB14	2130	1580	1530	3010
12V396 TB14	2600	1580	1700	4040
16V396 TB14	3060	1580	1750	5150

① Basic-configuration engine, dry

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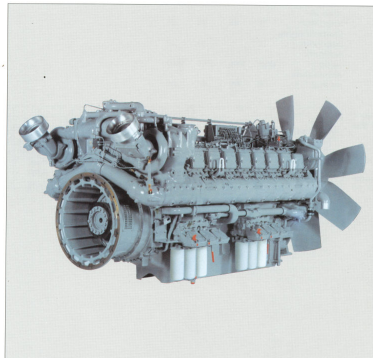
396

Series 396
Vehicular Applications 785 kW–2000 kW



16V 396 TC

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Power Ratings (kW)

Application Group	5A	
Engine Model	Fuel Stop Power ① ②	
	1900 rpm	2000 rpm
8V 396 TC44	785	–
12V 396 TC44	1180	–
16V 396 TC44	1570	–
8V 396 TB44/TE44	920	–
12V 396 TB44/TE44	1380	–
16V 396 TB44/TE44	1840	–
8V 396 TB44 L	–	1000
12V 396 TB44 L	–	1500
16V 396 TB44 L	–	2000

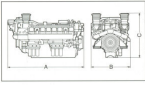
Application Group
5A Heavy-vehicle propulsion

Rating Definition
① Net brake power per DIN/ISO 3046.
② Radiator fan power requirement not deducted.

Reference Conditions

Engine model		396 TC	396 TB	396 TE
Intake air temperature	°C	25	25	25
Charge-air coolant temperature	°C	–	50	47
Barometric pressure	mbar	1000	1000	1000
Altitude above sea level	m	100	100	100

Dimensions, Weights



Engine Model	A	B	C	Weight[1]
	mm	mm	mm	kg
8V 396 TC44/TE44	2130	1540	1520/1540	2840/2890
12V 396 TC44/TE44	2600	1540	1600/1700	3850/3900
16V 396 TC44/TE44	3060	1540	1650/1750	4950/5000
8V 396 TB44/TB44 L	2130	1580	1540	3010
12V 396 TB44/TB44 L	2600	1580	1700	4040
16V 396 TB44/TB44 L	3060	1580	1750	5150

[1] Basic-configuration engine, dry

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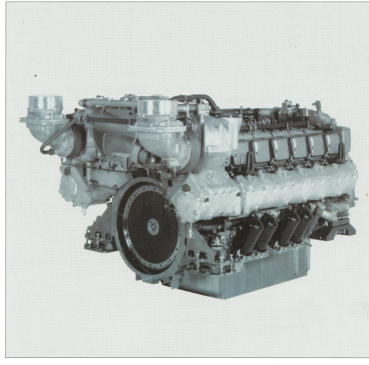
396

Series 396
Stationary Power Generation 540 kW–1965 kW



12V 396 TE

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Power Ratings (kW)

Application Group	3B		3C		4C
Engine Model	Continuous Power ①②				Continuous Power ①
	50 Hz 1500 rpm	60 Hz 1800 rpm	50 Hz 1500 rpm	60 Hz 1800 rpm	1800 rpm
8V 396 TC34 R	–	–	670	–	–
12V 396 TC34 R	–	–	1000	–	–
16V 396 TC34 R	–	–	1330	–	–
6V 396 TB34 R	–	–	540	–	–
8V 396 TB34 R	–	–	725	–	–
12V 396 TB34 R	–	–	1090	–	–
16V 396 TB34 R	–	–	1450	–	–
6V 396 TC34	–	–	575	–	–
8V 396 TC34	–	–	770	900	–
12V 396 TC34	–	–	1155	1350	–
16V 396 TC34	–	–	1540	1800	–
6V 396 TB34	–	–	625	–	–
8V 396 TB/TE34[h]	725	835	835	980	890
12V 396 TB/TE34[h]	1090	1250	1255	1475	1340
16V 396 TB/TE34[h]	1450	1670	1675	1965	1785
6V 396 TC34 D*	–	–	900	–	–
12V 396 TC34 D*	–	–	1350	–	–
16V 396 TC34 D*	–	–	1800	–	–
8V 396 TB34 D/TE34 D*[h]	–	–	980	–	–
12V 396 TB34 D/TE34 D*[h]	–	–	1475	–	–
16V 396 TB34 D/TE34 D*[h]	–	–	1965	–	–

* with 1910 / 1500 rpm reduction gearing

Application Groups

3B Electric power generation, continuous duty (75% average utilization based on operating time)

3C Electric power generation, continuous duty (annual limit)

4C Industrial-machinery drive; Short-time operation: Fire pumps, emergency water supply

Reference Conditions

Engine model		396 TC	396 TE	396 TB
Intake air temperature	°C	25	25	25
Charge-air coolant temperature	°C	–	47	50
Barometric pressure	mbar	1000	1000	1000
Altitude above sea level	m	100	100	100

Rating Definition

① Continuous power is net brake power per DIN/ISO 3046

② Design power for electric power generation per DIN 6280/ISO 8528 (overload capability 10%)

[h] TB or TE, dependent on application and site conditions

Dimensions, Weights

Engine Model	A	B	C	Weight[1]
	mm	mm	mm	kg
8V 396 TE34/TE34 D	2130	1540	1530	2840/3540
12V 396 TE34/TE34 D	2600	1540	1700	3850/4600
16V 396 TE34/TE34 D	3060	1540	1750	4950/5760
6V 396 TB34, 34 R/TC34	1690/1590	1460	1430	2080/2010
8V 396 TB34, 34 R/TC34, 34 R	1920/1820	1440	1430	2590/2520
12V 396 TB34, 34 R/TC34, 34 R	2440/2340	1530	1550	3600/3510
16V 396 TB34, 34 R/TC34, 34 R	2900/2800	1530	1650	4830/4700
8V 396 TB34 D/TC34 D	2150/2050	1440	1430	3160/3090
12V 396 TB34 D/TC34 D	2600/2500	1530	1550	4160/4070
16V 396 TB34 D/TC34 D	3160/3060	1530	1650	5350/5220

[1] Basic-configuration engine, dry

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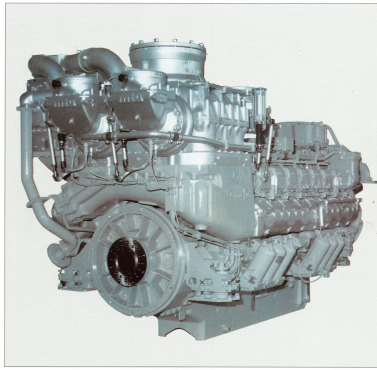
396

Series 396 TB
Marine Main Propulsion 1920 kW–2560 kW



16V 396 TB

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Power Ratings (kW)

Application Group	1D	1DS
Engine Model	Fuel Stop Power	
	2000 rpm	2100 rpm
16V 396 TB84	2240	–
12V 396 TB94	–	1920
16V 396 TB94	–	2560

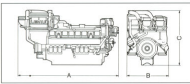
Application Groups
1D Fast vessels with medium load factors
1DS Fast vessels with low load factors

Rating Definition
Fuel stop power, net brake power per DIN/ISO 3046

Reference Conditions

Intake air temperature	°C	25
Raw water temperature	°C	25
Barometric pressure	mbar	1000
Altitude above sea level	m	100

Dimensions, Weights



Engine Model	A	B	C	Weight[1]
	mm	mm	mm	kg
12V 396 TB94	3040	1480	1910	4685
16V 396 TB84, 94	3550	1480	1960	5725

[1] Basic-configuration engine, dry

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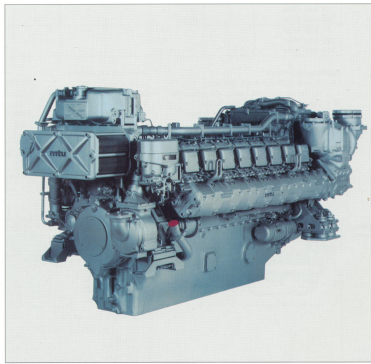
396

Series 396 TE, TC
Marine Main Propulsion and Ship's Services
640 kW–2240 kW



16V 396 TE

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Power Ratings (kW)

Application Group	1A	1B	1D	1DS	3A		3C	
Engine Model	Fuel Stop Power ①				Continuous Power ②			
	1600 rpm	1900 rpm	1900 rpm	2000 rpm	50 Hz 1500 rpm	60 Hz 1800 rpm	50 Hz 1500 rpm	60 Hz 1800 rpm
8V 396 TE54/TC54	–	–	–	–	680/640	790/750	790/750	925/870
12V 396 TE54/TC54	–	–	–	–	1030/960	1200/1125	1185/1130	1390/1310
16V 396 TE54/TC54	–	–	–	–	1360/1280	1580/1500	1580/1500	1850/1740
8V 396 TE64	680	–	–	–	–	–	–	–
12V 396 TE64	1020	–	–	–	–	–	–	–
16V 396 TE64	1360	–	–	–	–	–	–	–
8V 396 TE74	–	840	–	–	–	–	–	–
12V 396 TE74	–	1260	–	–	–	–	–	–
16V 396 TE74	–	1680	–	–	–	–	–	–
8V 396 TE74 L	–	1000	–	–	–	–	–	–
12V 396 TE74 L	–	1500	–	–	–	–	–	–
16V 396 TE74 L	–	2000	–	–	–	–	–	–
8V 396 TE84	–	–	1000	–	–	–	–	–
12V 396 TE84	–	–	1500	–	–	–	–	–
16V 396 TE84	–	–	2000	–	–	–	–	–
8V 396 TE94	–	–	–	1120	–	–	–	–
12V 396 TE94	–	–	–	1680	–	–	–	–
16V 396 TE94	–	–	–	2240	–	–	–	–

Application Groups

1A Vessels with unlimited operating range and/or unrestricted continuous operation

1B Fast vessels with high load factors

1D Fast vessels with medium load factors

1DS Fast vessels with low load factors

3A Electric power generation, continuous duty (no restrictions)

3C Electric power generation, continuous duty (annual limit)

Reference Conditions

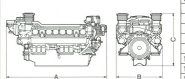
Application groups		1B,1D,1DS	1A,3A, 3C
Intake air temperature	°C	25	45
Raw water temperature	°C	25	32
Barometric pressure	mbar	1000	1000
Altitude above sea level	m	100	100

Rating Definition

① Fuel stop power, net brake power per DIN/ISO 3046

② Design power for electric power generation per DIN 6280/ISO 8528 (overload capability 10%).

Dimensions, Weights



Engine Model	A	B	C	Weight[1]
	mm	mm	mm	kg
8V 396 TE54/TC54	2300	1540	1520	2840
8V 396 TE64	2290	1540	1520	2890
8V 396 TE74	2300	1540	1520	2890
8V 396 TE74 L, 84, 94	2330	1540	1520	2890
12V 396 TE54/TC54	2830	1540	1600	3850
12V 396 TE64	2810	1540	1600	3900
12V 396 TE74	2830	1540	1600	3900
12V 396 TE74 L, 84, 94	2870	1540	1600	3900
16V 396 TE54/TC54	3350	1540	1650	4950
16V 396 TE64	3350	1540	1650	5000
16V 396 TE74	3350	1540	1650	5000
16V 396 TE74 L, 84, 94	3430	1540	1750	5000

[1] Basic-configuration engine, dry

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