MARC® Steam Turbines

The modular turbine concept

Engineering the Future – since 1758.

MAN Diesel & Turbo

Originating from the Blohm+Voss shipyard, MAN Diesel & Turbo combines experience and tradition with state-of-the-art technology in its Hamburg workshop.

The first steam turbines were manufactured by us in 1907 under the name of Blohm+Voss – initially for ships built in the shipyard and subsequently for electric power generation in power plants. From 1952 on, the company concentrated on the development and manufacture of industrial steam turbines. Our list of worldwide references encompasses more than 2,000 generator drives for electricity generation.

Several renowned companies and utilities use our turbines in:

- industrial power plants
- co-generation plants
- waste incineration plants
- biomass power plants
- combined-cycle plants

Our advanced production facility in Hamburg features powerful machine tools and covers more than 27,000 m^2. The quality management system is certified according to DIN EN ISO 9001. Centrally located in the free port of Hamburg, MAN Diesel & Turbo offers ideal transport connections, even for large component transport.

The Concept

In the development of MAN Diesel & Turbo steam turbines, our top priority has always been to deliver the operational safety, efficiency and availability according to our customers needs. During the 15 years since its introduction, the MARC® (Modular Arrangement Concept) steam turbines family has proven these qualities in numerous facilities, and is continuously developed further. The modular turbine concept allows for a variable arrangement of the main components and enables the overall assembly to be set up in line with individual requirements.

MARC® Turbines
Modular **AR**rangement **C**oncept

MARC® 1	MARC® 2	MARC® 4	MARC® 6
power range 1.5 up to 3 MWe	power range 4 up to 10 MWe	power range 9 up to 20 MWe	power range 16 up to 40 MWe
max. flange diameter Live steam: up to 125 Exhaust: up to 700	max. flange diameter Live steam: up to 200 Exhaust: up to 1,200	max. flange diameter Live steam: up to 250 Exhaust: up to 1,500	max. flange diameter Live steam: up to 300 Exhaust: up to 2,400
max. live steam conditions 65 bar(a) / 450 °C	max. live steam conditions 90 bar(a) / 520 °C	max. live steam conditions 120 bar(a) / 520 °C	max. live steam conditions 120 bar(a) / 530 °C
12,000-14,000 min^{-1}	10,000-12,000 min^{-1}	7,000-10,000 min^{-1}	5,000-7,000 min^{-1}

The turbine/generator unit comprises the following modules:

- Steam turbine
- Gear
- Generator
- LP lubrication oil system
- HP control oil system
- Instrumentation and control system

The lubrication oil module, the control oil module (in some cases a combination of both), and the I&C module can be freely grouped around the unit.

Benefits of the modular concept:

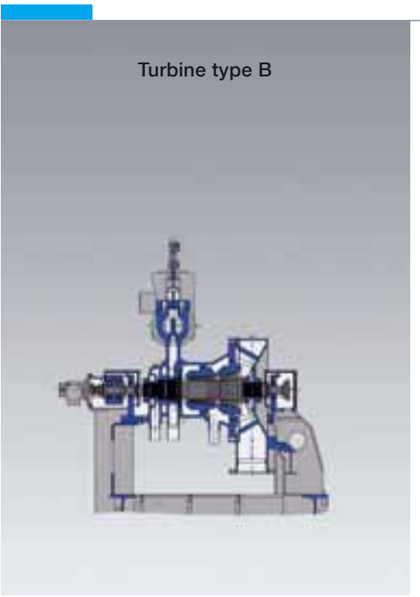
- Proven turbine design with robust technology and high availability
- Very high efficiency based on optimized turbine design
- Use of proven system modules for lubrication oil and control oil
- Compact I&C module as black box for connection via a bus system to the central control system
- Low investment cost
- Adaptable, space-saving arrangement

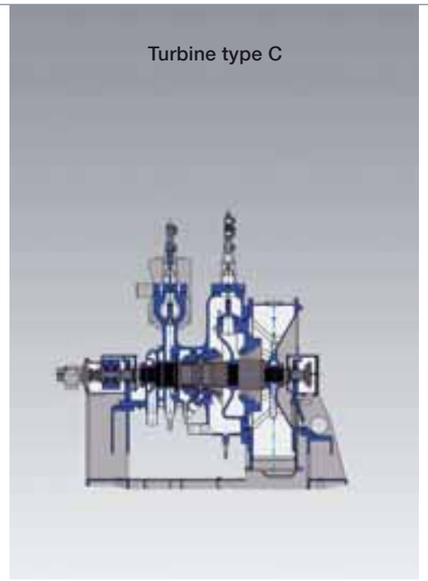
Four different turbine sizes cover the performance range from 1.5 MW to 40 MW. The MARC® production program includes backpressure and condensation turbines that can also be fitted with extraction and bleed ports.

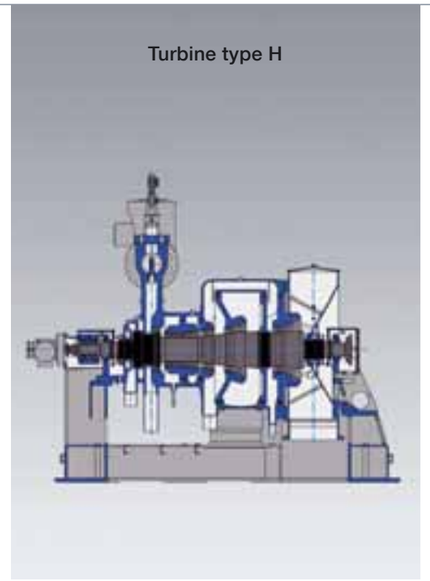
Explanation of type codes – MARC® x - A B C

x – Code for turbine size
A – Code for turbine type
  C: Condensing
  B: Backpressure
  H: Heating
B – Number of controlled extractions
C – Number of bleed ports

Module: Turbine







Turbine type B:
Backpressure

Backpressure turbines are used as generator drive units in combined heat and power plants and for on-site electricity generation of industrial facilities. They are also used in co-generation applications.

Turbine type C:
Condensing

The applications for condensation turbines range from turbo generators for industrial power plants and waste incineration plants to chemical and petro-chemical production facilities. The extraction steam is typically used for heating, production purposes and feed water prewarming. To achieve a good part-load behavior, the HP part is provided with nozzle group control. Depending on the operating conditions the LP part is provided with throttle control.

Turbine type H:
Heating

A typical application for heating turbines is in power plants for electricity and heat generation. The special feature of this type of turbine is the double-flow exhaust steam section. The split steam co-generation ensures optimal pressure levels for the generation of heating water.

In industrial steam turbines, portions of the available steam are often extracted for production purposes, heating steam networks or for regenerative feed water heating. In addition to multiple bleed ports, controlled extraction can also be provided. The MARC® series allows turbine components to be optimally designed to meet individual requirements based on pressure levels and extraction volumes.

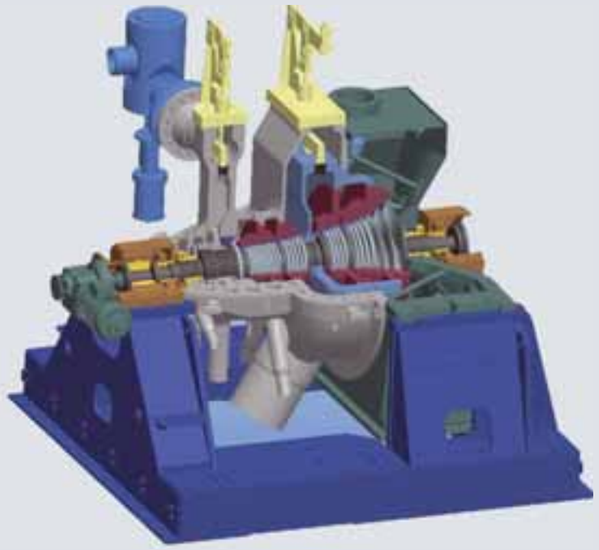
Depending on live-steam conditions and the specified operating mode, blading is adjusted to suit the specific requirements. The exhaust steam nozzle is a welded structure and can be positioned upward or downward.

MAN Diesel & Turbo steam turbines are designed and manufactured for maximum operational safety and reliability.

As the highest thermal load occurs on steam carrying parts when loads change, casings, stator blade carriers and inner casings therefor have been developed for maximum elasticity when subjected to thermal expansion and contraction.

The following design features apply to all turbine types:

- Multi-stage reaction-type design
- Nozzle group control
- Largely symmetrical temperature distribution on the circumference for all cross-sections and for all load categories
- Integrally forged rotor
- Labyrinth seals for the shaft between rotor and casing



Turbine rotor

Reaction turbines are constructed in a drum-type design. The turbine rotors, the balance piston, the impulse wheel disc and the subsequent drum parts are integral forgings of high-temperature material. The rotor design is based on advanced calculation methods to meet the highest demands for smooth and non-resonant operation. The bladed rotors are statically and dynamically balanced in an advanced vacuum balancing unit so that shaft vibrations over the full speed range are significantly below specified values, e.g. ISO 10816.

Bearings

The journal bearings are of the multi-face sleeve or tilting pad type. Hydrodynamic oil wedges distributed evenly along the circumference keep the rotor in a stable position.

The axial forces resulting from pressure differences in the blading are mainly compensated by the balance piston. A double-sided segmental thrust bearing accommodates the residual thrust and frictional force of the coupling.

Blading

The blading, consisting of control stage and reaction component, converts the potential energy of high-pressure steam into mechanical energy.

Multi-stage blading in the reaction component ensures high operational safety and economic efficiency based on:

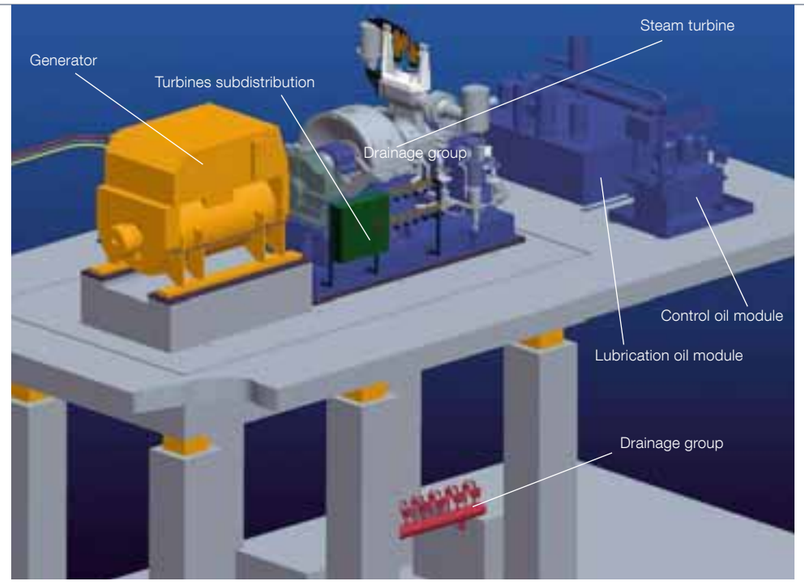
- high resistance of stator vanes and rotor blades to mechanical and thermal stress during operation
- high section modulus to prevent vibration
- low flow losses in the blading over a wide operating range

The stator vanes and rotor blades have the same profile, which was theoretically and experimentally investigated in great detail during its development. A significant feature of part-load operation is the inlet flow angle, which differs from the one during normal inlet flow conditions.

This results in the need for a very large smooth inlet flow angle range, which ensures high part-load efficiency even under operating conditions that differ from the rated load. These requirements are fully met by the overpressure profile employed by us.

Gap and secondary losses in backpressure turbines and high-pressure components of condensation turbines are minimized thanks to the use of shrouds. The rotor blade including the blade root and the shroud is milled from a single piece. After blading the rotor, the shroud is machined to take its final shape. In stages where gap losses are small, the blade ends are not provided with a shroud but sharpened on one edge.

Module: Gearbox and Generator
Lubrication Oil- and Control Oil System



Lubrication oil module

Hydraulic aggregate

Control mechanism

Depending on the live-steam condition and the specified operating mode, the operator can select between nozzle group control with or without bypass and throttle control. In nozzle group control, the steam control valves of MAN Diesel & Turbo turbines are of the diffuser type. Small valve dimensions allow a large number of valves and nozzle groups, so throttling losses can be kept very low, even in the part-load range. The conical shape of the valve has been adjusted for optimum flow. Valve spindles, valve cone and valve bar are made of high-temperature steel. These component parts undergo special surface treatments for long service lives.

The small valve dimensions allow the valves to be actuated directly. This so-called group actuation is a compact and reliable solution. The actuator is a single-acting hydraulic cylinder that works against spring force and is supplied with 160 bar oil pressure from the control oil system. In the event of a trip or shut-down from full load, the valves are closed by the preloaded spring. This protects the turbine plant if malfunctions should occur. If the pressure in the control oil system drops, both the control valves and all trip valves will be closed automatically as they work on the same principle (single-acting hydraulic piston against a preloaded spring). This means double safety for the turbine and the steam system.

A lever system for parallel motion of both valve spindles precisely transmits changes in controller output onto the valve bar and, depending on the valve lift, onto one or more valve cones. The articulated parts are corrosion-free and maintenance-free components manufactured from self-lubricating materials. The valve spindles are sealed by maintenance-free glands of precompressed graphite spiral gaskets and reinforced carbon guide rings.

Gearbox

Gearboxes used in industrial steam turbine construction allow for optimum adjustment of turbine speed to the particular operating conditions. The already low mechanical losses of the gearbox are more than compensated by the higher turbine efficiency that can be achieved. The gearbox used throughout the MARC® series is of the spur gear type.

Generator

Generators from renowned European manufacturers complete the product range.

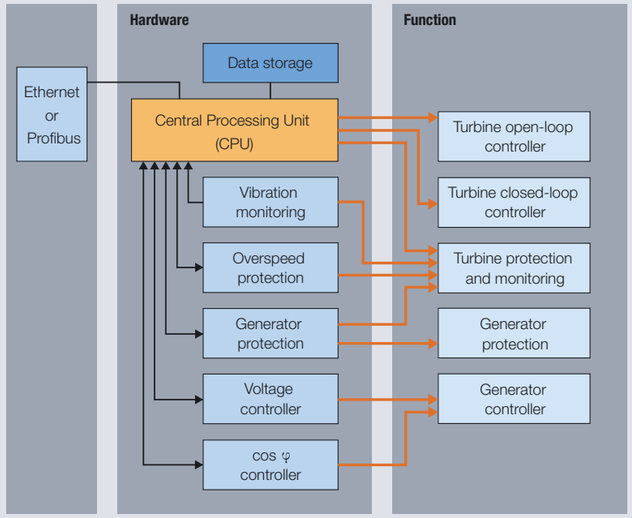
Lubrication oil system

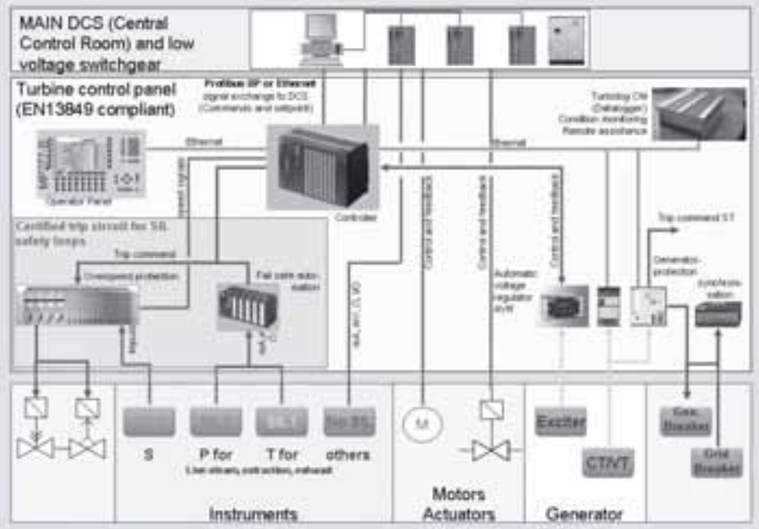
The lubrication oil system is a compact unit designed as a low-pressure oil system to supply the turbine, the gearbox, and the generator.

Control oil system

The control oil system, like the lubrication oil system, is a compact modular unit. In addition to the control valves, the system also supplies the live-steam trip valve, the extraction trip flap valves and, where applicable, the control valves in the bleed port with 160 bar system oil pressure.

Module: Instrumentation and Control System





Control cabinet

The turbine control cabinet is a compact unit that can be arranged variably within the turbine unit. All control and protective functions for the turbine and the generator are integrated in a single control cabinet with a user control interface arranged on the front. This saves space and ensures minimum installation and commissioning times – all desired signals can be sent to a host control system via a data bus (e.g. Ethernet or PROFIBUS) and commands and set-point values can be received from there.

Control system

To maintain flexibility when meeting the varied process requirements, the turbine control system is implemented in a modern programmable logic control (PLC) system. The comprehensive range of modules allows flexible and user-friendly handling, provides a wide range of communication gateways to other systems, and easily facilitates any expansion necessary to meet additional requirements. Start-up, shut-down and operation of the entire turbine unit are completely automated in the control system, with ease of use as a key feature.

Control

Based on our many years of experience in the field of steam turbine unit control, we have developed a digital steam turbine controller. The integration of this regulator in the existing control system hardware enables a consistent control concept and optimal integration of the regulator without additional interfaces. The steam turbine controller is a powerful and flexible device.

Operation

The steam turbine can be operated either via a central I&C system or locally via the operator panel on the control cabinet. In the automatic mode only the turbine start/stop commands and input of the set-point values are required. All operating states and fault messages are displayed locally and supplied to the central control system via a bus system.

Safety

All turbine units are provided with extensive safety equipment that safely shuts down the steam turbine and generator when critical conditions are reached. The classification of safety criteria is in accordance with IEC 61508. Measuring systems, trip and alarm criteria are specified such that an optimum balance between safety and availability is achieved.

Remote access

A data logger with ISDN interface enables remote support for your operating personnel. Important operating data is saved to a data logger and can be analyzed by our service team, while our service engineers have direct access to the control system and control panel. This enables us to provide you with quick and cost-effective support.

Quality Assurance

The first priority in turbine manufacture is to ensure that all components meet high quality standards.

Continuous quality control is ensured by the implemented ISO 9001 quality management system.
The turbine and the base frame are erected in-house and the internal piping is installed.

Gearbox, generator and oil modules are tested according to strict quality standards on the manufacturer's premises, and are allocated and properly connected to the turbine on the job site.

To meet the requirements of smooth running, operational safety and availability, each turbine rotor is subjected to high-speed dynamic balancing and overspeed testing in a vacuum-balancing and overspeed test facility before installation.

Service and Installation

Our experienced Turbine Service Department ensures the correct installation of the turbine units supplied, including commissioning and trial operation – in parallel operating personnel receive the necessary training.

The availability and lifespan of equipment is primarily dependent on maintenance and servicing. We offer you a full service package to help you cope with the tasks ahead and to ensure maximum plant availability. Whether it's a new installation, repair or modernization, our specialized personnel are committed to professional on-time service delivery. The Service Department is available round the clock in order to get your equipment working again as soon as possible.

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