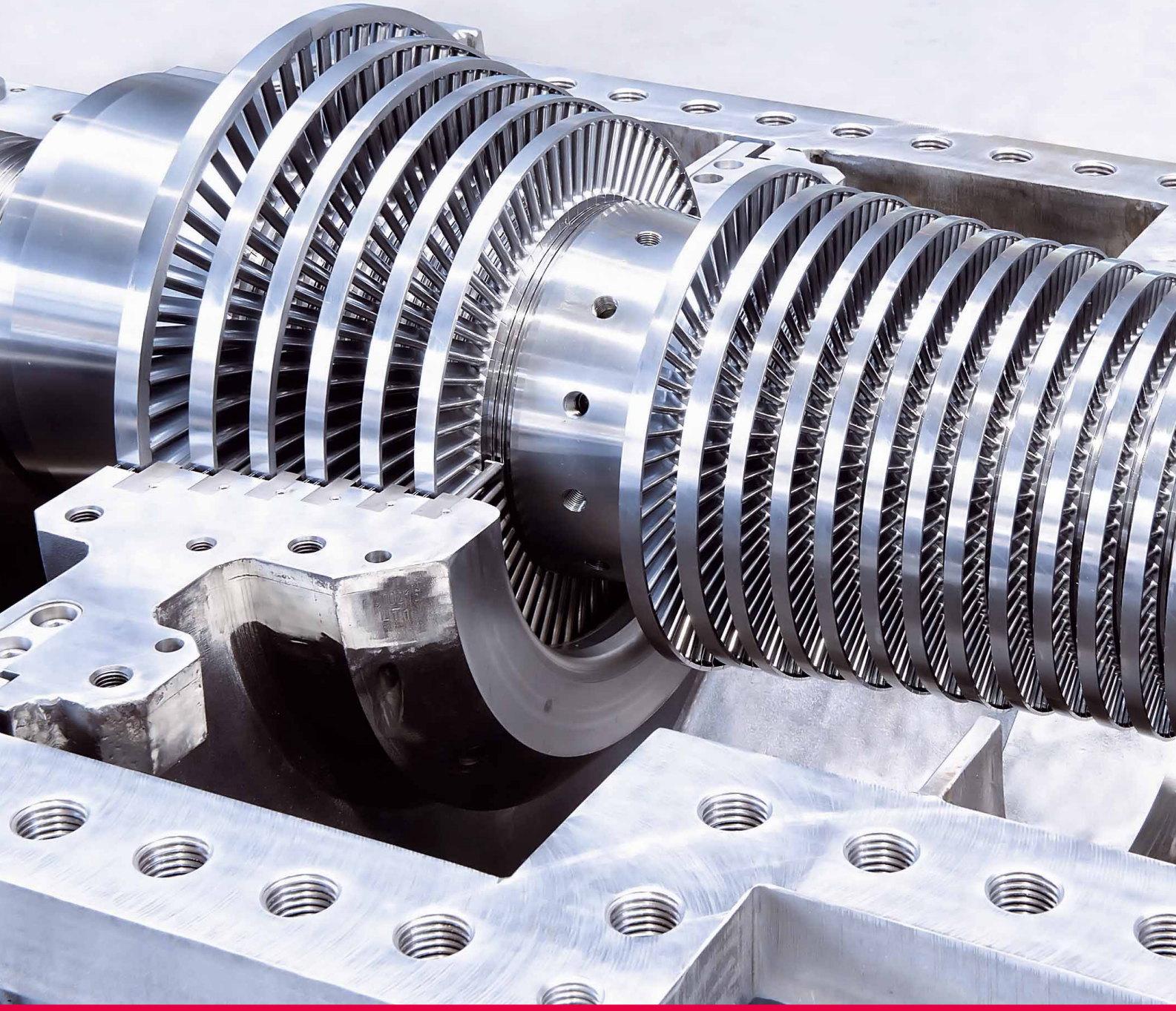
MARC® Steam Turbines

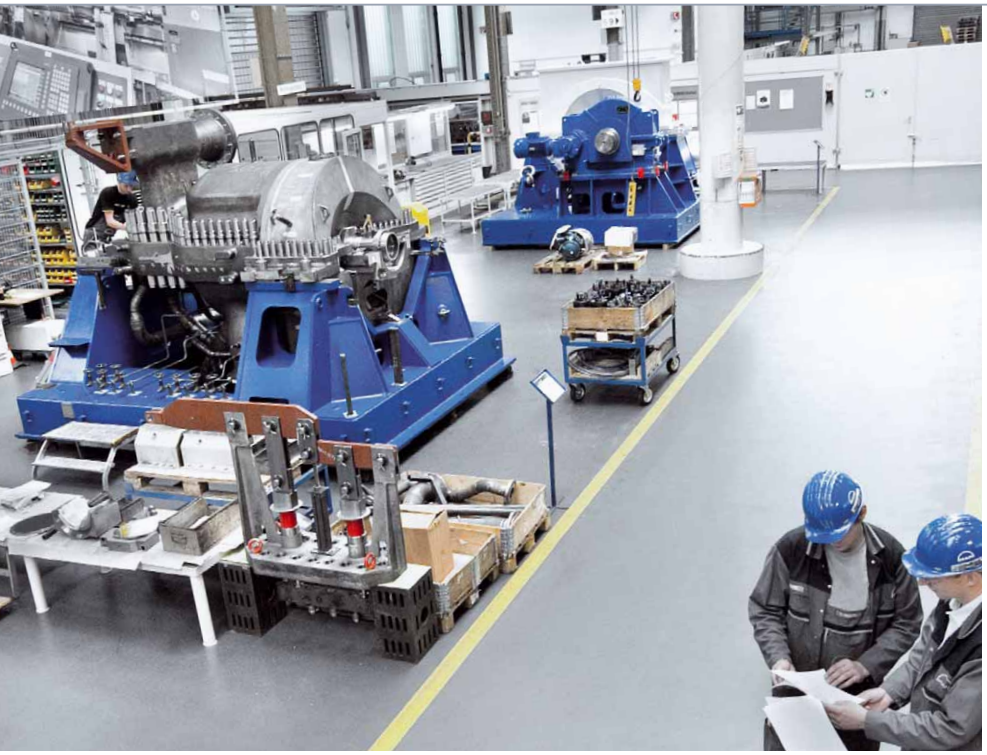
The modular turbine concept



Engineering the Future – since 1758.

MAN Diesel & Turbo

MARC® steam turbine roots lie in the historical Blohm+Voss Hamburg shipyard: Combining experience and tradition with state-of-the-art technology.



The first steam turbines were manufactured in 1907 under the name of Blohm+Voss – initially to propel ships built in the shipyard and subsequently for electric power generation. From 1952 on the company has been concentrating on developing and manufacturing of industrial steam turbines. The list of worldwide references encompass more than 2,000 steam turbine generator sets.

Several renowned companies and utilities use MAN Diesel & Turbo steam turbines in:

- Industrial Power Plants
- Co-Generation Plants
- Waste-to-Energy Plants
- Biomass Power Plants
- Combined-Cycle Plants

MAN Diesel & Turbo's advanced production facility in Hamburg features state-of-the-art manufacturing centers and tools on an area of approximately 30,000 m^2. The quality management system is certified according to both DIN EN ISO 9001 as well as DIN EN ISO 14001. Located in the free trading zone of the port of Hamburg, ideal shipping infrastructure is guaranteed, especially for large and heavy components.

The Concept

Top priority of MAN Diesel & Turbo steam turbine development has always been to deliver safe, efficient and reliable units according to its individual customers needs. During the 15 years since its introduction, the MARC® (Modular Arrangement Concept) steam turbine family has proven these qualities in numerous facilities, and underlies a continuous optimization process. The modular turbine concept allows for a flexible arrangement of the main components and enables the overall expedient assembly to be set up in line with specific customer and/or process requirements.

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

MARC® 1	MARC® 2	MARC® 4	MARC® 6
typical power range 1.5 up to 3 MWe 2,000 up to 4,000 HP	typical power range 4 up to 10 MWe 5,400 up to 13,400 HP	typical power range 9 up to 20 MWe 12,000 up to 26,800 HP	typical power range 16 up to 40 MWe 21,400 up to 53,600 HP
max. flange diameter (mm) Live steam: up to 125 Exhaust: up to 700	max. flange diameter (mm) Live steam: up to 200 Exhaust: up to 1,200	max. flange diameter (mm) Live steam: up to 250 Exhaust: up to 1,500	max. flange diameter (mm) Live steam: up to 300 Exhaust: up to 2,400
max. live steam conditions 60 bar(a) / 450 °C 870 psi(a) / 842 °F	max. live steam conditions 90 bar(a) / 520 °C 1,305 psi(a) / 968 °F	max. live steam conditions 120 bar(a) / 520 °C 1,740 psi(a) / 968 °F	max. live steam conditions 120 bar(a) / 530 °C 1,740 psi(a) / 986 °F
speed 12,000 up to 14,000 rpm	speed 10,000 up to 12,000 rpm	speed 7,000 up to 10,000 rpm	speed 5,000 up to 7,000 rpm

The turbine/generator unit includes:
- Steam turbine
- Gearbox
- Generator
- Lubrication oil system
- Control oil system
- Instrumentation and control system

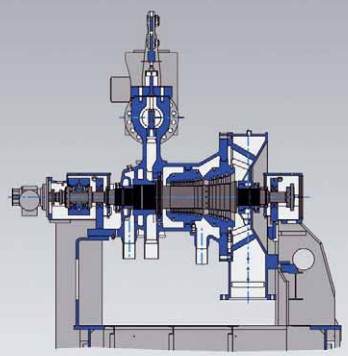
The lubrication oil module, the control oil module (in some cases a combination of both), and the control panel can be freely grouped around the unit.

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

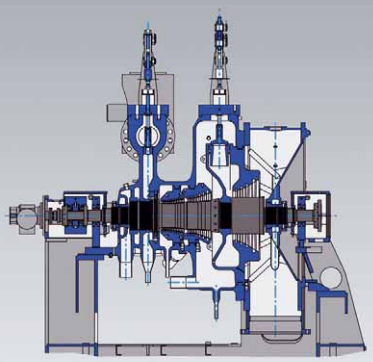
Four different turbine sizes cover the performance range from 1.5 MWe (2,000 HP) up to 40 MWe (53,600 HP). The MARC® steam turbine family comprises backpressure and condensing turbines that can also be fitted with extractions and bleed ports.

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

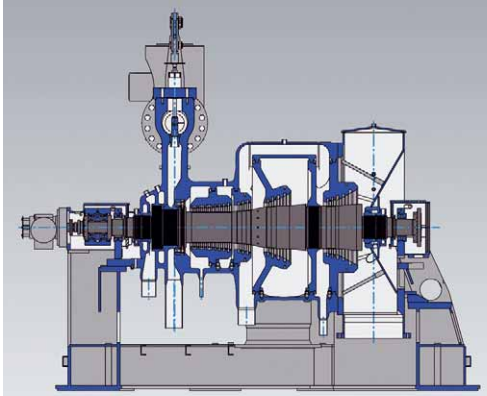
Backpressure Turbines (Type B)



Condensing Turbines (Type C)



Heating Turbines (Type H)



MARC® Backpressure Turbines

The 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. The exhaust steam may be used for further processes.

MARC® Condensing Turbines

The applications for condensing steam turbines range from turbo generators for Industrial Power Plants and Waste-to-Energy Plants to chemical and petrochemical production facilities. The extraction steam is typically used for heating, production purposes, drying process and feed water prewarming. To achieve an optimized part-load behavior, the high pressure part is provided with nozzle group control. Depending on the operating conditions the low pressure part is provided with throttle control.

MARC® Heating Turbines

The heating turbine can be provided with divided condensing part.

After the first expansion stage the steam is divided into two streams, each guided to one of two different downstream expansion stages within the same casing. Both exhausts deliver steam at differing temperature and pressure to the district heating system.

Module: Turbine

Industrial steam turbine applications require steam extraction for production processes, heating or for regenerative feed water prewarming. In addition to multiple bleed ports, controlled extraction can be provided. The MARC® steam turbine series allows turbine components to be optimally designed; meeting individual process requirements.

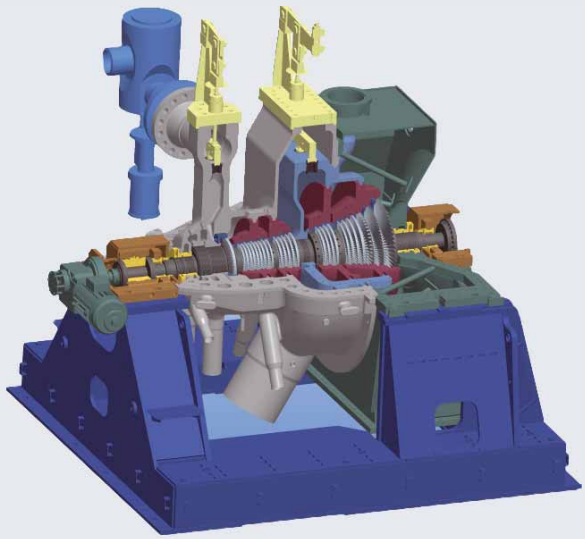
Depending on live-steam conditions and the specified operating mode, blading is adjusted to suit the specific needs. The exhaust steam nozzle is welded and can be positioned upward or downward.

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

The highest thermal load occurs on steam carrying parts when loads change. Therefore, casings, stator blade carriers and inner casings have been developed for maximum flexibility in terms of thermal expansion and contraction.

The following design features apply to all MARC® steam turbine types:

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



Turbine rotor

Reaction-type turbines are constructed in a drum-type design. The turbine rotor, the balance piston, the impulse wheel disc and the subsequent drum parts are integral forgings of high temperature material. The rotor design is based upon 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 at MAN Diesel & Turbo to ensure that vibrations over the full speed range are significantly below specified tolerance limits, 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 section 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 upon:

- High stator vane and rotor blade resistance to mechanical and thermal stress during operation
- High resisting torque to prevent vibration
- Low flow losses in the blading over a wide operating range

The stator vanes and rotor blades have the same profile type, calculated and proven in various test series. 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 in turn ensures high part-load efficiency. These requirements are fully met by the overpressure profile employed.

Gaps and secondary losses in backpressure turbines and high pressure components of condensing-type turbines are minimized by using integral shrouds.

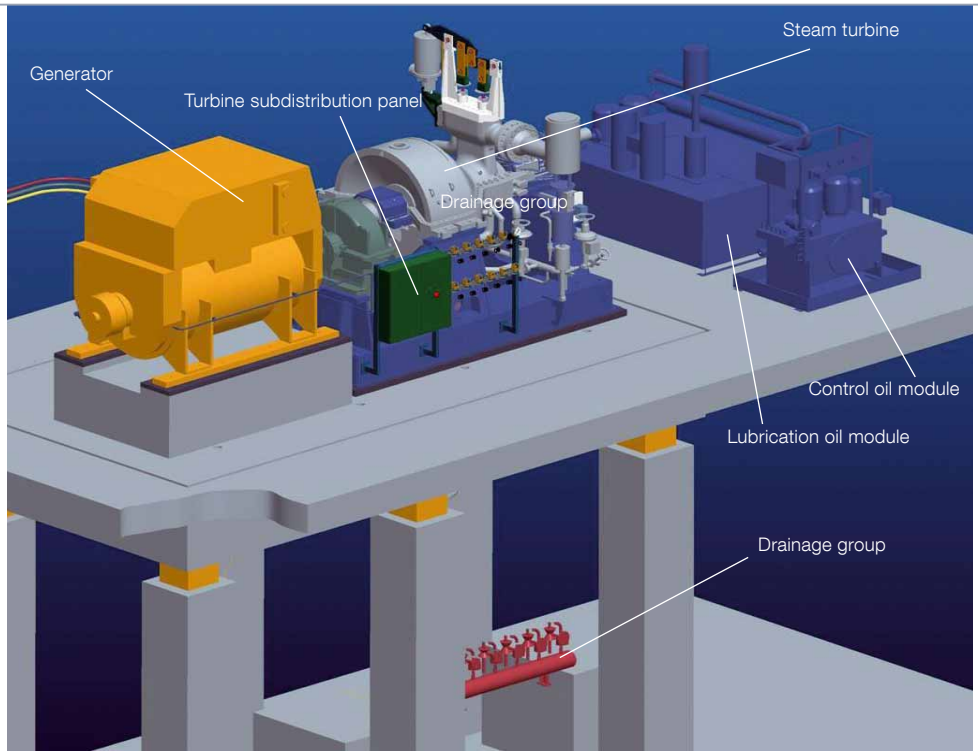
Control mechanism

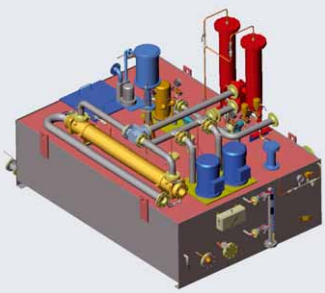
Depending on the live-steam condition and the specified operating mode, the operator can select between nozzle group control (constant pressure) with or without bypass and throttle control (sliding pressure).
In case of nozzle group control, and based on use of diffuser type valves, throttling losses can be kept very low, even in the part-load range. The conical shape of the valve has been designed for optimum flow. Valve spindles, valve cone and valve bar are made of high-temperature steel. These parts undergo special surface treatments for optimized service intervals.

The small valve dimensions allow the valves to be directly actuated. This so-called group actuation is a compact and reliable solution. The actuator is a single-acting hydraulic cylinder that works against the spring force. It is supplied with 160 bar (2,320 psi) 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 spring to protect the turbine generator set. If the pressure in the control oil system drops, both the control valves as well as all trip valves will be closed automatically as they work on the same principle (single-acting hydraulic piston versus preloaded spring); resulting in optimized safety for the turbine and the steam system related thereto.

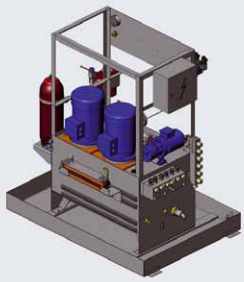
A lever system for parallel motion of both valve spindles precisely transmits changes in controller output onto the valve bar and, depending on the valve lift, onto one or more valve cones. The articulated parts are corrosion-free and maintenance-free components manufactured from self-lubricating materials.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

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





Lubrication oil module



Hydraulic module

Gearbox

Gearboxes reduce the turbine speed to the generator speed. The turbine can be designed according to optimum conditions at higher speed ranges leading to high efficiencies. The relatively low gearbox losses are more than compensated by the higher turbine efficiency.

All MARC® steam turbines are equipped with spur gear units.

Generator

Generators from renowned manufacturers complete the scope of supply.

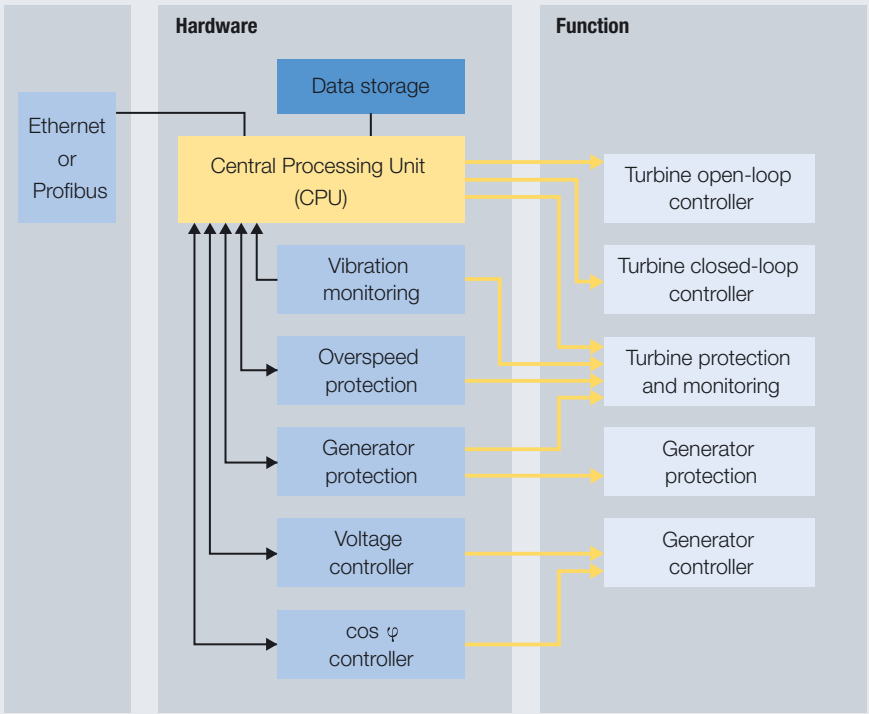
Lubrication oil system

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 and/or 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 (2,320 psi) system oil pressure.

Module: Instrumentation and Control System



Control cabinet

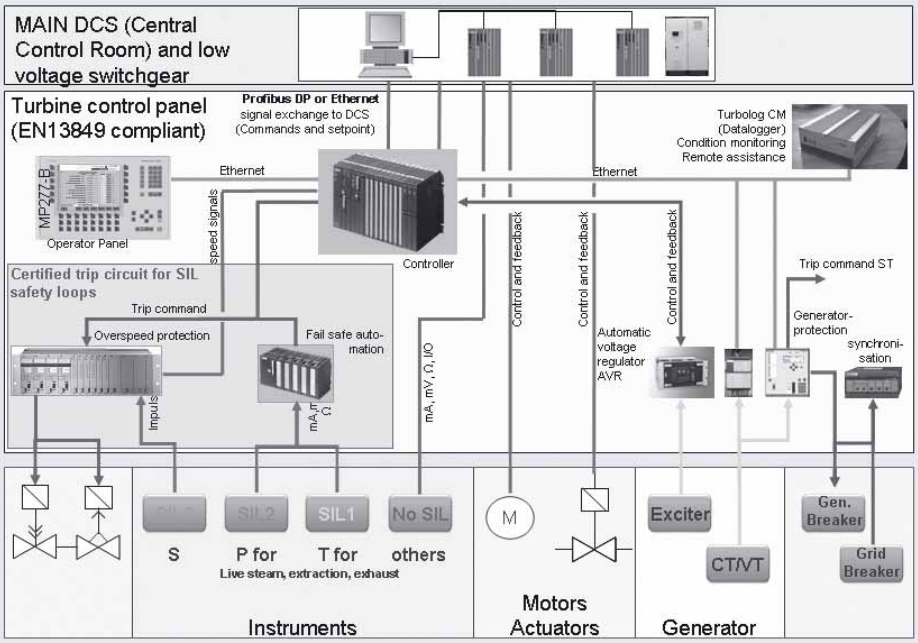
The turbine control cabinet is a compact unit that may be located variably within the turbine unit. All control and protective functions for the turbine and the generator are integrated in a single control cabinet with a user control interface arranged on the front. This saves space and ensures optimized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

Control system

To maintain flexibility when meeting the different process requirements, the turbine control system is integrated 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 and/or future requirements. Start-up, shut-down and operation are completely automated in the control system, with ease of use as a key feature.

Control

Based upon MAN Diesel & Turbo's extensive experience in the field of steam turbine unit control, it has 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.



Operation

The steam turbine can be operated either via a central control 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 data is displayed locally and supplied to the central control system via a bus system.

Safety

All turbine units include adequate 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.

Remote access

An ISDN interfaced data logger enables remote support for the operator. Pertinent operating data can be analyzed by MAN Diesel & Turbo's service team, while its dedicated service engineers have direct access to the control system and control panel. This provides MAN Diesel & Turbo's customers with quick and cost efficient service solutions.

Quality Assurance

MAN Diesel & Turbo's highest priority in designing and manufacturing steam turbines is quality.

Continuous quality control is carried out according to the ISO 9001 quality management system.
The turbine is mounted on the baseframe, piping and wiring within the confines of the base plate is assembled at MAN Diesel & Turbo's workshop.

Gearbox, generator as well as oil modules are tested at the manufacturer's premises and installed and commissioned at site.

Each rotor is dynamically balanced and an overspeed test is carried out prior to shipment.

Service and Installation

MAN Diesel & Turbo's experienced Field Service team ensures the accurate installation of the steam turbine generator set including commissioning and trial operation – in parallel operating personnel is trained either at site and/or during specific training courses at MAN Diesel & Turbo Hamburg.

The availability and life-time of turbomachinery can be improved by specific and custom made service concepts. MAN Diesel & Turbo offers a broad range of After Sales Services to optimize the overall performance and to improve the availability of the steam turbine generator set.

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