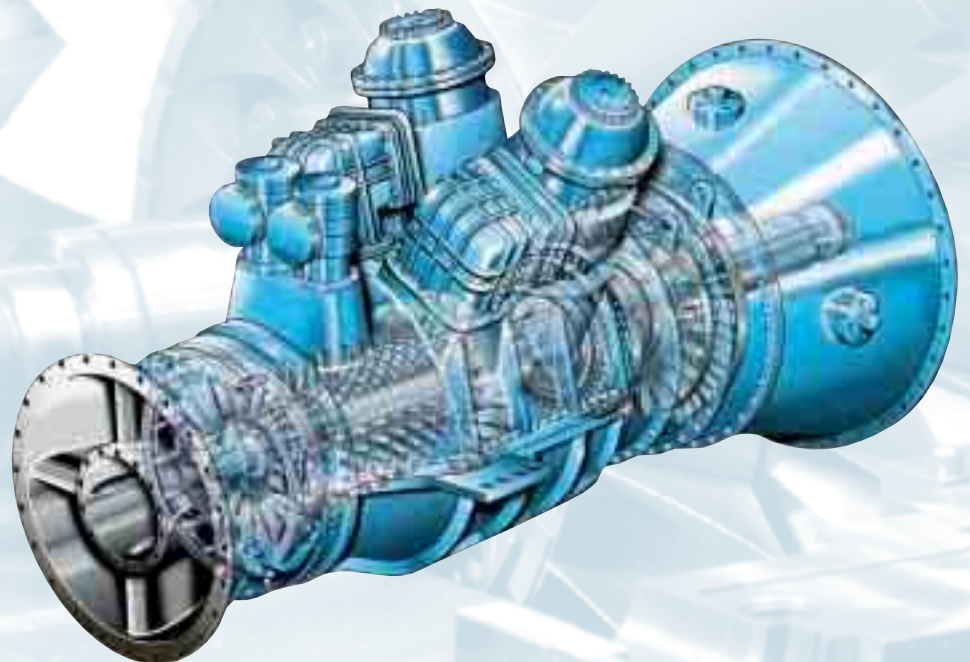


# THM Gas Turbine Family



## Product Line

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**THM industrial gas turbines form part of the MAN TURBO gas turbine product range. The 1203 and 1304 gas turbine series were taken over by MAN TURBO in 1988 and have been further developed.**

**The basic design is identical for both series and both frame sizes have many parts in common.**



## **General Features**

The THM family has the following main features:

- Robust industrial design
- High availability and reliability
- Long life due to comparatively low turbine firing temperatures
- Extended overhaul intervals
- Suitability for a wide range of fuels
- Low fuel gas inlet pressure
- Local maintenance capability
- Continuous improvement of machine components and enhancement of performance parameters based on many years of in-service experience
- Machine peripherals such as instrumentation & controls, filtration etc. can be supplied either as the MAN TURBO standard or can be custom built to individual requirements.
- The two shaft design – the ideal solution for mechanical drive applications due to fast transient behavior during load changes and good part load performance when used for driving a generator.



## Machines in Service

The machines in service account for more than 14 million operating hours in many different applications:

- Power generation
- Combined heat and power generation (cogeneration)
- Compressor drive for pipeline and process applications
- Pump drive for oil pipelines and water injection

The installations range from industrial sites to remote operation far from civilisation as well as for the offshore sector.

Among such installations, there are machines that work under extreme ambient conditions with temperatures ranging from  $-40$  to  $+50^{\circ}\text{C}$ .

The wide experience of MAN TURBO is continually incorporated into new product developments.



## Modular Design

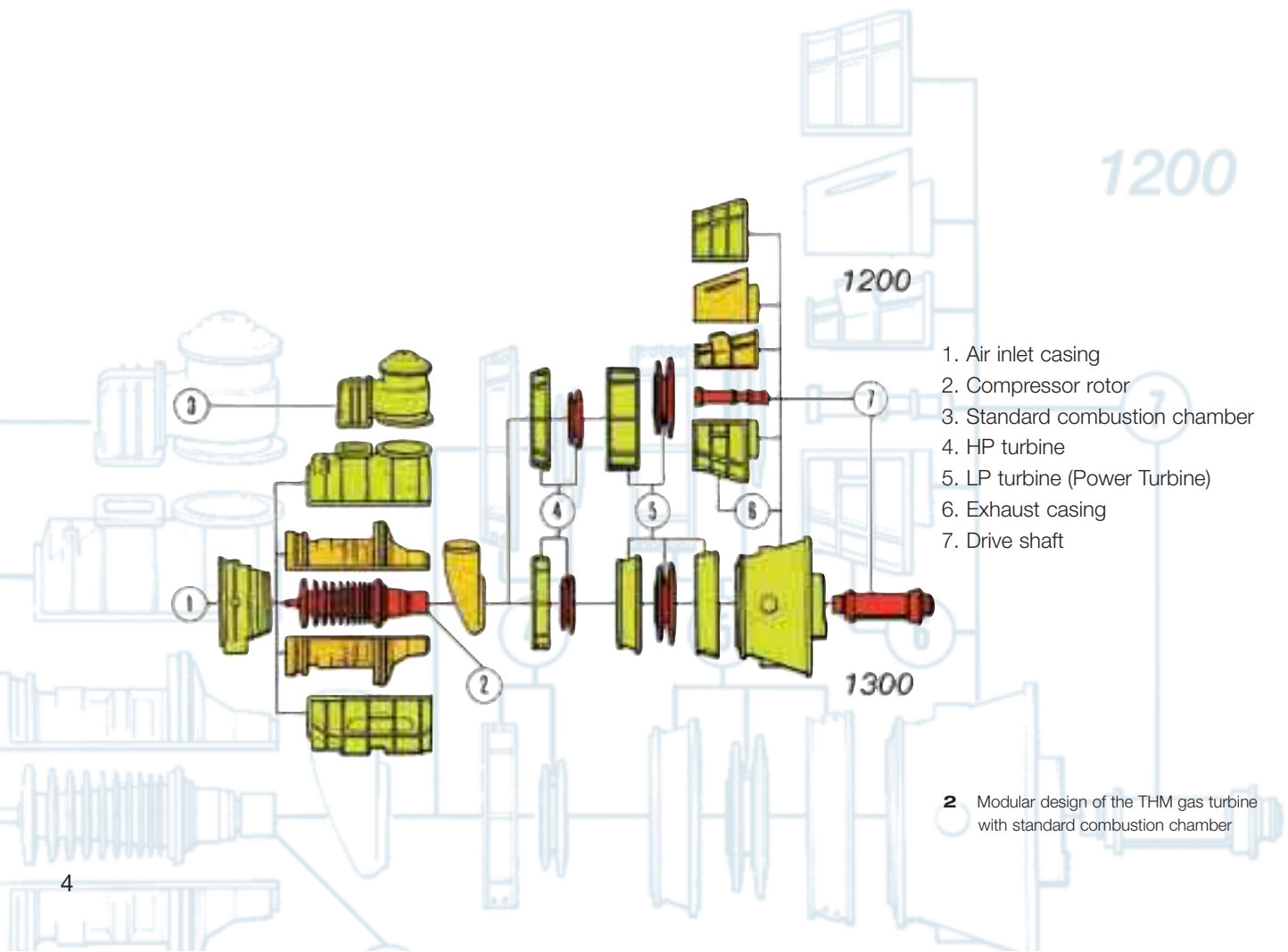
The THM gas turbines are split into three main modules: air inlet casing, gas generator and power turbine. The gas generator comprises the three submodules compressor, combustion section and high pressure turbine.

The power turbine also comprises three submodules, i.e. low pressure turbine, drive shaft and exhaust gas casing. The modular design is maintenance friendly and consequently offers the highest availability.

Figure 2 shows the modular design for gas turbines of the THM 1203 and THM 1304 series.



1 Modular design with power turbine, gas generator and air inlet casing (from left to right)



## The Modules in Detail

### 1. Air inlet casing

The air inlet casing also includes the front bearing housing and, for the THM 1304, the variable inlet guide vanes of the compressor.

The variable inlet guide vanes improve the starting performance of the gas turbines and reduce fuel combustion at part load.

They also offer the ability to run at reduced loads without having to open the bleed valves of the compressor.

### 2. Gas Generator

#### a) Compressor

The number of axial stages of the air compressor is

- Nine for the THM 1203 and
- Ten for the THM 1304

followed by a radial stage.

The rotor blades are made from precision forged high Cr alloy.

Additional corrosion protection is achieved by coating the rotor blades with an aluminium based compound.

The compressor rotor is carried on two tilting pad journal bearings with high rotor-dynamic safety.

The tilting pad type double acting thrust bearing is located in the front bearing housing.

### 3 Compressor rotor



## b) Combustion Section

THM series gas turbines are fitted with two external combustion chambers arranged in V-configuration on top of the machine.

These combustors have been developed with injector nozzle systems for a wide range of gaseous and liquid fuels as well as dual fuel operation. They enable long periods of continuous operation with optimum flexibility.

The range of fuels that can be burnt comprise:

- Combustible gases with a wide range of calorific values
- Various types of liquid fuel including light crude oil, diesel, kerosine, naphtha and light distillates.

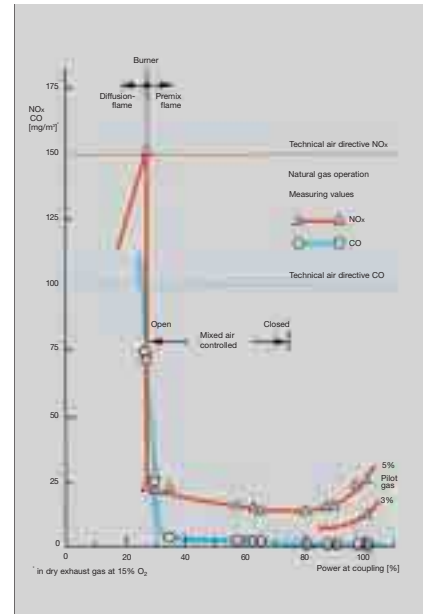
Two combustion systems are available. The standard combustion chamber is a compact and efficient solution. Beside the standard combustion system MAN TURBO has developed a low emissions combustion system (DLN - DryLowNO<sub>x</sub>) in order to achieve particularly low emission limits. The DLN system has the following merits which are different from the standard system:

- Enlarged combustion chambers are provided to ensure optimal premixing of fuel and air, these chambers are accommodated within the package without any changes to the basic gas turbine design
- The combustion system employs a well proven dual fuel hybrid burner design which is based on a cooperation agreement with Siemens
- The DLN control system is nearly identical to that fitted to the standard combustion system and uses the same control valves.

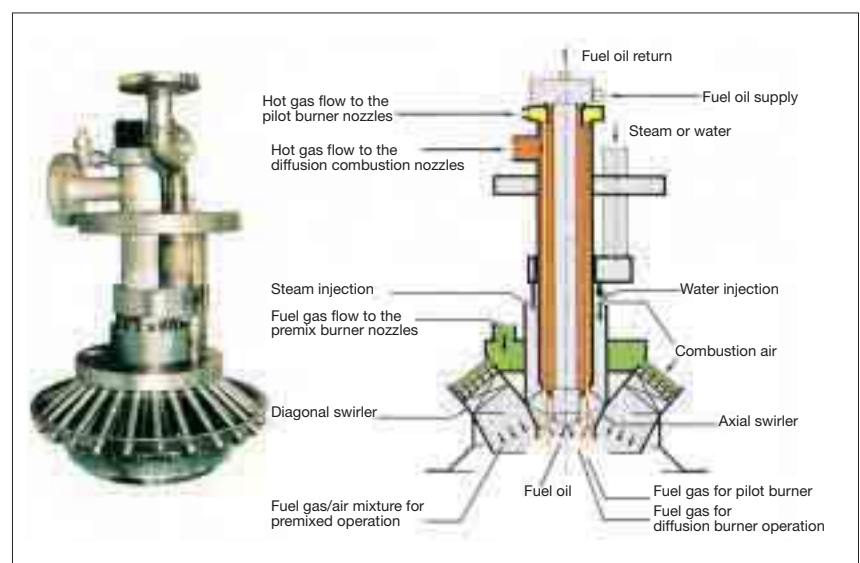
Test results on THM 1304 DLN units built to date have confirmed that NO<sub>x</sub> values of 18 mg/m<sup>3</sup> (9 ppm) or below are obtained with almost negligible values for CO and unburnt hydrocarbons at full load.

Even over a wide part load range, NO<sub>x</sub> and CO values are achieved which are also far below the permissible limits of the German TA Luft (Technical Air Directive) and similar regulations (see Figure 4).

The DLN system is interchangeable with the standard combustion system and therefore existing THM 1304 units can be retrofitted to meet changes in emission limits.



4 Measurements of NO<sub>x</sub> and CO emissions on the THM 1304 gas turbine with DLN combustion chamber



5 Siemens hybrid burner

### c) High Pressure Turbine

The high pressure turbine consists of two axial flow stages and drives the compressor through a common shaft. The horizontally split casing enables the high pressure turbine to be inspected easily.



6 Guide vanes and rotor blades of the high pressure turbine

Optimum operating clearances are achieved by a combination of honeycomb seals in the casing and a shroud on the rotor blades. The blades themselves are anchored in the rotor disc of the turbine by fir tree roots.

The high pressure turbine guide vanes and rotor blades are produced by a precision casting process, where vanes are made from a cobalt based alloy and blades from a nickel based alloy. The stator rings supporting vanes are made from nimonic alloy.

In addition, the turbine blades are protected from corrosion by a chromium aluminising treatment. For the special conditions that apply in offshore applications a double coating of MCrAlY and CrAl is used, which gives the longest life against the combined attack of sulphur and sodium.

The temperature of the hot gas section of the turbine is controlled by a sophisticated cooling system. This causes air to flow from the compressor outlet through the turbine discs and the stator ring. In the THM 1304 vanes and blades of the first stage are fitted with an internal cooling system.

With the first stage of the THM 1203, only the guide vanes are internally cooled, whereas the rotor blades include the option of using an ultramodern single crystal material.

Long life is guaranteed for the THM due to moderate firing temperatures.

7 High pressure turbine rotor

### 3. Power Turbine

The power turbine has its own shaft and consists of two axial flow stages. Its vanes are made from a high temperature precision cast Fe-based alloy and the blades from a precision cast nickel alloy.

The power turbine is an overhung design, the shaft of which is mounted in two tilting pad journal bearings. Axial thrust from the aerodynamic forces is absorbed by a self-aligning tilting pad thrust bearing in the driven end bearing housing.



## Configuration of the Gas Turbine Package

Safe operation of a gas turbine unit is very much dependent on the functioning of the individual components of the package (oil supply, air filtration, starting equipment, etc.) and the monitoring and control equipment. To this end the unit control system must be matched with the driven machinery which may be a compressor, generator or pump for integration into a power station, cogeneration plant, or compressor or pumping station.

THM gas turbines can be delivered by MAN TURBO as a completely assembled package.

The package concept offers various configurations in modular design. All configurations use standardised assemblies and components which give the following advantages:

- Many years of in-service experience
- Ease of maintenance and servicing
- Stock holding of spare parts or short lead times.

Other options available are:

- Diesel starter
- Electric starter with torque converter and auxiliary gearbox
- Electric starter with frequency converter that drives the gas turbine shaft
- Gas starter with direct drive of the gas turbine shaft
- Oil supply with two electrically driven main lube oil pumps (redundancy conforming with API).

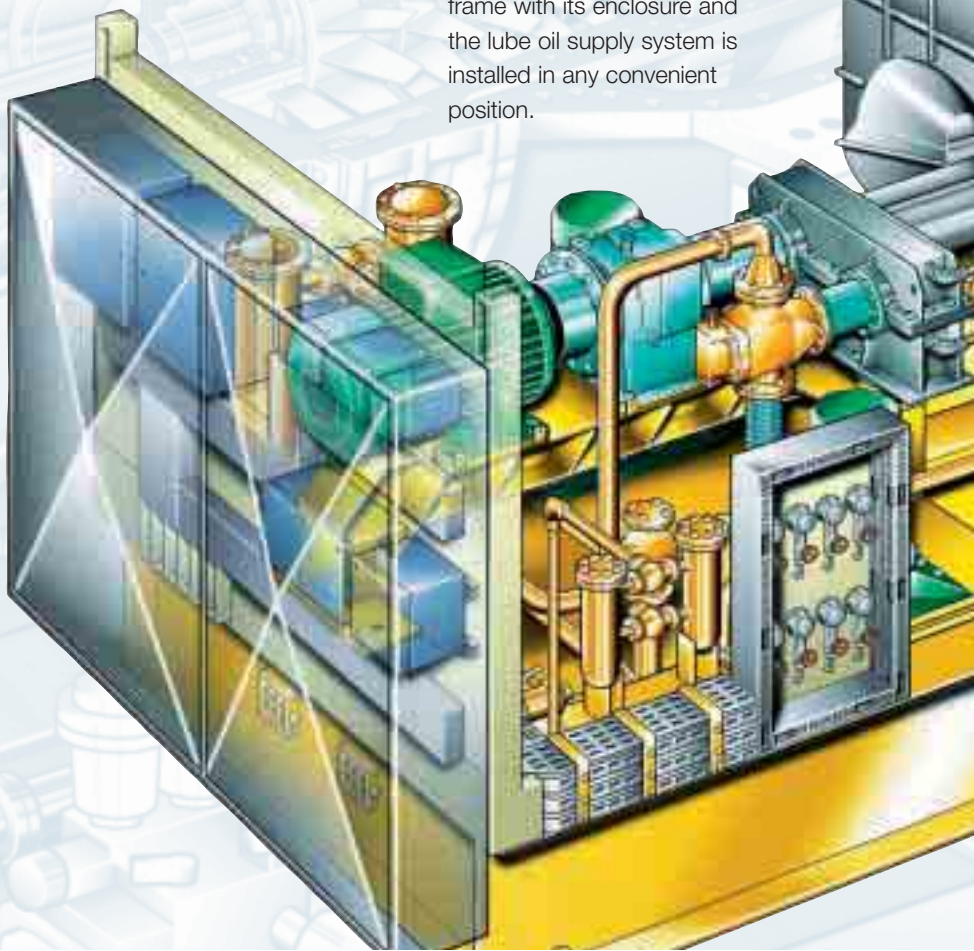
Figure 8 shows the package configuration with a single lift baseframe, fuel plate and gas starter with auxiliary gearbox.

The picture illustrates in addition the integrated oil supply with a mechanically driven main lube oil pump.

The single-lift configuration uses a common acoustic enclosure for the gas turbine and the lube oil system.

With retrofits, or if there is reduced space, the package can be divided into two separate modules.

In this case the gas turbine is mounted on a separate base-frame with its enclosure and the lube oil supply system is installed in any convenient position.



8 THM 1304 industrial gas turbine with standard combustion chamber

## Auxiliaries

The modular THM design means that the auxiliaries can easily be customized, such as, for example, the air filter, the enclosure, the exhaust system or fuel plate to suit the environment i.e.:

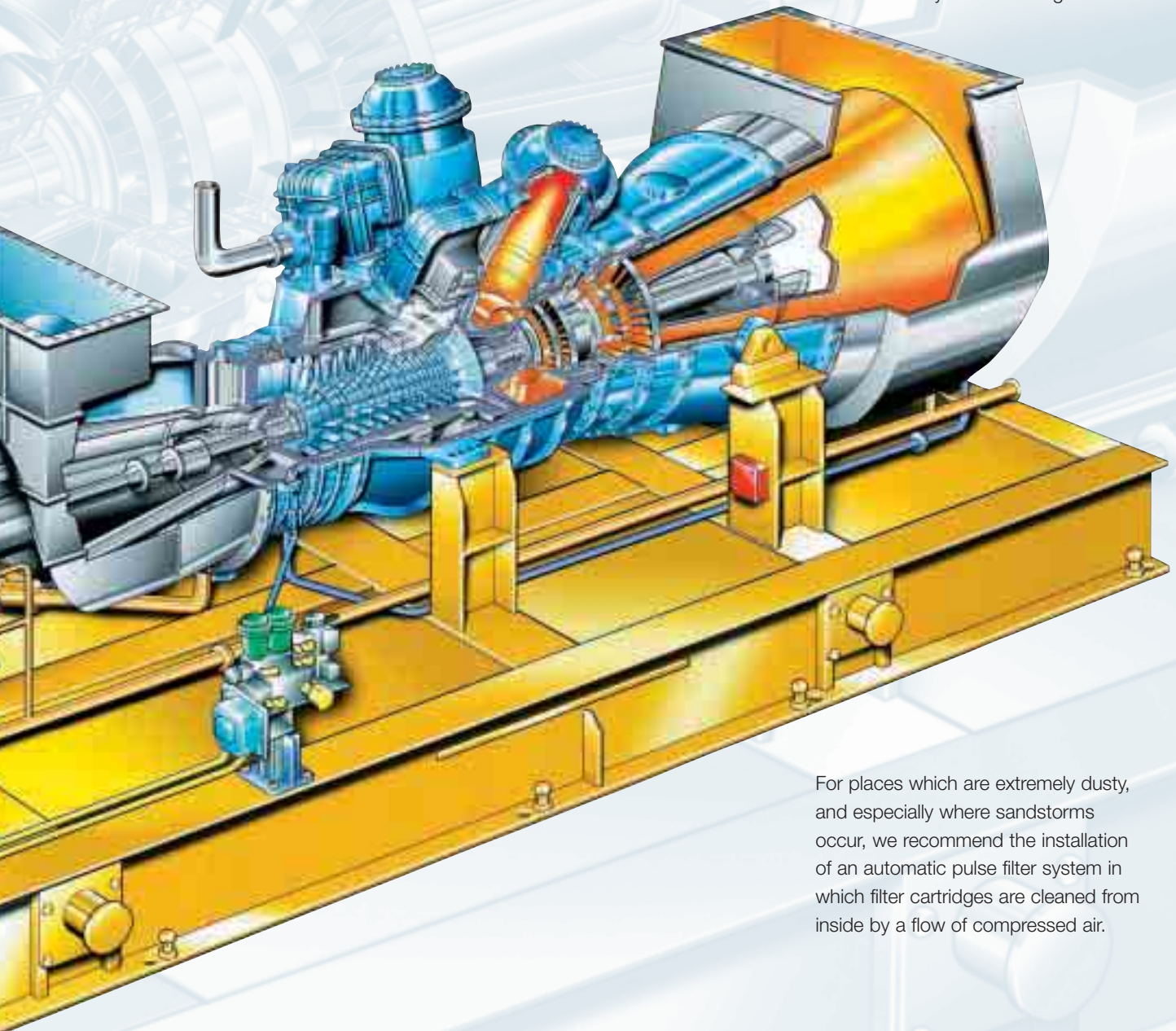
- Industrial sites with severely contaminated atmospheres
- Residential locations with particularly high requirements for noise reduction

- Desert zones with sandstorms and extreme temperature conditions
- Marine locations with high salt loading, or special requirements of offshore environments
- Arctic climatic conditions.

## Air Filter

The standard arrangement consists of a two stage filter system with bag filters and/or cartridge filters installed.

For offshore installations and plants located in areas of high humidity, demister/ coalescer pre-filters can be provided. Units which are subject to freezing conditions can be fitted with heating elements in front of the filters. Heating can be conducted by steam, hot water or by the exhaust gas.



For places which are extremely dusty, and especially where sandstorms occur, we recommend the installation of an automatic pulse filter system in which filter cartridges are cleaned from inside by a flow of compressed air.

## Acoustic and Air Flow Control

The silencers for both the combustion air and the enclosure ventilation system ensure that specified sound emissions are not exceeded.



The air intake plenum connected behind the silencer leads the combustion air with the smoothest possible flow into the gas turbine. Immediately in front of the turbine inlet is a nozzle ring for connection of the compressor washing equipment.

9 THM 1304 gas turbine package for compressor station

## Acoustic Enclosure

An acoustic enclosure is provided to attenuate the noise level in the local environment to the prescribed value. It ensures also that the electrical components are cooled and protects outdoor installations from the effects of weathering.

The enclosure is fitted with several maintenance doors, through which, with the help of an internal hoist, individual gas turbine modules can be removed from the enclosure.

Cooling is carried out using filtered air by means of forced draft fans.

The enclosure is fitted with lighting. Glass viewing windows are provided on both sides of the unit to enable visual inspection whilst the gas turbine is in service. If required by the customer, a walk-in version of enclosure can be supplied.

## Exhaust Gas System

Depending upon plant concept, the exhaust gas can be arranged vertically upwards or alternatively to either side of the unit.

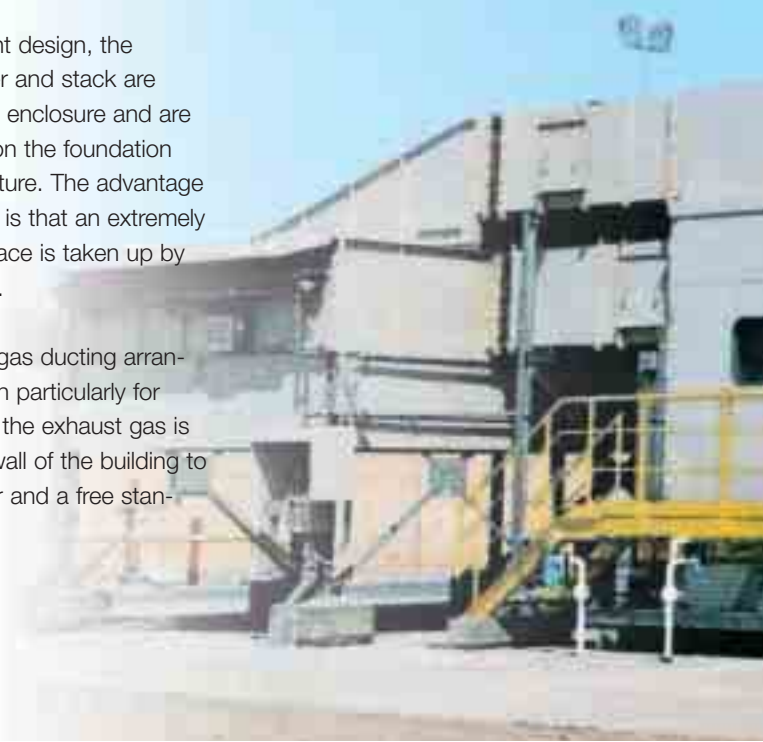
In the standard plant design, the exhaust gas silencer and stack are arranged above the enclosure and are directly supported on the foundation by a separate structure. The advantage of this arrangement is that an extremely small amount of space is taken up by the gas turbine unit.

Horizontal exhaust gas ducting arrangements are chosen particularly for indoor installations; the exhaust gas is taken through the wall of the building to the exhaust silencer and a free standing stack.

## Fuel System

The fuel system ensures fuel supply to the combustion chamber burners, and control of the fuel flow, which, depending on power requirement, is carried out by the fuel control valves.

The know-how and hardware for fuel treatment can also be provided by MAN TURBO.



## Starting System

The starting device carries out several functions:

- Ventilation of the turbine and exhaust duct before starting the engine (in accordance with the safety requirements)
- Run-up of the gas generator during starting sequence
- Barring the gas generator when washing the compressor

The type of starting device chosen depends on the energy available; the following options are available/ exist:

- Turbostarter. This is an expander which uses compressed air or gas to turn the gas generator shaft of the gas turbine
- Electric motor. The electric drive can either be speed controlled using a frequency converter directly on the gas turbine shaft or through a torque converter and an auxiliary gearbox

- Diesel engine. With this solution the gas generator shaft is driven by a diesel engine (or petrol engine).

## Lube Oil System

THM gas turbine units use mineral oil as both a lubrication and cooling medium. The gas turbine, the driven machine and any gearbox that may be installed are all supplied from a common oil circuit.

Independent of the design of the lube oil system an emergency oil pump is always provided, which guarantees safe lubrication and cooling of the bearings if the power supply fails.

Recooling generally takes place in an air cooler, but water cooling is, of course, also available. Upstream the machine oil cooling with a temperature control bypass is provided together with duplex oil filters. The oil reservoir is fitted with an immersion heater which keeps the oil permanently preheated so that the plant is always available.



## Control System

The control system fulfils the following main functions:

- Control of gas turbine speed and power output
- System logic and sequencing of auxiliary
- Monitoring the main engine and unit parameters
- Diagnosis in case of malfunction
- Interface and communication with station and supervisory control systems
- Operator and machine protection.

It consists of the following main components:

- Gas turbine governor
- Unit control system
- Emergency shutdown system
- Man Machine Interface (MMI) to monitor all relevant parameters of the gas turbine linked to the station.

For compressor set applications, the anti surge control of the driven equipment is also included in the MAN TURBO developed turbolog<sup>®</sup> system.



## Gas Turbine Governor

The main function of the gas turbine governor is speed or power control of the power turbine, which is rigidly coupled to the shaft of the driven equipment.

In case of a mechanical drive application or an island mode generator set, the speed set point is compared with the actual speed, and fuel flow to the combustion chambers is adjusted accordingly. For generator drives, where the turbine speed is coupled to the grid, the fuel flow is matched to the power output of the generator.

For reliable control of the fuel flow, MAN TURBO tailored the fuel gas metering valve to the requirements of the THM gas turbine family. The valve is actuated by an electric motor allowing rapid and precise adjustment. Further functions as performed by the turbolog<sup>®</sup> governor include:

- Adjustment of the compressor inlet guide vanes as a function of the speed of the gas generator
- Integrated control loops to protect the gas generator against over-speed
- Limitation of power turbine inlet temperature to a set value to prevent excessive material temperatures
- Flameout detection.

10 Unit control panel

## Compressor Anti Surge Protection

For compressor set applications, the turbolog<sup>®</sup> DSP system is employed as a common hardware platform for both THM gas turbine control and compressor anti surge control.

Rapid response times effectively protect the machines against critical transient conditions.



11 turbolog<sup>®</sup> DSP

## Gas Turbine Unit Controller

The unit controller controls and monitors the auxiliary systems (pumps, fans, valves etc.) of the gas turbine and its driven equipment.

This system also processes all the alarm signals from stand-alone subsystems such as the vibration monitoring, gas detection and fire fighting systems etc.

For the operator, the unit controller constitutes the MMI.

All operating commands are processed at this level. The control system is of modular design for each application. MAN TURBO uses control systems from reputable suppliers, but is prepared to employ equipment according to customer specification.

The decision in favour of one of these systems is taken with due consideration of the customer in order to optimise the interfaces and the spare parts stocking requirements. All the systems mentioned offer a wide range of pre-configured functions, so reducing the engineering time and offering maximum user-friendliness to the operator and his personnel.

### Remote Data Transmission and Diagnosis

The remote data transmission systems are available which permanently collect operating and alarm data on site. Experts at the MAN TURBO Service Centre can log into gas turbine installations by modem and analyse the engine condition using condition monitoring and trend monitoring methods.

Necessary maintenance work can be identified and scheduled for planned maintenance outages, thus allowing maximum availability of the turbine. Recognition of possible upcoming problems permits corrective action at an early stage, so maintenance costs are minimised and unplanned down times may be avoided.

Should a problem occur, however, remote analysis of the data permits an immediate diagnosis by our expert team, so systematic technical support and consulting can be provided without delay.

With its remote data transmission facility, MAN TURBO maintains significantly improved service and substantially reduced response times resulting in high unit availabilities.

**12** Control room; operator and engineering stations.



## Gas Turbine Testing

The gas turbines of the THM family can be tested in the MAN TURBO works both as a bare turbine or as a train when connected to a driven compressor or generator. Testing on the gas turbine test bed can include a full load test run. The test conditions and specifications that apply for the machines and their accessories and associated plant are in compliance with ISO 2314, as well as the appropriate standards of ASME and API.

The gas turbine test bed is not only used for customer acceptance tests but also has the necessary instrumentation to carry out test series as part of the research and further development of our THM components. The test bed has the following equipment:

- Fuel system for liquid and gaseous fuels
- Air intake metering
- Water brake for adjusting power output and speed of the power turbine, as well as
- Highly developed digital measuring and evaluation system.

## Testing of Complete Turbomachinery Sets

In addition to the test bed there are several test areas available for the testing of complete machine sets (string tests).

Figure 13 shows, by way of example, the test bed configuration for a complete plant. The package consists of a gas turbine which drives a two casing centrifugal compressor set through a gearbox.



To ensure comparable test conditions during the thermodynamic string tests, the simultaneous testing of the stage groups of the driven centrifugal compressor can be done in a closed circuit. Also the other main components of the system, e.g. seal oil unit, can be tested under service conditions and correspondingly adjusted.

A new open air test facility is available for testing of compressors and generators with engine or gas turbine drivers. Compressors are able to use the same gas composition as in operation and thereby meet ASME PTC10 Type I conditions.

With its ability to carry out complete works testing of gas turbine packages, MAN TURBO provides their customers with optimum facilities to ensure trouble-free erection and commissioning of the delivered unit on site.

**13** Gas turbine test bed - view of gas turbine THM 1304 with DLN combustion chamber



**14** String test



15 MAN TURBO Service Center

## Maintenance

The modular design of the THM gas turbine facilitates easy maintenance and ensures optimum availability.

The following features underline how easy the THM gas turbine is to service:

- The individual modules of the gas turbine can be removed and refitted with the lifting equipment contained within the enclosure without any difficulty.
- The "easy to assembly" modular system of the THM gas turbine enables repair of modules either on site, in a customer service workshop, a MAN TURBO Service Point or in the central MAN TURBO Service Shop.

Borescope openings are available for inspection and condition monitoring of important components without opening the machine:

- The external combustion chambers facilitate checking and maintenance of the burners and flame tubes.
- The horizontally split compressor casing allows easy access to the rotor and to the blading.
- The instrumentation & control system enables the collection and evaluation of important machine parameters, in order to carry out diagnosis and plan service measures.

The systematic evaluation over many years of service experience with the THM was used in the consistent further development of the series. Special attention was paid to retrofittability with the existing machine population.

In its power class, the THM series is characterized by high reliability and long service intervals.

Individual service concepts are offered for an economical engine operation over many years.



16 Borescope examination



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