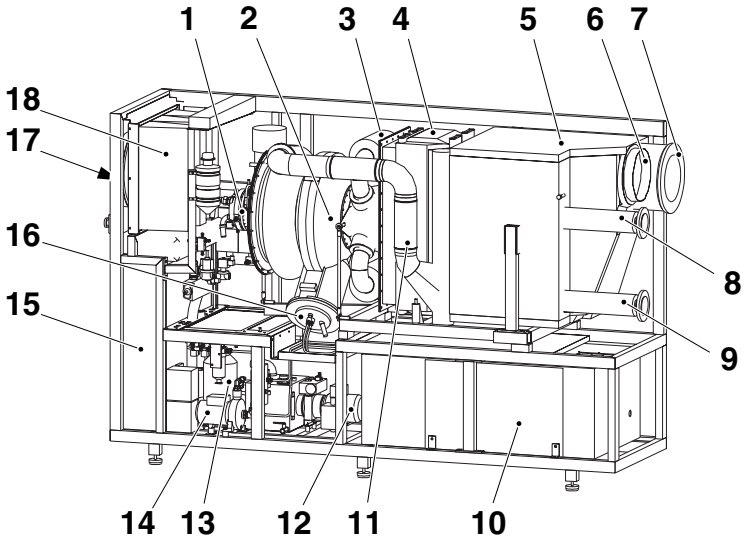
T100 microturbine CHP system

Technical Information

Turbec

1. Product description



1. Generator
2. Gas turbine engine
3. Pipe from recuperator
4. Recuperator
5. Exhaust gas heat exchanger
6. Ventilation air outlet
7. Exhaust outlet
8. Water inlet
9. Hot water outlet
10. Power electronics
11. Pipe to recuperator
12. Oil pump
13. Buffer air pump
14. Cooling water pump
15. Control system
16. Combustion chamber
17. Air inlet
18. Air filter

1.1 Main components

The Turbec T100 microturbine CHP system is a Combined Heat and Power unit. The unit produces electricity and heat fuelled by natural gas. The system is designed for indoor installation and takes air from an outside intake. The CHP unit is divided into the following main parts:

- Gas turbine engine
- Electrical generator
- Electrical system
- Exhaust gas heat exchanger
- Supervision and control system

Gas turbine engine

The gas turbine is a single shaft engine. The main components are:

- Housing
- Compressor
- Recuperator
- Combustion chamber
- Turbine

Housing

The electrical generator and the rotating components of the gas turbine are mounted on the same shaft. The two engine parts together with the shaft are mounted in the same housing.

Compressor

The Turbec T100 uses a radial centrifugal compressor to compress ambient air. The pressure ratio is about 4.5:1. The compressor is mounted on the same shaft as the turbine and the electrical generator.

Recuperator

The recuperator is a gas to air heat exchanger attached to the microturbine. The heat is exchanged from the hot exhaust gases to the compressed air that is fed to the combustion chamber. The recuperator increases the electrical efficiency of the gas turbine.

Combustion chamber

The preheated compressed air is mixed with the natural gas. During start up an electrical igniter in the combustion chamber ignites the mixture. The combustion chamber is of lean pre-mix emission type, achieving low emissions of NOx, CO and unburned hydrocarbons in the exhaust gases.

Turbine

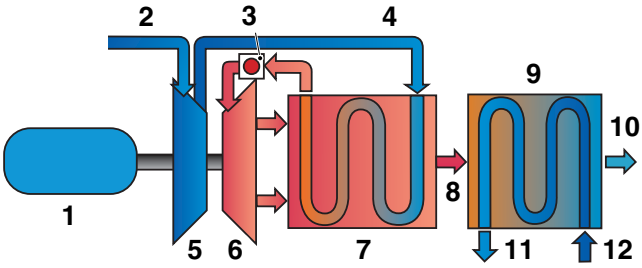
The turbine drives the compressor and the generator. When the combustion gases leave the combustion chamber the temperature is approx. 950°C (1742°F) and pressure is approx. 4.5 bar (65 psi). As the combustion gases expand through the turbine the pressure decreases to close to atmospheric pressure and the temperature drops to approx. 650°C (1202°F).

Electrical generator

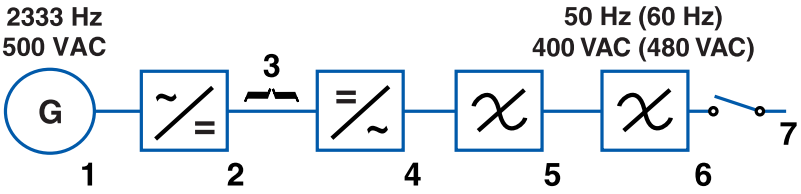
The electric power is generated with the rotating permanent magnet. The rotor is suspended by two bearings on each side of the permanent magnet. The generator acts as an electric starter for the gas turbine to bring the CHP unit into operation. The generator is designed for high conversion efficiency and is water-cooled.

Electrical system

Before the generated AC reaches the grid it needs to be rectified and transformed to the preferred frequency. The AC is first rectified to DC and then converted to a three-phase AC. An inductor stabilizes the AC output. An EMC filter protects the operation to prevent generated interference. The electrical system is entirely controlled and automatically operated by the Power Module Controller (PMC).The electrical system is used in reverse when it works as the electric starter to the gas turbine.



1. Generator
2. Inlet air
3. Combustion chamber
4. Air to Recuperator
5. Compressor
6. Turbine
7. Recuperator
8. Exhaust gases
9. Exhaust gas heat exchanger
10. Exhaust gas outlet
11. Hot water outlet
12. Water inlet



1. Generator
2. Rectifier/ Start converter
3. DC bus
4. Converter
5. Line filter
6. EMC filter
7. Main circuit breaker

Exhaust gas heat exchanger

The exhaust gas heat exchanger is of gas-water counter-current flow type. The temperature of the exhaust gases is approx. 270°C (518°F), entering the exhaust gas heat exchanger. The thermal energy from the exhaust gases is transferred to the hot-water system by the exhaust gas heat exchanger. The outlet water temperature depends on the incoming water conditions, temperature and mass flow. The exhaust gases leave the exhaust gas heat exchanger through an exhaust pipe and the subsequent chimney.

Supervision and control system

The Turbec T100 is controlled and supervised with an automatic control system. The CHP unit needs no attendance of personnel in normal use. In case of critical distortion the system automatically shuts down and records the fault to the PMC. The PMC is used to start, stop and supervise the CHP unit. The PMC runs the system by using values from sensors monitoring:

- Heat demand
- Gas pressure
- Oil temperature
- Vibrations

If a critical fault should appear in the CHP unit the PMC is programmed to execute one of the following actions:

- Normal stop
- Emergency stop

The fault is presented on the display on the control panel and logged in the system.

1.2 Auxiliary systems

- Lubrication system
- Cooling system
- Air intake and ventilation system
- Fuel gas system
- Buffer air system
- Fuel gas compressor
- Remote control

Lubrication system

The purpose of the system is to lubricate the squeezed film bearings of the unit. The system consists of a closed piping system and a oil tank placed within the enclosure. A motor-driven pump circulates the lubrication oil. The heated lubrication oil circulates from the bearings to an oil-to-air cooler and is cooled to 50°C (122°F). The PMC system monitors oil pressure and oil temperature in filters, oil preheater (before start-up) and oil tank to safeguard a reliable and continuous operation of the microturbine unit.

Cooling system

The generator and the electrical system are cooled with a separate cooling water system placed within the enclosure.

Air intake and ventilation system

The CHP unit draws ambient air from an outdoor intake. As the air reaches the CHP unit the air flow is divided into two partial flows. The main flow acts as combustion air in the microturbine. The secondary flow ventilates the excess heat out from the CHP unit. An induced draft fan placed on the outside wall creates a negative pressure inside the Turbec T100 enclosure, for safety reasons and for cooling. The ventilation air leaves the CHP unit through an air duct. Due to the relatively large diameter of the air duct the T100 can be placed several meters from the outside wall. There are two air filters in the Turbec T100 system, the prefilter (optional supply) is placed close to the outdoor intake of the air and the fine filter is placed close to compressor within the enclosure for filtering the combustion air. The full air requirement is approx. 1.7 kg/s, (3.7 lb/s) distributed on approx. 0.9 kg/s (1.9 lb/s) for ventilation and approx. 0.8 kg/s (1.8 lb/s) for combustion.

Fuel gas system

The fuel gas system includes piping from the gas entrance at enclosure, auto shut off valves, filter, fuel block, pressure sensor, fuel control valves and pipes to injectors. The inlet gas system is designed with fuel gas evacuation. The fuel system fulfils applicable gas installation- and safety standards.

Buffer air system
The buffer air system includes an air pump, interconnecting piping and filter for removal of oil mist. The air pump circulates compressed air to the sealing system to block the lubrication oil from entering the gas turbine engine. After the sealings, the air passes through an oil filter in which the oil mist is separated from the air and collected in the lubrication oil tank.

Fuel gas compressor
If the natural gas pressure is below 6 bar (g) (87 psig), it is necessary to use a fuel gas compressor to raise the pressure. The fuel gas compressor is situated outside the CHP unit.

Remote control
The control system is fully automated but can be remote controlled via the modem or with a PC network. The remote control allows an operator to remotely start and stop, download supervisory data and set values on the CHP unit to the same extent as a local operator can do on the operator's panel.

Additional emergency stop
The T100 is prepared to meet the requirements of an extra wall mounted emergency stop.

BMS
An already site existing BMS (Building Management System) can act as a complementary to the remote control system submitted by Turbec. This feature gives means of adjusting the electrical power output, obtaining a run and fault signal, starting and stopping the CHP unit via a BMS.

External power metering
The T100 is prepared for external power metering to measure the delivered power net to the grid. The nominal power value can be displayed on the operator's panel and via the remote control.

1.3 Technical data

General identification

Type:	Microturbine
Manufacturer:	Turbec AB, Sweden
Model:	T100
Application:	Combined Heat and Power
Usage:	Indoors
Dimensions of CHP unit:	Width 840 mm (33.1") Height 1 920 mm (75.6") Length 2 900 mm (114.2")
Weight:	2000 kg (4410 lb)
Fuel:	Natural gas
Ambient inlet air temperature:	–25°C to 40°C (–13°F to 104°F)
Ambient inlet humidity:	100%
Surrounding air temperature:	±0°C to 40°C (32°F to 104°F)
Surrounding humidity:	80%

Gas turbine

Compressor type:	Centrifugal
Turbine type:	Radial
Type of combustion chamber:	Lean pre-mix
Number of combustion chambers:	1
Pressure in combustion chamber:	4.5 bar (a) (65 psia)
Turbine inlet temperature:	950°C (1742°F)
Number of shaft:	1
Nominal speed:	70 000 rpm
Consumption of lubrication oil:	<9 litre/6 000 h operation (<2.4 gal/6 000 h operation)

Electrical data

Frequency output:	50 Hz (60 Hz)
Max. allowed mains frequency variation:	± 5%
Max. allowed mains voltage variation:	± 10%
Adjustable power factor:	0.80 leading to 0.80 lagging
Nominal voltage output:	400/230 VAC, 3 phases (480/277 VAC)
Start up voltage:	400 VAC, 50 Hz (480 VAC, 60 Hz)
Start up power:	Max 15 kW
Harmonic current:	
Maximum total distortion:	5 %
Maximum single distortion:	3 %
Output circuit:	5 wire connection
Protection circuit containing:	Over/under frequency trip*
Over/under voltage trip*	Phase error*
	Short circuit current protection
	Ground fault detection
	*(*Located in power electronics)*

Gas requirements

Pressure min/max:	6/8.5 bar (g) (87/123 psig)
Temperature min/max:	0°C/60°C (32°F/140°F)
Wobbe index*:	43-55 MJ/m_n^3 (1154-1476 Btu/scf)
Maximum content in natural gas:	$H_2$0 150 ppm v H_2S 45 ppm v
Fuel gas flow:	Depending on gas composition
Example at nominal load, 100 kW:	
Fuel gas LHV:	*39 MJ/m_n^3 (1047 Btu/scf)*
Volume flow:	*31 m_n^3/h (1095 scf/h)*
**Definition of Wobbe index:*	$W = \frac{HHV}{\sqrt{\frac{\rho_{gas}}{\rho_{air}}}}$

Gas compressor

Compressor type:	Scroll compressor
Inlet gas pressure:	0.02 - 1.0 bar (g) (0.3 - 14.5 psi)
AC Power supply:	345 - 525 VAC, (50/60 Hz)
Noise level	75 dBA at 1 m (3.3 ft)
Dimensions:	Width 610 mm (24") Height 1 070 mm (42") Length 1 370 mm (54")

2. Scope of Supply & Terminal Points

2.1 Scope of Supply

The delivery covers a complete Combined Heat and Power unit, ready for installation at terminal points below. The main parts of the scope of supply are as follows:

- Microturbine unit including turbine, compressor, generator and recuperator
- Fuel gas system
- Fuel gas compressor, delivered as a separate item
- Closed cooling water system for generator and electrical system
- Hot water temperature sensor
- Closed cooling system for gas turbine
- Closed lubrication system for gas turbine
- Exhaust gas heat exchanger for hot water production
- Enclosure for insulation of heat and noise
- Induced draft fan for ventilation of the enclosure, delivered as a separate item
- Frequency and voltage converters for the supply of 400 VAC, 3 phase, 50 Hz (480 VAC, 3 phase, 60 Hz)
- High performance electrical output filtering
- Automatic voltage regulation
- Circuit breaker
- Starting system including synchronizer
- Control panel with digital LCD display
- Computer modem for remote operation.
- Documentation:
  - Operation- and maintenance manual
  - Installation manual
  - Electrical manual

2.2 Options

- Pre filter (mandatory)
- Power generation only
- Hot air
- Bypass of water heat exchanger
- Load following
- Additional relay protection (if required)

2.3 Terminal points

The following terminal points applies to the scope of delivery of this proposal:

- Connections for in- and outlet for the water on the exhaust gas heat exchanger, located at the T100 enclosure wall.
- Connection for air inlet, located at the T100 enclosure wall.
- Pre filter (can be purchased from other supplier)
- Connection to exhaust gas outlet located at the T100 enclosure wall.
- Fuel gas evacuation system outlet
- Connections to fuel gas compressor with terminal points on the fuel gas compressor enclosure wall.
- Main inlet to gas fuel system, located at the T100 enclosure wall.
- Outlet connection of the ventilation air system, located at the T100 enclosure wall.
- Electrical connection at the T100 enclosure wall and connection to ventilation fan, hot water pump, hot water temperature, fuel gas compressor start signal, network cable and phone line for modem connection.

2.4 Terminal Points (option)

- Extra connection at the T100 enclosure wall for BMS, external emergency stop and external power meter.

3. Performance

Performance notes

The performance data includes the T100 auxiliary consumption powered by T100, i.e. cooling water pump, oil pump, induced draft fan, buffer air pump. The data are based on the following conditions for new and clean equipment operating at ISO standard conditions:

Site elevation:	0 m above sea level
Ambient temperature:	15°C (59°F)
Relative humidity:	60%
Fuel type:	Natural gas
Data for LHV	39 MJ/m_n^3 (1047 Btu/scf)
Pressure drop to air inlet flange:	0 Pa (0 psi)
Pressure drop from exhaust gas flange:	0 Pa (0 psi)
Water inlet temperature:	50°C (122°F)
Water outlet temperature:	70°C (158°F)

3.1 Performance data

Fuel gas pressure:	> 6.0 bar (g) (87 psi)
Electrical output:	105 kW (±3)
Electrical efficiency:	30 % (±1)
Total efficiency:	78 % (±1)
Thermal output(hot water):	167 kW (±5) (570 000 Btu/h)
Fuel consumption:	350 kW (1 194 000 Btu/h)
Exhaust gas flow:	0.80 kg/s (6350 lb/h)
Exhaust gas temperature:	85°C (185°F)
Noise level:	70 dBA at 1 meter (3.3 ft)

Volumetric exhaust gas emissions at 15% O_2:

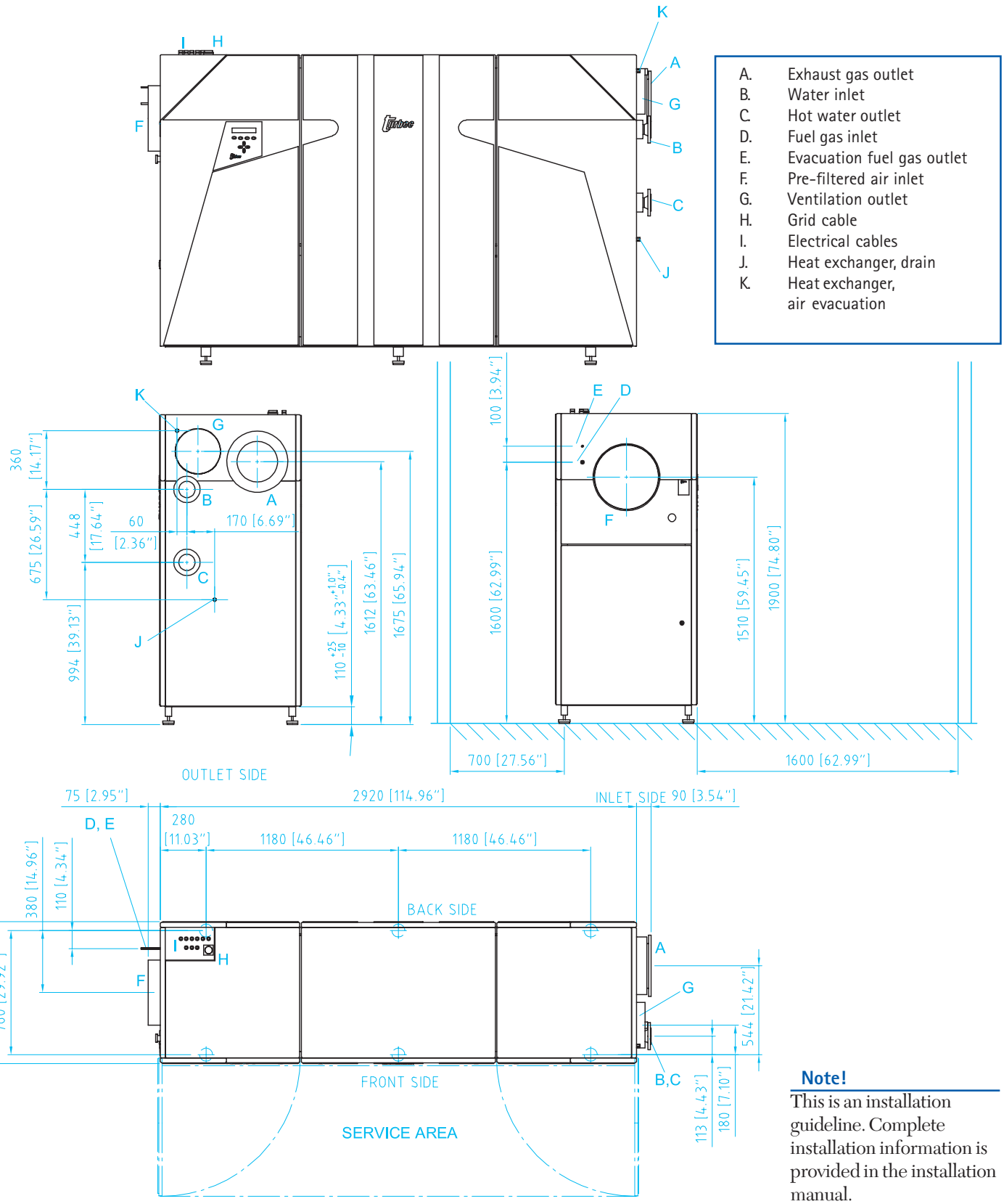
	100% load
NO_x:	< 15 ppm v = 32 mg/MJ fuel
CO:	< 15 ppm v = 18 mg/MJ fuel

Performance with low pressure gas source;
0.02 - 1.0 bar (g) (0.3 - 14.5 psi)
Nominal power consumption of fuel gas compressor is about 5 kW

Net electrical power output	*100 kW (±3)*
Net electrical efficiency	*28,5 % (±1)*
Net total efficiency	*76,5 % (±1)*

4. Installation

4.1 Layout & terminal points



Note!

This is an installation guideline. Complete installation information is provided in the installation manual.

5. Maintenance & CE complience

5.1 Maintenance concept

Lifetime of components

The simple and rugged design of the T100 power module provides for a durable operation for many years. Expected lifetimes of main components are listed below:

Gas turbine engine	> 60 000 hrs
Recuperator:	> 60 000 hrs
Combustion chamber:	> 30 000 hrs (some parts < 30 000 hrs)

Maintenance concept

Inspections, maintenance and overhaul intervals and duration

	Interval (h)	Outage (h)
Inspection	6 000	24
Overhaul	30 000	48

Inspection and maintenance

- General checks
- Inspection of the combustion chamber and the change-out of the fuel nozzle
- Change of consumables, filters, oil and water refill (if necessary)
- General visual check
- Fuel gas compressor inspection and refill of oil and change-out of oil filter
- Check/change of 24 VDC battery

Overhaul

- Same procedure as in Inspection
- Change of the entire combustion chamber
- Engine refurbishment
- Change of bearings in lubrication oil pump, ventilation fan and buffer air pump

5.2 CE compliance

This equipment complies with the basic health and safety regulations of the European Economic Area (EEA). The T100 CHP unit follows these directives:

Machinery Directive 98/37/EC
Electromagnetic Compatiblity Directive 89/336/EEG with amendments 92/31/EEG and 93/68/EEG
Low Voltage Directive 73/23/EEC, 93/68/EEC.

CE

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