CHAPTER 3 – STEAM TURBINE

CONTENTS

1 Turbine Set

1.1 Design Features

Heating turbine, according to DIN 4312,

Model MARC 4 – B00

Direction of turbine exhaust: *downwards.*

Turbine of multiple-stage reaction design, containing the following design features:

- Horizontally split turbine casing of cast construction for the HP-part and welded construction for the exhaust casing.
- Guide blade carriers as support for the guide blading of the reaction section, of forged or cast construction
- Nozzle group control.
- Drum type turbine rotor.
- Steam sealing glands between casing and rotor are of the labyrinth type.
- Radial split journal bearings of multi-face sleeve type, protected against unacceptable heating, stripping of bearing halves without removal of turbine casing is possible.
- Self-aligning thrust bearing of double-sided segmental bearing design.
- Base frame for the turbine unit.

1.2 Drain System

A complete turbine draining system is provided to allow the safe start-up and operation of the turbine.

The drain system includes:

- Isolating valves for start-up with manual actuators.
- Steam traps.
- All internal drain pipes.

Drains are installed at the following points:

- Upstream of the turbine stop valve.
- At the lowest points of the turbine casing, where condensate can accumulate.
- At any other point where condensate could collect, either during plant start-up, normal operation or standstill.

Turbine drains are arranged to individually discharge into the gland sealing steam/drain collector.

1.3 Gland Sealing System

A complete turbine leakage steam system is provided, comprising a water-cooled gland steam condenser (optional price), including all necessary piping, fittings, instruments and controls necessary for operation at all loads, stand-by conditions, starting and stopping.

1.4 Rotor Barring Gear

- Rotor barring gear with AC-motor, which will disengage/engage automatically as soon as the turbine speed reaches the turning gear speed without turbine stand-still (Note: manual turning is possible).
- Electronic motor soft starter for the rotor barring gear.

The turning device is necessary for turbine plants during warm-up and cool-down periods. This device is arranged on the front bearing pedestal of the turbine. The speed corresponds to the turning speed of the turbine. During starting periods the turning device will be connected at standstill. A self-engaging overrunning clutch automatically provides for connection with the turbine shaft. When the turbine speed exceeds the turning speed during run-up the overrunning clutch will automatically disconnect. In the transmission stage from mechanical operation to turning operation, the overrunning clutch will automatically engage as soon as the turbine speed reaches the turning speed. Thus, the turning device overtakes the turning of the turbine plant.

1.5 Coating

General (for turbine): Prime and final coating according to MARC standard. All parts in contact with steam are coated with heat-resistant silver bronze all other parts are coated in RAL 5010 “blue”.

<u>Surface Preparation:</u>
According to DIN 55928, part 4 ; degree of purity: Sa = 2 ½

<u>Prime Coating:</u>
1 x Permatop 2029 (or equal)
Coat thickness 80 µm (dry)
Colour of undercoat: RAL 7001, silver-grey
Turbine casing: heat-resistant silver bronze

<u>Final Coating:</u>
1 x Permatex 2407 (or equal)
Coat thickness 50 µm (dry)
Colour of final coat: RAL 5010, blue

1.6 Thermal Insulation

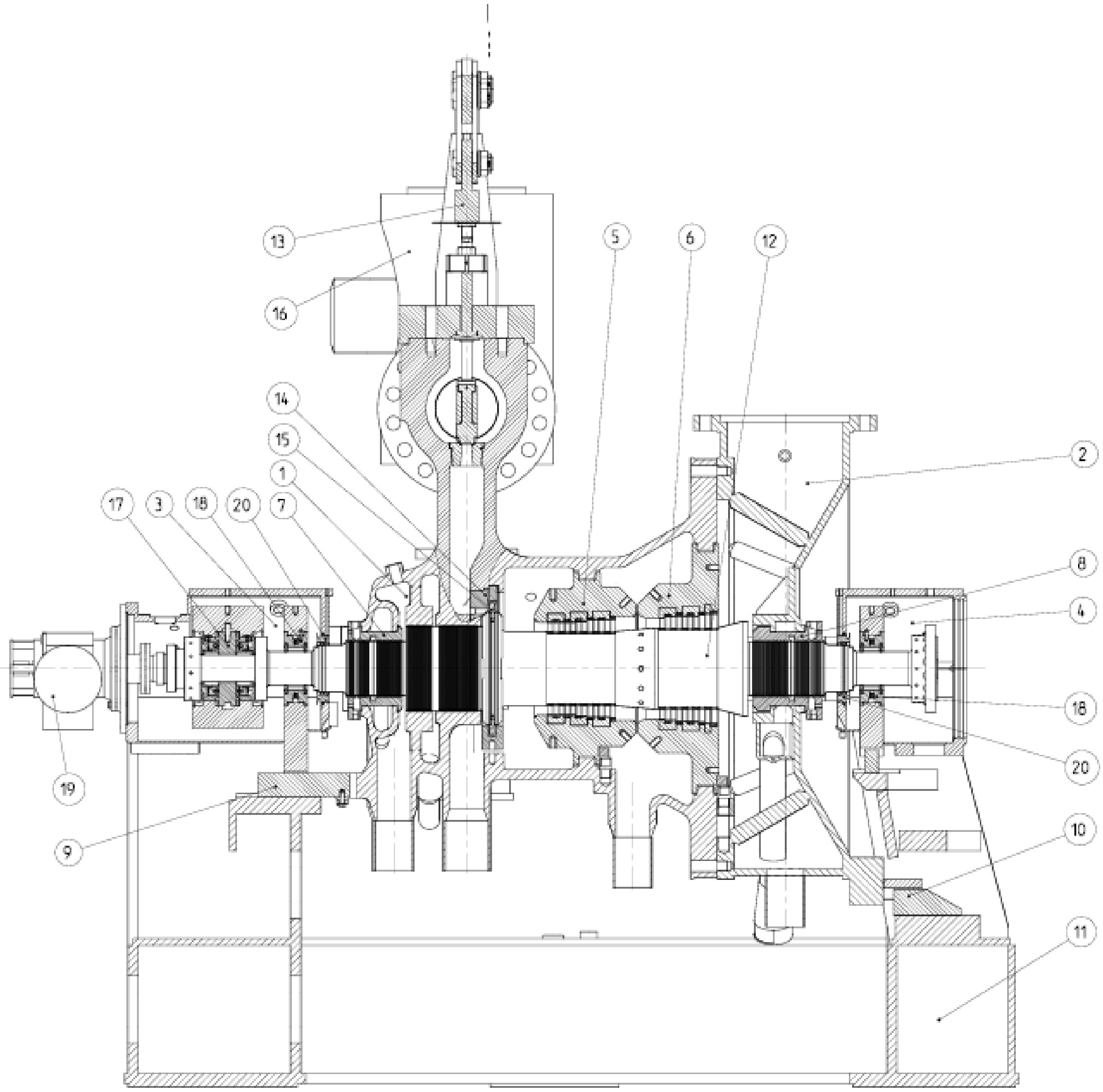
All surfaces with a temperature exceeding 60 °C during normal operation will be thermally insulated. Exceptions will be made for oil supply, gearbox, safety valves and similar components whose function is limited by insulation.

The insulation consists of glass fibre mats with mineral wool filling with a density of 70-100 kg/m^3.

1.7 Miscellaneous

- Dynamic and static calculation for the turbo-generators foundation including design and drawings of reinforcements.
- Trip valve with hydraulic actuator.
- Steam strainer for the live steam, integrated in the inlet chest.
- Identification code for the turbo-generator set according to KKS-system.
- The turbine will be provided with a connection for a hot air drying unit (e. g. Munters type).
- The turbine will be provided with endoscopic openings (wheel chamber and exhaust) for inspection of turbine blades without removal of turbine casing.

1.8 Sectional Drawing Turbine



Pos.	Anz.	Benennung	Designation
1	1	Gehaeuse	Housing
2	1	Abdampfgehaeuse	Exhaust steam housing
3	1	Lagerbock-vorne	Bearing housing front
4	1	Lagerbock-hinten	Bearing housing rear
5	1	Leitschaufeltraeger 1	Stationary blade carrier 1
6	1	Leitschaufeltraeger 2	Stationary blade carrier 2
7	1	Stopfbuchse vorne	Stuffing box front
8	1	Stopfbuchse hinten	Stuffing box rear
9	1	Gehaeusefuehrung vorne	Housing guide front
10	1	Gehaeusefuehrung hinten	Housing guide rear
11	1	Grundrahmen	Base frame
12	1	Turbinenlaeufer	Turbine rotor
13	1	Stellventil-HD	High pressure control valve
14	1	Duese-HD	High pressure nozzle
15	1	Regelstufe-HD	High pressure regulation step
16	1	Schnellschlußventil	Quick closing valve
17	1	Axiallager	Thrust bearing
18	2	Radiallager	Journal bearing
19	1	Rotordrehvorrichtung	Turning device
20	2	Oelabstreifer	Oil deflector

2 Gearbox

2.1 General

- Generator mounted epicyclic gearbox according to DIN 3990.
- Coaxial high speed and low speed shafts.
- Couplings:
  - High speed curved tooth coupling between turbine and gearbox
  - Flange coupling between gearbox and generator
- Coupling casing

2.2 Design Data

Stages	1
Toothing	double helical or spur
Inlet speed	approx. 8,000 rpm
Drive speed	1,500 rpm
Max. continuous output	105 %

2.3 Technical Description of Epicyclic Gear Unit

The description may change according to the chosen gear box supplier. The following description is based on a BHS type gear box. The description of other Sub-suppliers like Renk or Allan Gears can be handed in on request.

- Single stage, Stoeckicht epicyclic gear unit, star gear design (the annulus rotates, the planet carrier is fixed to the gear housing)
- Double helical gearing
- Sun gear and planet gears shaved and nitrated
- Annulus shaped, tempered steel
- Planet gears with hydrodynamic bearings
- Star carrier supported by gear housing / generator housing
- Annulus directly coupled to the generator shaft flange with a tooth ring
- Coaxial high speed and low speed shaft rotating in opposite directions, tooth coupling on the high speed shaft
- Gearing design according to DIN 3990 / AGMA 421.06

Compensation of axial forces:

- Double helical gears prevent internal axial forces when the teeth are meshing
- External axial forces are compensated through a thrust bearing in the turbine

2.4 Connection to Generator Frame

The gear housing is screwed to the generator frame through an adaptor flange

2.5 Coupling

Double sided tooth coupling between steam turbine and gear unit with curved gearing

2.6 Design Features

The epicyclic gear in principle consists of the planet carrier with 3 planet bolts (item 18), 3 planet wheels running in sleeve bearings (item 13), the two annuli (item 15) radially movable in the annulus sleeve (item 16) for load compensation, the sun-wheel (item 12) and the gear coupling on the high speed side.

The epicyclic gear is of star gear design, i.e. the planet carrier is fixed to the housing and the annuli with the annulus sleeve rotate (low speed side). The sun-wheel (high-speed side) is freely floating between the 3 planet wheels (load equalization), The gear coupling compensates the radial movement of the sun-wheel.

The gearing is of the double helical design.

2.7 Internal Oil Distribution and Sealing

The oil enters the gear laterally through an oil connection and lubricates the hydro-dynamic sleeve bearings of the planet wheels through the annuli (small outlet bores). Through bores in the planet carrier the oil is then fed to the sun-wheel where the gear is also fed with oil through small bores. The remaining oil is used to lubricate the gear coupling before accumulating at the bottom of the gearbox and being returned to the oil system.

The gearbox is sealed to the generator by a floating ring seal and a thrower on the generator shaft. The floating ring seal is mounted on the back-plate of the flange where the gearbox is fitted to the generator.

2.8 Efficiency

The gear losses (epicyclic or helical gear) in principle are calculated as follows:

total loss = gear mesh losses + bearing losses + ventilation losses

Gear mesh losses are totally unimportant for turbo-gears with high peripheral speeds (< 2 % of the total losses). The main sources of loss are bearing and ventilation losses increasing as the gear size increases and the power to be transmitted.

Compared to the helical gear the epicyclic gear achieves a much higher efficiency (the higher the ratio, the larger the difference), due to

- Compact dimensions, thus lower peripheral speed and less ventilation losses
- No high-speed and heavily loaded sleeve bearings as in a helical gear (bearings of the planet wheels having only supporting function).

2.9 Sectional Drawing Gear Box