CHAPTER 7 – MISCELANUOUS

CONTENTS

1 Documentation

1.1 Operation Manual

Three (3) sets of instruction manuals for operation, maintenance and overhaul, for the equipment will be supplied.

Execution: MARC-Standard.

Language: Flemish for the operation & maintenance Documentation
English for the other parts as long Flemish is not available

The manual includes:
- General description of system
- Start/stop procedures
- Process monitoring
- Revision/maintenance

1.2 Documents

Three (3) sets of documentation, for the equipment will be supplied.

Execution: MARC-Standard.

Language: Flemish for the operation & maintenance Documentation
English for the other parts as long Flemish is not available

The documentation includes:
- Drawings
- P&I schematics
- lists (measuring points, signals, armatures)
- Documentation of devices

1.3 Planning Documents Time Schedule

Planning documents (for the steam turbine) will be earliest prepared and issued in accordance with the following time schedule:

No.	Document	Preliminary	Final	Remarks	
		Weeks after technically clarified order			
1	General arrangement drawing	20	28		
2	Order drawing foundation	---	30	soil data expertise must be available at date of order	
3	Planking and reinforcement drawings. with stress analysis	---	34		
4	Pipe connection table	20	28		
5	Forces + moments on turbine connection	20	28		
6	P&I diagrams (steam, control oil, lubrication oil)	20	28		
7	List of measuring points	20	28		
8	List of electric consumers	20	28		
9	Signal transfer list	20	28		
10	Cable list	32	38		
11	Terminal tie-up plan	---	38		

Note:

Even final documents may be altered within the MAN scope of supply, unless interfaces to customer are involved.

2 Erection, Commissioning, Test-Run

2.1 General

Our offer includes a lump sum position for personnel for erection, commissioning and test-run. In the following we have listed the expected time periods:

Erection	:	6	weeks
Commissioning (cold and hot)	:	4	weeks
Test run	:	2	weeks
Instructions to operating personnel	:	during test run	

The above mentioned periods for erection and commissioning are based on 8 working hours per day and 5 working days per week. Any additional personnel needed for erection as well as any additional technical equipment is in the responsibility of the customer.

The test run will be executed by the customer's operating personnel. During test run our Erection Manager will be available 8 hours per day, at night on request only.

Erection works will start directly after delivery of the turbo-generator to site. Prior to the start of erection the powerhouse needs to be in a condition that the work can be performed without interruption. In particular, it is required that foundation works are completed before delivery of the main components. Any delays and waiting times as well as additional travelling expenses resulting thereof will be invoiced separately.

Our offer is based on the assumption that the main components will be brought into the turbine hall through an opening in the roof. A mobile crane service is comprised within the scope of supply of MAN.

2.2 Criteria for Completion of Installation

- Turbine aligned and grouted - Prerequisite: foundations capable of bearing, installation practicable, hall crane available
- Steam and drainage systems piped - Prerequisite: steam blasting finished
- Control oil and lubricating oil modules installed
- Oil systems piped
- Oil systems flushed and filled - Prerequisite: oil pumps provisionally connected to mains
- Condensers installed, aligned and grouted - Prerequisite: foundations capable of bearing, installation practicable, hall crane available
- Condensate system piped
- Electric panels installed
- Plant cabled - Prerequisite: terminal boxes and cable routes with trays ready for commencement of cabling

Not Completed Works:

- Insulation work can also be carried out during cold commissioning.
- Residual work can also be carried out during cold commissioning.

2.3 Arrangements at Site and Coordination of the Costs

S = Supplier, BVI
C = Customer

Assembly Staff

	Not	Supplied by		Paid by	
	needed	C	S	C	S
1.1 Supervision/assembly instr.			x		x
1.2 Skilled labour			x		x
1.3 Assistant labour			x		x
1.4 Controllers			x		x
1.5 Travelling expenses of labour			x		x
1.6 Accommodation			x		x
1.7 Start-up engineer			x		x
1.8 Start-up and test run staff		x		x	

Site Offices

	Not	Supplied by		Paid by	
	needed	C	S	C	S
2.1 Office 1 pc 40 m2			x		x
2.2 Equipment			x		x
2.3 Phone and telefax/suppliers usufruct			x		x
2.4 Telephone and telefax expenses			x		x
2.5 Tool store m^2	x				
2.6 Warm store m^2	x				

2.7 Cold store m^2	x				
2.8 Unsheltered store m^2	x				
2.9 Staff room 4 men			x		x
2.10 Site canteen x men	x				
2.11 X-ray room m^2	x				
2.12 Cleaning of staff rooms concerning deliverer's delivery			x		x

Construction Engineering

	Not	Supplied by		Paid by	
	needed	C	S	C	S
3.1 Groundwork		x			
3.2 Grouting		x			
3.3 Boring and pick dressing		x			
3.4 Erection holes incl. protection		x		x	
3.5 Geodetic measures and marking the lines		x			
3.6 Anchor ground, lifting and hauling equipment			x		x
3.7 Adhesion steel of groundwork		x		x	

Transport and Storage

	Not	Supplied by		Paid by	
	needed	C	S	C	S
4.1 Machine and equipment transport			x		x
4.2 Transport of erection tools			x		x
4.3 Discharging from the vehicle		x		x	
4.4 Storage and cover material	x				
4.5 Transport to the intermediate store			x		x
4.6 Transport and transfer to the site			x		x
4.7 Roads and cleaning the unsheltered store from snow		x		x	

Tools and Accessories

	Not	Supplied by		Paid by	
	needed	C	S	C	S
5.1 Mobile Cranes			x		x
5.2 Hoists			x		x
5.3 Hand tools			x		x
5.4 Welding machines, welding and combustion gas			x		x
5.5 Material needed for welding			x		x
5.6 Pipe brackets			x		x
5.7 Timber		x		x	
5.8 Bracket work		x		x	
5.9 Electricity costs		x		x	
5.10 Connection costs	x				
5.11 Electricity distributions central (main central)		x		x	
5.12 Compressed air m^3/min aty		x		x	
5.13 Instrumentation air m^3/min aty		x		x	
5.14 Water		x		x	
5.15 Water for the test effort		x		x	
5.16 Lubrication oils and hydraulic oil			x		x
5.17 First filling of lubrication			x		x
5.18 Treatment of acid cleaning water and alkali wash water	x				
5.19 Sampling & analysis during start-up and test run		x		x	
5.20 First filling of hydraulic oil			x		x

General

	Not	Supplied by		Paid by	
	needed	C	S	C	S
7.1 Heating on the site		x		x	
7.2 Venting on the site		x		x	
7.3 Cleaning of installation site and waste treatment according to the clients instructions			x		x
7.4 Safety equipment		x		x	
7.5 Personal protecting devices			x		x
7.6 First aid equipment		x	x	x	x
7.7 Fire appliances / Fire guard (general)		x		x	
7.8 Fire guard in the working object			x		x
7.9 Factory guard		x		x	
7.10 General illumination		x		x	
7.11 Illumination in the working objects			x		
7.12 Electricity work		x		x	
7.13 X-ray and U-sonic controls			x		x
7.14 Repair painting			x		x
7.15 Final surface painting			x		x
7.16 Official inspections of machines and equipment		x	x	x	x

3 Personnel Training

Training Objective

MAN provides a training for the Purchaser's operation personnel according to the below outlined programme. The principal objective of this programme is to introduce the Purchaser's technical staff into the essential aspects of the turbine unit for proper operation and maintenance of the equipment supplied by MAN.

Trainees Qualification

The trainees selected by the Purchaser for the training shall possess adequate power plant knowledge. The training courses will be held in Swedish (general information) and English (special knowledge by the site manager/ commissioning engineer). The operating staff should be able to read, write and converse in the English language.
Further on they shall have approx. three years experience in the fields they are assigned to work in. If this is not the case the client should suggest a feasible solution for a successful good training. It is expected that the trainees are capable to read and understand technical documents such as: layouts, flow diagrams, single line diagrams, isometric diagrams, etc.

Time Table

The operating personnel will be instructed in detail with regard to operation and maintenance at the time of commissioning and test-run by the respective MAN service technician.

Programme

The instruction includes:

- Preparations for start up and shut-down
- Turbine control principle
- Power increase / decrease
- Operational reports
- Measures to be taken after turbine tripping
- Possible risks during operation of the plant and measures in case of danger
- Regular control
- Maintenance measures and their purpose
- Electrical installations and automation

4 Quality Assurance/Inspection and Testing

4.1 General

MAN TURBO AG Hamburg, formerly Blohm & Voss, build steam turbines of own design and development since 1907 and is thus one of the oldest steam turbine makers in the world. After the Second World War, the development primarily led to industrial steam turbines for any industrial application, such as chemical, petro-chemical, paper, wood, textile, tobacco and food industries etc. as well as for heating power stations and incineration plants with heat/power co-generation.

The special feature of modern reaction turbines are best efficiencies and quick thermal adaptation to differing loads due to the guide blade carrier or inner casing design.

The high quality of MAN turbines is based on consistent and permanent development, close co-operation with our customers as well as research and test work with renowned universities.

Each requirement is individually treated with regard to expected operating conditions and characteristics in respect of thermodynamic calculation, design and equipment with control system, measuring and monitoring as well as safety devices.

All thermodynamic, strength, torsion and vibration calculations are carried out with internal computer programs, partly directly coupled with our CAD/CAM system which we have been using for our design work for several years.

Besides company standards, all relevant rules and regulations such as DIN/ISO/VDI/VDE/API etc. are applied and considered in accordance with the specific requirements.

MAN workshops are equipped with the most modern machine tools. Our experienced personnel ensure the proper manufacture of our turbines and technical assistance to our customers during planning, construction, erection, commissioning and start-up as well as during operation of the plant.

All work is subject to permanent supervision, starting with calculation and design drawings, from material procurement, incoming inspection, intermediate and final inspections of manufacture, function checks in assembled condition in our workshop to erection supervision on site. All inspections and tests are accompanied by documentary evidence in the form of certificates. Effective scheduling ensures the follow-up of our orders in due time.

4.2 Non-Destructive Tests

The following tests are carried out in our factory subject to the standards set out below.

Magna-flux test	DIN 54 130 Non-destructive test, Magnetic fringing flux process.
Dye penetrate test	DIN 54 152, part 1 Non-destructive test Dye penetrate process.
Radiographic test	DIN 54 111, part 1 Testing of metallic material by means of x-rays and gamma rays, Radiographic images of fusion welds. Assessment according to DIN 8563, Part 3, fusion welds, Requirements, quality groups.
Hydraulic pressure test	DIN 50 104 Hydraulic pressure test, leak test.

In addition to the tests specified in the following, dimension and quality checks are carried out regularly during manufacture and assembly.

4.3 Turbine Quality Inspection Plan

Part	Testing	Certificate
all electrical equipment	certificate of conformity acc. to EU-Rule 89/336/EEC EM-compatibility	certificate of conformity acc. to EU-Rule 89/336/EEC EM-compatibility
Turbine casing (Casting) Part : Raw material foundry	Material analysis and mechanical properties Ultrasonic test Magn. particle test Heat treatment Wall thickness	Inspection certificate 3.1B EN 10204
Welding steam lines + other structure welding Part : Raw material foundry	Magn. particle test Radiography test	Inspection certificate 3.1B EN 10204
Turbine exhaust- casing (welded) Part: finished by subcontractor	Material analysis and mechanical properties Heat treatment	Inspection certificate 3.1B EN 10204 heat treatment certificate
Guide blade carrier Part : Raw Material	Material analysis and mechanical properties Ultrasonic test Magn. particle test Heat treatment	Inspection certificate 3.1B EN 10204
Baseplate Part: finished by subcontractor	Material analysis and mechanical properties dimension check	Specific test report 2.3 EN 10204
Front and rear bearing housing Part: finished by subcontractor	Material analysis and mechanical properties dimension check	Specific test report 2.3 EN 10204
Turbine rotor Part: Raw Material	Material analysis and mechanical properties Ultrasonic test Magn. particle test Heat treatment	Inspection certificate 3.1B EN 10204
Thermal stability test accord to SEP 1950	Material analysis and mechanical properties Ultrasonic test Magn. particle test Heat treatment	Inspection certificate 3.1B EN 10204
Front/Rear gland Part: Raw Material foundry	Material analysis and mechanical properties Ultrasonic test Magn. particle test	Inspection certificate 3.1B EN 10204
Radial bearing Part: finished product from subcontractor	Ultrasonic test white metal bond	Specific test report 2.3 EN 10204 or statement of compliance (for Kingsbury bearing)
Axial bearing Part: finished product from subcontractor	Ultrasonic test white metal bond	Specific test report 2.3 EN 10204 or statement of compliance (for Kingsbury bearing)

Nozzle ring Part: Raw Material	Material analysis and mechanical properties Ultrasonic test Magn. particle test Heat treatment	Specific test report 2.2 EN 10204
Blade material Part: Raw Material	Material analysis and mechanical properties Ultrasonic test Magn. particle test Heat treatment	Inspection certificate 3.1B EN 10204
Heat resisting screws and nuts Part: Finished product from subcontractor	Material analysis and mechanical properties Heat treatment	Inspection certificate 3.1B EN 10204
Steam control valve plate Part: Raw Material	Material analysis and mechanical properties Heat treatment	Inspection certificate 3.1B EN 10204 heat treatment certificate
Turbine control Part: Finished product from subcontractor	function test of electronic control EM-compatibility check	Certificate of conformity acc. to EU-Rule 89/336/EEC EM-compatibility
Parts for control valve and trip valve of heat resisting material Part: Raw mat. Forge	Material analysis and mechanical properties	Inspection certificate 3.1B EN 10204
Oil filter Part: Finished product from subcontractor	Pressure test	see oil-supply-unit
Oil cooler Part: Finished product from subcontractor	Pressure test	see oil-supply-unit
Main oil pump(s) Part: Finished product from subcontractor	Pressure test EM-compatibility check for drive motor	see oil-supply-unit
Auxiliary pump(s) Part: Finished product from subcontractor	Pressure test EM-compatibility check for drive motor	see oil-supply-unit
Emergency pump(s) Part: Finished product from subcontractor	Pressure test EM-compatibility check for drive motor	see oil-supply-unit
Non-return-flap Part: Finished product from subcontractor	inspection certificate 3.1B EN 10204	Certificate of conformity acc. to EU-Rule 89/336/EEC CE-mark
Blend quick-action valve Part: Finished product from subcontractor	Material analysis and mechanical properties	Certificate of conformity acc. to EU-Rule 89/336/EEC CE-mark
Steam pipes and accesso-ries Part: Manufacturer B+V	Material analysis and mechanical properties Heat certificate weld seam by subcon-tractor	Inspection certificate 3.1B EN 10204

Steam pipes and accesso-ries Part: Site construction by subcontractor	Material analysis and mechanical properties Annealing certificate weld seam steam pipes by subcontractor	Inspection certificate 3.1B EN 10204
Safety valves Part: Finished product from subcontractor	Material analysis and mechanical properties Pressure test Adjustment of valve	Inspection certificate 3.1B EN 10204 TÜV-acceptance test or adjustment
Accessories (motor operated valves, non-return flaps) Part: Finished product from subcontractor	function test Pressure test	Certificate of conformity acc. to EU-rule 89/336/EEC CE-mark
Gear Part: Finished product from subcontractor	Material analysis and mechanical properties Dyn. balancing of pinion-/wheel shaft Test run; gear contact reflection; measuring data of oil pressure; temperatures; power loss; vibration measurement; noise level; no load/low load	Certificate of conformity acc. to EU-rule 89/392/EEC CE-marking
Rotor turning device Part: Finished product from subcontractor	Performance test SSS-Coupling	Certificate of conformity acc. to EU-rule 89/392/EEC and 89/336/EEC CE-marking
Coupling Turbine/Gearbox Part: Finished product from subcontractor	Material analysis and mechanical properties Dynamic balancing	Specific test report 2.3 EN 10204
Generator Part: Finished product from subcontractor	EU-Certificate of conformity acc. to EU-Rule 89/392/EEC app. IIA Certificate of conformity acc. to EU-Rule 89/336/EEC EM-compatibility	EU-Certificate of conformity acc. to EU-Rule 89/392/EEC app. IIA Certificate of conformity acc. to EU-Rule 89/336/EEC EM-compatibility
Oil-Supply-Unit - control oil - bearing oil	- function test - pressure test 0,5 bar	Certificate of conformity acc. to EU-rule 89/392/EEC and 89/336/EEC CE-marking

4.4 Epicyclic Gear Unit - Standard QCP

	Low speed shaft	Planet wheel carrier	Sun wheel	Planet wheels	Annulus gear	High speed shaft	Annulus gear suspension	Axial-radial bearing	Planet wheel spindles	Housing	Power take-off	
Chemical analysis	x	x	x	x	x	x	x	x	x	x	x	
Mechanical strength properties	x	x	x	x	x	x	x					
Ultrasonic test	x	x	x	x	x	x					x	
Gearing test			x	x	x	x	x				x	
Hardness test [2)]			x	x		x						
Surface cracking test	x	x	x	x	x	x	x				x	
Balancing	x	[1)]	x	x	[1)]	x	[1)]				x	
Equilibration				[1)]						[1)]		
Bonding error test									x	x		
Test run											x	
Conformity	x	x	x	x	x	x	x	x	x	x	x	x

1) If required
2) Mech. strength values determined tensile and notched bar test, in exceptional cases by means of Brinell hardness test.

4.5 Schedule of Generator Tests

The following tests would be carried out at works:

Static Tests

- Cold winding resistance's.
- Insulation resistance's.
- Air-gap check.
- Bearing insulation.
- Diode checks.
- Auxiliaries and fittings check.

* Application of high voltage between windings and earth.
* Inspection of bearing sleeves.

Mechanical Running Tests

* Vibration check.
- Water quantity (if applicable).
- Oil quantity and pressure.
* Over-speed at 120% rated speed.
* Vibration check after over-speed.

Electrical Running Tests

- Phase rotation check.
* Open circuit saturation and losses.
* Short circuit saturation and losses.
* Temperature rise at zero power factor.
- Zero power factor points.

After these tests have been completed the gearbox will become attached to the generator and a no-load run will be carried out to check alignment and vibration.

Allowance has been made for the tests marked * to be witnessed by you.

5 Required Steam Quality

Conductivity	at continuous operation	< 0.2 µS /cm
Silica	at continuous operation	< 0.02 mg SiO_2/kg
Total – Iron	at continuous operation	< 0.02 mg Fe/kg
Sodium + Potassium	at continuous operation	< 0.01 mg/kg
Copper	at continuous operation	< 0.003 mg/kg
Oxygen	at continuous operation	< 0.02 mg O_2/kg
Chlorine	at continuous operation	< 0.1 mg CL-/kg
pH value	at continuous operation	9.2 – 9.6

The above steam quality corresponds to dry saturated steam and ensures an absolutely reliable operation.

6 Steam Blasting

Steam Blasting - General

The purpose of steam blasting is to achieve a steam cleanliness to ensure a safe operation of the turbine plant. In this way loose particles of rust, scales and sand are removed by means of high steam velocity. Furthermore, more adhesive deposits are thermally removed i.e. shrinkage stress between metal and metal oxide through cooling down will cause the oxide deposits to be chipped off.

Besides all relevant publications on this subject, we refer to the VGB-Guideline *VGB-R 513 „Innere Reinigung von Wasserrohr-Dampferzeugungsanlagen und Rohrleitungen*“ (recommendation for the interior cleaning and blasting of high-performance boilers and steam pipes)

Connection of the live steam pipe to the turbine

The MARC-turbine is provided with a weld end at the live steam trip valve where the live steam line will be connected. The live steam trip valve is connected to the admission chest of the turbine through a flange connection and to the live steam line through a welded connection. The pipe supplier consults BVI in due time concerning the pipe connection dimensions.

The live steam trip valve will be loose delivered to site and mounted by BVI to the admission chest of the turbine. The live steam pipe is laid until just in front of the turbine by the pipe supplier. The alignment will be done by the preliminary mounted live steam trip valve.

Afterwards, the live steam trip valve will be dismounted by the pipe supplier, in order to connect blasting pipe.

After steam blasting, the blasting pipe will be removed, the live steam trip valve will be mounted by the pipe supplier and the joint between live steam trip valve and live steam pipe is welded by the pipe supplier.

Assembly welds which are welded after steam blasting in principal have to be WIG welded. The area of the pipe to be welded is to be provided with forming gas to avoid the formation of scales inside the piping. The inert atmosphere has to be maintained during annealing. Any work executed on the live steam pipe after blasting has to carried out with utmost caution. It has to be observed in particular that no foreign bodies can enter the blasted system. Any residues from separation processes (when removing the blasting pipe) have to be sucked off. The pipe supplier is responsible for this work.

Instructions for the design of the blasting pipe

The blasting pipe is designed and fabricated by the boiler or piping supplier. Their work comprises the correct support of the whole blasting pipe as well as the arrangement of the test rod in the pipe. The test rod should be fitted at the entry of the blasting pipe. To avoid pressure and/or velocity losses it is necessary to extend the blasting pipe in way of the test rod so that the free cross-section corresponds at least to that of the live steam pipe. The test rod is located right after the extension. For noise reasons the blasting pipe should be designed 1-2 nominal widths larger than the diameter of the live steam pipe.

Blasting velocity /necessary steam mass flow

The blasting is only effective if the steam velocity is higher than the velocity at full load operation. The necessary mass flow is determined by means of the following formula:

$$\dot{m}_B \geq \dot{m}_v * \sqrt{\frac{V_V}{V_B} * K}$$

$\dot{m}_B$ steam mass flow during blasting

$\dot{m}_v$ steam mass flow at full load

V_B specific steam volume during blasting

V_V specific steam volume during full load operation

K disturbance factor (put in at least *1,4)*

The specific steam volume as a function of steam temperature and steam pressure is to be taken from the specific literature (steam tables, h,s-Diagram). The measuring points for these parameters are always right before the turbine.

Testing of steam cleanliness

A high-polished test rod free from scars has to be fitted at the entry of the blasting pipe (material acc. to table below). The length of the test rod in way of the pipe shall cover 2/3 of the inner pipe diameter, the rod having a minimum width of 30 mm. The test rods with the necessary holders have to be supplied by the piping/boiler supplier.

To achieve the maximum piping expansion during operation already on steam blasting, the pipe wall temperature of the live steam pipe during steam blasting should almost correspond to the later operating temperature.

It should be waited between the individual blasting processes until the surface temperature of the pipe wall has cooled down by 150 - 200 °C. Before the last blasting, the piping must cool down to 100°C. After blasting the impacts on the test rod may show following diameters (area 30 x 30 mm):

Material			Brinell hardness [HB]	Impacts
E-Cu57 F25	///	2.0060	70-90	none > 0,5 mm max 1 impact 0,5-0,2 mm max 5 impacts 0,2-0,1 mm
St37.0 RSt37-2	/// ///	1.0254 1.0038	100-130	none > 0,3 mm max 1 impact 0,3-0,1 mm max 5 impacts 0,1-0,05 mm

Steam blowing was successful, if the results of two sequence blasting meet the requirements.

Logging

The successful completion of steam blasting is certified by a protocol which has to be signed by the operating company, the boiler manufacturer, the pipe supplier and the turbine suppler. They further certify by their signature that the inlet pipe connection of the turbine shows the required cleanliness. The original protocols as well as the test rods remain in the operating company.

Responsibility

Following the VGB-Guideline *VGB-R 513 „Innere Reinigung von Wasserrohr-Dampferzeugungsanlagen und Rohrleitungen*““ the boiler manufacturer is responsible for the correct steam blasting of new plants. He has to include the pipe supplier in his responsibility. Any responsibility may not be ensured from the turbine supplier's attendance at the last steam blasting.

7 Maintenance

7.1 Recommendation for Maintenance Intervals

For a high availability of the steam turbine unit maintenance is necessary. The availability is ensured by regular revisions. The revisions give information about the condition of the steam turbine unit and serve for an early recognition of damages. The maintenance intervals are furthermore determined on the basis of the evaluation of previous revisions.

After long revision pauses, more extensive revisions are to be expected, e. g. screws and nuts which have been strongly heated for a long period are hard to unscrew and mostly cannot be removed without damage.

The following chart contains an overview of recommended maintenance intervals. These intervals are based upon BVI's long experience in steam turbine maintenance. The maintenance intervals also depend upon the standards of the machinery insurance company.

7.2 Maintenance Intervals

- after 2,000 hours of operation, or three month after commissioning inspection of steam turbine unit (no standstill planned)
- after 8,000 hours of operation, or latest one year after commissioning small revision of steam turbine unit
- after 16,000 hours of operation, or latest two years after commissioning inspection of steam turbine unit (no standstill planned)
- after 24,000 hours of operation, or latest three years after commissioning small revision of steam turbine unit
- after 32,000 hours of operation, or latest fours years after commissioning inspection of steam turbine unit (no standstill planned)
- after 40,000 hours of operation, or latest five years after commissioning large revision of steam turbine unit

Service	time period	Staff
inspection	1 day + travelling	1 MAN mechanic
small revision	10 days + travelling	1 MAN mechanic + 1-2 local assistants supplied by customer
large revision	30 days + travelling	2 MAN mechanics + 1-2 local assistants supplied by customer

7.3 Description of Maintenance Work

Inspection
- detailed visual control of turbine
- checking of over-speed safety functions
- checking of rotor turning device
- checking of automatic hydraulic control
- measuring of turbine shaft vibration and check of vibration control during operation

Small Revision
- The following may be regarded as guidance for a usual small revision:
- Bearing check
  - dismounting of bearings
  - measuring of clearances of bearing sealing rings, journal and thrust bearings
  - measuring of stuffing box clearances
  - measuring of rotor displacement
  - checking of alignment
- checking of all oil pipes and overhauling of lubrication and control oil system
- checking and overhauling of steam control valves and trip valve
- checking and overhauling of speed governor (for turbines with hydraulic control) and starter
- checking and overhauling of all protection devices

Large Revision
The following may be regarded as guidance for a usual large revision:
- protection equipment
  - checking and cleaning of safety governor
  - checking of pressure switches
  - checking of solenoid valves
  - checking of rotor position measuring device
  - checking of trip switch
  - checking of clearance between shaft and latch
- casing
  - checking of bracket seating
  - checking of diffusers and nozzles
  - checking of guide blade carrier
  - cleaning of nozzles and blading, if necessary
  - checking of joint
  - checking of joint screws
  - checking of insulation with respect to danger of oil fire
  - dismounting of casing centre guide
- rotor
  - cleaning of blading, if necessary
  - checking of journals and thrust bearing discs
  - checking of tip thinning
  - checking of locking assemblies
  - high-speed balancing at operating speed, if necessary

- checking of blade clearances
- stuffing boxes
  - stuffing box clearances checked
- bearings
  - bearings thoroughly cleaned
  - checking of bearing sleeves
  - checking of thrust bearing segments
  - checking of journal bearing and thrust bearing clearances
  - control valves
  - cleaning of bolts and bushes, to be renewed, if necessary
- checking of control valve traverse
  - checking of valve spindles and bushes
  - checking of valve cone and valve seat
- trip valve
  - checking of valve spindle and pre-stroke cone
  - checking of valve spindle sealing
  - checking of valve seat
  - checking of oil piston and valve seat
- servomotor
  - checking of pilot piston and bush for easy running fit
  - checking of ball bearing, to be renewed, if necessary
  - checking of power piston
  - checking of compensation cone
- control
  - Checking of bellows
  - Checking of pilot valve plunger, pilot sleeve, governor plate and guide sleeve for easy running fit
- gearbox
  - checking of alignment
  - checking of coupling
  - checking of wheel set

The driven unit should be overhauled simultaneously in conformity with the supplier. Worn parts should be repaired, if possible, or replaced for spare parts. Any parts taken from stock should be ordered immediately after commencement of the revision, as according to our experience manufactured parts have a delivery time of several months (order, drawing and item numbers to be stated).

In order to ensure a quick service the customer should store some strategic spare parts. This will enable the customer to react immediately and long delivery periods with a possible shutdown of an entire process or plant can be avoided. The following list contains a stack of spare parts based upon MAN's long maintenance experience.

8 Spare Parts

MARC -Turbine (strategic planning)

Generator:	- 2 pieces bearing bushes AS with sealing, - 2 pieces bearing bushes NS with sealing, - 1 set diodes for exciter - 1 set electronic cards for the voltage control.
Turbine:	- 2 pieces radial bearings, - 1 set axial segment bearings, - 1 set valve spindle sealing (Grafiflex).
Lubrication oil system:	- 1 strainer for oil filter, - 1 pressure transducer, - 1 resistance thermometer.
Control equipment: -	- 1 pressure transducer per measurement domain in the system, - 1 PT100 or NiCrNi depending on design (1 piece each), - 1 double PT100 for bearing temperature (1 piece), - 1 temperature transducer, adjustable (1 piece).
Turbine control:	- 2 speed transducers.
Control oil system:	- temperature switch with three contract points, - level switch with three contract points, - 1 PT100, - filter element for high pressure filter, - bypass oil pump, - oil - water cooler, - cooling water control valve, - filter element for return-line filter.

9 Extract from IEC 45

Limitation of variation from rated steam pressure and temperature

The turbine shall be capable of accepting variations from the rated conditions within the limits stated below.

a) Pressure

The average pressure at the turbine inlet over any twelve months of operation shall not exceed the rated pressure. In maintaining this average, the pressure shall not exceed 110% of the rated pressure, accept that swings to 120% of the rated pressure shall be admissible, provided the aggregate duration of such swings over any twelve months of operation shall not exceed 12 h.

The re-heater safety valves shall be set so that the turbine exhaust pressure before the re-heater cannot exceed 120 % of the pressure at this point when the machine is operating at rated power output.

b) Temperature

For rated steam temperatures up to and including 565 °C (1 050 F) the permissible variations are as stated in the succeeding paragraphs. For specified temperatures in excess of 565 C, the permissible variations should be the subject of special agreement. The average steam temperature at any inlet to the turbine over any twelve months of operation shall not exceed the rated temperature. In maintaining this average, the temperature shall not normally exceed the rated temperature by more than 8.3 °C (15 °F). If exceptionally the temperature exceeds the rated temperature by more than 8.3 °C the instantaneous value of the temperature may vary between this figure and a value 14 °C (25 °F) in excess of the rated temperature, provided that the total operating time between these two limits does not exceed 400 h during a twelve months operating period. Operation between limits of 14 °C and 28 °C (50 °F), in excess of the rated temperature, may be permitted, providing that the total operating time between these two limits does not exceed 80 h during a twelve months operating period. In no case shall the temperature exceed the rated temperature by more than **28 °C (50 °F)**.

Should steam be supplied to any terminal point on the turbine through two more parallel pipes, the steam temperature in any of these pipes should not differ from that in any other by more than 17 °C (30 °F), except that during fluctuations not exceeding 15 min in duration, a temperature difference not exceeding 28 °C (50 °F) shall be admissible. The steam temperature in the hottest pipe shall not exceed the limits given in the preceding paragraph.

10 Standstill Measures

In spite of best-suited material, the turbine has to be carefully protected against the penetration of humidity and vapour in case of longer standstill (more than 1 day).

A rather simple, but effective standstill preservation can be achieved by means of a hot-air blower:
Dehumidified air flows through the turbine against steam direction and absorbs the humidity. For this purpose the control valves must be open.

During turbine standstill it is advisable, at intervals of maximum 3 weeks, to pump the turbine oil through the plant by the auxiliary oil pump and to turn the turbine during this procedure. On this occasion the control valves and the trip valve are to be checked for easy running fit by means of the trip switch. This measure assures the easy running fit of all components and corrosion is avoided to a large extent.

11 Cooling Water Velocities

Following cooling water velocities are to be kept:

Material	Recommended velocity	Minimum velocity*
CuZn 28 Sn (SoMs 71)	1.4 – 2.0 m/s	1.0 m/s
CuZn 20 Al (SoMs 76)	1.8 – 2.2 m/s	1.0 m/s
CuNi 30 Fe (CuNi 70/30)	2.4 – 3.5 m/s	1.5 m/s
CuNi 10 Fe (CuNi 90/10)	1.8 – 2.5 m/s	1.5 m/s
Cu (SB + SF)	1.5 – 2.0 m/s	1.0 m/s
Steel	2.0 – 4.0 m/s	1.0 m/s

* Note:

Do not operate at minimum velocity for longer periods! Frequent fluctuations of the water velocity are disadvantageous for the formation of a protective layer. Too low velocity will lead to dirt deposits and too high velocity to erosion.