CHAPTER 4 – OIL SYSTEMS

CONTENTS

1 General

MAN provides the complete oil supply system for the turbine/generator set. Two separate oil systems will be installed, one for control oil and one for lubrication oil, including complete internal piping, valves and required fittings.

2 Lubrication Oil System

2.1 System Description

The lubrication oil system will be designed as a low pressure system (5 bar(a)) and equipped with:

- Separate oil reservoir with de-aeration and calming chambers, oil level indicator and all necessary accessories.
- Main oil pump with AC-motor, for the oil supply during normal operation.
- Full-load auxiliary oil pump with AC-motor, with automatic starting device.
- Emergency run-down pump with DC-motor, with automatic starting device, supplies the lubrication oil system after emergency shutdown.
- Automatic oil temperature control device (three-way valve) to maintain the oil temperature within permissible limits. The oil temperature is regulated by partial or total bypass of oil to the oil cooler.
- Oil mist ventilation with ventilator, air filter, motor and aerosol separator, for installation on the oil tank.
- Single water-cooled oil cooler (carbon steel), designed for 100% heat dissipation. A redundant cooler is offered as an option.
- double oil filter, designed for 100%.
- Initial fill of oil.
- Necessary control and safety equipment.
- All internal pipes, valves and instruments.
- All lubrication oil pipes downstream of the filter will be carbon steel and 10 % of the pressurised oil pipe weldings will be x-ray tested and evaluated according to EN 25 817-C. As an option we offer the downstream oil piping in stainless steel.

2.2 General Description

The lubricating oil system supplies all of the sleeve bearings on the turbine unit as well as the gearbox. During normal operation, the entire lubrication oil flow is supplied by a screw type main oil pump which is driven via an AC motor. The main oil pump sucks the oil out of a collecting tank and feeds into the oil cooler. A temperature controller on the lubrication oil side keeps the lubrication oil temperature constant. Downstream of the cooler 2 x 100% capacity oil filter will be installed. The oil pressure is reduced to approx. 2.5 bar by the pressure drops of the cooler and filter.

In case of a failure in the lubrication oil supply the auxiliary lubrication oil pump is started by a pressure transmitter. If the auxiliary oil pump fails or the lubrication oil pressure drops very quickly the turbine is shut down.

2.2.1 Main Oil Pump

The electric main oil pump with AC motor supplies the lubrication oil system with oil during starting, normal operation and after shutdown (also during operation with the turning gear for re-cooling of the bearings).

The main oil pump unit consists of a geared pump and an electric motor mounted on a common base plate.

The geared pump consists of the casing, the gear wheels, the cover drive end, and the cover tail end. The suction and pressure connections are located on the casing. Depending on the design, the journals of the pump shafts are located in the bearing bushes or roller bearings. A cover closes the casing on the driving side. On the opposite side the casing is closed by the end cover. The shaft is sealed, depending on the design, by a gland, a radial sealing ring or a free of maintenance axial seal. The shaft bearings are lubricated by the suction fluid.

2.2.2 Emergency Oil Pump

The electric emergency oil pump will be provided to ensure an adequate oil supply for bearing cooling purposes, when the set is shut down and when there is no AC power supply. The pump will be driven by a DC motor that will be fed from a 110 V DC / 220 V DC station battery (optional price).

The pump will be capable of supplying sufficient oil to the bearings to permit the set to run down to standstill safely under emergency conditions.

The emergency oil pump unit consists of a geared pump and an electric motor mounted on a common base-plate.

2.2.3 Oil Filter

The lube oil filter is supplied as double filter for the maximum quantity of oil.

The filter is a steel construction, satisfying with regard to design and resistance all international and national standards and regulations. The advantage of the filter is that the filtration takes place from inside to outside, i.e. the residues are eliminated inside the filter body and are removed from the housing together with the filter body, when removing the latter.

The standard design of this type of filter is equipped with a magnetic body. Due to extraordinarily strong magnetic fields of force all magnetically sensitive metal pieces are removed from the fluid to be filtered, circulating with reduced velocity around the magnetic body. The filter bodies consist of a wire fabric made of VA (stainless steel).

2.2.4 Oil Cooler

The single or redundant oil cooler is a tubular heat exchanger with straight tubes, expanded in tube plates, in horizontal design with fixed feet. The tube bank is extractable.

The oil flows through traverse baffles around the tubes.

The oil-carrying elements without protective coatings are pickled and flushed. A pressure test with factor 1.5 of the service pressure is carried out on the water side with water, and on the oil side with petrol.

2.2.5 Oil Mist Separator

The oil mist separator removes the oil vapour from the lubrication system. The separated oil will be returned to the system.

Through the suction line, contaminated air is drawn into the filter unit. The air flows through the micro fibre cartridges located in the filter housing. Here, superfine drops of oil carried along with the spent air are trapped. Beyond the bounds of the filter units, these combine to form larger drops. The large drops are forced by the air stream to the outer surface of the filter elements, where the oil can drain due to its own weight.

Since the intake quantity of liquid is identical to the separated quantity, the filter cartridges have a virtually unlimited working life expectancy for the separation of relatively pure liquids. A rear-positioned demister traps any drops of oil being carried along.

2.3 Technical Data

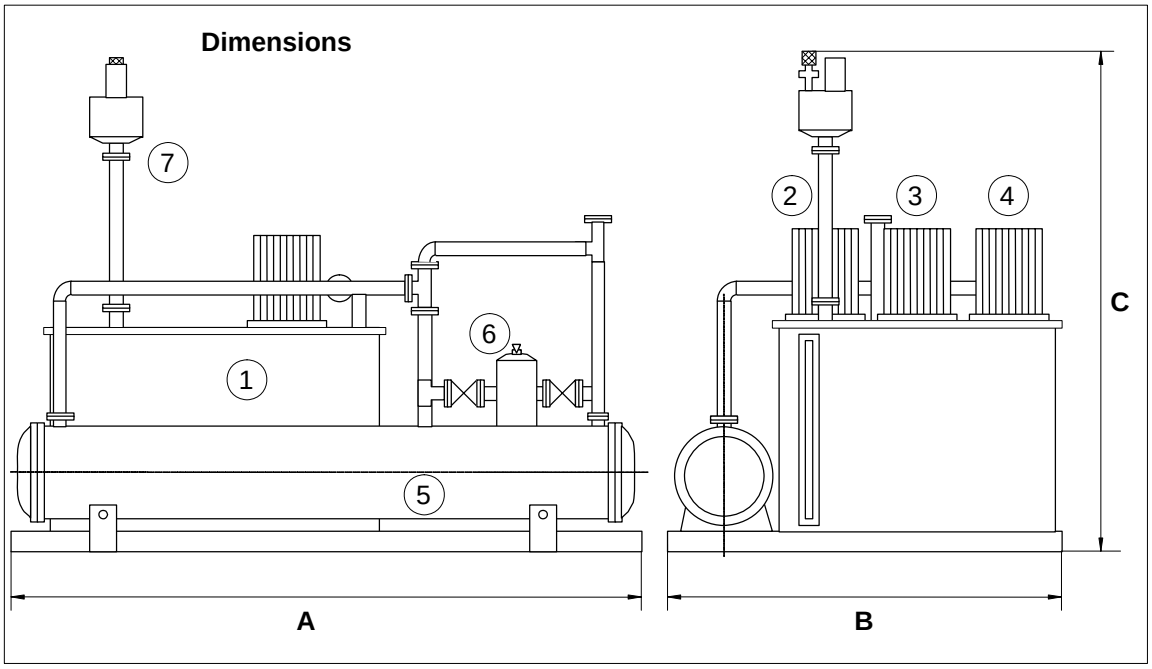
Lubricating Oil System	Unit		Remarks
Type of oil		Mineral oil	acc. to ISO VG 46
Oil tank volume	m^3	approx. 5 m^3	
Oil temperature cooler inlet (max)	°C	66	
Oil temperature cooler outlet	°C	43	approx.
Oil temperature control		Incl.	continuously operating
Oil pressure control		Incl.	
Normal supply pressure	bar	5	system pressure 2.5 bar
Auxiliary pump starts at	bar	2.2	
Emergency pump starts at	bar	1	
Materials			
- Oil tank		St35.8 / HII	
- Oil piping		CS	
- Valves		CS	
- Valve inlets		Stainless steel	
- Pumps		GG	
Main oil Pump			
Drive system		AC Motor	
Type		Screw pump	
Speed	rpm	2,900	
Pressure	bar	5	
Motor	kW	15	
Auxiliary Oil Pump			
Drive system		AC Motor	
Type		Screw pump	
Speed	rpm	2,900	
Pressure	bar	5	
Motor	kW	15	

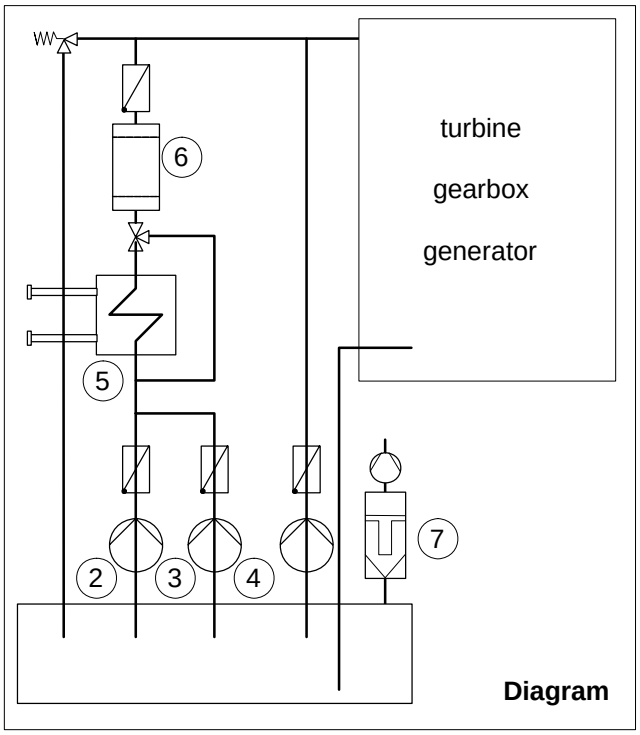
	Unit		Remarks
Emergency Oil Pump			
Drive system		DC Motor	
Type		Screw pump	
Speed	rpm	2,900	
Pressure	bar	2.5	
Motor	kW	7.5	
Lubrication oil Filters			
Configuration		2 x 100%	double oil filter
Type		Cartridge filter	
Filter mesh size	micron	10	
Oil Cooler			
Configuration		1 x 100%	single oil cooler / 2nd as an option
Type		Shell-and tube heat exchanger	
Water temperature rise	°C	5	
Design pressure			
- water side	bar	8	
- oil side	bar	3.5	
Design temperature			
- water side	°C	80	
- oil side	°C	80	
Materials			
- Tubes		St	
- Tube sheets		H II	
- Oil shell		GG	
- Water shell		GG	

	Unit		Remarks
Oil Vapour Fan			
Number		1	
Motor	kW	0.64	
Oil droplet/mist separator type		Aerosol separator	
Oil Purifier			
Manufacturer			Optional price
Dimensions			
- length A	mm	approx. 4500	
- widths B	mm	approx. 2500	
- heights C	mm	approx. 3250	
Weight empty			
approximately	kg	6000	

2.4 Overview

Lubricating Oil System





Designations

1. Oil tank
2. Main oil pump 1
3. Main oil pump 2
4. Emergency oil pump
5. Oil cooler
6. Oil filter
7. Oil mist van

3 Control Oil System

3.1 System Description

The control oil system will designed as a high pressure system (160 bar) and equipped with:

- Combined hydraulically operated actuators with integral spring pack ("fail-safe") for:
  - the shut-off/tripping valve
  - the control valves

Complete oil supply system, equipped with:

- Oil reservoir.
- Main oil pump with AC-motor, continuously running during normal operation.
- Optionally, a full-load auxiliary oil pump with AC-motor, with automatic starting device can be installed.
- Double oil filter the main oil circuit
- Auxiliary oil circuit with oil pump with AC-motor and single oil filter, continuously running in bypass to the main oil circuit during normal operation.
- Single oil cooler in the auxiliary oil circuit, designed for 100% heat dissipation.
- Initial oil filling.
- Necessary control and safety equipment.
- All internal pipes, valves and instruments.
- All control oil pressure pipes will be of carbon steel and 100% of the welding will be x-ray tested and evaluated according to EN 25 817-C.

3.2 General Description

The hydraulic unit supplies the necessary control oil to the actuators of the steam turbine.

Under normal operating conditions of the turbine the actuator movements are small and executed at low speed. However, specific operating conditions such as load dump of the turbine require large and quick actuator movements.

In view of these requirements the hydraulic unit is provided with a pressure-controlled adjustable hydraulic pump with additional hydraulic accumulator in the main oil system. Under normal operating conditions the hydraulic pump delivers the necessary oil flow to maintain the set system oil pressure. This oil flow covers the leakage loss of the actuators and ensures the charge of the hydraulic accumulator to the necessary working volume. Any pressure variations are compensated for by changing the flow capacity. For this purpose the hydraulic pump is equipped with an integral hydraulic governor.

The temporarily high oil demand for quick and large actuator movements is covered by discharging the accumulator.

The required oil purity is achieved through a bypass filter which reduces the solids contamination in the cooling system of the hydraulic unit. A constant feed pump delivers the oil from the tank via a bypass filter and the oil/water heat exchanger back into the tank. The cooling is activated by a control valve at the cooling water inlet of the oil/water heat exchanger.

Necessary switch, alarm and indicating devices for the operation and supervision of the hydraulic unit through an external control gear are available.

3.3 Technical Data

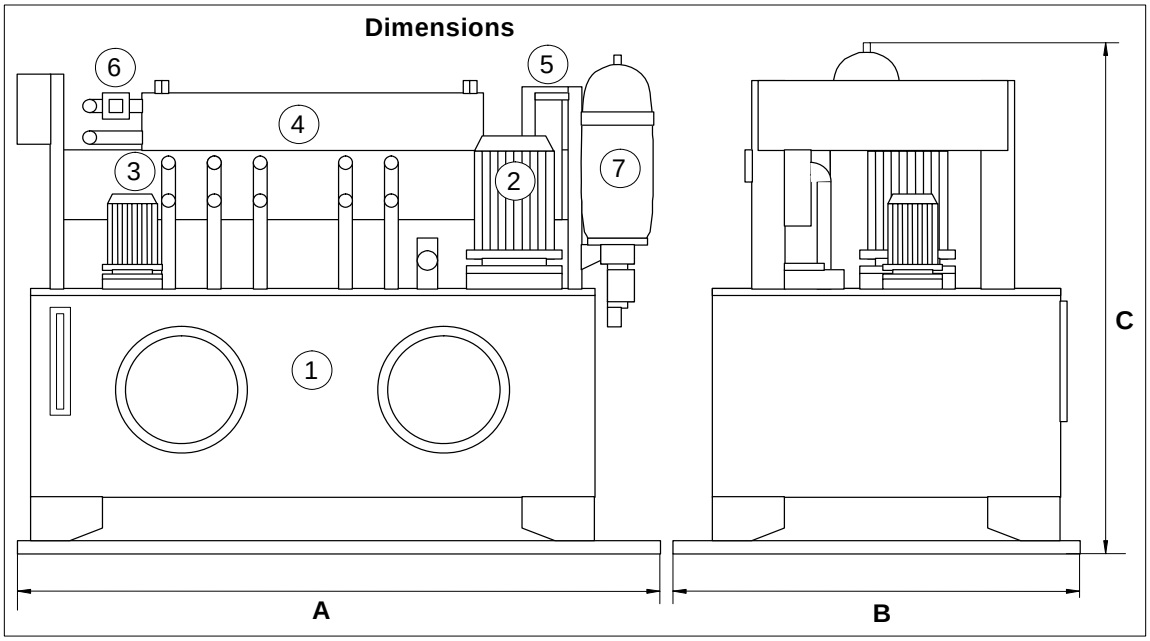
Control Oil System	Unit		Comments
Type of oil		Mineral oil	acc. to ISO VG 46
Oil tank volume	m³	approx. 0.4	
Accumulator size	m³	approx. 0.02	
Oil temperature to system	°C	42	
Oil temperature control		Incl.	
Oil pressure control		Incl.	
Normal supply pressure	bar	160	
Oil volume	l/min	approx. 22	
Temporary oil volume flow	l/min	max. 105	for 0.6 sec
Materials			
- Oil tank		CS	
- Oil piping		CS	
Dimensions of oil tank			
- length A	mm	1,800	
- width B	mm	1,200	
- height C	mm	1,500	
Weight (empty)	kg	approx. 750	
Hydraulic Pump			
Number		1	
Type		Adjustable radial reciprocating pump	
Flow	l/min	27	
Pressure	Bar	160	+/- 10 bar
Minimal speed	1/min	1,450	
Motor	KW	11	
Bypass Pump			
Number		1	
Type		Vane pump	
Flow	l/min	44	
Pressure	bar	3	
Minimal speed	1/min	1,450	
Motor	kW	1.5	

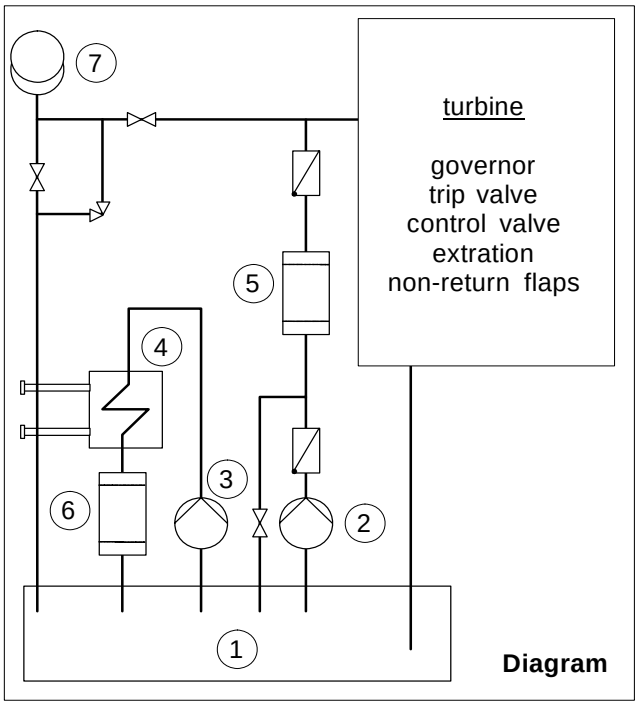
	Unit		Comments
Oil Cooler			
Design		shell-and-tube exch.	2nd cooler as an option
Configuration		1 x100 %	
Water flow	l/min	60	
Water flow	kg/s	1	
Heat dissipated	kW	8.5	
Design pressure			
- water side	bar	8	
- oil side	bar	3	
Design temperature			
- water side	°C	80	
- oil side	°C	80	
Materials			
- Tubes			
- Tube sheets			
- Oil shell			
- Water shell			
Hydraulic Accumulator			
Design		Bladder-type	
Pressure medium		Nitrogen	
Nominal volume	l	approx. 20	
Useful volume	l	0.8	
Gas pre-charge pressure	bar	130	
Min. oil operating pressure	bar	150	
Max. oil operating pressure	bar	160	
Pressure filter		2x100 %	
Design		filter for installation into pipe with electrical and optical contamination indicator	
Nominal pressure	bar	210	
Switching pressure contamination indicator	bar	5 (delta p)	
Filter mesh size	micron	10	$\beta_{10} > 75$

	Unit		Comments
Bypass filter			
Design		filter for installation on tank with electrical and optical contamination indicator	
Nominal pressure	bar	19	
Switching pressure contamination indicator	bar	2.2 (delta p)	
Opening pressure bypass	bar	3.5 (delta p)	
Filter mesh size	micron	10	$\beta_{10} > 75$
Oil Vapour Fan		-	not necessary
Number		-	
Motor	kW	-	
Oil droplet / mist separator type		-	

3.4 Overview

Control Oil System





Designations

1. Oil tank
2. Control oil pump
3. Cirulation oil pump
4. Control oil cooler
5. Control oil filter
6. Circulation oil filter
7. Pressure tank

4 Recommendations and Instructions for Steam Turbine Oils

When filling a turbine oil system for the first time the complete lubrication and control oil system must be cleaned (in scope of supply by MAN). It is important that special attention is paid to the cleaning of the piping (pickling and neutralising) during installation, as it is difficult to trace dirt deposits after installation and to remove them from the oil system. They can cause serious trouble at a later stage. Never use cotton waste and kerosene for cleaning, but only clean absorbent rags and clean turbine oil.

Avoid under all circumstances blending with other media (motor oils, solvents, grease deviates). Take care that delivery and filling is effected with scrupulously clean filling devices, i.e. hoses, pipes, valves and pumps must be subject to the same cleanliness regulations as those valid for the delivered units.

Flushing

After initial installation the complete oil system must be thoroughly flushed with warmed turbine oil (approx. 140°F = approx. 60°C) for at least 24 hours. For this purpose approx. 40 to 60% of the normal fill required for operation is needed. The flushing oil must be subsequently drained. However, it may be reused as part of the oil required for operation if tested and cleaned. This can be done by the technical service section of the oil supplier. The quantity required for operation must be carefully introduced through a fine mesh screen and be such that the specified minimum level is maintained in the oil tank. Furthermore, a sufficient standby quantity should be available.

During operation

Check daily whether water has accumulated in the sludge drain. Water must be drained. In the case of large turbines it is expected to use an oil separator. Approximately every 6 months a sample of turbine oil should be sent for inspection (water separation/air release to be inspected beside normal inspections). Normally the oil supplier inspects the oil free of charge. When a certain neutralisation number, indication of ageing, has been reached it should be decided in co-operation with the technical service section of the oil supplier whether to change the oil or not.

The proper lubrication of the steam turbines largely depends on the quality and the correct selection of the oil and is very important for safety in operation. Therefore, the use of a branded turbo oil meeting **DIN 51 515** is necessary.