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An American National Standard

Standard Practice for
Design of Steam Turbine Generator Oil Systems[1]

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INTRODUCTION

The ever-increasing size and complexity of steam turbine generators makes the oil system more important than ever. The system is required to provide not only lubrication but surface protection, cooling, sealing, and control as well. Failure in any one of these functions could result in damage to expensive equipment with loss of system capability and increased generation costs due to the use of less efficient equipment or the purchase of power through interconnections.

This practice has resulted from a culmination of the experiences of the turbine builders, the erectors, the oil suppliers and the operators. Out of necessity, it is a generalized and minimal standard. Previous issues of this standard have been used in specifications to aid in obtaining satisfactory performance of the lubricating oil system.

1. Scope

1.1 This practice is applicable to steam turbine-generator units and provides recommended practices for the design of the oil system.

1.1.1 The oil system is defined as that assembly which uses and circulates the turbine-generator lubricating oil. The oil system generally includes high pressure, bearing, control, generator seal, and drain systems. The system may also include the supply and return lines for a boiler feed pump and hydraulic coupling.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ISO Standard:*[2]

ISO 4572 Hydraulic fluid power filters-multi-pass method for evaluating filtration performance

[1] This practice is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.C0 on Turbine Oils.

All previous recommended practices have been published by ASME as joint ASTM-ASME-NEMA standards. With the issuance of this document, all standards under the auspices of Subcommittee C of ASTM Committee D02 will be published by ASTM as ASTM standards. This standard replaces ASME Standard Practice No. 116.

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[2] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

3. Significance and Use

3.1 The purpose of this guide for turbine generator oil systems is to ensure that:

3.1.1 Lubrication, control, and sealing will be performed satisfactorily by the oil in a manner mutually acceptable to the parties concerned.

3.1.2 Installation, cleaning, and flushing will be facilitated.

3.1.3 Satisfactory system cleanliness can be maintained.

3.1.4 Safe practices are observed.

4. System Components

4.1 *Materials*:

4.1.1 Steel piping, tubing, valves, fittings, and fabrication plates are acceptable and recommended. The use of catalytic and corrodible materials, such as copper, zinc, and lead, should be minimized, and if used, they should be properly alloyed. Bearing linings should be made of tin base babbitt.

4.1.2 All materials used in system construction, including gaskets, seals, diaphragms, interior permanent type surface coatings, and hoses, should be resistant to turbine oils and maintain adequate physical and chemical properties at the maximum expected operating temperatures and service life.

4.2 *Pumps*:

4.2.1 Pumps must circulate lubricating oil from the reservoir to the bearings, controls, and other points of use. The pressure level must be high enough to ensure proper distribution and satisfy control functions.

4.2.1.1 Satisfactory circulation and pressure levels must be provided for start-up, operation, and shut down.

4.2.2 Several commonly used pumps are defined as follows:

4.2.2.1 The main pump normally supplies the oil circulation and pressure for the steam turbine generator operation.

4.2.2.2 The auxiliary pump is sized to permit continued operation if the main pump fails.

4.2.2.3 The emergency pump is of reduced capacity. Its function is to provide last resort lubrication for coastdown, should the other pumping fail.

4.2.2.4 Many combinations of pumps can be satisfactory. As a minimum these should be two pumps driven from two independent and different power sources. Thus, no single incident or equipment failure can cause loss of pumping.

(1) An exception can be made to the two pump recommendation if the turbine generator can survive shut-downs without oil circulation.

4.2.3 Examples of these pump drive combinations are listed as follows:

Main	Auxiliary	Emergency
shaft	ac motor	dc motor
shaft	none	ac/dc motor
shaft	ac motor	turbine
ac motor	none	dc motor

4.2.4 The auxiliary and emergency pump drivers shall be sized for adequate capacity when operating with the oil viscosity corresponding to the minimum temperature for start-up.

4.2.5 Control of the auxiliary and emergency pump drivers can significantly affect reliability.

4.2.5.1 The auxiliary and emergency pump drive controls shall provide for automatic starting and in-service testing.

4.2.5.2 The pump motor overloads shall not trip the motor breaker. The overload shall only provide a warning.

4.2.6 Several application requirements shall be considered for proper pump functioning.

4.2.6.1 The main shaft driven pump shall have adequate suction conditions to provide uninterrupted supply of oil. Pumps shall be provided with a positive suction.

4.2.6.2 Pump suctions shall be below the minimum reservoir operating level. The exact submergence will be determined by the pump suction requirements including the consideration of air entrainment in the pump suction. In many cases the pump suction is at least 150 mm (6 in.) below the minimum operating level.

4.2.6.3 The auxiliary and emergency pumps shall be submerged with their suction below the minimum reservoir operating level.

4.2.6.4 The emergency pump suction shall be lower than other pumps so that with the loss of oil in the reservoir, shut down oil would still be available.

4.2.6.5 Coarse strainers should be provided in the suction system of all pumps.

4.2.7 Pump suctions should be at least 150 mm (6 in.) from the bottom of the reservoir.

4.2.8 The pump suction is defined as starting at the solid fluid conveyance to the pump inlet. Normally this begins at attachment of the suction strainer to the pump inlet or to the pump suction pipe.

4.3 *Reservoirs*:

4.3.1 The capacity of the reservoir should be sufficient to hold the sum of the operating oil volume contained within the normal operating range plus the volume that will drain from the remainder of the system when the turbine generator unit is shutdown.

4.3.2 To allow for the separation of entrained air and the settling by gravity of water and solid contaminants the normal operating oil volume should not be less than five times the flow per minute to the bearings.

4.3.3 A drain connection should be provided at the lowest point on the reservoir. A shut off valve should be located in the drain near the reservoir. To avoid accidental draining of the oil, the valve should be locked closed or have a blank in the drain line immediately downstream.

4.3.4 The bottom of the reservoir should slope towards the drain connection. On rectangular reservoirs the slope should be 40 mm/m (½ in./ft) or greater.

4.3.5 Connections for the oil purification system should be provided. The supply should be so located that oil is taken from as close as possible to the reservoir bottom. Both the supply and return connections should be arranged and located so that siphoning of the reservoir below a safe level is not possible.

4.3.6 Oil reservoir connections for major drain lines from bearings should be as far from the pump suction as practical or baffled to prevent return oil from flowing directly to pump suction, thereby providing a maximum oil rest period. Drains should be arranged to provide for maximum deaeration and minimum oil agitation.

4.3.7 A method for oil level determination should be provided.

4.3.8 The discharge of relief valves should be at least 150 mm (6 in.) below the operating oil level.

4.3.9 A vapor extractor connected to the highest point of the reservoir should be provided for the removal of gases and vapors. Internal baffles should have openings above the oil level to equalize the vacuum within the reservoir. The vacuum produced in the bearing housings should not average more than approximately 0.5 KPa (2 in. water) to minimize the entrance of atmospheric contaminants into the oil system.

4.3.10 The interior surfaces wherever possible should be protected by a permanent type, oil resistant surface coating unless a corrosion resistant metal is used.

4.3.11 The entire inside of the reservoir should be accessible.

4.3.12 For hydrogen cooled generator application, the reservoir should contain an explosion door capable of maintaining the reservoir internal pressure at a safe level at all times. This explosion door may serve as an access door.

4.3.13 All connections and openings should be sealed to minimize air leakage and the entrance of atmospheric contaminants into the reservoir.

4.3.14 The reservoir should be located such that the entire oil system external to the reservoir can drain, by gravity, into the reservoir.

4.3.15 Pumps and ejectors located inside the reservoir should be so located that the inlet is completely submerged at all times but no less than 150 mm (6 in.) from the reservoir bottom.

4.3.16 Strainers for the main-bearing oil return to the reservoir can be provided for the removal of solids. Strainer openings should not exceed 0.6 mm (0.025 in.). Means for removal, inspection, and cleaning of the strainers while the turbine is in operation should be provided. Strainers are not necessary when full flow filtration is provided.

4.4 *Piping*:

4.4.1 Welded or flanged and bolted joint construction should be used for all oil piping. When screwed or threaded fittings are used, they should be guarded within a housing or pipe or seal welded.

4.4.2 Pipe joints, field welds, and bends should be minimized commensurate with shipping, erection, and cleaning requirements.

4.4.3 When butt welds are made with backing rings, the rings should be carefully fitted to minimize the gap between the ring and pipe. If butt welds are made without backing rings, care must be taken to minimize the weld splatter on the inside of the pipe. If necessary to assure a clean weld, the inside of the pipe should be ground or back welded when accessible.

4.4.4 The inside surface of all pressure and drain piping should be cleaned and coated with an oil soluble rust preventive. The outside surface of the pressure piping contained within an oil transmitting guard pipe and the inside surface of oil transmitting guard pipes should be cleaned and coated with a permanent type rust preventive or an oil soluble rust preventive.

4.4.5 The drain and ventilation system should be designed to assure atmospheric pressure or less in all bearing housings. When drain lines are used for system ventilation, they should be sized and pitched to maintain adequate air space above the normal steady state oil level at all points. If low loops cannot be avoided in the piping drain system, supplementary vents and means for drainage during shutdown should be provided.

4.4.6 For hydrogen cooled generator application, the generator drain piping system should be separated from the turbine drain system and main oil reservoir by a loop seal to minimize the system volume subject to possible hydrogen contamination. A vent to atmosphere should be provided on the generator side of the loop seal with a vapor extractor if necessary to maintain a vacuum in the generator bearing housings.

4.4.7 Vents to atmosphere and discharge lines from vapor extractors should be routed to a safe location for the possible discharge of hydrogen and oil vapors.

4.4.8 The piping system should be designed to:

4.4.8.1 Minimize local heating from external sources, such as turbine shells or casings, steam pipes, and induced heating from buss ducts.

4.4.8.2 Withstand vibration by adequate bracing and contain adequate flexibility to account for the thermal expansion of the unit.

4.4.8.3 Avoid contamination of the condensate system.

4.4.8.4 Minimize potential fire hazards by providing guards or baffles to prevent oil from contacting high-temperature surfaces.

4.5 *Coolers*:

4.5.1 The oil coolers should be located so that the tube bundle removal will be possible.

4.5.2 If the location of the cooler does not permit gravity drain to the reservoir, means for draining the oil side of the cooler during shutdown should be provided.

4.5.3 Vent connections should be provided on the coolers to permit continual air removal.

4.5.4 When dual coolers are used, the three-way change over valve should be designed so that oil flow will not be interrupted when transferring from one cooler to the other.

4.5.5 Separate gaskets or seals with provision for an intermediate telltale to indicate leakage should be provided for the water and oil side of the coolers.

4.6 *Filters*:

4.6.1 Full-flow or bypass filtration is recommended to reduce the contamination level of the lubricating oil system.

4.6.2 The filter shall be designed compatible with the lube oil system requirements including the operating pressure and temperature.

4.6.2.1 A filter element with a $\beta_{10} \geq 20$ rating, or finer, is recommended. The beta rating, β_x, represents a ratio of particles of a given $size_x$ (in microns) that enter a filter to those that leave the filter as determined in a filtration performance test carried out in accordance with ISO 4572.

4.6.2.2 The element pressure drop shall not significantly increase with as much as 10 % water in the oil.

NOTE 1—Do not interpret this as condoning unit operation with this much water in the oil.

4.6.2.3 Filter pressure drop with the start-up viscosity shall be within the system capabilities.

4.6.2.4 Filter housing drains should be provided.

4.6.2.5 Provisions should be made for removing air that may be trapped in the filter.

4.6.2.6 Use of mechanical indicators or electrical pressure switches, or both, is recommended to provide indication that the filter element(s) should be changed.

4.7 *Instruments*:

4.7.1 Provision should be made for determining oil temperatures at each bearing discharge and at the oil cooler inlet and outlet. Welded or threaded and seal welded thermometer and thermocouple wells should be used if located in pressure lines or below the oil level in drain lines.

4.7.2 Provision should be made for determining the significant operating pressure of the oil system.

4.7.3 All unguarded gage lines should be provided with shutoff valves and orifices near the source connection.

5. General

5.1 All valves capable of draining the oil system should be locked or blanked downstream when not in use.

5.2 All flange joint bolting should be secured with an appropriate locking means.

5.3 All bearing oil drains are to be provided with an accessible oil flow observation point.

5.4 Storage facilities should be provided for the oil when drained from the system.

5.5 Consideration should be given to the protection of electrical devices and wiring that can be exposed to oil vapors.

6. Keywords

6.1 coolers; filters; lubrication; oil systems; piping; pumps; reservoirs; steam turbines; strainers