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The document is based on ASTM D 4378-92 and practical experience from SIEMENS Industrial Turbomachinery AB (SIT).

This document is intended to assist the user to maintain effective lubrication of all parts of the turbine. It includes sampling and testing schedules for the lubricating oil.

The recommended quality of a lubricating oil in operation is given in this document as well as instruction about necessary actions that must be taken if the quality of the lubricating oil is not within given limitations.

1 PROPERTIES OF A NEW TURBINE OIL

Most turbine oils consist of highly refined mineral oil with more or less additives that change some properties of the base oil. Depending upon the requirements on the lubrication oil, additives such as oxidation inhibitors, rust inhibitors, anti wear agents, antifoam agents etc. are added.

New turbine oils should exhibit good resistance to oxidation, low tendency to sludge formation and adequate anti-rust, demulsibility and foaming properties. However, these properties cannot be expected to remain unchanged during the life of the oil. Some deterioration can be tolerated without prejudice to the safety or efficiency of the system. Reinhibition can improve some properties of the oil. Good monitoring procedures are necessary to determine when and how the properties of the oil have changed. This helps the user to judge the condition of an oil and decide for further action.

2 WHY DO TURBINE OILS DEGRADE

Regardless of the initial quality of the oil, the turbine oil will deteriorate in service. Air (oxygen), elevated temperature, metals and water are always present to some extent in the turbine oil systems. These elements promote oil degradation. Deterioration process occurs by one or a combination of processes mentioned below.

- Oxidative degradation - Initially, hydroperoxides are formed due to presence of oxygen.
- Thermal/oxidative degradation - At elevated temperatures, hydrocarbons are subject to thermal cracking forming unstable compounds. These unstable compounds are easily oxidized and do also tend to polymerize, forming resins and sludge.
- Water accumulation in system - Water promotes degradation as well as interferes with lubrication.
- Loss of additives - This can result in more rapid oxidation and premature rusting.

- System impurities - Motor lubricating oils, rust protection fluids and cleaning agents will influence the properties of the turbine oil.
- Influx of contaminants - Contaminants arising within the system (corrosion and wear products) or entering the system from outside (fly ash, dirt, fluids) cause lubrication and wear problems.

The deterioration process cannot be stopped but it can be delayed. This can be achieved with a proper designed lubricating system where the possibilities of contamination are minimized and if the system is clean before it is filled up with a lubricating oil of high quality. In order to achieve a high reliability of lubricating system a proper maintenance and adequate monitoring of lubrication oil is necessary.

3 MONITORING PROGRAM FOR TURBINE OILS

The main purpose of a monitoring program is to ensure long trouble-free operation of the turbine. This can only be achieved by taking prompt and proper action steps. Such action steps should be based on correct interpretation of test results usually gathered over a period of time. Sampling and testing schedules for the lubricating oil in service should be tailored depending on conditions and severity (how the turbine stresses the oil) of the turbines.

During an initial period of a new turbine and/or new oil, a more frequent testing of the oil is required. The purpose of this is, to determine the severity of the turbine and the quality of the oil. The amount of degradation occurring during this period should serve as a guide to establish future sampling frequency.

The sampling and testing schedule of the oil in normal operation can be used as guide if no tailored monitoring program for the lubricating oil is done.

When the test results indicates that the oil is becoming degraded and may be approaching the end of its service life, the sampling frequency should be increased.

When changing to a new oil the monitoring program starts from beginning. The new oil has to be checked at delivery, after flushing and as scheduled during the initial period and normal operation.

3.1 Examination of new oil delivery

It is essential that all incoming supplies of oil are analyzed to guard against incorrect or contaminated oil being delivered.

Samples should be taken according to our documents Technical delivery terms DL 1171-1 and Delivery control of lubricating oil K-1171-7.

The delivered oil should be checked. The results from loading sample (suppliers test) and tank sample should fulfill the requirements in the lubricating oil specification. At least the following properties should be analyzed:

- Appearance
- Viscosity
- Total acid number
- Wear metals/ Contaminants
- RBOT
- Foaming
- Air release
- Emulsion characteristics
- Water (for steam turbine applications)

The system shall be flushed with the new oil charge according to our instructions. A sample of the oil should be taken after flushing for analysis. The same properties as for the samples taken during filling should be analyzed.

3.2 Examination of oil in initial service

Sampling and testing schedules for oil in initial service during first 6 month:

TURBINE TYPE	Gas turbine first 6 months	Steam turbine first 6 months
Appearance	Weekly	Weekly
Total acid number	730h/ 1460h/ 2190h/ 4380h	730h/ 1460h/ 2190h/ 4380h
Water content		730h/ 1460h/ 2190h/ 4380h
Viscosity	4380 h	4380 h
Wear metals	730h/ 1460h/ 2190h/ 4380h	730h/ 1460h/ 2190h/ 4380h
RBOT	4380 h	4380 h

3.3 Examination of oil in normal operation

This sampling and testing schedule, for an oil in normal operation, applies to turbine oils with normal performance and testing results during the initial testing period mentioned above.

TURBINE TYPE	Gas turbine	Steam turbine
Appearance	Weekly	Weekly
Total acid number	4380 h (6 month)	4380 h (6 month)
Water content		4380 h (6 month)
Viscosity	8760 h (12 month)	8760 h (12 month)
Wear metals	4380 h (6 month)	4380 h (6 month)
RBOT	4380 h (6 month)	4380 h (6 month)

4 CONTINUOUS MONITORING AND SUPERVISION OF THE OIL SYSTEM

Continuous supervision of the oil system ensures optimum efficiency and high availability.

Representative samples of the lubricating oil should be taken accordingly to the schedules by the personnel on site and sent for analysis. The personnel on site should check the weekly samples and notice any disturbance in the lubricating system. At least following checks should be done.

- Check the weekly samples. Check for water in the sample. If the sample of the oil is **not clear and bright** or if its **color** has suddenly changed, a sample of the oil should be taken for analysis.
- Check for accumulation of **sludge** or **deposits** in any part of a turbine oil system or in oil sample. Samples of the deposits as well as a sample of the oil should be taken for analysis, if sludge or deposits are found.
- Sample of the oil should be taken for analysis if there are problems due to **foam** in the system.
- Check if water accumulates in bottom of tank. Take regularly an oil sample from bottom of tank. Check for water in the sample. If the sample contains water, actions must be taken in order to reduce the water in the oil (see section 6).

Filters should be changed/cleaned regularly. Openings in tank and pipes should only be uncovered for a short time and only if absolutely necessary. The oil tank should be cleaned properly before refilling of new oil.

5 SAMPLING OF TURBINE OILS

Samples submitted for examination must be representative of the product being sampled. To obtain a representative sample from the lubricating system the sample should be taken either from a free flowing line or an agitated tank. The samples should be taken in clean bottles. If no instructions are given by us the samples should be taken accordingly to ISO 3170-1988.

The samples should be marked with sampling date, site-no, product name, supplier, operating hours of machine, operating hours of lubricating oil, make up oil, sampler and contact person.

5.1 Sampling from line

The sample should be taken, if possible, at a location downstream of lubricating oil filters in the main circuit. The sampling line as well as bottles should be rinsed thoroughly to avoid contamination. The sampling pipeline should not be shut between the flushing and sampling, in order to not remove any dirt from the shut-off valve. Adequate amount of flushing will depend on the dimensions of the sampling line.

5.2 Sampling from tank

Sampling of the lubricating oil from the tank can be necessary if there are no possibilities to take it from the circuit. The sample should be taken by dipping from the tank top. The oil should be thoroughly circulated with the pumps before the sample is taken.

6 LUBE OIL QUALITY DURING OPERATION

The properties of a turbine oil can not be expected to remain unchanged during the life of the oil.

Some deterioration can be tolerated without prejudice to the safety or efficiency of the system. Reinhibition can improve some properties of the oil.

In table 1 are recommended limitations for certain properties given for an oil in operation. If these limitations are reached or exceeded actions must to be taken in order to restore the quality of the oil or the oil must be changed. Suggested actions when different properties are out of limitations are also listed in table 1.

Table 1. Required lubricating oil properties for lubricating oils in operation and proper action steps when limitations has been exceeded.

Property	Limitations (*)	Possible cause	Action
Appearance	If not clear and bright	Contamination of water and/or dirt or deterioration of oil.	Check water content and solid impurities.
Water	max. 200 ppm	Water/steam leakage.	Determine and remedy cause. Drain water from bottom of tank if possible. Reduce water by centrifugation or by passing through coalescer filters. Resample after actions to check that proper levels have been reached
Impurities -Sediment -Particles (ISO 4406)	<ul style="list-style-type: none"> • max. 50 ppm • max. 17/14 (ISO 4406) 	Possible cause is depending on type of impurities.	Determine and remedy sources of contamination if possible. Check function of filters. Check type of impurities.
		a) Wear particles. Improper lubrication.	a) Wear particles. Consult SIT.
		b) Organic sediment. The oil may be deteriorated or contaminated by other chemical (type of oil).	b) Organic sediment. Check RBOT. Consult SIT or oil supplier.
		c) Rust particles. Water in oil causing corrosion of lubricating oil system.	c) Rust particles. Check water content. Remedy cause of any leakage. Clean oil by centrifugation or by passing through fine filters. Check with oil supplier the rust inhibitor level in oil. Resample after actions to check that proper levels have been reached.
		d) Dirt. Dirt left in system or entering system during operation.	d) Dirt. Investigate and remedy the cause. Clean oil by centrifugation or filtration. Resample after actions to check that proper levels are reached.
Viscosity	± 10% from initial value	Contamination (wrong top filling) or oil is severely deteriorated.	Determine cause. Consider oil change. Consult SIT or oil supplier.
RBOT	min. 50 % of new oil	Deterioration of oil.	Increase frequency of testing.
	min. 25% of new oil	Deterioration of oil.	Resample and retest. If same result, consider oil change. Consult SIT or oil supplier.
Total acid number	max. increase 0.3-0.4 mg KOH/g over new oil	Deterioration of oil.	Look for signs of increased sediments on filters. Check RBOT. If low RBOT consider oil change. Consult SIT or oil supplier.
Wear metals	Follow trend.	Improper lubrication. Particle contamination in combination with bad filtration.	Check for solid impurities. Consult SIT.
Chemical contamination	Follow trend	Contamination	Check physical properties. Consult SIT or oil supplier.
Foaming	Se limits in lubricating oil specification	Contamination or deterioration of oil.	Consult SIT or oil supplier. Consider reinhibition or oil change.
Air release	See limits in lubricating oil specification	Contamination or deterioration of oil.	Consult SIT or oil supplier. Consider oil change.
Emulsion characteristics	Se limits in lubricating oil specification	Contamination or deterioration of oil.	Consult SIT or oil supplier. Consider oil change.

*) For appropriate test method check the SIT lubricating oil specification.