GEK 28143A
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GE Power Systems
Gas Turbine

Hydrocarbon Base Lubricating Oil Recommendations For Gas Turbines

I. GENERAL

The successful operation of the gas turbine and driven equipment is vitally dependent upon the lubrication system. It is necessary that all factors contributing to correct lubrication be present and that the entire system be maintained in good order.

These instructions contain information intended to help the purchaser of a General Electric gas turbine and the oil vendor select the proper grade and quality of lubricating oil for the turbine application. For phosphate ester fire resistant lubricants refer to GEK 28136, “Phosphate Ester Based, Fire-Resistant Recommendations for Gas Turbines”.

These recommendations apply to General Electric’s Heavy Duty Gas Turbines only. For lubrication recommendations for equipment other than General Electric, refer to the instructions provided by the manufacturer of that equipment.

The life of the apparatus depends upon a continuous supply of oil of proper quality, quantity, temperature, and pressure.

The life of the oil itself, if it is free from solids, has the proper viscosity, and is noncorrosive, is of prime importance to the user, therefore, any values relative to oil life are given for reference only.

Any request to use grades or types of oils other than those specified in this instruction should be directed to the General Electric Company Field Representative.

II. RECOMMENDED PHYSICAL PROPERTIES

Three viscosity grades of rust and oxidation inhibited petroleum oils have generally covered the requirements for gas turbines and their load devices. The properties are summarized in Table 1, and they are termed “light, medium, and heavy”. The preferred oil for a General Electric gas turbine is the light grade oil having a viscosity of 140 to 170 SUS* at a temperature of 100°F.

*Saybolt Universal Seconds (see Test Methods)

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser’s purposes the matter should be referred to the GE Company.

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If it is necessary to use the medium or heavy grade oil, equipment changes may be necessary in the lubricating system, pressure regulating system, or orificing of machine bearings. Therefore, it is necessary that the General Electric Company Field Service Representative review all requests for use of any oil other than the light grade turbine oil.

Typical total acid number (TAN) of new oils range from 0.05 to 0.15 MG KOH/g. After a new oil has been in use for a period of time, the TAN will probably decrease as the oil additives, which have acid-like characteristics, plate out (as they should do) on the internal metal surfaces of the oil system. After these additives are depleted from the oil, the neutralization value will gradually increase with age and use.

III. ANTI-WEAR OILS

In some applications the use of anti-wear additives in addition to rust and oxidation inhibitors may be required. The use of these additives may give an initial total acid number much higher than with oils not containing such additives. With use, the acid number will go down as these additives are used. Eventually as the oil oxidizes the acid number will increase.

The properties of three grades of oils containing anti-wear additives are listed in Table 1.

NOTE

Oil with chlorine or other halogen containing additives are not to be used in General Electric gas turbines. Oils with tricresyl phosphate (TCP) are preferred. Oils with zinc dialkyl dithiophosphate (ZDDP) are acceptable and are being used in these turbines. The operator should be aware that ZDDP is a variable product and is less thermally and hydrolytically stable than other materials such as tricresyl phosphate. Other additives may be satisfactory, but the proper use of these additives should be established between the operator and his supplier, therefore, the operator should discuss his particular application with the supplier of the oil.

IV. LOW POUR POINT OILS

A low pour point oil may be required for some turbines. Generally, those containing direct oil to air heat exchangers should use an oil with a pour point temperature of at least 20°F below the minimum expected ambient temperature. The properties of two such oils (petroleum base and a synthetic hydrocarbon) are listed in Table 1.

V. OIL SERVICE LIFE

It is the joint responsibility of the user and the producer of the oil to establish criteria for determining limiting property values for the oil in service. Usually this may be based on a combination of factors: acid number, viscosity, inhibitor concentration, etc. General Electric makes no recommendation in this regard.

Table I
Turbine Oil Properties

Property	Units	I Light Grade	II Medium Grade	III Heavy Grade	IV Light Grade With Anti-Wear Additives	V Medium Grade With Anti-Wear Additives	VI Heavy Grade With Anti-Wear Additives	VII Light Grade Low Pour Point	VIII Synthetic Hydro-carbon Low Pour Point
Viscosity at 100°F (min) (max)	Saybolt Universal Seconds	140 170	270 325	380 560	140 170	270 325	380 560	140 170	140 170
Viscosity at 210°F (min)	Saybolt Universal Seconds	43	47	55	43	47	55	43	43
Pour Point (max)	°F	20	25	30	20	25	30	–25	–65
Flash Point (min)	°F	330	350	360	330	350	360	330	450
Fire Point	°F	370	390	400	370	390	400	370	490
Total Acid Number (TAN) (max)	mg KOH/gm	0.20	0.20	0.20	1.60	1.60	1.60	0.20	0.20
Rust Preventing Characteristics	- - -	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Oxidation Characteristics (min)	Hours to TAN of 2.0	1000	1000	1000	1000	1000	1000	1000	1000
Load Carrying Capacity (min)	Pounds Per Inch	*	*	*	1750	2000	2000	*	*

***Not required**

VI. LUBRICATION SYSTEM

The lubrication oil system is designed to provide an ample supply of filtered lubricating oil at the proper temperature and pressure for operation of the turbine and its associated equipment.

Protective devices are incorporated into those systems where it is necessary to protect the equipment against low lubricating oil supply, low lubricating oil pressure, and high lubricating oil temperature. The protective devices either sound a warning or will automatically shut down the unit if any of these conditions occur.

The particular arrangement of the system, the protective devices, and the system settings are shown on the schematic piping diagram for the specific gas turbine. Other information on the Lubrication System found in this section includes the system's operation, maintenance and instructions for the various component equipment included in the system.

VII. OPERATING TEMPERATURES

Lubricating oil is exposed to a range of temperatures while circulating through the gas turbine. For reliable circulation of oil before starting, the viscosity must be 800 SUS or less. Converting this to temperatures, the minimum oil temperature before starting shall be 50°F, 70°F, or 90°F, respectively for the light, medium, or heavy grades of oil.

Figure LOR shows the effect of temperature on the viscosity for three different grades of turbine oil. The viscosities of the three oils at 100°F are quite different. At this temperature, the viscosity of oil number 1 is 150 SUS, the viscosity of oil number 2 is 300 SUS, and the viscosity of oil number 3 is 500 SUS. The viscosity of the three oils is the same (150 SUS), however, when the temperature of oil number 1 is 100°F, oil number 2 is 126°F, and oil number 3 is 145°F. Therefore, the performance of bearings, gears, hydraulic controls, etc. would be similar when any one of the three oils is used, provided the oil temperature is adjusted to maintain the desired operating viscosity.

The normal bearing inlet oil temperature is 130°F, however, because of ambient conditions and/or water temperatures, the actual operating conditions may be different.

The cooling equipment for the lubricating system is designed to maintain the nominal 130°F (bearing inlet oil temperature) when raw water is available for cooling. When radiator systems are involved, the sizing is such that for the maximum recorded ambient temperature at the site, the bearing header temperature may be 160°F. The gas turbine bearings are designed to operate satisfactorily at this inlet oil temperature. With radiator systems, the nominal 130°F bearing header will be maintained for a high percentage of the operating time. In special cases, other design header temperatures are used as dictated by the load devices.

Operating bearing temperature rises are discussed in appropriate sections of this manual. Typically, the oil temperature rise from inlet to drain is in the 25° to 50°F range. If a reduction gear is involved, this temperature rise may be 60°F.

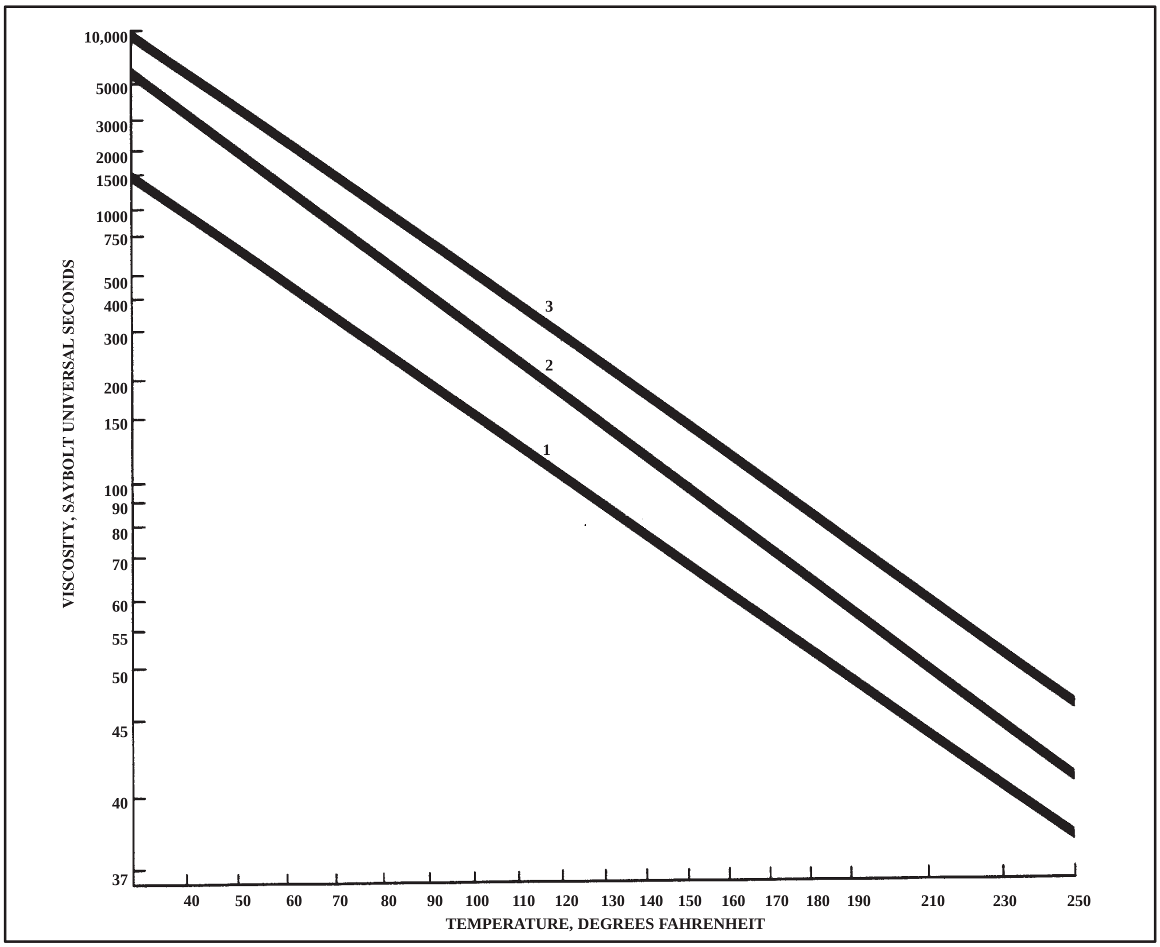

Figure LOR Effects of Temperature on Viscosity

Some gas turbines have bearings that are in an ambient of hot pressurized air. The bearing housing is sealed with labyrinths and the air flow is such that the bearing housing and drain spaces are at approximately atmospheric pressure. This ambient and the sealing air may be 500°F to 750°F. A portion of the lubricating fluid will be mixed with a small quantity of hot air and will wash metal surfaces at temperatures between 500°F to 750°F.

The lubricant temperature in the tank will be 25°F to 40°F above the bearing header. Thus, the bulk temperature will be 155°F to 200°F during operation.

VIII. CORROSION-PREVENTIVE MATERIALS

Manufacturing procedures provide for corrosion protection by cleaning and treating all metal surfaces contacting the lubricating oil in the lubrication system.

The inside walls of the lubricating oil tank are processed at the factory using an oil-resistant paint.

The inner surfaces of all lubricating oil piping, bearings, hydraulic control devices, and surfaces of other components in contact with the turbine lubricating oil are coated with a vapor space rust-inhibited lubricating oil which is used as a combination test and shipping oil. The oil and its vapors which remain on the wetted surfaces after the turbine has completed the factory test run serve as a corrosion-preventive agent. This remaining oil is generally compatible with turbine oils, but it is left to the discretion of the purchaser and oil vendor to decide whether the residue of this test oil should be removed by “field flush”. At installation it is expected that most of the remaining oil will be removed and the interior of the oil tank inspected for cleanliness.

All exterior finished machine surfaces of parts and assemblies which could be exposed to corrosive conditions during storage and shipment are coated with slushing oil. This material is not compatible with turbine oil and must be removed from all surfaces. (Sludging oil can be removed with petroleum spirits or kerosene.)

IX. CLEANING REQUIRED AT INSTALLATION

Reliable operation of controls and machine bearings is dependent upon the cleanliness of the lubricating oil system. During manufacture, considerable care has been taken in processing, cleaning, and flushing this system to maintain cleanliness. Oil filters have been installed to provide filtering of all oil that is used in the system. At installation, the entire lubricating system must be thoroughly cleaned; weld spatter, metal chips, dirt, and other foreign matter incident to erection and installation of the piping, etc., and any slushing oil which has been applied to metal surfaces contacting the turbine oil, must be totally removed.

Any surface, internal or external, contacting the lube oil must be thoroughly cleaned. This is to include any new components to be installed in the system.

If the lubricating oil system becomes contaminated during installation of the gas turbine, it is recommended that the lube oil system, load devices system, and interconnecting piping be flushed with hot oil. During this flush a hot oil and pipe arrangement should be used, and it should be made to bypass the machine bearings and other critical accessory devices. Careful planning of this flush is essential to prevent any dirt, introduced during the installation, from being flushed into clean, critical devices. The unit lube oil filters should be operative during this flush.

For assistance in flushing and cleaning, refer to ASME Standard LOS-4C1 ASTM-ASME — Recommended Practices for Flushing and Cleaning of Gas Turbine Generator Lubricating Oil Systems.

Most General Electric Company gas turbines are equipped with a completely assembled package including the lubricating system and turbine equipment. It may not be necessary to hot-oil-flush these at installation, except when the shipping oil has to be flushed out to satisfy the compatibility considerations of the turbine oil. If it should be decided by the purchaser and the oil vendor that a field flush is not required, particular care must be taken during installation to maintain cleanliness of this package, the cleanliness of the load devices, and the cleanliness of the interconnecting piping.

X. RESPONSIBILITY OF OPERATOR

After the unit is installed, and prior to its initial starting, the operator should take all precautions to ensure that:

1. The lubricating system has been thoroughly flushed and/or is clean.
2. The supply of turbine oil is ample for operation of the unit.
3. The type of oil is in accordance with this instruction.

During operation of the unit, the operator should establish a routine inspection procedure to ensure that:

1. The temperature and pressure levels of the lubrication system are within the limits specified by this instruction manual and the piping schematic diagrams.
2. The oil purity is maintained by checking for water leaks, by draining tank bottoms of sludge, and by adhering closely to the recommendations set forth by the oil vendor for sampling, purifying, and replenishing the lube oil supply.

XI. RESPONSIBILITY OF OIL VENDOR

It is generally recognized that turbine lubricating fluid should be a petroleum derivative free from water, sediment, inorganic acids, or any material which, in the service specified, would be injurious to the oil or the equipment. There should be no tendency toward permanent emulsification or rapid oxidation with the formation of sludge.

The responsibility of supplying the proper oil for the lubricating system rests with the oil vendor and the turbine operator. This responsibility includes specifications for flushing, purifying, inspection, and treatment of the oil to ensure satisfactory performance of the equipment in service.

XII. TEST METHODS

A. Viscosity

The viscosity of an oil is its resistance to flow. For turbine oils, it is usually reported in Saybolt Universal Seconds (SUS or SSU) at a given temperature and determined per ASTMD88, “Saybolt Viscosity”. It is the time in seconds for 60 milliliters of oil to flow from a container through a calibrated orifice at a specified temperature. In the design of lubrication systems, consideration is given to the viscosity at which the oil becomes too viscous to be pumped. For General Electric gas turbines the viscosity should be less than 800 SUS for proper circulation of the oil before starting.

B. Pour Point

The pour point is the lowest temperature at which oil will flow. It is reported in increments of 5°F. It is determined as the temperature at which the oil contained in a tube with an inside diameter of 30 to 33.5 mm. will not flow within five seconds of rotating the tube 90 degrees from the vertical to the horizontal position.

C. Flash Point

Flash point is determined per ASTM D92, “Flash and Fire Points by Cleveland Open Cup”. It is the temperature at which the fluid contained in a test cup and heated at a constant rate will flash but not burn when a flame is passed over the cup. It is indirectly a measure of both the volatility of the oil and the flammability of these volatiles. Since there are more accurate ways of determining these, such as distilling to determine volatiles, this is mainly of value as a quality control test.

D. Fire Point

Fire point is the temperature at which the oil in a test cup will continue to burn when tested as indicated under paragraph “Flash Point”.

E. Total Acid Number

The total acid number is the milligrams of potassium hydroxide (KOH) required to neutralize the acidic constituents in a gram of sample. It is determined per ASTMD 974, “Neutralization Number by Color-Indicator Titration”. The total acid number (TAN) is sometimes called the neutralization number (NN) or neut number and also the acid number (AN).

Turbine oils as well as most other lubricants normally contain additives for oxidation and rust inhibition and other purposes. For this reason the total acid number of a new or used oil should not be considered an indication of a tendency of the oil to corrode. The ASTM procedure states that there is no general correlation between bearing corrosion and acid numbers. The total acid numbers which are taken from a system over a period of time, are a method to follow additive depletion and subsequent decomposition of the base oil. In a lubricant containing additives such as rust inhibitors, anti-wear additives, etc., the total acid number should go down in value as the inhibitor is plated out on the surface of the system and then gradually increase as the oil oxidizes.

F. Rust Prevention

The rust prevention characteristics of the oil are determined per ASTM D665. A mixture of 300 ml of oil and 30 ml of distilled water (Procedure A) or synthetic seawater (Procedure B) is stirred while held at a temperature of 140°F. A carbon steel rod conforming to ASTM specification A108, Grade 1018, is immersed in the oil for a period of 24 hours, then examined for rust.

G. Oxidation Resistance

This test is run per ASTM D943, “Oxidation Characteristics of Inhibited Steam-Turbine Oils”. It is the time in hours for the acidity to reach 2.0 milligrams of potassium hydroxide per gram of sample in a sample of oil containing steel and copper wire coiled together and maintained at a temperature of 95°C (203°F) with oxygen passing through it and to which water has been added.

This test is used primarily to determine the life of the oxidation inhibitor and does not necessarily indicate the stability of the base oil.

H. Load Carrying Capacity

The load carrying capacity is determined per ASTM D1947. It is reported as the “pounds per inch of face width” at which the average tooth face scuffing of 22-1/2 percent has been reached. A four-square tester is loaded in specified increments. Standard test speed is 10,000 rpm; inlet oil temperature is 160°F to 170°F.

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