TECHNICAL INFORMATION LETTER

LUBE OIL VARNISHING

APPLICATION
This TIL applies to all heavy-duty gas turbines.

PURPOSE
This TIL is to provide customers with information regarding the formation of varnish or lacquers within the lube oil system, their effects and information regarding mitigation technologies. Please note that this information represents the current information gathered to date.

Compliance Category

O - Optional	Identifies changes that may be beneficial to some, but not necessarily all, operators. Accomplishment is at customer's discretion.
M - Maintenance	Identifies maintenance guidelines or best practices for reliable equipment operation.
C - Compliance Required	Identifies the need for action to correct a condition that, if left uncorrected, may result in reduced equipment reliability or efficiency. Compliance may be required within a specific operating time.
A – Alert	Failure to comply with the TIL could result in equipment damage or facility damage. Compliance is mandated within a specific operating time.
S – Safety	Failure to comply with this TIL could result in personal injury. Compliance is mandated within a specific operating time.

Timing Code

1	Prior to Unit Startup / Prior to Continued Operation (forced outage condition)
2	At First Opportunity (next shutdown)
3	Prior to Operation of Affected System
4	At First Exposure of Component
5	At Scheduled Component Part Repair or Replacement
6	Next Scheduled Outage
7	Optional

BACKGROUND DISCUSSION

Varnish formation in lubricating oil and hydraulic systems has been present for many years in the power generation industry. Historically, varnish formation has been attributed to a singular root cause. For example, there was a #2 bearing drain line of a gas turbine was touching the inside of the exhaust strut, which caused thermal degradation of the oil and varnish formation.

Varnish can be reddish brown to black in appearance, depending on the mechanism that caused the oil molecule to break and varnish to form.

Recent studies have revealed that oil varnishing is usually the result of a complex string of events. To start this chain of events, oil molecules must be broken. The mechanisms that break oil molecules fall into these general categories: chemical, mechanical, and thermal.

Chemical: Many chemical reactions occur as the oil ages. Oxidation of the oil leads to numerous decomposition products, including acids and insoluble particulates. Heat and the presence of metal particulates such as iron or copper accelerate the process. Additionally, highly aerated oils are far more susceptible to oxidation. Ensure that oils are compatible before adding or mixing them, as different oil additives may react adversely, further degrading the oil.

Mechanical: "Shearing" occurs when oil molecules are torn apart as they pass between moving mechanical surfaces.

Thermal: When air bubbles become entrained in the oil, severe failure of the oil may occur due to conditions known as Pressure-Induced Dieseling (PID) or Pressure-induced Thermal Degradation (PTG). These phenomenons are enabled in areas of high pressure within the hydraulic systems. Pressure Induced Dieseling, also known as micro-dieseling, occurs when air bubbles are collapsed under high pressure. This yields localized temperatures in excess of 1000 deg F (538 deg C), which in turn leads to thermal degradation and oxidation.

Electrostatic charge may also cause localized thermal-oxidative oil degradation and occurs in fluids systems as a result of internal molecular friction and electrostatic potential between the fluid and machine surfaces. The magnitude of the static charge within the oil will increase due to factors such as low viscosity, low conductivity, low moisture content, low levels of entrained air and high oil cleanliness. Most of these conditions are desirable attributes for an oil system and therefore cannot be eliminated. Investigations are ongoing to develop methods to prevent electrostatic discharge within the system. Static discharge can also occur due to high flow rates through main lube oil filters, despite design intentions to minimize this phenomenon.

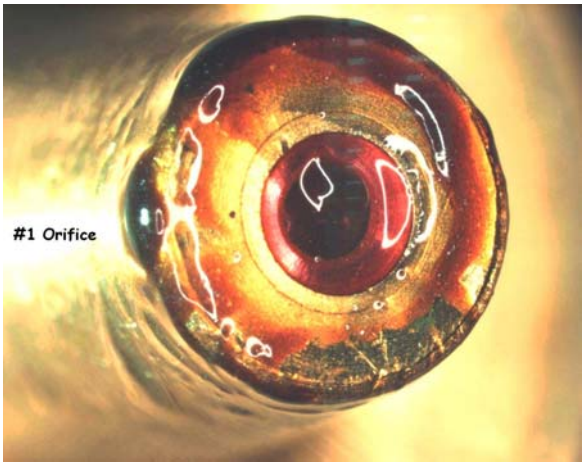

Figure 1: Varnish on Servo Orifice

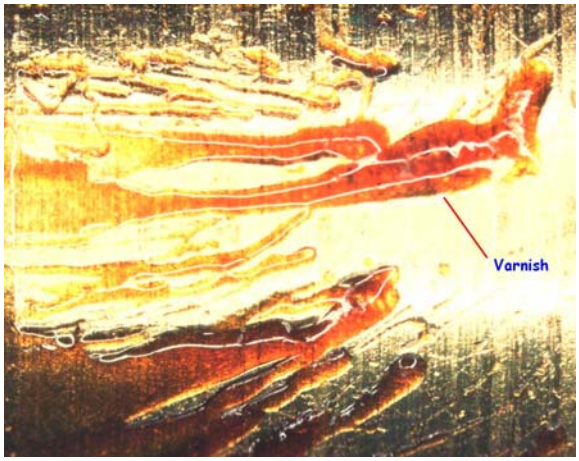

Figure 2: Varnish on Servo Filter

Effect of Group II Base Oils

Around 1990, oil suppliers started switching to Group II base oils for the manufacture of turbine oils. The oil suppliers made this change in response to stricter requirements from the automotive and transportation industry. Group II stock has much better oxidation stability as well as viscosity/temperature properties compared to the previous Group I stocks.

While the highly pure nature of Group II base stocks have the properties that tend to prevent the formation of impurities, they also have a lower ability to maintain these impurities in solution once formed. For this reason, the Group II base oils are more susceptible to varnish formation once oil degradation has begun.

Unit and System Impact

While the issue of oil varnishing typically does not lead to extended forced outages, the availability and reliability of the units can be greatly affected. The varnish tends to accumulate in small, low flow passages within the hydraulic system – typically in servo valves associated with hydraulically operated components. Once the varnish is established, the servo valves become sluggish or fail to operate, leading to a trip of the unit.

Fleet experience indicates that turbines being operated in a peaking or cycling mode are more susceptible to oil varnishing. This is due to the thermal cycling of the oil and the time at which the systems are in a relatively cold/low flow condition. Data also shows that for a peaking/cycling turbine, the component most likely to be affected first will be the inlet guide vane (IGV) servo. Units that are base loaded may not experience varnishing until later in life. The first component affected on based loaded units is typically the gas or liquid fuel control valves.

A recent study (primarily on "F" class GTs) suggests that as many as 1/3 of all units show some signs of oil varnishing.

Methods for Detecting Varnish

An oil condition-monitoring program should be part of normal maintenance including a combination of inspections and oil analysis screening tests. Inspections include viewing sight glasses for varnish and fouling, examining used filters for end-cap varnish and sludge, inspection of servo inlet ports and last-chance filters, and periodic inspection of tank bottom sediment.

While there is no direct way to measure (quantify) varnish formation on servo valve surfaces, the active use of screening tests may provide an effective early warning. The patch colorimetric test can be used to trend the varnish potential of oil. Lower numbers indicate a lower risk of varnish formation. For general reference, a varnish potential rating between 0 and 40 would be considered acceptable. The range 41-60 would be a reportable condition, indicating the need to monitor the oil more frequently. Readings above 60 are considered actionable and should trigger a work plan to quickly remediate the condition.

Monitoring of the sub micron particles in the oil along with the results from patch colorimetric testing can help in determining the effectiveness of removal of varnish particles. The test used to measure the sub micron particles is ASTM F 312-97 (Standard Test Method for Microscopical Sizing and Counting Particles from Aerospace Fluids on Membrane Filters)

It is recommended that both of these tests be used to monitor the performance of oil conditioning equipment.

Mitigation and Prevention

Customers currently utilizing electrostatic type filtration, or Balanced Charge Agglomeration, have reported very good results in reducing the varnish potential of their oil. These results show that trips caused by sticking servo valves have been drastically reduced or eliminated. Unlike conventional mechanical filters, these technologies induce electrical charges on suspended particles (oxides, carbon fines, etc.) that facilitate their transfer out of the oil, either by agglomeration/filtration or simply by electrostatic precipitation onto a collection device.

GE has performed extensive studies to validate the use of Balanced Charge Agglomeration technology. A recent test on seven 7FA+e turbines with this technology installed was run for 75 days while performing routine colorimetric sampling. The results of this test can be seen in Figure 3. Note that the results for two turbines are shown. The other five have been removed for clarity. All turbines exhibited similar results.

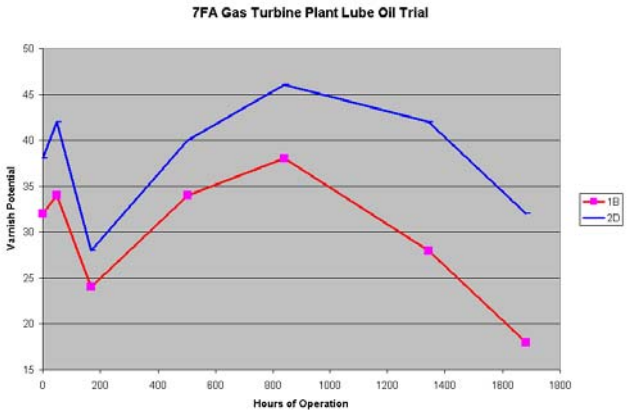

Figure 3: Balanced Charge Agglomeration Validation test

It should be noted that an initial downward trend is realized during the clean up phase followed by and upward trend as varnish that had been plated out on the system surfaces becomes reabsorbed into the oil. Over time, this varnish bloom will drop back down to desirable levels as the reclamation unit remains in service, leaving the oil system's surfaces and turbine oil clean.

This technology can be used either to mitigate a current varnishing issue or to prevent the occurrence of it.

RECOMMENDATIONS

Sites should fully investigate any trips involving IGVs or control valve mis-operation. Failure to eliminate all possible causes may result in a repeat occurrence.

Fleet information has shown that charged particle agglomeration and electrostatic precipitator filtration technology have been successful in mitigating, as well as preventing, the effects of varnishing. These systems are typically set up as a side-stream configuration to the existing lube oil system. They can operate continuously while the turbine is online or off-line.

For those customers who have not experienced trips associated with varnish formation, it is recommended that varnish removal systems be used as a preventive measure. The formation of varnish is partly dependant on the oil's age, and it is believed that all customers may experience this issue over time. Please note that the systems referenced are considered a mitigation strategy that addresses the symptoms of oil degradation and not the root cause. There are ongoing studies with oil manufacturers aimed at developing methods of prevention of oil varnishing.

Contact your local GE IF&S Service Manager or Contract Performance Manager to inquire about submitting a CM&U.

PLANNING INFORMATION

Compliance

- Compliance Category: **O**
- Timing Code: **7**

Manpower Skills

Basic skills associated with the ability to properly draw oil samples and prepare for shipment.

General knowledge of lubricant testing and analysis

Parts

N/A

Special Tooling

N/A

Reference Documents

GEK 32568 or the latest revision of the applicable Lube Oil recommendations GEK as supplied with the turbine.

Previous Modifications

N/A

Scope of Work

N/A

Contact your local GE IF&S Service Manager or Contract Performance Manager for assistance or for additional information.

NOTE: *If you would like to receive future TILs by email, contact your local GE I&FS Service Manager or Contract Performance Manager for assistance.*

TIL COMPLIANCE RECORD

Compliance with this TIL must be entered in local records. GE requests that the customer notify GE upon compliance of this TIL.

Complete the following *TIL Compliance Record* and FAX it to:

TIL Compliance
FAX: (678) 844-3451
Toll free FAX: 1-888-896-TILS (1-888-896-8457)

TIL COMPLIANCE RECORD	For Internal Records Only # _____
Site Name:	Customer Name:
Customer Contact Information	**GE Contact Information**
Contact Name:	Contact Name:
Address:	Address:
Email:	Email:
Phone:	Phone:
FAX:	FAX:
Turbine Serial Number(s):	

INSTALLED EQUIPMENT	TIL Completed Date: _____
	100% TIL Completed: _____
Description:	

Unit Numbers:	Part Description:	Part Number	MLI Number

Comments:

NOTE: *If there are any redlined drawings that pertain to this TIL implementation, please FAX the drawings along with this TIL Compliance Record.*

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GE values your opinions and comments.

GE requests that you complete the *User Satisfaction Survey* below to help us better serve you with accurate and timely information on your equipment.

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TIL Survey
GE Customer Technology Services
FAX: (678) 844-6737
Toll free FAX: 1-866-604-2668

USER SATISFACTION SURVEY

Serial Number: _____ **Date:** _____

1. How many days after TIL issue date did you receive this TIL?

1 - 5 days **6 - 10 days** **+ 10 days**

NOTE: *If you would like to receive future TILs by email, contact your local GE Energy Services representative for assistance.*

Rate the following based on a scale of 1 to 5, where **1** is Excellent and **5** is Poor.

2. Please rate how well this document informed you of the technical issue.

1 **2** **3** **4** **5**

3. Please rate the overall effectiveness of this TIL.

1 **2** **3** **4** **5**

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