GE ENERGY SERVICES TECHNOLOGY
CUSTOMER TECHNOLOGY SERVICES
18 NOVEMBER 2005

Compliance Category - O
Timing Code - 7

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.

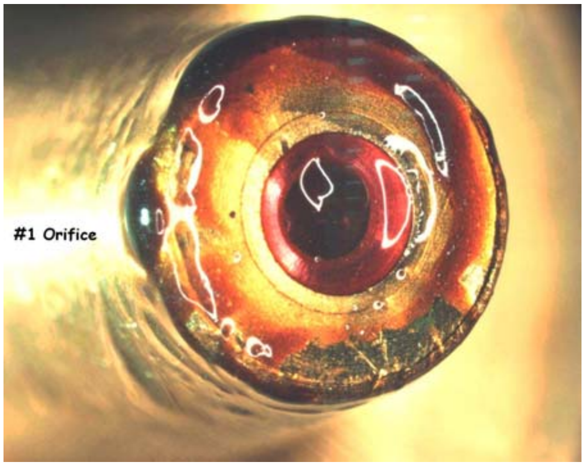

Figure 1: Varnish on Servo Orifice

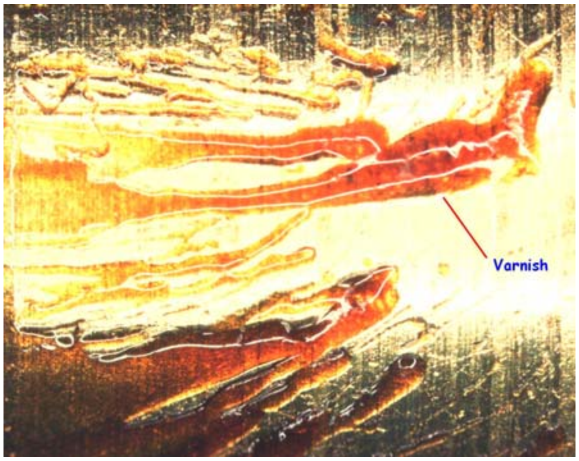

Figure 2: Varnish on Servo Filter

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.

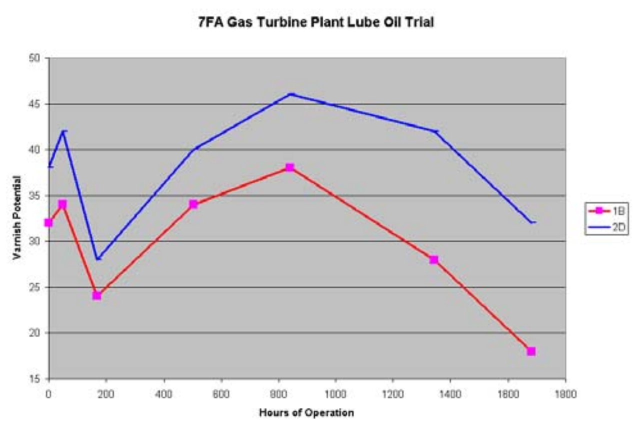

Figure 3: Balanced Charge Agglomeration Validation test

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.*

FAX this form to:

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FAX: (678) 844-3451
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USER SATISFACTION SURVEY

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.

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

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**

Comments / Suggestions:

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Toll free FAX: 1-866-604-2668

(中文推荐信仅供参考，以英文版本为准)

技术推荐信 1528-3
GE 能源技术服务
GE 客户技术服务部
2005 年 11 月 18 日

Compliance Category- O
Timing Code- 7

技术推荐信

润滑油胶质物的形成

应用

此推荐信适用于所有重型燃气轮机

宗旨

此信旨在告知广大用户有关润滑系统胶质物、漆皮的形成、影响以及补救措施。请注意这些信息是迄今为止收集的所有信息的总和。

背景知识

胶质物在电力行业的润滑系统和液压系统中已是个老生常谈的问题了。 从多年使用历史来看，胶质物都是由于非正常情况引起的，比如，一台燃气轮机的 2#轴承排油管路触碰到了排气支柱，引起油热能降解，形成了胶质物

根据油分子破裂和胶质物形成机制的不同, 胶质物的颜色可能是从红棕色到黑色不等。

目前的调查显示胶质物通常是一系列复杂事件的产物。油分子的破裂首先挑起了事端，引起油分子破裂的机制总的可以分为 3 类: 化学类、机械类和热能类。

化学类: 随着油老化，许多化学反应就出现了，油氧化会带来大量分解物，包括酸性物质和非溶解性的小颗粒物，而热量和金属颗粒物的出现，如铜和铁则加速了这一反应，此外, 充注二氧化碳的油对氧化特别敏感，油液在添加和混合前是可以相互融合的，但是不同的添加剂引起的反应南辕北辙，也加速了油品的恶化

机械类: 当油流经运动的机械表面，油分子被“撕开、剪开”

热能类: 当油里有气泡时，油可能会引起的严重故障，这是因为压力导致柴化(PID)或压力导致热性能降低(PTG)。这些现象会在液压系统的高压区域出现，油中的气泡在高压下破裂会引起柴化，即微观柴油机现象，这会使周围的温度超过 1000F(538C), 反过来又导致热能降解和氧化

静电电荷可能会引起局部热氧化、油降解，电荷在流体中形成是由于内部分子相互摩擦或流体和机械表面接触形成静电电压所至。某些因素将大大增加油中静电电荷的数量，如粘度低、传导性低、湿度低、油中空气含量低以及油的洁净度高。 而这些因素大部分都是油系统的理想状态，因此必须保留，正在进行的调查就是研发一种方法防止系统中的静电现象。但润滑系统中流经主过滤器，随着流量增加也会使静电电荷数量增加，尽管过滤的初衷是要消除这种现象。

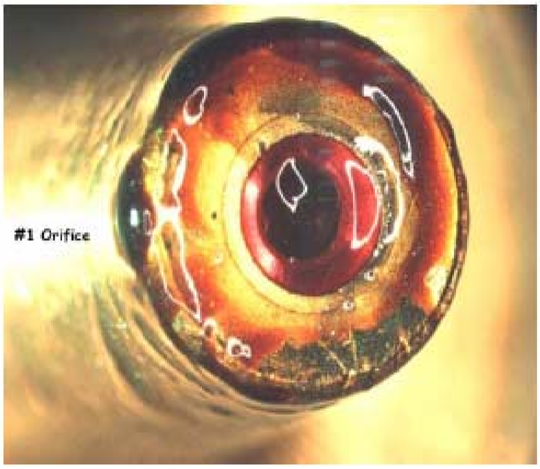

图 1: 伺服阀口的油泥

对 II 类基础油的影响

大约 1990 年左右，油品供应商开始转用 II 类基础油制造透平油。作出这一变革是适应汽车业和交通业更为严格的用油要求。 II 类油原料相比于 I 类油原料更具氧化稳定性和优越的粘度/温度特性

高纯度的天然 II 类基础油原料的特性是防止纯度下降，然而当纯度一旦下降，却对此无能为力。所以，一旦油状况开始恶化， II 类基础油就更容易受影响

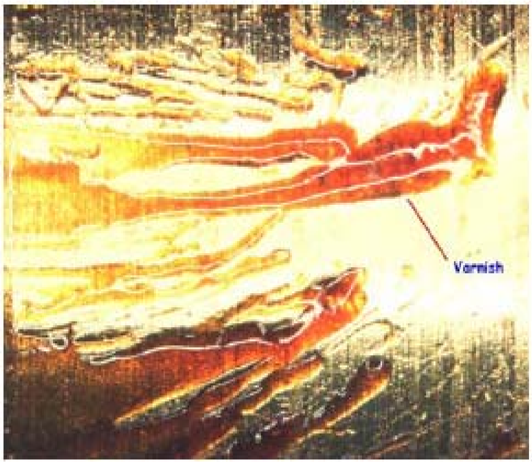

图 2: 伺服过滤器上的油泥

对设备和系统的冲击

通常情况下，胶质物不能延长寿命，而是严重损害了设备利用性及可靠性，胶质物很容易在液压系统的低流量、小通道中积聚沉淀，特别是伺服阀等精密部件，一旦产生胶质物会使伺服阀动作缓慢，无法正常动作，引发设备故障

一系列经验表明：在高峰期运行或联合循环运行的燃气轮机更容易受胶质物侵害。这是由于油的热循环而设备处于相对低温/低流量的状态下。数据还显示在高峰期/联合循环运行的燃气轮机中，最可能先受影响的部件是导向叶片伺服系统，当然也可能到了设备老化到相当程度才会受胶质物侵害。基本负荷机组先受影响的部件通常是气体\液体燃料控制阀。

最近的研究显示多达 1/3 的燃气轮机有胶质物的迹象出现。(主要是 F 级燃气轮机)

检查胶质物的方法

燃气轮机的正常维护应该包括油况监控程序，检测和屏蔽测试相结合。检测包括查看玻璃观测管是否有胶质物或污垢，检查使用过的过滤器末端是否有胶质物，以及伺服阀进口处，最后一道过滤器是否有胶质物，定期检查箱底是否有沉积物

因为没有一种方法能直接测量出伺服阀表面淤积的胶质物数量，屏蔽测试是一种积极的做法，有效起到前期预警作用。可以用切片色度测试区分胶质物潜在等级，数字越小说明胶质物形成的概率越小，一般来说，0-40 是可容许范围，41-60 是需要报告的状况，即需要经常监控油况，超过 60 就需要采取措施，应立即制定计划迅速改善这种状况。

监测油中的亚微米级颗粒物以及切片色度测试有助于检查去除胶质物颗粒物的效果，衡量亚微米级颗粒物的测试是 ASTM F312-97

建议双管齐下监控油况.

改善和防护措施

用户目前使用的静电型过滤器，平衡电荷净化技术(BCA)在降低胶质物形成方面十分有效，使用结果证明伺服阀粘连引起的故障大大降低甚至没有了，跟传统的机械式过滤方式不同, 此技术(爱索普公司专利)在悬浮的颗粒物(如氧化物，炭化物等等)上加载可控电荷，更容易被收集过滤器捕捉。

GE 公司做了全面的试验证实了平衡电荷净化技术的有效性。 试验在 7 台 7FA+e 型燃气轮机上使用了 BCA 这项技术，运行 75 天，同时进行常规色度测试。试验结果请见图 3，注意：图上只显示了 2 台机组曲线，另 5 台机组曲线被拿掉以便图形显示的更清楚。所有 7 台燃气轮机的结果大致相同。

注意最初净化阶段曲线向下，随后曲线又向上是因为设备表面的胶质物被清除掉，暂时回到油中，随着设备在线净化的时间推移，胶质物曲线开始降回到理想的程度，表明润滑系统表面以及透平油本身均变的洁净如新。

平衡电荷净化技术既可以改善已有的胶质物问题，也可以防止胶质物形成。

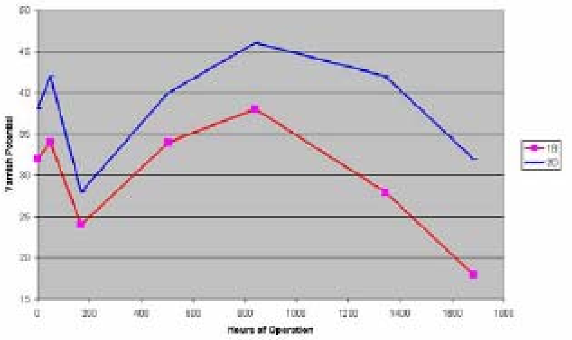

图 3:　平衡电荷净化技术有效性试验

建议

各用户端都应全面检查是否有导向叶片的伺服系统或控制阀失灵引起的故障，如不消除可能的成因就会导致故障频频发生。

全面信息显示平衡电荷净化技术能成功改善和防止胶质物的侵害，此技术产品通常并联在现有润滑油系统上，无论设备在线或离线都可使用。

有些用户的设备可能还没有胶质物引起的故障，对他们来说，建议使用净化系统作为防护措施。胶质物的形成部分取决于油的老化，我们相信随着时间的推移，所有用户都将经历胶质物带来的故障。请注意在此提及的净化系统是一种改善胶质物的方法，只能显示油况恶化征兆，而不能显示油况恶化的根本原因。正在进行与油品制造商的研究旨在开发避免胶质物的新方法。

请联系当地通用 IF&S 服务经理或者执行经理询问 CMU 情况。