FLUITEC CONSULTATIVE SERVICES

Fluid Failure Investigation

Power Plant
Gas Turbine

EXAMPLE REPORT

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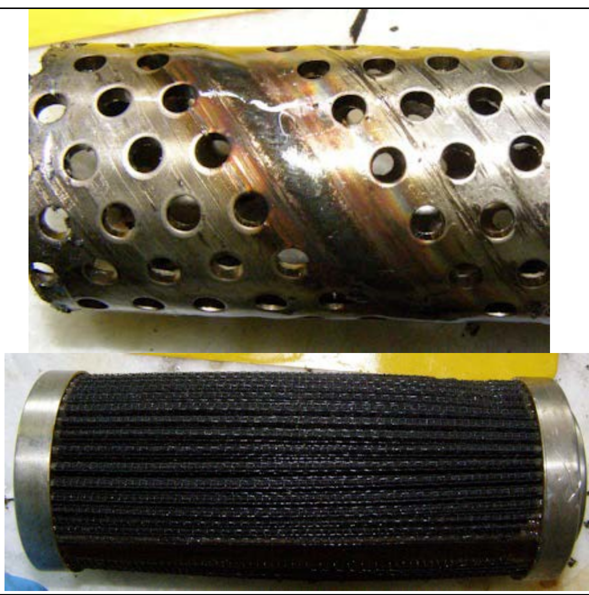
Customer	Power Plant (Example Report 2)
Subject	GE 6B Gas Turbine Filter Analyses
Principal Analyst	Fluitec SME
Date	January 20XX

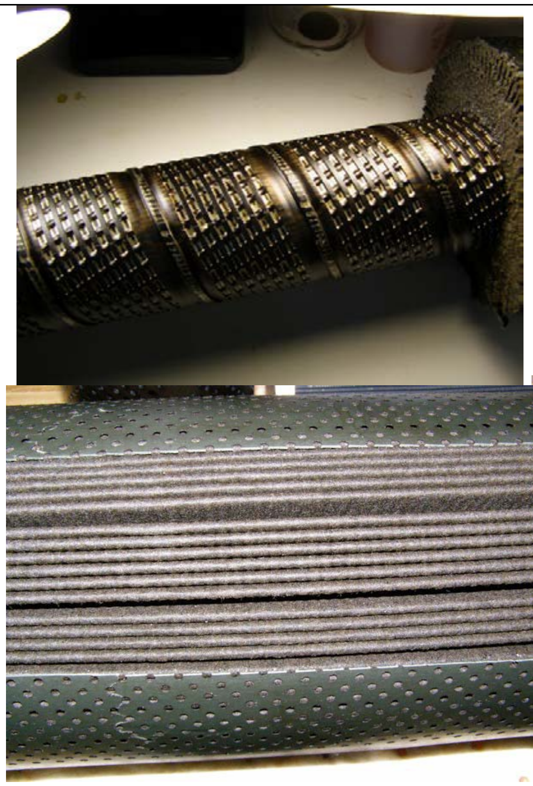
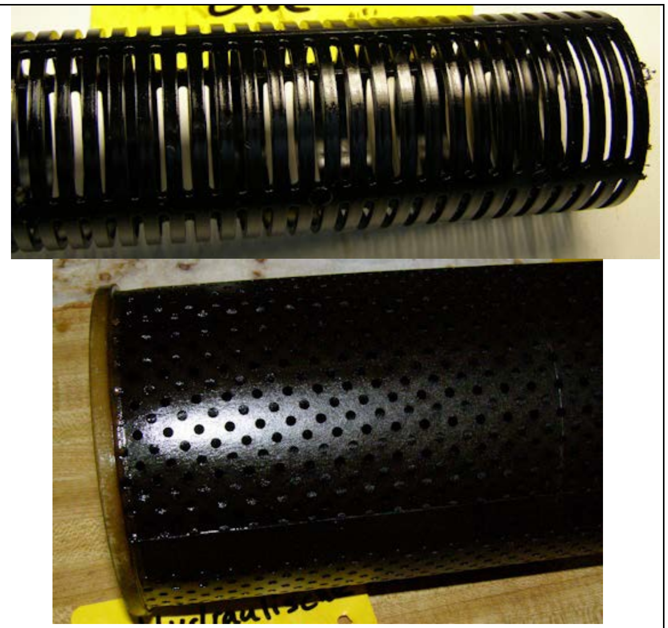
BACKGROUND

A package was submitted containing the filters from GE FRAME 6B gas turbines units from a European Power Plant. The plant has 3 GTs on site, all suffering from heavy varnish which is causing valve sticking in the hydraulic oil circuits. The Membrane Patch Colorimetry (MPC) results ranged between 25 and 46 for the 3 GT's. In addition, particle counts were high. The oil type was Brand X ISO 32. The plant would like to investigate the possibility of Electrostatic Spark Discharge (ESD) as a contributing factor to the varnish problems.

The collection of filters included:

- Last Chance filter from the IGV servo
- Fritted Metal – Toru Pump Oil
- Main Lube Filter
- Hydraulic Oil Filter

	
IGV Last Chance filter and Center Core	Fritted Metal – Toru Pump Oil

	
Main Lube Filter and Center Core	Hydraulic Oil Filter and Center Core

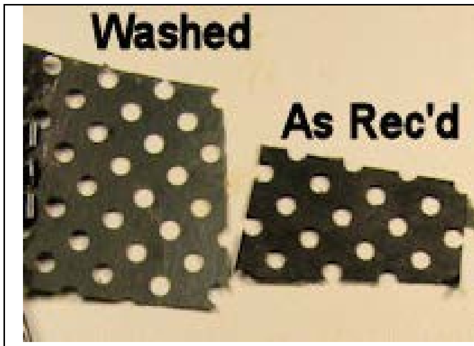
Each of the filters were dissembled and dissected to study both the filter media and the center core for evidence of ESD.

The filter media was opened and studied with back-light techniques for the existence of ESD-burnt holes in the media. Varnish material on and within the media was extracted from the media by first washing the media with petroleum ether – then extracting the varnish with methylene chloride in an ultrasonic bath.

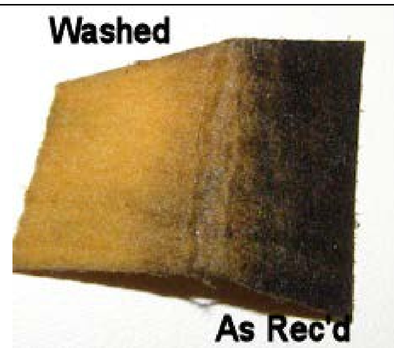
The center core was physically studied using magnification for the ESD evidence. This process included washing the core with solvent to remove the varnish for better examination.

All the varnish samples isolated were studied for chemical identification using FTIR spectroscopy. The FTIR spectral data was obtained using a PerkinElmer Frontier fitted with a UATR sampling accessory.

ESD Analysis
All the filters showed extensive varnish deposits – both inside as well as outside. As seen below for the Main Lube filter, this varnish was a brown coating on all the parts of the filter. Methylene chloride was successful in dissolving the varnish for removal.



Outside shield Main Lube Filter



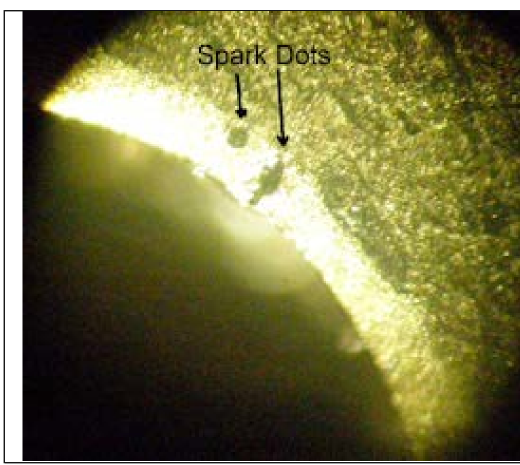
Media Main Lube Filter

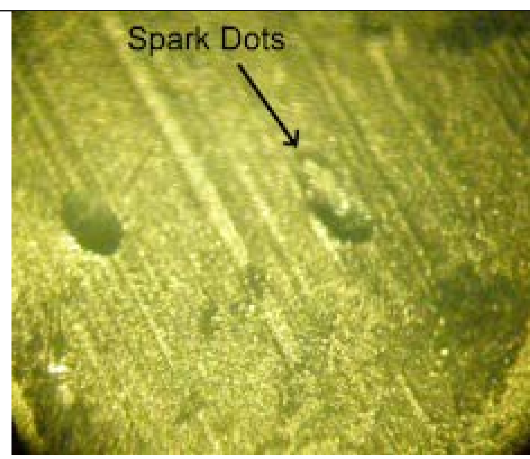
The center core of the hydraulic filter was a plastic material. As seen from the pictures above, this filter has varnish material throughout the filter. Although the center core was a black plastic material, one could still observe serious levels of varnish on it – as well as the filter material itself. Previous ESD studies have not revealed any evidence of spark damage to plastic filter cores. This filter was no exception as there was no evidence of ESD. The examination of the filter media also showed no evidence of ESD. It can be concluded that the hydraulic filter has not been experiencing observable ESD events. The filter was not affecting the varnish presence or level in the fluid – there were no measurable levels of varnish differences between outside or inside of the filter.

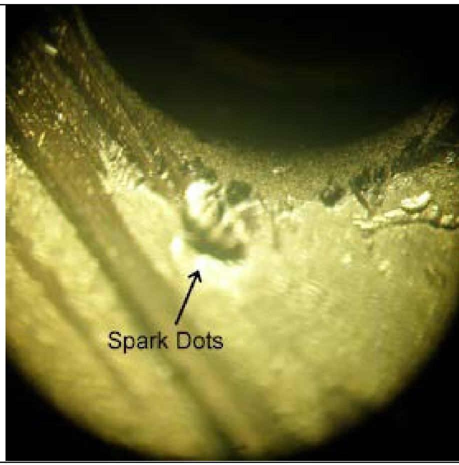
The Main Lube filter had a crimped metal core design. It was dark brown coated with varnish, over a silver colored core. Studies of this core did not show any ESD evidence. Study for the outer shield and the filter media also showed no evidence of ESD events. Like the hydraulic filter, this filter had heavy varnish throughout. There were no measurable levels of varnish differences between outside or inside of the filter.

The Toru Pump Oil filter was a different type of filter media. This filter was a small circular fritted bronze material. There was not center core for the ESD to focus. Because of its fritted design it was difficult to determine a location to study for ESD. Like the other filters, this filter was also thick with varnish throughout.

Like the other filter, the IGV last chance filter has varnish throughout. The level of varnish was not as heavy on this filter. The filter was studied for ESD by both examining the filter media and the center core. The filter media did not show ESD evidence. However, the center core did show ESD evidence.







The center core of this filter showed many small “spark dots” under microscope examination. These spark dots were the location that the spark contacted the metal core. They looked like a moon-creator where there was an indention in the metal surrounded by melted metal. One can observe the visual differences of these spark dots from metal scrapes and dents in the above pictures.

FTIR Analysis
The varnish was separated into two chemistry types: inorganic and organic.

The inorganic portion was the material that contained no hydrocarbon. This material is typically insoluble in polar-organic solvents like methylene chloride. Often these inorganic materials are observed included in the organic because it is “pulled” out with the polarity of the organic materials. It can also be thought of as the “sand on the sandpaper” that can cause abrasive wear from the varnish. The inorganic varnish portion has been isolated through extraction of the total varnish sample with methylene chloride – leaving this material as the insoluble fraction. The chemical characterization of this material is shown in Fig. 1.

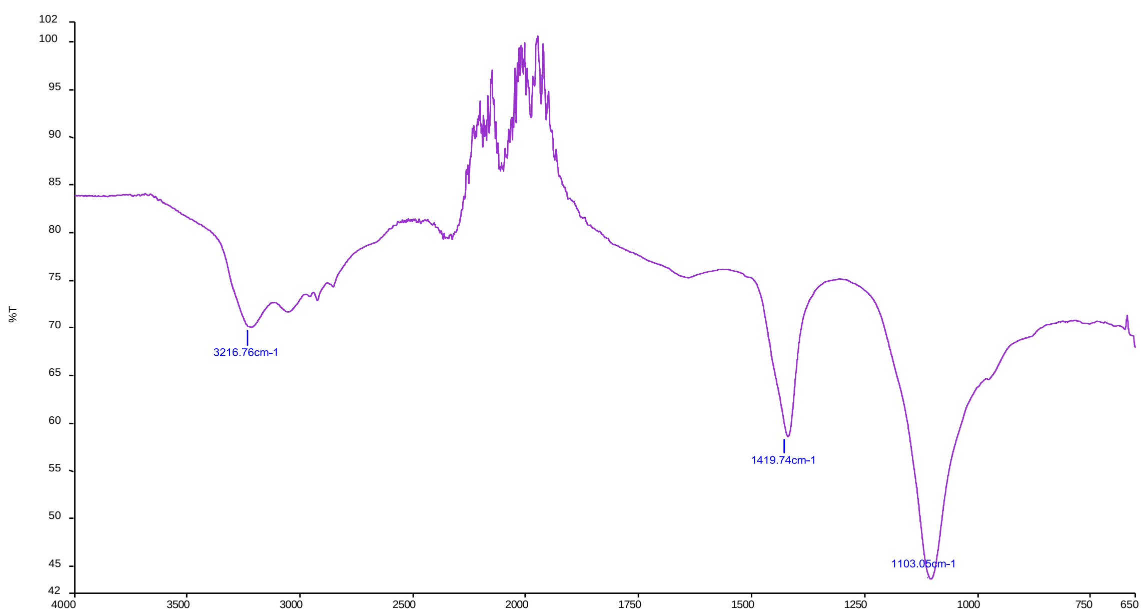


Fig. 1 FTIR Spectrum Inorganic varnish fraction.

The inorganic varnish showed three major FTIR peaks that identify the three chemistries present – water and hydroxides (3217 cm^{-1}), silica (1103 cm^{-1}) and carbonate (1419 cm^{-1}). This chemistry is classic for the presence of dirt. The isolation of dirt from a filter is not uncommon, especially the Main Lube Filter.

Several samples of varnish were collected from the different filters. The organic portion of these varnishes is defined as the methylene chloride soluble fraction. In many cases, some of the inorganic fraction will be included in this fraction if the quantity is large enough. The chemistry for several of these varnish samples are shown in the FTIR spectra in Fig. 2.

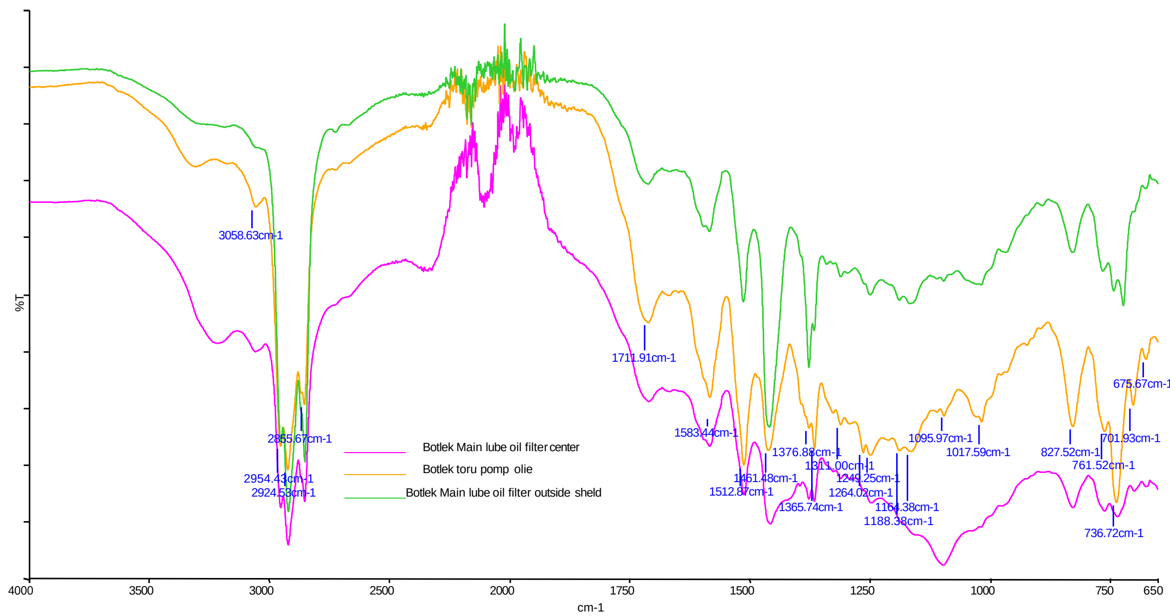


Fig. 2 FTIR Spectrum varnish fractions.

In addition to the inorganics observed (1103 cm^{-1}) included in the Main Lube Filter Center sample, all the varnish samples taken showed the same chemistry. This chemistry included aromatics (3058, 1583, 1512, 830-720 cm^{-1}) and carboxylic acid (1711 and 1188 cm^{-1}).

The varnish isolated was first compared with the fluid that came with the filters (Fig. 3). One can observe the fluid contains some of the aromatics in common with the varnish samples. Knowing the formulation chemistry of this particular turbine oil and comparing this fluid with new oil, there are very little differences observed. The fluid is a Group I base stock (high aromatics) with an aromatic amine antioxidant. The in-service fluid shows a very small additional peak at 1686 cm^{-1} that can be associated with some of the ESD observed on the filters. However, the varnish did not show this component – indicating the contributing effect of ESD to degrading the oil and causing varnish was small.

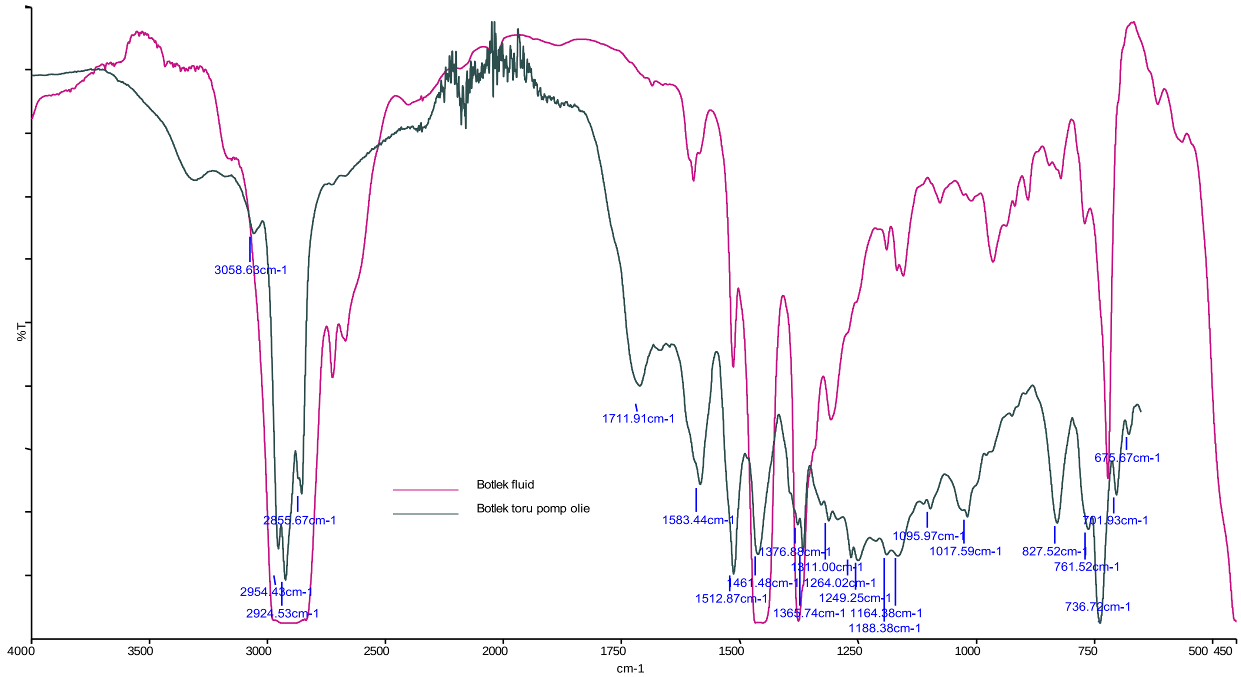


Fig. 3 FTIR Spectrum varnish and system fluid

Comparing the isolated varnish with other known/identified varnish samples (Fig. 4) shows that this varnish is related to the aromatic amine antioxidant formulated in the fluid – PANA.

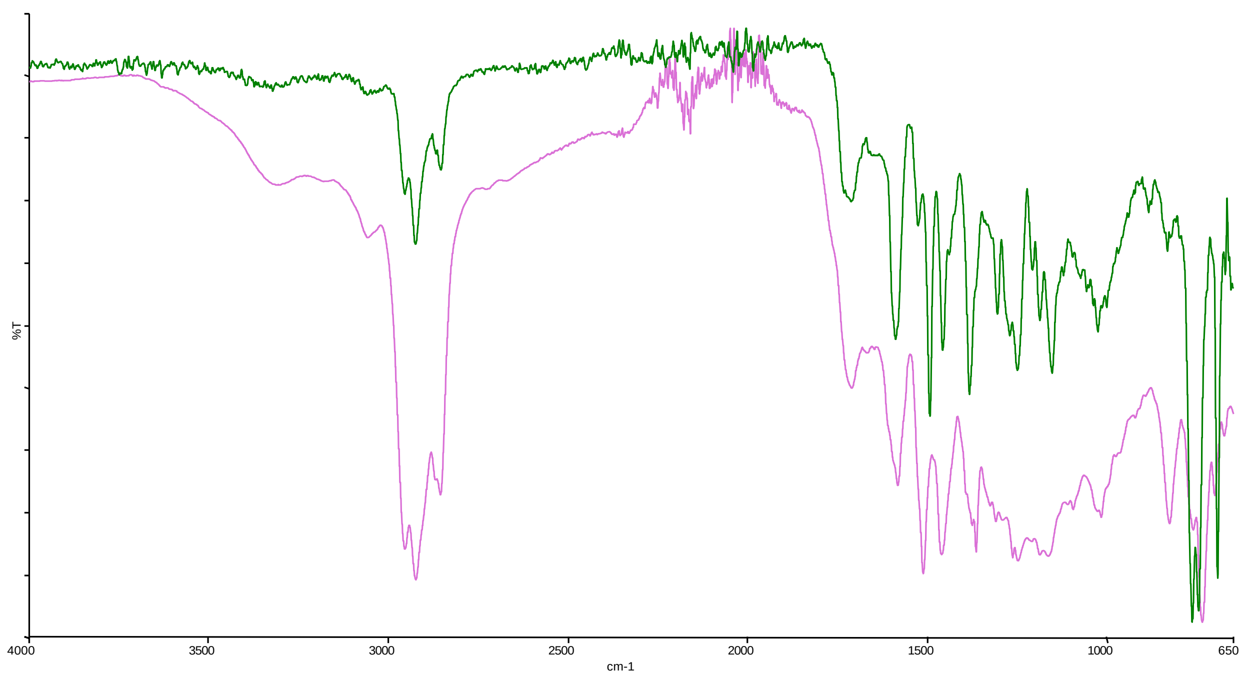


Fig. 4 FTIR Spectrum varnish and decomposed PANA.

PANA (phenyl alpha naphthyl amine) is known to decompose and produce a varnish component. The FTIR spectrum of the isolated varnish in this system shows that it is the same chemistry as that previously isolated and identified as the decomposition products of PANA.

CONCLUSIONS

A series of filters were studied for evidence of ESD. Only the IGV's last chance filter showed ESD presence. All the filters showed severe varnish throughout the filter. This varnish was isolated and identified. The varnish contained primarily decomposed amine antioxidant – PANA. In the varnish, especially that from the main lube filter, there was some dirt identified.

There are multiple mitigation methods that we can suggest to eliminate ESD from occurring in your IGV last chance filter. In addition, we have suggested mitigation methods to manage PANA as it degrades and before it develops deposits in the system. Finally, when the oil is at the end of its useful life, we can provide guidance on using a better turbine oil that is free of PANA.