

Great Lakes Generation

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Machine No: 19-1-3007
Fluid Type: Phosphate Ester
Machine Type: EHC Hydraulic System
Sample Source: Unit 1 EHC Skid Filter
Analyst: Monika Malcolm
Report Date: 08/03/2016
Lab Number: 1746783



Background

Filters from the Unit 1 EHC hydraulic control skid have been clogging at an excessive rate. The EHC system is using Phosphate Ester fluid, and has a 150 gallon sump. Previous varnish testing on fluid from this system showed elevated MPC color results, as well as elevated phenol levels with the RULER test.

Objective

The goal of this analysis is to characterize materials captured in this filter, to help determine the root cause of the frequent filter clogging.

Summary of Findings

Varnish materials with two different chemistries were isolated from the filter. The first varnish material isolated was characterized as varnish produced by oxidation of the phosphate ester fluid. The second varnish material isolated was identified as mono-alkylphenol di-acid phosphate, which is produced when the phosphate ester fluid is hydrolyzed in the presence of water. The hydrolysis process produces acids and phenols. Acid scavengers can remove the acids produced, but the phenols remain in the system and can further degrade to form varnish material.

Materials Identified

- Varnish produced by oxidation of phosphate ester
- Varnish produced by hydrolysis of phosphate ester

Recommendations Based on Findings

Both electrostatic and ion-exchange type filtrations may be required to effectively remove the varnish chemistries identified. It is also recommended to maintain as low a water concentration as possible for this type of fluid, to help control degradation due to the presence of water. Dry-air blanket/headspace dryer technology may help prevent atmospheric moisture ingress into the system.

Analysis



Figure 1. From left to right: filter as received, filter media selected for analysis.

The filter was received intact, with no visible damage to filter media or supports. The filter was disassembled, and a section of media was selected for analysis. The first solvent wash was with a hydrocarbon solvent to remove the included phosphate ester fluid.

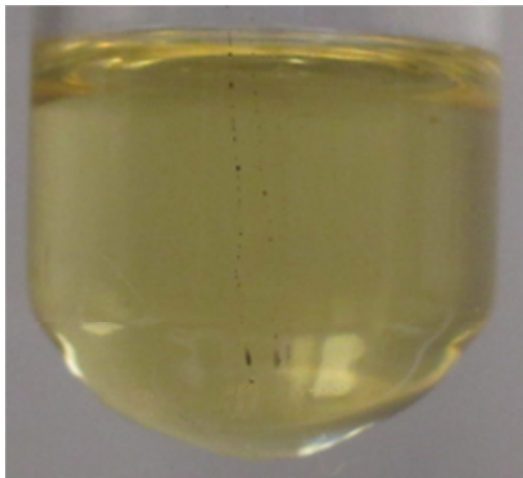


Figure 2. Hydrocarbon solvent soluble fraction.

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The hydrocarbon solvent soluble fraction was analyzed with FTIR spectroscopy. The FTIR spectrum exhibited the phosphate ester chemistry of the lubricant, as was expected.

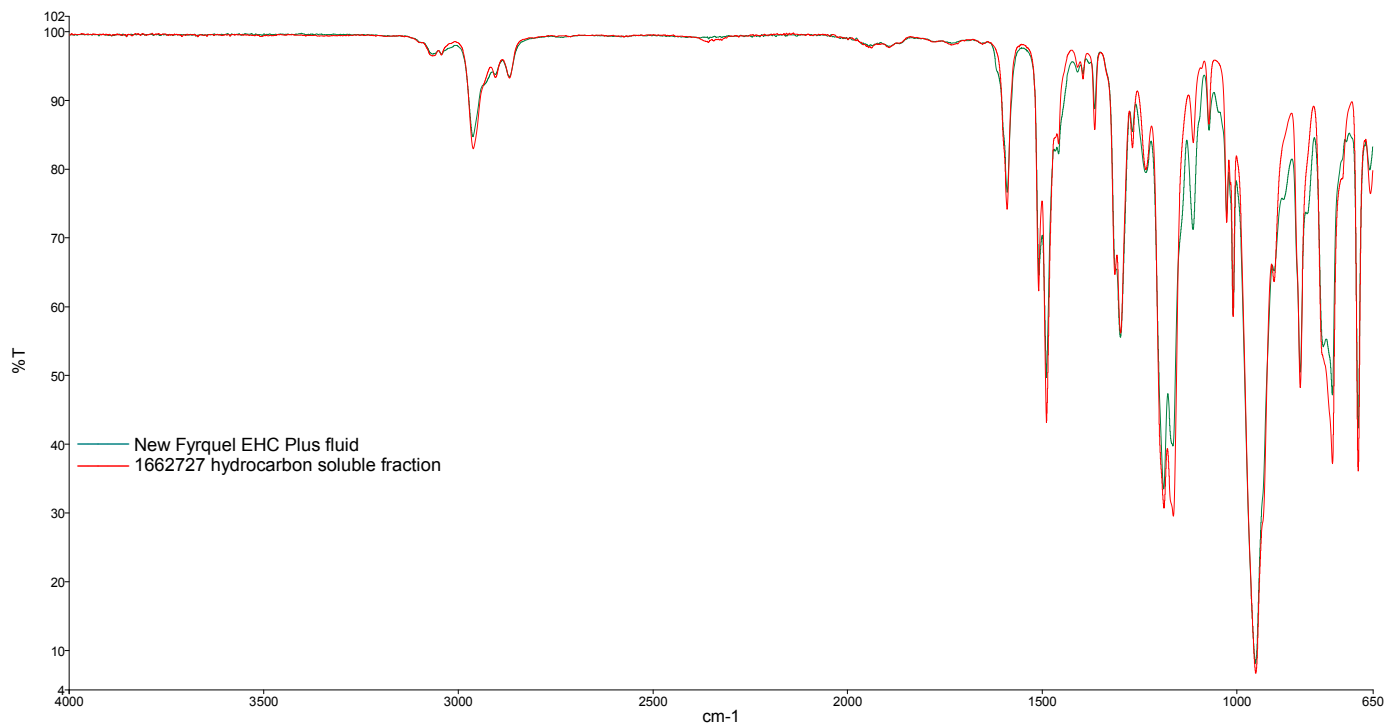


Figure 3. FTIR spectrum of hydrocarbon solvent soluble fraction with new phosphate ester reference spectrum.

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The filter media was then washed with a slightly polar organic solvent. The purpose of this wash is to extract lightly polar fluid oxidation products from the filter media. The polar organic solvent soluble fraction was analyzed with FTIR spectroscopy. The FTIR spectrum of the polar organic solvent soluble fraction exhibited phosphate ester chemistry and carboxylic acid ester. Carboxylic acid esters are a degradation product formed by oxidation of phosphate ester fluid.

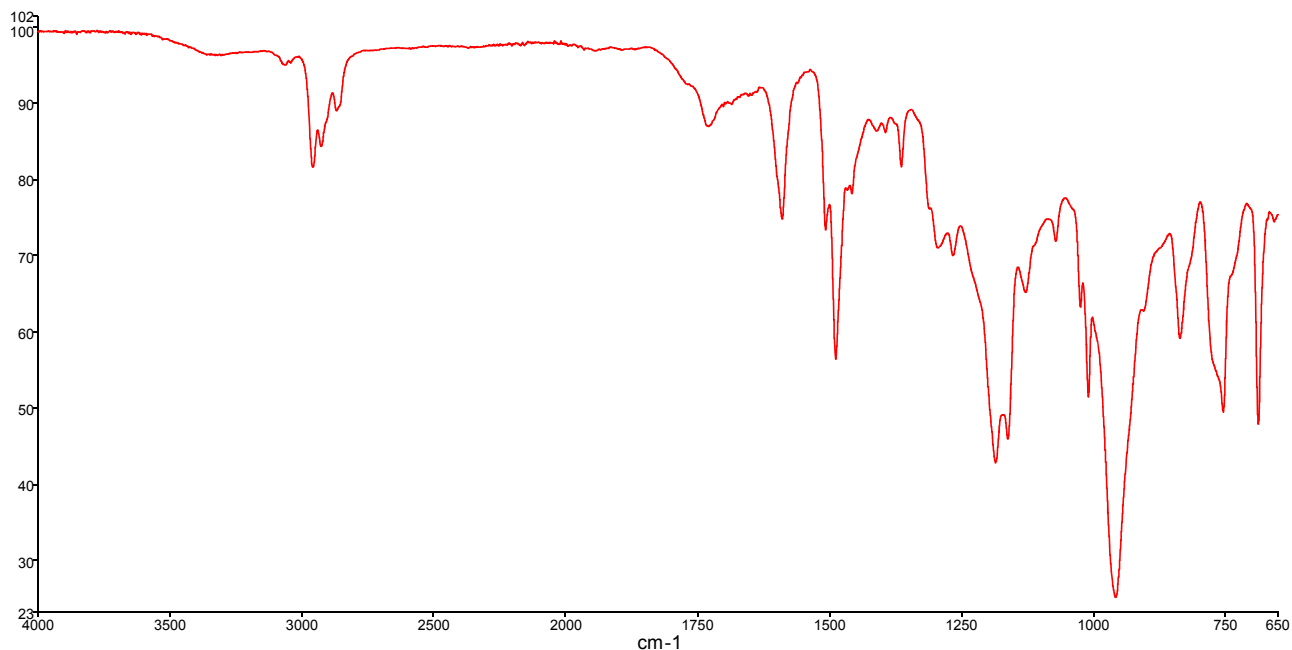


Figure 4. FTIR spectrum of the polar organic solvent soluble fraction.

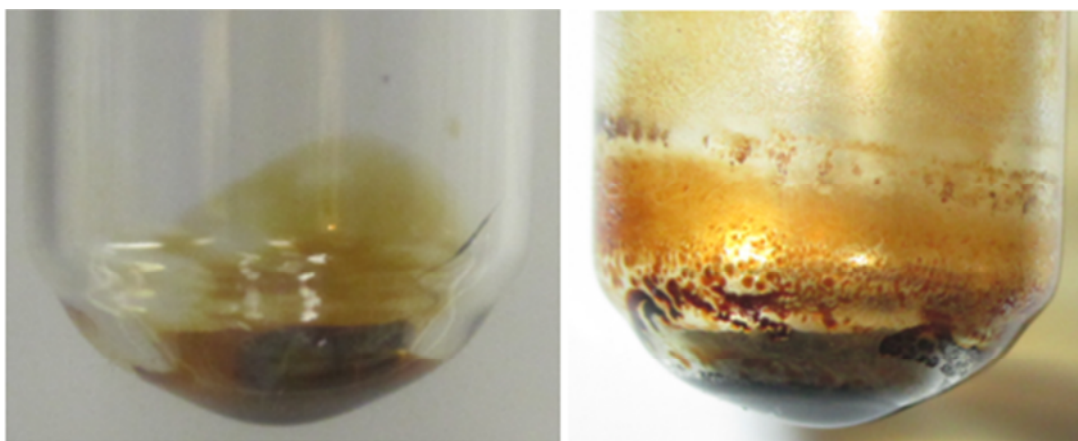


Figure 5. from left to right: polar organic solvent soluble fraction, alcohol solvent soluble fraction.

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The final wash of the filter media was with a polar alcohol. The purpose of this wash is to extract strongly polar phosphate ester fluid degradation products.

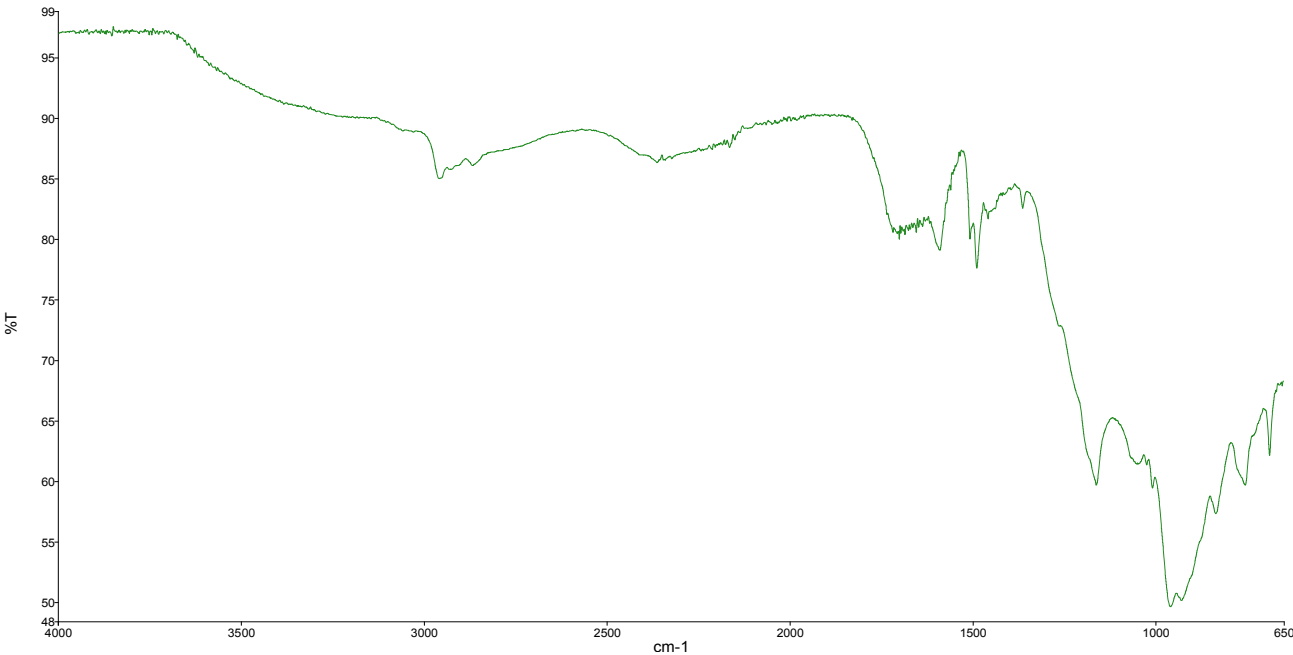


Figure 6. FTIR spectrum of polar alcohol soluble fraction.

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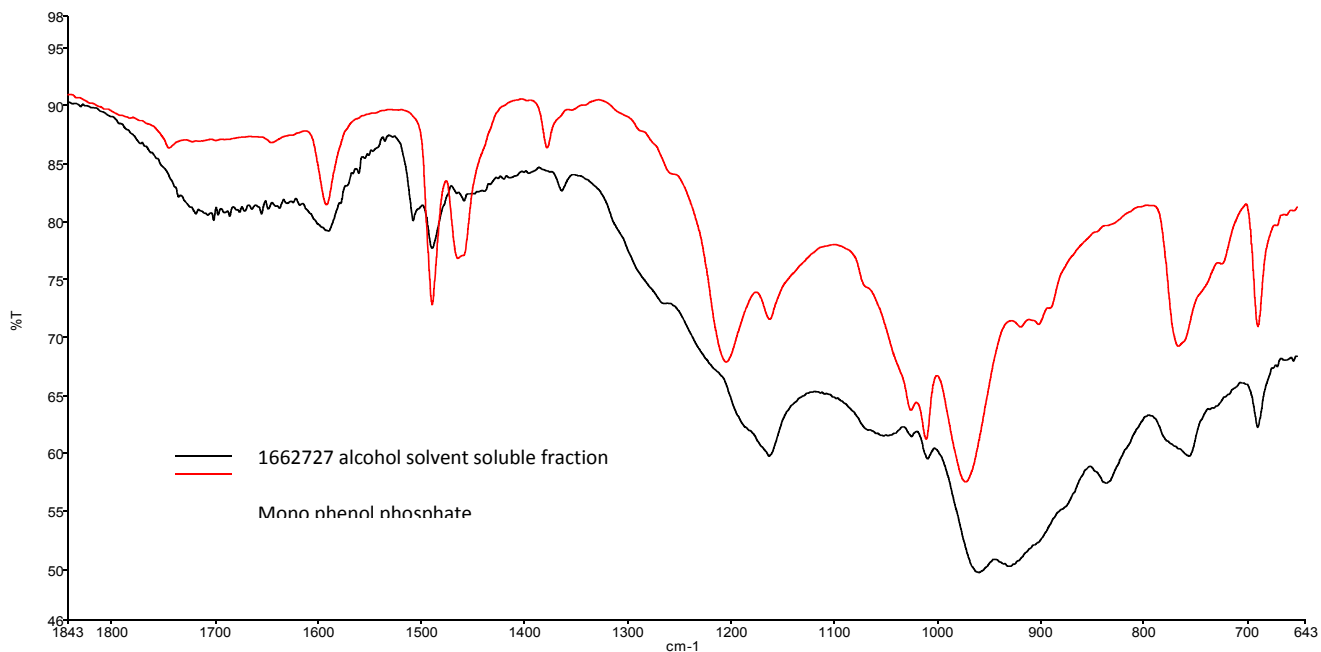


Figure 7. FTIR spectra of alcohol soluble fraction and reference.

The FTIR spectrum of the alcohol soluble fraction shows that it contains mono-alkyl phenol di-acid phosphate. This is a decomposition product of phosphate ester, and is produced when the phosphate ester fluid interacts with water in a process known as hydrolysis.

Please refer to the Summary of Findings section located at the beginning of the report for a conclusion of the results. Analysis completed by Monika Malcolm. For questions please e-mail mmalcolm@testoil.com.

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