TRACE LABORATORIES, INC
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Website: www.tracelabs.com / Email: info@tracelabs.com

TEST REPORT FOR:

NTSB
490 L'Enfant Plaza
Washington, DC 20594

Attn: Nancy McAtee

DATE IN:

August 12, 2008

P/O #:

Credit Card

SUBMISSION IDENTIFICATION:

Two (2) solenoid valve assemblies, serialized as S/N's P2942C and P3052C, were submitted for a Contamination Analysis consisting of Fourier Transform Infrared Spectroscopy (FTIR) Analysis to evaluate an observed liquid contaminant.

We offer our results and observations.

RESULTS SUMMARY:

Based on the FTIR analysis performed, the observed liquid contaminant material appears to be an oil used in aircraft-based applications.

APPROVED:

John M. Radman
Senior Technical Director

VISUAL EXAMINATION

TEST SPECIMENS:

Two (2) solenoid valve assemblies, serialized as S/N's P2942C and P3052C

METHOD:

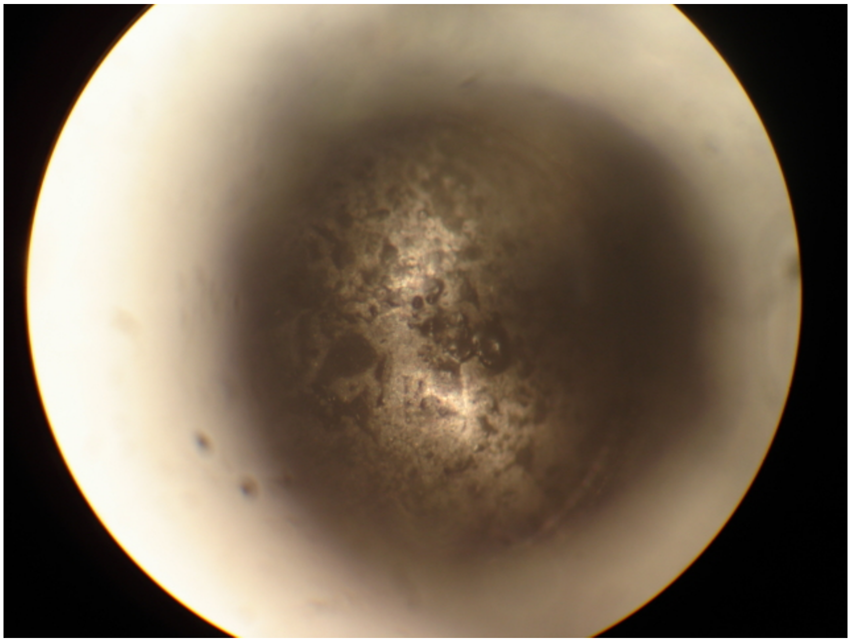
Each sample was examined using various light sources and magnifications ranging from 10X to 60X.

RESULTS:

A visual examination of the submitted solenoid samples found varying levels of a black liquid contaminant inside of the hole within each assembly. The contaminant material was observed on the internal ball as well as on the walls of the hole.

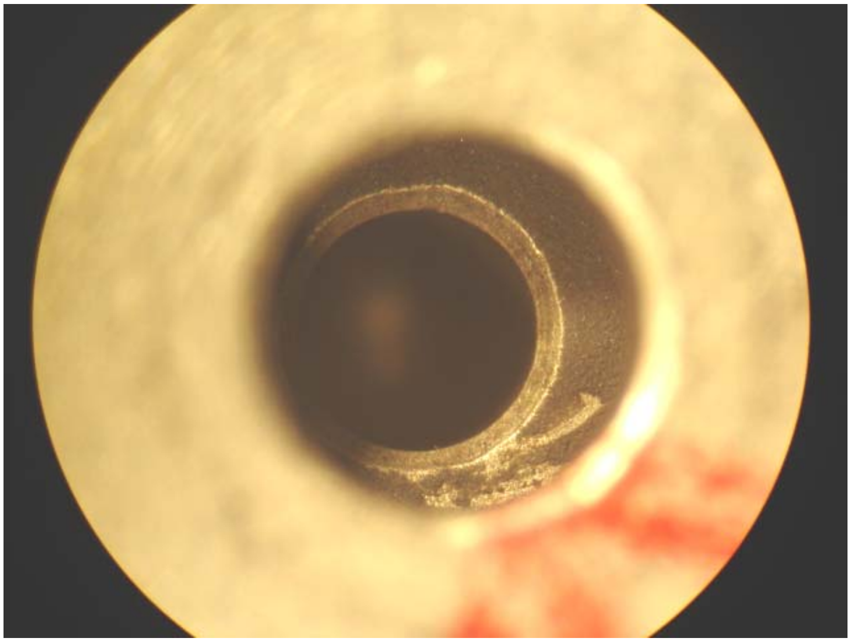
Photographs #1 through #4, below, show overview and close up images of the submitted specimens and the observations described above.

Photograph #1: Overview of Submitted Solenoid Valve Assembly Sample – S/N P2942C



Photograph #2: Representative Close Up of Contaminant Observed Within Sample S/N P2942C

Photograph #3: Overview of Submitted Solenoid Valve Assembly Sample – S/N P3052C



Photograph #4: Representative Close Up of Contaminant Observed Within Sample S/N P3052C

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FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR)

TEST SPECIMENS:

Two (2) solenoid valve assemblies, serialized as S/N's P2942C and P3052C

SPECIMEN PREPARATION:

The internal walls of the hole in each valve assembly body, along with the ball surfaces, were rinsed with a small amount of acetonitrile. These rinse solutions were then transferred to individual clean zinc selenide (ZnSe) windows and were allowed to evaporate. Upon evaporation, the resulting residues were then analyzed by micro-FTIR.

METHOD:

A Fourier Transform Infrared Spectrometer was used to collect and process infrared wavelength absorbance / transmission spectra of the specimens. These spectra are created when a molecule converts infrared radiation into molecular vibrations. There are two types of molecular vibrations, stretching and bending. These vibrational movements create bands in a spectrum that occur at specific wavelengths (cm^{-1}). Each wavelength is dependent on a number of things. Most importantly of which are the mass of the atoms present, the force constants of the bonds present, and the geometry of the molecule present.

Infrared spectra can help in identifying the chemical composition and / or bonding present in an unknown molecule. The greatest use of infrared spectroscopy is that the tool provides structural information about the presence of certain functional groups that are present in the sample.

The spectrometer radiates a broad band of infrared light through the specimen. Depending on the bonding present, the light will be absorbed, transmitted, or reflected at various wavelengths. From the spectrum produced, information about the bonding present is obtained from the location of group frequency peaks. Also, most spectra contain additional "fingerprint" peaks that are unique to a particular molecular structure.

All molecules have a unique spectrum in IR. The "fingerprint" region, below ~1500 cm^{-1}, is typically used to identify the molecule or molecules present. This region is different when comparing two molecules even with identical group frequency peaks. The group frequency peaks are typically strong and convey the presence of numerous organic functional groups. These include, but are not limited to, alcohols (-O-H), amines (-N-H), carbonyls (-C=O), etc.

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The spectrometer has the ability to analyze samples in two distinctly different ways. The methods are referred to as bench analysis and micro-FTIR analysis.

Bench analysis consists of forming the specimen to be analyzed into a thin film between two zinc selenide (ZnSe) windows. The infrared beam is then passed through the windows and a spectrum is recorded. This method is typically used on homogenous liquid samples.

Micro-FTIR analysis consists of using a microscope attachment on the spectrometer to analyze areas as small as 25 microns in diameter. This technique is particularly useful in analyzing small areas of surface contamination (given the proper sample geometry) or microscopic materials. Specimens can be analyzed in reflective or transmission mode with this method. In reflective mode, the infrared beam is passed through the sample and then reflected off of a reflective IR plate and passed back through the sample where it is detected and analyzed. In transmission mode, the infrared beam is passed through the sample where it is detected and analyzed. Both modes allow for in situ analysis, limited by the specimen's geometry. In addition, this type of analysis is typically performed on specimen residues or when a precise location analysis is required.

A specimen's spectrum can then be compared with spectra of standard materials from an IR reference library or compared with customer-supplied references. Upon analysis of some specimens, a spectrum is obtained that is nothing more than an erratic signal with no distinguishable features. A spectrum of this type is referred to as a noise spectrum. Noise is created in a specimen's spectrum when the absorbance by the specimen of a particular frequency is extremely low. With extremely low absorbance values, any minor increase or decrease in the absorbance of a frequency can create what appears to be a peak. Primary absorbance peaks lower than approximately 0.4 are generally considered indistinguishable in comparison to any noise present. Additionally, low absorbance values of primary absorbance peaks cause comparisons and identifications to be extremely difficult.

The photograph below shows the Mattson FTIR Spectrometer with Galaxy Microscope Attachment.

RESULTS:

The spectra obtained from the rinse solutions were found to be basically the same, suggesting that the "contaminant" material within each solenoid valve assembly is most likely the same.

Further, the scans suggest that the "contaminating" material is organic as evidenced by the presence of characteristic carbon-hydrogen bonding peaks between ~3000 and ~2800 cm^{-1}. Additionally, the scan suggests that the material may also contain a carbonyl group(s) due to the presence of characteristic carbon-oxygen bonding peaks near ~1725 cm^{-1}. Carbonyl groups are common to esters, organic acids, ketones, and aldehydes. Some additional peak structures were found in the fingerprint region, below 1500 cm^{-1}, of the scan and are typically used to help identify the contaminating material(s) detected.

A search of our FTIR spectral libraries found numerous "strong" spectral matches for the "contaminant" spectra obtained. All of these matches were to spectra of oils used in aircraft-based applications.

Specifically, the following were found to be the strongest matches:

- Exxon Turbo Oil 25
- Shell Aero Turbine Oil 555
- Mobil Jet Oil 254

The sample spectra obtained, as well as comparison spectra, can be found attached at the end of the report.

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Trace Laboratories, Inc. certifies that the test equipment used complies with the calibration test purposes of ISO 10012-1, ANSI/NCSL Z540-1-1994, and MIL-STD-45662A and that the data contained in this report is accurate within the tolerance limitation of this equipment.

All test procedures detailed within this report are complete. The results in this report relate only to those items tested. If any additional information or clarification of this report is required, please contact us. This test report shall not be reproduced except in full, without the written approval of Trace Laboratories, Inc.

Thank you for selecting Trace Laboratories, Inc. for your testing purposes.

Keith M. Sellers
Senior Scientist

Attachments: seven (7) FTIR scans

SAMPLE DISPOSITION: Samples returned to customer

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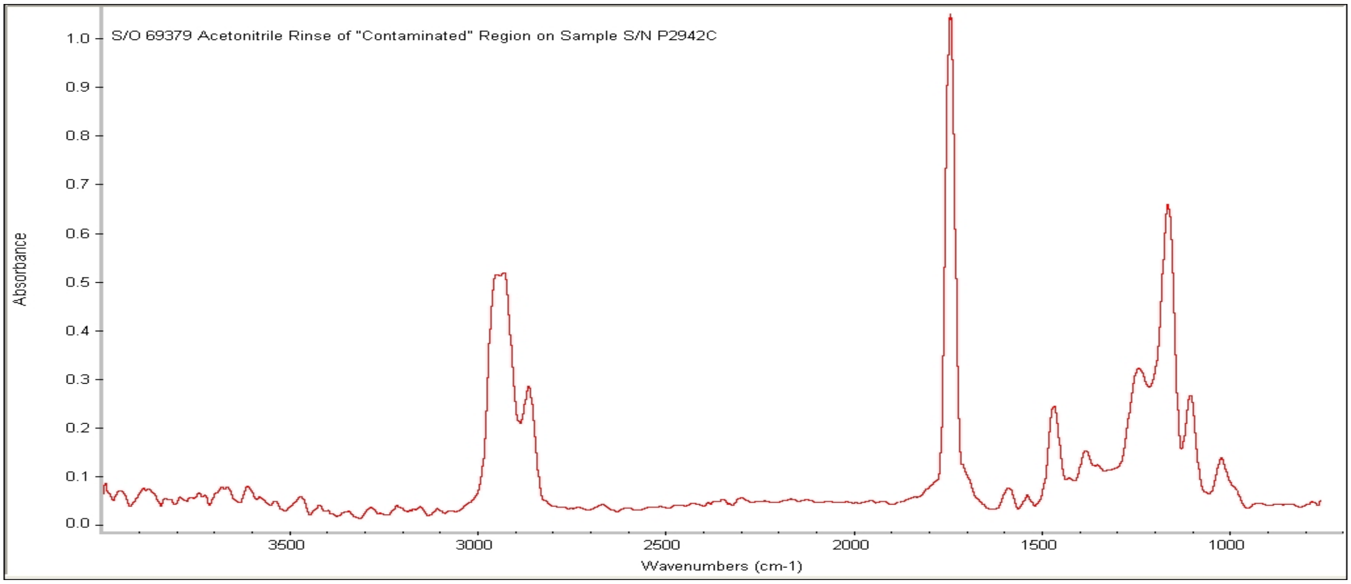
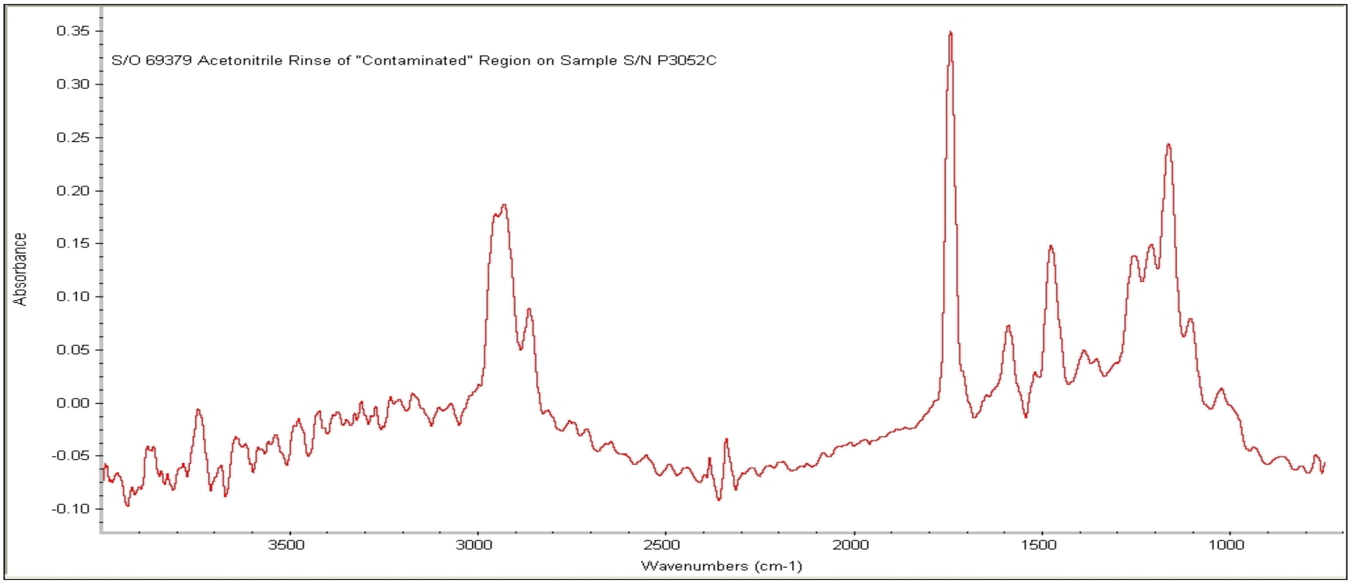
FTIR Spectrum Obtained from Acetonitrile Rinse of "Contaminated" Area on S/N P2942C:



FTIR Spectrum Obtained from Acetonitrile Rinse of "Contaminated" Area on S/N P3052C:



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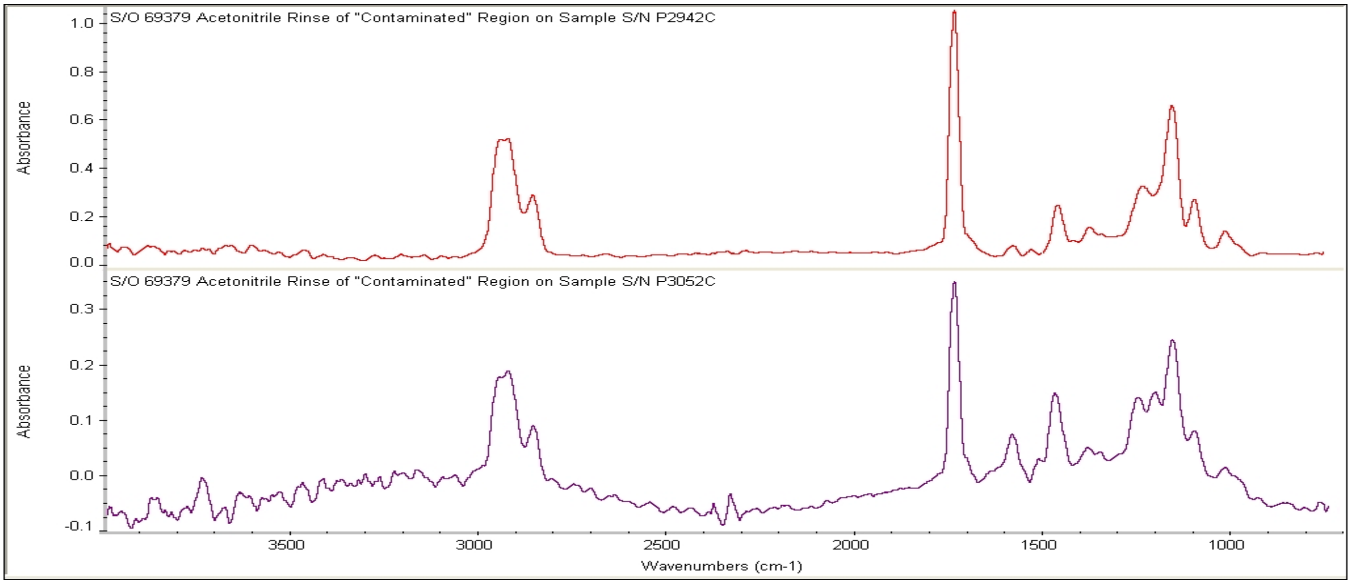
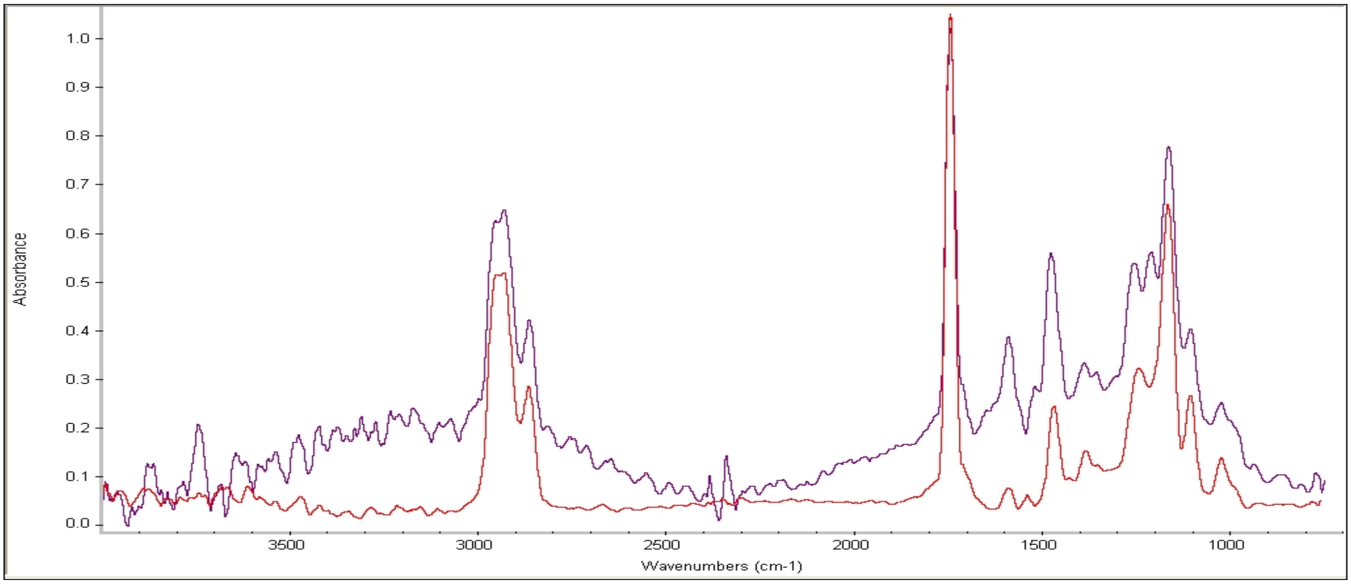
FTIR Spectral Comparison of "Contaminated" Region Scans for S/N P2942C (red) and S/N P3052C (purple), stacked:



FTIR Spectral Comparison of "Contaminated" Region Scans for S/N P2942C (red) and S/N P3052C (purple), overlay:



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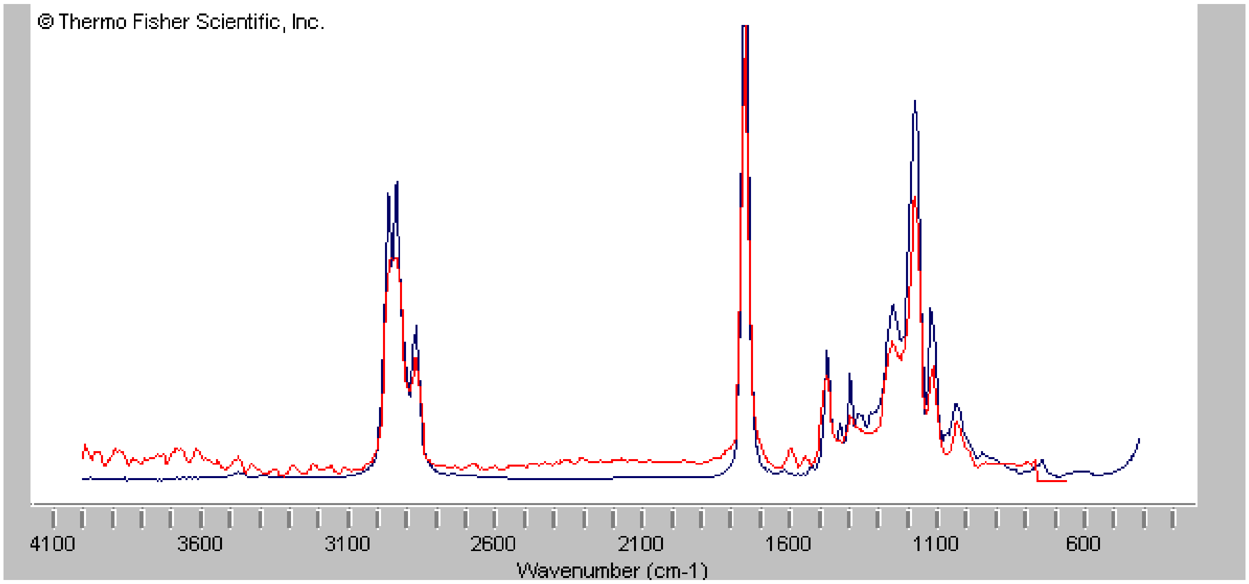
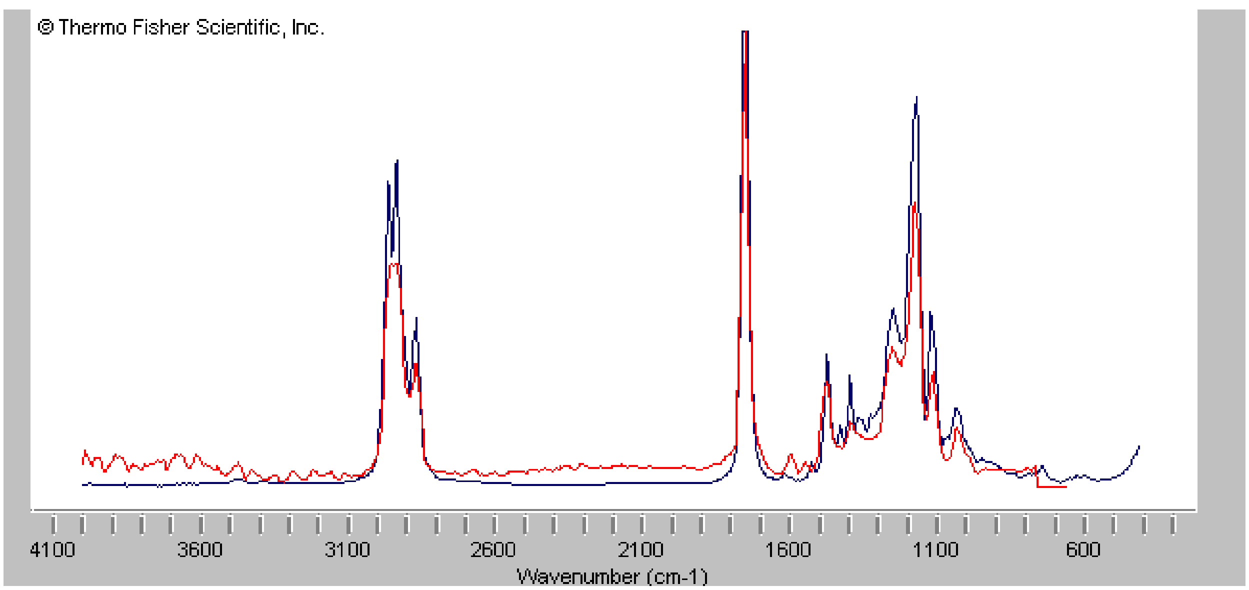
FTIR Spectral Comparison of "Acetonitrile Rinse of "Contaminated" Area on S/N P2942C" Spectrum (red) and a Reference Spectrum of Exxon Turbo Oil 25 (blue), overlay:



FTIR Spectral Comparison of "Acetonitrile Rinse of "Contaminated" Area on S/N P2942C" Spectrum (red) and a Reference Spectrum of Shell Aero Turbine Oil 555 (blue), overlay:



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FTIR Spectral Comparison of "Acetonitrile Rinse of "Contaminated" Area on S/N P2942C" Spectrum (red) and a Reference Spectrum of Mobil Jet Oil 254 (blue), overlay: