

JPL ANALYTICAL CHEMISTRY LABORATORY
 Analytical Chemistry and Materials Development Group 3531
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T013

To: Robert Taylor 2/6/2008
 From: Mark S. Anderson
 Subject: **LIGO Molecular Contamination Analysis, 2/5/08 Set
 Taken from 10 random parts in Second Half Crate 1**

Purpose

The purpose is to determine the level and identity of molecular (oily) contamination on the surface of parts. The samples were received 2/5/08.

Method

The analytical swabs consisted of pre-extracted, fiber-free lens tissue using Freon-TF solvent. The low volatility residue (LVR) was analyzed using Diffuse Reflectance Infrared Fourier Transform (DRIFT) spectroscopy (1). Blank samples were run along with the samples (2). FTIR provides chemical functional group information for quantitative analysis and qualitative identification of materials. The analysis followed the JPL ACL-120 procedure that complies with IEST-STD-CC1246D (3) and is sensitive to stringent levels (4).

Results and Discussion

The surfaces were all relatively clean in terms of oily, molecular contamination.

Sample	Chemical Functional Group	Amount
1. D071063	AHC	≤0.02 µg/cm ²
2. D071063-2	AHC	≤0.02 µg/cm ²
3. D071063-3	AHC	≤0.02 µg/cm ²
4. D071053	AHC	≤0.02 µg/cm ²
5. D071053-2	AHC	0.04 µg/cm²
6. D071056-3	AHC	0.05 µg/cm²
7. D071056	AHC	≤0.02 µg/cm ²
8. D071056 -2	AHC	≤0.02 µg/cm ²
9. D071058	AHC, ester, silicone	0.1 µg/cm²
10. D071069	AHC	0.04 µg/cm²

Terminology:

AHC: Aliphatic hydrocarbon, base oil of common lubricants
 µg/cm²: micrograms per square centimeter

References and Notes

1. M. S. Anderson et al "Analysis of Semi-Volatile Residues Using Diffuse Reflectance Infrared Fourier Transform Spectroscopy" in Optical System Contamination: Effects, Measurements, and Control VII; July 2002, edited by Phillip T. C. Chen and O. Manuel Lee; Proceedings of the SPIE, Vol. 4774, pp. 251-261, (2002).

2. The wipe blanks are less than 10% the amount in the sample and this is subtracted from the reported sample amount. High blanks (greater than 10% of the sample) are noted in the report. A typical solvent wipe has a detection limit of $\sim 0.005 \mu\text{g}/\text{cm}^2$ of removed residue from a 100cm^2 sample. Note this limit is well below the adventitious carbon level (ref. 4). Lower limits are possible using modified methods.

3. The analysis conforms to the Institute of Environmental Science and Technology (IEST), Contamination Control Division Document IEST 1246D “Product Cleanliness Levels and Contamination Control Program”. The contamination limits are generally set by Contamination Control Engineering. At typical limit is “Level A” (IEST-STD-CC1246D) and this is 1 microgram per square centimeter ($\mu\text{g}/\text{cm}^2$) and this corresponds to an average film thickness of 100 angstroms (assuming a density of 1.0). In many cases more stringent limits apply (4).

4. Very clean surfaces, $\leq 0.02 \mu\text{g}/\text{cm}^2$, with mono-molecular layers or less are more complex to describe when cleaning or analyzing. Carbon/hydrocarbon based substances are known to rapidly (within ~ 1 hour) accumulate on most, if not all, freshly exposed surfaces. This “adventitious” carbon is well documented in clean rooms and vacuum systems and compositionally varies by environment. Adventitious carbon is a discontinuous layer of approximately ~ 0.2 nanometers thick or $\sim 0.02 \mu\text{g}/\text{cm}^2$ up to $0.1 \mu\text{g}/\text{cm}^2$ (for $\rho = 1$). The last mono-layer fractions may in some cases be strongly adsorbed to the surface as a “corrosion” layer. Therefore solvent based sampling methods may not remove these fractions, particularly if the surface is porous. When specifying cleanliness level to less than A/10 IEST-STD-CC1246D ($0.1 \mu\text{g}/\text{cm}^2$) these monolayer effects become more significant. See also: H. Piao and N. S. McIntyre, “Adventitious carbon growth on aluminum and gold–aluminum alloy surfaces”, *Surface and Interface Analysis*, 2002; 33: 591–594.

APPROVED By: