***JPL* ANALYTICAL CHEMISTRY LABORATORY** **S262**
Analytical Chemistry and Materials Development Group 3531

To: **Rusyl Wooley, Robert Taylor** **11/14/07**

From: Mark S. Anderson

Subject: LIGO Molecular Contamination Analysis : HAM6 Vacuum Septum Plate for LLO

Purpose

Part surfaces were swab-sampled on site and submitted for chemical analysis. This was to determine the level and identity of molecular (oily) contamination on the surface of parts.

Method

The analytical swabs consisted of extracted fiber-free lens tissue using Freon-TF solvent. The low volatility residue (LVR) was analyzed using Diffuse Reflectance/ Fourier Transform Infrared (DRIFT/FTIR) spectroscopy. FTIR provides chemical functional group information for quantitative analysis and qualitative identification of materials (1). The analysis followed the ACL-120 procedure that complies with IEST-STD-CC1246D and is sensitive to the most stringent level (A/100).

Results and Discussion

The surfaces were all very clean with only trace levels of aliphatic hydrocarbon oil (2, 3). A level of 1 microgram per square centimeter (µg/cm^2) corresponds to an average film thickness of 100 angstroms (assuming a density of 1.0).

Sample	Chemical Functional Group	Amount µg/cm^2
1	AHC	0.03
2	Trace AHC	~0.02
3	Trace AHC	~0.02
4	Trace AHC	~0.02
5	Trace AHC	~0.02
6	Trace AHC	~0.02
7	Trace AHC	~0.02
8. Outer O-ring Grove	Trace AHC	~0.02
9. Inner O-ring Grove	Trace AHC	~0.02
10. Surface O-ring Side	Trace AHC	~0.02
11. Center Conflat	Trace AHC	~0.02
12. Surface Conflat Side	Trace AHC	~0.02

AHC: Aliphatic hydrocarbon, base oil of common lubricants
µg/cm^2- micrograms per square centimeter

References

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 last mono-molecular layers are more complex to describe when cleaning or analyzing. Carbon/hydrocarbon based substances are known to rapidly (~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 ~0.2-1 nanometers thick or **~0.02** to 0.1 $\mu g/cm^2$ (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 corrosion fractions. This is further complicated if the surface is porous. When specifying cleanliness level to less than level A/10 IEST-STD-CC1246D (0.1 $\mu g/cm^2$) 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, *Surf. Interface Anal.* 2002; 33: 591–594.

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

REVIEW APPROVAL: Dennis Coyne

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