

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

S262

**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 ( $\mu\text{g}/\text{cm}^2$ ) corresponds to an average film thickness of 100 angstroms (assuming a density of 1.0).

Sample	Chemical Functional Group	Amount $\mu\text{g}/\text{cm}^2$
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 Groove	Trace AHC	~0.02
9. Inner O-ring Groove	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  
 $\mu\text{g}/\text{cm}^2$ - 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  $\mu\text{g}/\text{cm}^2$  (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 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  $\mu\text{g}/\text{cm}^2$ ) 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*, *Surf. Interface Anal.* 2002; 33: 591–594.

3. A typical solvent wipe has a detection limit of ~0.005  $\mu\text{g}/\text{cm}^2$  of removed residue from a 100 $\text{cm}^2$  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:**