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JPL ANALYTICAL CHEMISTRY LABORATORY **S285**
Analytical Chemistry and Materials Development Group 3531

To: **Robert Taylor, Helena Armandula** **12/20/2007**

From: Mark S. Anderson

Subject: LIGO Contamination Analysis: ISI Tables and Risers

Purpose

Part surfaces were swab-sampled on site and submitted (12/19/07) 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 areas are relatively clean in terms of oily molecular residue.

Sample	Chemical Functional Group	Amount
Vial 19 top center D071001 Stage 0 Base	Aliphatic hydrocarbon	~0.02 µg/cm^2
Vial 21 bottom center D071001 Stage 0 Base	Aliphatic hydrocarbon	~0.02 µg/cm^2
Vial 22 threaded hole D071001 Stage 0 Base	Aliphatic hydrocarbon	2.0 Total µg
Vial 23 helicoil D071001 Stage 0 Base	Aliphatic hydrocarbon	2.2 Total µg
Vial 24 top center D071051 Stage 1 Floor	Aliphatic hydrocarbon	~0.02 µg/cm^2
Vial 25 bottom center D071051 Stage 1 Floor	Aliphatic hydrocarbon	~0.02 µg/cm^2
Vial 26 threaded hole D071051 Stage 1 Floor	Aliphatic hydrocarbon	1.8 Total µg
Vial 27 helicoil D071051 Stage 1 Floor	Aliphatic hydrocarbon	14 Total µg
Vial 28 top center D071050 Table	Aliphatic hydrocarbon	~0.02 µg/cm^2
Vial 29 bottom center D071050 Table	Aliphatic hydrocarbon	~0.02 µg/cm^2
Vial 30 threaded hole D071050 Table	Aliphatic hydrocarbon	1.0 Total µg

Aliphatic hydrocarbon: base oil of common lubricants
µg/cm^2: micrograms/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 µg/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 µg/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 µg/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.

Comments:

All of the contamination areal density values are very low (clean). The total contamination levels (microgm total values) are (likely) samples from holes and not flat surface areas. Four of these total contamination levels are ~2 micrograms and one is 14 micrograms. A clean threaded hole is typically < ~5 micrograms total. The dirtier hole is associated with a helicoil insert which was not removed prior to cleaning by AstroPak. The helicoil was removed by LIGO and the hole spot cleaned. Since the cleanliness level is "only" a factor of 3 higher and is limited to a relatively small percentage of the holes, I find the part acceptably clean.

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