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JPL ANALYTICAL CHEMISTRY LABORATORY **S279**
Analytical Chemistry and Materials Development Group 3531

To: **Robert Taylor, Helena Armandula** **12/14/2007**

From: Mark S. Anderson

Subject: LIGO Contamination Analysis, Quad N-P Type Sleeve Samples SL1 & 2
Dark Powder Identification On Bright Dip
Test Sample 3

Purpose

Part surfaces were swab-sampled on site and submitted (12/13/07) 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). The powder elemental analysis was performed using an X-Ray Fluorescence Microscope (µXRF). This technique non-destructively excites the sample with high energy X-Rays and measures the energies and intensities of Fluorescence X-Rays emitted by the sample. This is sensitive to elements with the atomic number range from Na to U.

Results and Discussion

The samples 1 and 2 had relatively low levels of oily residue (2). Sample 3 (with dark powder) had AHC, mixed silicate dust residue and possible reduced carbon. No significant amount of aluminum was detected in the dark powdery sample.

Sample	Chemical Functional Group	Amount µg
SL 1	AHC	0.05
SL 2	AHC	0.06
3. with dark powder	AHC, Mixed silicate	~7 (AHC)

AHC: Aliphatic hydrocarbon, base oil of common lubricants
Mixed silicate: a mixture of silicates, a component of common dust
µg: micrograms

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.

NOTE; Sample 3 Dark Powder is a identification of a powder found on the test sample of Bright Dip Process.

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Also note that the bright dip process sample has nothing to do with the quadruple pendulum suspension structure sleeve; The sleeve was not bright dipped.
The contamination levels are expressed in micrograms (total) and not per unit area. If these are from typical 6 in. sq. sample areas (232 cm sq) then the contamination level is very low (more typically 0.02 to 0.05 microgm/cm^2). If these are samples are from threaded holes, a typical clean value is ~5 microgms (total).