

A3-J024-RJL-M-9501786  
22 September 1995

MEMORANDUM

Subject: **RESULTS OF ATOMIC OXYGEN AND VACUUM ULTRAVIOLET RADIATION EXPOSURE OF METALPHOTO LABEL SAMPLES**

To: H.W. Babel, C. A. Jones, SS M&P, J. Scheerer

From: R. J. LeVesque

References:

- 1) "Astro and Honeywell Label Vacuum Ultraviolet Stability Assessment," Memorandum A3-J024-M-9500710
- 2) "Astro and Honeywell Label Atomic Oxygen Stability Assessment," Memorandum A3-J024-M-9500916
- 3) Laboratory Case Sheets # 161311

Eight samples of photosensitive anodized Metalphoto<sup>®</sup> aluminum sheets were exposed to -20,000 equivalent sun hours (ESH) of vacuum ultraviolet radiation (VUV) and  $3.1 \times 10^{21}$  atoms/cm<sup>2</sup> of atomic oxygen (AO). This is equivalent to approximately ten years of VUV on-orbit, and approximately one year of on-orbit AO exposure. It appears that these label materials are suitable for use in exposed, exterior locations of the International Space Station (ISS). However, it also appears that the stability of the gold label process may vary significantly with processing technique.

Five shades of Metalphoto's Sunfast Gold, two black and one silver sample prepared by the raw material manufacturer, Metalphoto, were used in this exposure test. The gold samples were colored/sealed with different solution temperatures and durations. Earlier studies of Metalphoto labels tested samples prepared by a supplier using materials purchased from Metalphoto. These tests showed no visible changes after 4787 ESH of VUV (Reference 1), but significant fading of the gold color following AO exposure (Reference 2).

Metalphoto samples were subjected to three exposures of intense VUV radiation, followed by three periods in an oxygen plasma asher to simulate the AO exposure. The solar absorptance, infrared emittance and colorimeter values of each coupon were measured before the VUV and AO exposures, and after each incremental exposure step. Colorimeter values were not measured after the first or second AO exposure.

All of the exposed samples appeared more matte and diffuse, and slightly different in color. The gold samples darkened slightly and the black samples faded slightly. All colors remained clearly recognizable. Color photographs of pre- and post-test samples will be available for inspection after September 29. The gold sample results, compared to the earlier AO exposure test (Reference 2), suggest that the stability of the gold labels is dependent upon the method used to color and seal the coating. If this label system is selected for use on ISS it is recommended that samples from all suppliers be tested to verify stability in the production labels.

The absorptance values are generally consistent with the visual observations: absorptance increased for the gold and decreased for the black. The colorimeter "L" values, however, decreased for all samples, indicating a reduction in the light reflected by the coating (L=100 is bright white, L=0 is completely black). The silver sample

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exhibited no net change in absorptance, although it changed during the incremental exposures, and its L value decreased. Table 1 shows the change in optical properties observed after all exposures (Reference 3). Figures 1A - 1H and Tables 2A - 2H display the incremental optical property and colorimeter data obtained during the exposure tests.

The black samples decreased in absorptance significantly following these exposures. The gold samples increased, though, they appear to tend toward a limiting value. It appears that the AO exposure subsequent to the VUV exposure mitigates the absorptance changes to some extent. This is most evident in Figures 1A - 1H, which all clearly show an absorptance change during VUV exposures, followed by a reduction in this change after AO exposure. This may indicate some type of change in the surface of the coating, as opposed to within the coating, since confidence is high that no contaminants were introduced during the VUV or AO testing. The absorptance changes observed in this test are not acceptable for most thermal control coating applications.

In summary, it appears that the Metallphoto gold, silver and black photosensitive anodic coatings tested are acceptable candidates for exterior labeling on ISS. If this product is selected for such use, however, it is recommended that the VUV/AO stability of each supplier's product be verified due to the apparent variability of stability with processing technique.

Direct questions to the undersigned at 714/896-3311 x7-1582.

Sincerely,

*Original Signed By*

Raymond J. LeVesque, II  
Materials & Processes  
Space Station

Table 1. Summary of Optical Property changes following VUV and AO exposures

Sample	Color tested	$\Delta\alpha$	$\Delta\epsilon$	Colorimeter values			Actual total exposures	
				$\Delta L$	$\Delta a$	$\Delta b$	VUV (ESH)	AO atoms/cm <sup>2</sup>
S/B-S2	Silver	0.00	-0.01	-27.10	6.00	-7.50	20162	$3.1 \times 10^{21}$
S/B-B2	Black	-0.09	-0.02	-11.50	2.60	0.30	20162	$3.1 \times 10^{21}$
G/BX-G2	Gold	0.04	-0.01	-23.00	9.70	-11.40	18849	$3.1 \times 10^{21}$
G/B4A-G2	Gold	0.06	-0.01	-27.30	16.80	-17.20	18849	$3.1 \times 10^{21}$
G/B4A-B2	Black	-0.03	-0.01	-12.70	3.10	0.30	18849	$3.1 \times 10^{21}$
G/B4B-G2	Gold	0.08	-0.01	-26.00	3.90	-17.10	19694	$3.1 \times 10^{21}$
G/B5-G2	Gold	0.05	-0.01	-25.80	7.80	-16.20	19694	$3.1 \times 10^{21}$
G/B8-G2	Gold	0.06	0.00	-22.70	1.70	-16.10	19694	$3.1 \times 10^{21}$

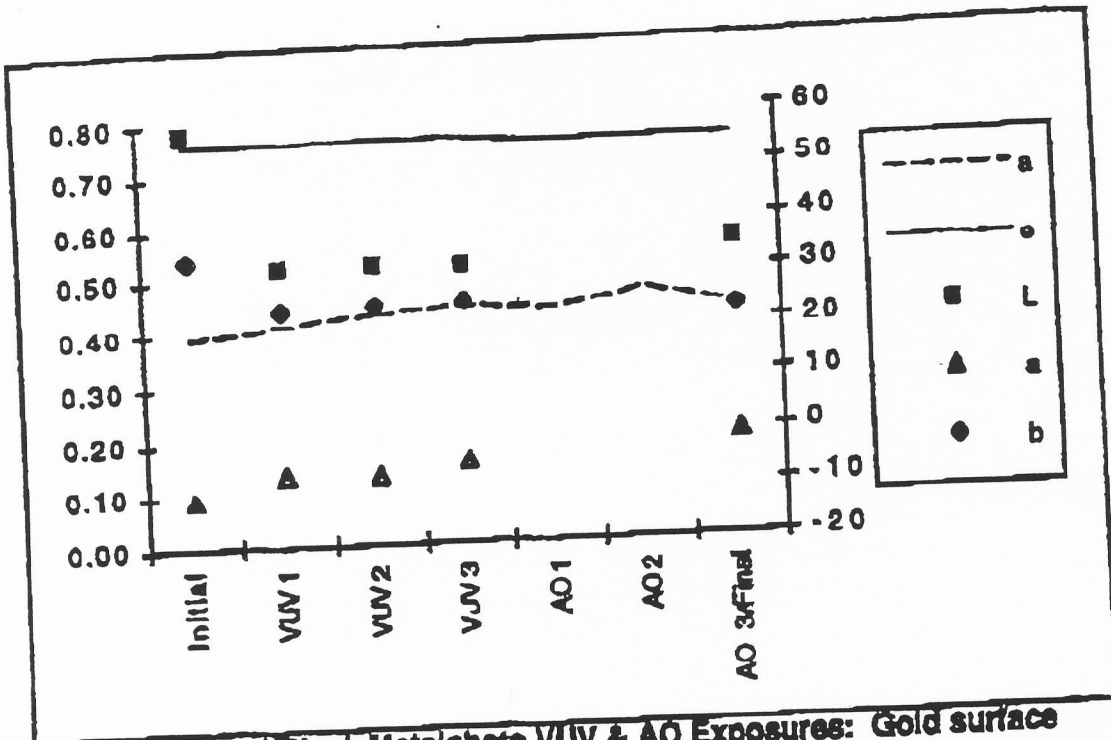


Figure 1C. Gold/Black Metalphoto VUV & AO Exposures: Gold surface

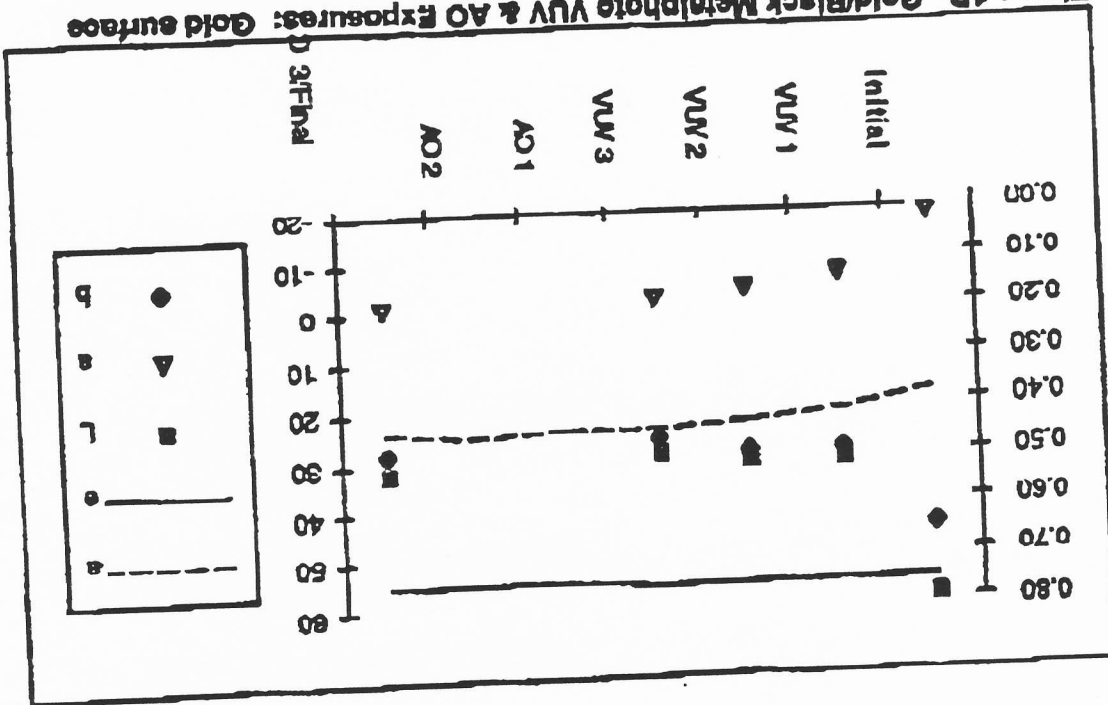
Table 2C. Gold/Black Metalphoto Coating Data: Gold surface  
Unspecified seal temperature and duration

Sample GBX-G2	α	e	Colorimeter values			Actual total exposures	
			L	a	b	VUV (ESH)	AO atom/cm <sup>2</sup>
Initial	0.30	0.76	58.2	-10.9	33.6	0	0
VUV 1	0.41	0.76	32	-6.6	23.7	6283	0
VUV 2	0.43	0.76	31.8	-7.9	24.5	12566	0
VUV 3	0.44	0.76	31.6	-5	24.8	18849	0
AO 1	0.43	0.75	N/A	N/A	N/A	18849	7.6 x 10 <sup>20</sup>
AO 2	0.46	0.75	N/A	N/A	N/A	18849	1.4 x 10 <sup>21</sup>
AO 3/Final	0.43	0.75	35.2	-1.2	22.2	18849	3.1 x 10 <sup>21</sup>
Final-Initial	0.04	-0.01	-23.00	9.70	-11.40	18849	3.1 x 10 <sup>21</sup>

Sample	AO 3/Final	AO 2	AO 1	VUV 3	VUV 2	VUV 1	Initial	Final-Initial
GB4A-Q2	0.44	0.45	0.44	0.44	0.43	0.41	0.38	0.06
2	0.75	0.75	0.75	0.76	0.76	0.76	0.76	-0.01
1	31.8	N/A	N/A	28.7	30.8	31.4	59.1	-27.30
2	-0.9	N/A	N/A	-2.2	-3.7	-6	-17.7	16.80
h	28	N/A	N/A	26.2	29.4	29.1	45.2	-17.20
VUV (ESH)	18849	18849	18849	18849	12566	6283	0	18849
AO absor/cm <sup>2</sup>	3.1 x 10 <sup>21</sup>	1.4 x 10 <sup>21</sup>	7.6 x 10 <sup>20</sup>	0	0	0	0	3.1 x 10 <sup>21</sup>

Table 2D. Gold/Black Metallphote Coating Data: Gold surface  
Sealed for 4 minutes at 150 °F

Figure 1D Gold/Black Metallphote VUV & AO Exposures: Gold surface



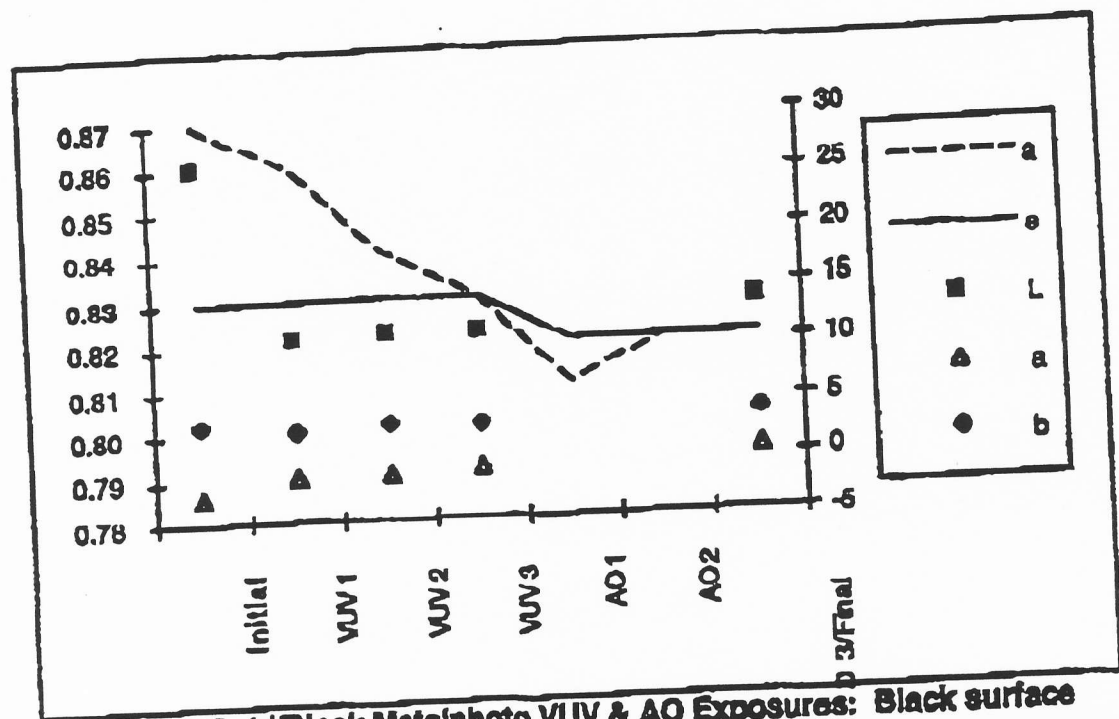


Figure 1E. Gold/Black Metalphoto VUV & AO Exposures: Black surface

Table 2E. Gold/Black Metalphoto Coating Data: Black surface  
Sealed for 4 minutes at 156 °F

Sample G/B4A-B2	α	ε	Colorimeter values			Actual total exposures	
			L	a	b	VUV (RSH)	AO atoms/cm <sup>2</sup>
Initial	0.87	0.83	20.3	-2.5	3.7	0	0
VUV 1	0.86	0.83	11.2	-0.9	3	6283	0
VUV 2	0.84	0.83	11.4	-1	3.4	12566	0
VUV 3	0.83	0.83	11.4	-0.6	3.2	18849	0
AO 1	0.81	0.82	N/A	N/A	N/A	18849	7.6 x 10 <sup>20</sup>
AO 2	0.82	0.82	N/A	N/A	N/A	18849	1.4 x 10 <sup>21</sup>
AO 3/Final	0.82	0.82	13.6	0.6	4	18849	3.1 x 10 <sup>21</sup>
Final-Initial	-0.05	-0.01	-12.70	3.10	0.30	18849	3.1 x 10 <sup>21</sup>

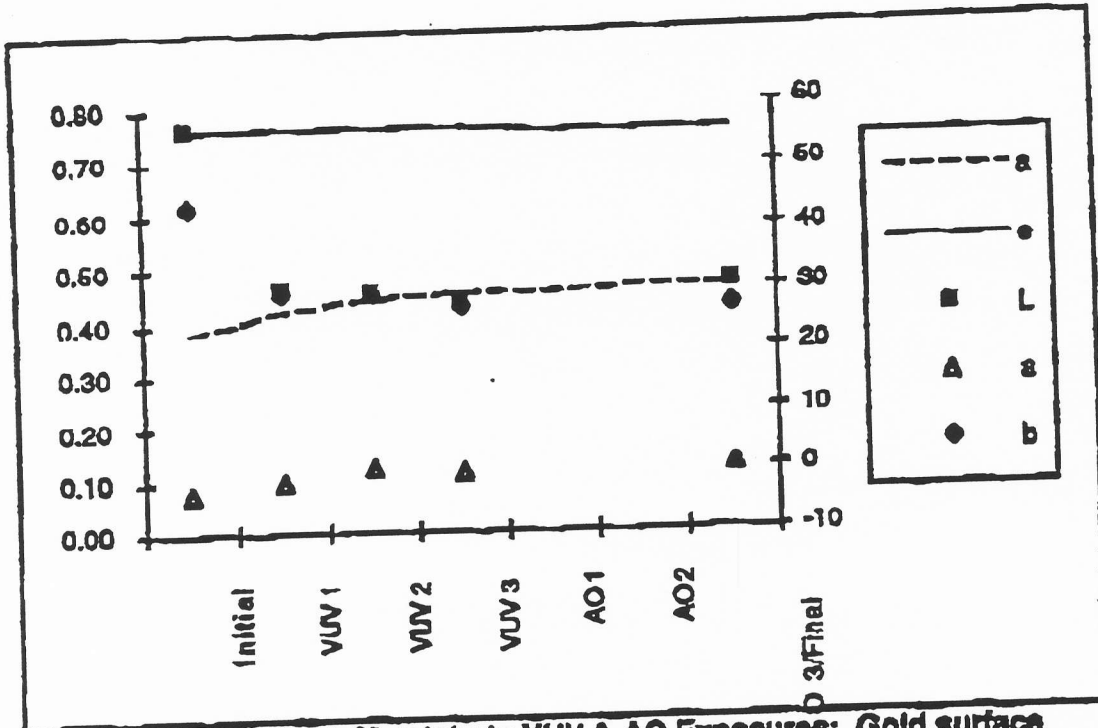


Figure 1F. Gold/Black Metalphoto VUV & AO Exposures: Gold surface

Table 2F. Gold/Black Metalphoto Coating Data: Gold surface  
Sealed for 4 minutes at 158 °F

Sample G/B4B-G2	α	ε	Colorimeter values			Actual total exposures	
			L	g	b	VUV (ESH)	AO atom/cm <sup>2</sup>
Initial	0.38	0.76	56.5	-3.2	44.2	0	0
VUV 1	0.42	0.76	30.2	-1.6	29.9	6002	0
VUV 2	0.44	0.76	29.5	0.5	29.5	12004	0
VUV 3	0.45	0.76	28.1	-0.4	27.3	19694	0
AO 1	0.45	0.75	N/A	N/A	N/A	19694	7.6 x 10 <sup>20</sup>
AO 2	0.46	0.75	N/A	N/A	N/A	19694	1.4 x 10 <sup>21</sup>
AO 3/Final	0.46	0.75	30.5	0.7	27.1	19694	3.1 x 10 <sup>21</sup>
Final-Initial	0.08	-0.01	-26.00	3.90	-17.10	19694	3.1 x 10 <sup>21</sup>

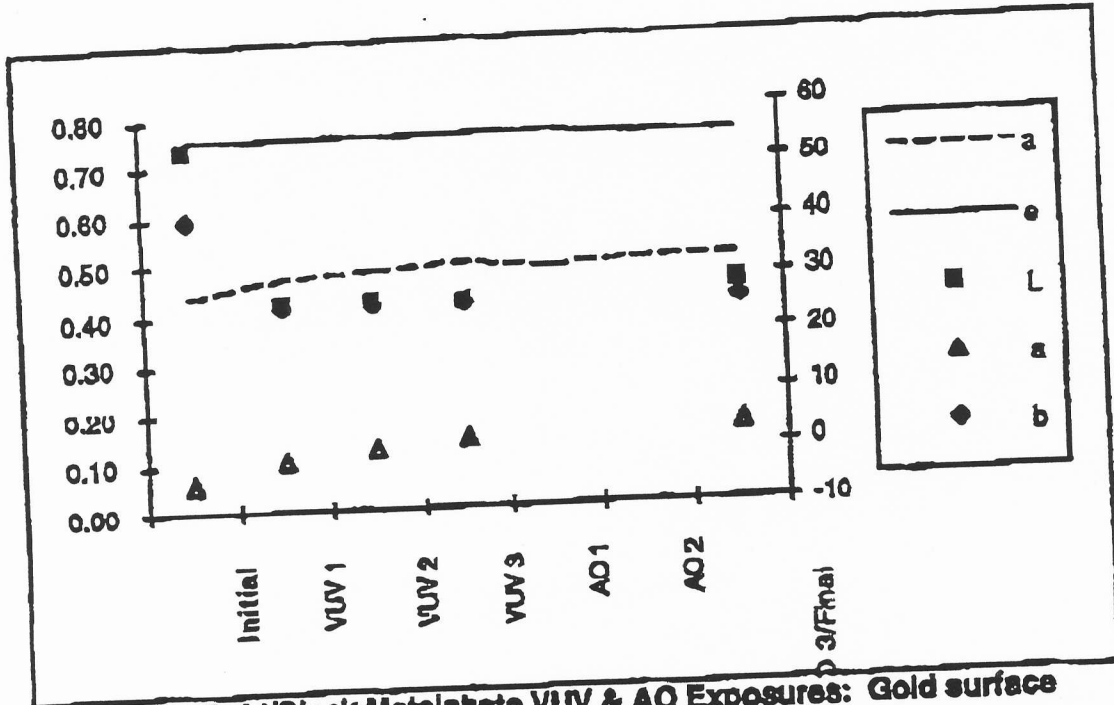


Figure 1G. Gold/Black Metalphoto VUV & AO Exposures: Gold surface

Table 2G. Gold/Black Metalphoto Coating Data: Gold surface  
Sealed for 5 minutes at 156 °F

Sample G/BS-G2	l	a	b	Actual total exposures			
				VUV (ESH)	AO atom/cm <sup>2</sup>		
Initial	0.44	0.76	54.2	-4.4	42.2	0	0
VUV 1	0.47	0.76	27	-1	26.5	6002	0
VUV 2	0.48	0.76	26.6	0.7	26.3	12004	0
VUV 3	0.49	0.76	26.2	2.1	26.3	19694	0
AO 1	0.48	0.76	N/A	N/A	N/A	19694	7.6 x 10 <sup>20</sup>
AO 2	0.49	0.75	N/A	N/A	N/A	19694	1.4 x 10 <sup>21</sup>
AO 3/Final	0.49	0.75	28.4	3.4	26	19694	3.1 x 10 <sup>21</sup>
Final-Initial	0.05	-0.01	-25.80	7.80	-16.20	19694	3.1 x 10 <sup>21</sup>

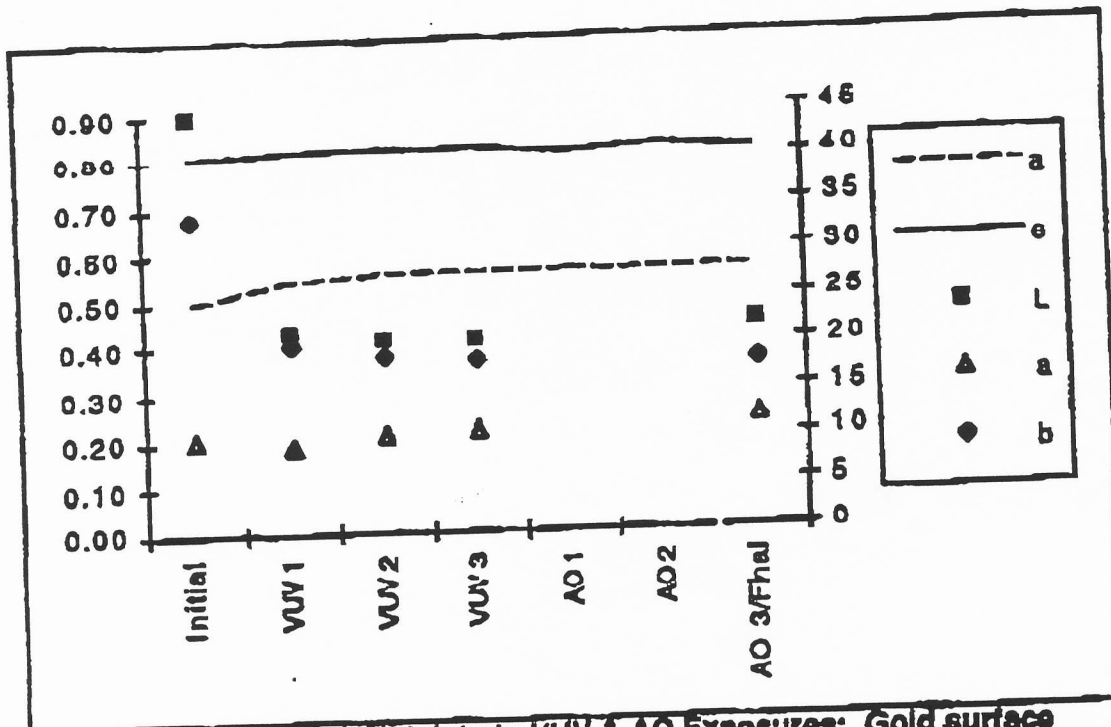


Figure 1H. Gold/Black Metalphoto VUV & AO Exposures: Gold surface

Table 2H. Gold/Black Metalphoto Coating Data: Gold surface  
Sealed for 8 minutes at 165 °F

Sample G/B8-C2	α	ε	Colodimeter values			Actual total exposures	
			L	a	b	VUV (ESH)	AO atom/cm <sup>2</sup>
Initial	0.50	0.81	44.7	10.1	33.7	0	0
VUV 1	0.54	0.82	21.5	9.4	20.2	6002	0
VUV 2	0.56	0.82	20.6	10.5	18.7	12004	0
VUV 3	0.56	0.82	20.4	10.7	18.2	19694	0
AO 1	0.56	0.81	N/A	N/A	N/A	19694	7.6 x 10 <sup>20</sup>
AO 2	0.56	0.82	N/A	N/A	N/A	19694	1.4 x 10 <sup>21</sup>
AO 3/Final	0.56	0.81	22	11.8	17.6	19694	3.1 x 10 <sup>21</sup>
Final-Initial	0.05	0.00	-22.70	1.70	-16.10	19694	3.1 x 10 <sup>21</sup>

**Test Plan**

**Appendix to A3-J024-M-9501786**

**Samples of Metalphoto silver/black and Sunfast Gold/black were received directly from Metalphoto. Four shades of gold are provided.**

1. **Samples definition (unknown alloy of supplier-provided samples):**
  - A. **Silver/Black (undyed):**  

Silver - S/B-S1, S/B-S2	Black - S/B-B1, S/B-B2
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  - B. **Lightest Gold/Black (unmarked immersion time, temperature):**  
 Gold - G/BX-G1, G/BX-G2
  - C. **Gold/Black - 4A (4-minute immersion time, 156 °F):**  

Gold - G/B4A-G1, G/B4A-G2	Black - G/B4A-B1, G/B4A-B2
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  - D. **Gold/Black - 4 (4-minute immersion time, 158 °F):**  
 Gold - G/B4B-G1, G/B4B-G2
  - E. **Gold/Black - 5 (5-minute immersion time, 156 °F):**  
 Gold - G/B5-G1, G/B5-G2
  - F. **Gold/Black - 8 (8-minute immersion time, 165 °F):**  
 Gold - G/B8-G1, G/B8-G2
2. **Wipe both surfaces of all samples with acetone to ensure cleanliness.**
3. **Measure the  $\alpha$ ,  $\epsilon$ , and color of all samples prior to exposure**
  - A. **Measure and record the solar absorptance using the Lambda-9 device.**
  - B. **Measure and record the infrared emittance using the DB-100 device.**
  - C. **Measure and record the L, a, b color values using the Paint Lab Colorimeter.**
4. **Expose the following samples to VUV (20,000 ESH) in four steps of -5,000 ESH each. Indicate gas used to repressurize the chamber - Nitrogen is preferred.**  

**S/B-S2, S/B-B2, G/BX-G2, G/B4A-G2, G/B4A-B2, G/B4B-G2, G/B5-G2, G/B8-G2**
5. **Measure & record  $\alpha$ ,  $\epsilon$ , and color of the VUV-exposed samples after each 5000 ESH step.**
  - A. **Measure and record the solar absorptance using the Lambda-9 device.**
  - B. **Measure and record the infrared emittance using the DB-100 device.**
  - C. **Measure and record the L, a, b color values using the Paint Lab Colorimeter.**
6. **Expose the following samples (previously VUV-exposed) to atomic oxygen (2 years on orbit equivalent, minimum). Indicate the total AO fluence received by the samples.**  

**S/B-S2, S/B-B2, G/BX-G2, G/B4A-G2, G/B4A-B2, G/B4B-G2, G/B5-G2, G/B8-G2**
7. **Measure & record  $\alpha$ ,  $\epsilon$ , and color of the AO-exposed samples from the Step 6.**
  - A. **Measure and record the solar absorptance using the Lambda-9 device.**
  - B. **Measure and record the infrared emittance using the DB-100 device.**
  - C. **Measure and record the L, a, b color values using the Paint Lab Colorimeter.**
8. **Individually protect each sample - both exposed and unexposed - in a labeled Fluoroware container and return with these results.**