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THE VACUUM-ULTRAVIOLET DEGRADATION OF SALT-SPRAY-CONTAMINATED THERMAL CONTROL COATINGS*

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ABSTRACT

An experimental program in which salt-spray-exposed coatings have been irradiated is described and discussed.

INTRODUCTION

In this paper we will describe the nature of, and the results and conclusions reached in a study to determine the effects of a coastal (seashore) environment, Cape Kennedy, Florida, on the solar absorptance values of S-13G samples. A major objective of the study was to assess the benefit (in terms of reduced optical degradation) obtained by rinsing and/or by scrubbing these exposed samples. Several other coatings of interest, though not salt-exposed, were also irradiated in the program. The specimens were irradiated in two (2) space simulation tests, IRIF Tests I-56 and I-57. In each irradiation test there were three (3) S-13G specimens that had been "salt-air" exposed for 6 weeks at beach level near high tide (designated "BL"). and three (3) S-13G specimens that had been "salt-air" exposed for 4 weeks at an approximate height of 150 ft on the Mobile Service Stand (designated "MSS")--both at the Saturn Launch Facility at Cape Kennedy. Other specimens in the tests included Cat-A-Lac White and A-429M (in I-57 only) and other S-13G (control) specimens. This work was performed under NASA Contract NAS8-28765; H.M. King was the NASA project monitor.

EXPERIMENTAL CONDITIONS

A series of three MSS and of three BL samples were prepared for IRIF Test I-56 and for IRIF Test I-57. One of each series of three samples was set aside without any cleaning or other treatment, and was further designated "control". A second sample of each series was given a light rinse, simulating the cleaning action which would be expected if a vehicle on a launch pad were hosed down to remove loose dirt and contamination; these samples were further designated "rinsed". The third sample was vigorously scrubbed with detergent and water to simulate the effect of a vehicle scrub-down, with the further designation "scrubbed".

Reflectance spectra of all samples were recorded in the wavelength range 325-2600 nm. During both irradiation tests, the equivalent solar ultraviolet irradiation rate was maintained at five (5) suns (solar equivalents). Sample temperature in test I-56 was maintained at +45°F; and in test I-57, at +153°F. The pressure during irradiation was well below $1X10^{-7}$torr in both tests.

RESULTS

The solar absorptance values are given in Table 1. The uncleaned ("control") and "rinsed" samples all evidence the accumulation of salt on their surfaces; note the high initial value of α_s. The degradation rates of salt-contaminated S-13G^s specimens compared to those of uncontaminated ("standard") S-13G specimens are approximately the same. In short, salt-contamination affects only the initial properties of S-13G, not its photostability. Additionally, the "rinsed" samples

TABLE 1A
SOLAR ABSORPTANCE VALUES, IRIF TEST I-56

Sample Description	Exposure, ESH				
	Initial	415	1100	3085	Air Bleach
MSS Series*					
S-13G-Control	0.270	0.273	0.286	0.307	0.306
S-13G-Rinsed	0.252	0.257	0.273	0.304	0.301
S-13G- Scrubbed	0.225	0.226	0.237	0.267	0.252
BL Series**					
S-13G-Control	0.293	0.289	0.303	0.340	0.333
S-13G-Rinsed	0.293	0.296	0.315	0.341	0.337
S-13G-Scrubbed	0.229	0.229	0.238	0.246	0.237
S-13G-Standard (Batch C-389)	0.197	0.198	0.201	0.244	0.222
Porcelain Enamel (HAC)	0.263	0.279	0.293	0.306	0.296
Al Mirror (Control)	0.298	0.302	0.309	0.314	0.313
Cat-A-Lac White	0.294	0.442	0.513	0.614	0.572
Cat-A-Lac White	0.306	0.415	0.506	0.634	0.567
S-13G; Batch C-392 (Standard)	0.197	0.203	0.210	0.220	0.218

TABLE 1B

SOLAR ABSORPTANCE VALUES - IRIF TEST I-57

Sample Description	Exposure, ESH						Air
	Initial	120	480	1032	1540	2010	Bleach
MSS Series							
S-13G, Control	0.245	0.272	0.302	0.317	0.319	0.332	0.312
S-13G, Rinsed	0.331	0.352	0.386	0.396	0.397	0.410	0.376
S-13G, Scrubbed	0.225	0.238	0.265	0.276	0.278	0.288	0.254
BL Series							
S-13G, Control	0.284	0.314	0.340	0.355	0.362	0.377	
S-13G, Rinsed	0.302	0.335	0.345	0.368	0.372	0.390	
S-13G, Scrubbed	0.215	0.248	0.261	0.273	0.282	0.297	
S-13G-Standard (Batch C-389)	0.190	0.221	0.235	0.249	0.253	0.262	0.246
Porcelain Enamel (HAC)	0.291	0.323	0.335	0.342	0.346	0.354	
Al Mirror (Control)	0.335	0.339	0.343	0.344	0.347	0.358	
A-429M (Batch C-406), 250°F/ 15 hr	0.211	0.213	0.223	0.224	0.227	0.232	
A-429M (Batch C-406), 250°F/ 15 hr	0.212	0.210	0.222	0.225	0.236	0.234	0.225
A-429M (Batch C-406), 350°F/ 4 hr	0.260	0.262	0.271	0.273	0.283	0.299	0.255

*Exposed at approximately 150 feet up on the Mobile Service Stand at Cape Kennedy.

**Exposed on the beach at high tide level at Cape Kennedy.

τA-429M is a paint using S-13G pigment in an IITRI-modified Owens-Illinois 650 "glass" resin.

appear not only to possess higher initial α_s values, but also to degrade slightly more than the "control" samples.

The overall results of these tests show that the degradation of salt-spray exposed samples is decreased by vigorous scrubbing, but essentially unaffected by rinsing or no cleaning at all. The "scrubbed" samples in I-56 degraded even less than unexposed ("standard") S-13G samples, presumably because the scrubbing action removes excess curing agent from the surface. Irradiation at high temperatures, however, minimizes this curing agent effect - probably because excess curing agent is removed by high temperature also. Consequently, no significant benefit will accrue as a result of cleaning S-13G surfaces that have been exposed to a seashore environment, unless they are vigorously scrubbed.

As expected, higher temperatures increase the initial rate of solar absorptance degradation; however, after the initial rapid rate, the degradation rate apparently diminishes to a level approaching the room temperature rate. The general trends of the high temperature test, nevertheless, parallel those of I-56, with the total degradation, of course, being greater. An analysis of the spectral reflectance data from I-57 shows that the effect of temperature (153°F vs 45°F) outweighs the effects of initial cleanliness; the beneficial effect of scrubbing is not, therefore, as evident. Degradation appears to depend to some extent on the initial reflectance; the higher the initial reflectance, the greater the total degradation. In both tests the initial α_s values of the "scrubbed" samples, even though lower than those of the "control" or of the rinsed samples, are not as low as those of

unexposed ("standard") S-13G samples.

The extraordinary stability of the A-429M paint systems stands out very plainly among all the test data. Although this paint system has yet to be optimized with respect to PVC, thickness, curing conditions, primers, etc., it has consistently exhibited excellent stability. In tests at room temperature the degradation of A-429M has never exceeded 0.01 in 2000 ESH.

The Cat-A-Lac White coatings sustained extensive optical damage in I-56; α_s values more than doubled, nominally from 0.29 to 0.62, in 3085 ESH. Since this amount of degradation occurred at room temperature, this coating system was not tested in the high temperature irradiation test.

The high initial solar absorptance values of A-429M result from non-optimum paint film thicknesses; nevertheless, its optical performance in ultraviolet exposure tests shows it to be superior to any coating system thus far tested. Cat-A-Lac White, in contrast, represents a clearly inferior choice.

CONCLUSIONS

From the perspective of the thermal control researcher, the results obtained point up once again the need to protect critical thermal control surfaces prior to launch. Thermal control surfaces are indeed optical surfaces and they must be effectively protected from the influences of harmful environments during the entirety of their pre-launch life. The principle involved is simple: an ounce of prevention is worth a pound of cure. The data presented here strongly re-inforce this principle. Accordingly, we must re-assert the need for process engineering, quality control and other organizations responsible for establishing the criteria and procedures for protection to specify and assure that the optical properties of critical surfaces will not be compromised by unnecessary exposure to deleterious environments.

We have seen also that even vigorous scrubbing of salt-spray exposed S-13G samples, even though it reduces the degradation substantially, does not restore the original (design) optical properties. These results, we feel, can be extended to any porous or semi-porous coating, - e.g. any coating based on a silicone rubber. Since there are no study results which indicate the contrary, we feel strongly that pre-launch protection, particularly in the case of long term storage at a coastal launch site, is mandatory for all thermal control surfaces - not just the white coatings.

The observation that salt contamination evidently affects the initial optical properties of S-13G more than it effects subsequent performance is significant in several respects, and merits some discussion. First,

this effect is not entirely unexpected or difficult to understand; the salt deposit is essentially inorganic and relatively inert. The important point, however, is that this effect should not be presumed to be operative in the case of other contaminants on S-13G or in the case of salt contamination on other coatings. Second, the loss of initial reflectance as a result of salt contamination can be substantial (as much as 0.09 in α_s), making it even more important to protect critical thermal control surfaces. It should be noted that the appearance of the exposed S-13G samples did not betray any evidence of contamination - with the exception of one sample. Hence, salt contamination will in most instances remain invisible to the unaided eye. In fact, the inability to detect contamination of any kind by visual inspection seems to be more the rule than the exception. Finally, we should emphasize that the type of protection afforded "stored" surfaces should be carefully considered. Many of the so-called "strippable" protective coatings, though satisfactory for short term use, tend to "age" and to leave degradable residues after periods of approximatelv 4-6 weeks. Plastic sheets, unless they are unplasticized, may transfer plasticizer to the "protected" surface. The protection problem thus involves insuring that the protecting system itself does not contribute to the contamination threat.