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CCL REPORT NO. 178

DEVELOPMENT OF A LOW COST SOLAR HEAT REFLECTING AND LOW VISIBILITY COATING

FINAL REPORT

BY

M. H. SANDLER

10 MARCH 1965

AMCMS CODE NO. 5025.11.842
DA PROJECT IC024401A329

U. S. ARMY COATING & CHEMICAL LABORATORY
Aberdeen Proving Ground
Maryland

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ABSTRACT

This report covers the development of an experimental low cost green solar reflectant and low visibility coating for use on missile systems. The currently specified enamel based on a special and single source pigment, cobalt titanate, has a raw material cost of approximately $9 per gallon compared to $1.50 per gallon for the experimental material. In addition the test data indicated the experimental material to have a 2 - 3°F. advantage over the currently specified material. Exterior exposure and field tests are in progress.

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I. INTRODUCTION

Electronic components of missile systems have maximum temperature limits which cannot be exceeded without impairing their operational reliability. When missiles are on site and exposed to solar heating, temperatures can approach the limiting temperature and thereby reduce the margin for operation without overheating. As a result, many missiles have been painted white to take advantage of its high reflectivity and thus minimize the solar heating effect under both storage and operating conditions. Since the white is readily visible and is not desirable for tactical purposes and olive drab will increase heating because of its low heat reflectively, a solar reflectant green enamel covered by Military Specification MIL-E-46061 (MO) "Enamel, Camouflage, Solar and Heat Reflecting" was developed. In a test program[1] conducted by the Nike Hercules system under contract DA-30-069-ORD 1448 comparing the heat reflectance of white, olive drab, and the specification green it was shown that the latter had solar heat reflecting properties falling between white and olive drab. It was therefore recommended for use on this system for solar heat reflectance.

As a result, other missile systems are also considering the adoption of the solar heat reflecting green paint. However, price quotations on this paint have ranged from 15 to 20 dollars per gallon in quantity lots, whereas the white enamel would range from 2.50 to 3.50 dollars per gallon. This represents a substantial increase in finishing costs. The high cost of the solar heat reflecting enamel is the result of its being based on a special and single source pigment, cobalt titanate. This results in a raw material cost of approximately $9.00 per gallon of finished paint as compared to approximately $1.50 for conventional enamels.

On the basis of earlier work conducted by this laboratory on heat reflecting and insulating coatings for rocket motors (see CCL Report No. 75)[2] and the data obtained under the DA contract it was the considered opinion of this laboratory the solar heat reflectance, and visual color match for the MIL-E-46061 material could be obtained through the use of a less expensive, more conventional and readily available pigmentation. If this were possible a significant cost reduction could be obtained without sacrifice in the needed performance characteristics.

II. DETAILS OF TEST

An enamel conforming to the sample formula of MIL-E-46061 (Table I) was prepared as a standard for use in this program. An experimental enamel (Table I) which was considered an acceptable visual color match for the MIL-E-46061 enamel was prepared using the same type vehicle but utilizing chromium oxide green as the major color pigment in place of the cobalt titanate. The spectral reflectance curves for both enamels are given in Table II. In addition, since the vehicle is the same type used in Federal Specification TT-E-516 "Enamel, Lustreless, Quick Drying, Styrenated Alkyd Type" the experimental enamel was formulated along the compositional requirements of this specification. This resulted in a substantial reduction in the prime pigment to extender pigment ratio and subsequent cost reduction. The ratio of the former being 86.5/13.5 compared to 35/65 for the latter. Despite the increased quantity of extender pigment the hiding power of the two enamels was comparable.

The enamels were then evaluated for solar heat reflectance by coating one-gallon paint cans with the systems listed in Table III, placing them outdoors, and measuring internal and skin temperatures at various time intervals during the day. The cans were placed at a 30 degree angle and shielded against air currents with clear plastic inclosures (see photo 1). The position of the containers was shifted during the day to take advantage of the direct rays of the sun. The white and olive drab undercoat in systems 1 and 2 were included to study the effect of undercoat color on solar heat reflectance. Systems 5 and 6, olive drab and white finish coats, were included to provide the extremes in temperature that may be reached. The daily skin temperatures reached by these systems over a 6 day period in August 1964 are listed in Table IV. Internal temperatures, as expected, were lower but showed the same trends as the skin temperature.

In reviewing Table IV, the effect of undercoat may be seen. In all cases the systems with the white undercoat maintained lower temperatures than those using olive drab. The olive drab undercoat, systems 2 and 4, averaged 4.5 degrees higher than the corresponding white undercoat, systems 1 and 3. This may possibly be explained by the fact that at the dry film thickness used for these tests, the finish coat did not provide complete hiding thus permitting the undercoat to affect the temperature. Table IV also indicates that the experimental enamel will offer comparable solar heat reflectance and possibly some improvement. Of the 33 temperature readings made with each of the systems over a period of six days the experimental enamel with white undercoat (system 3) registered temperatures averaging 4 degrees lower on 27 occasions; the same temperature twice; and higher temperatures only 4 times with no reading being more than two degrees higher. The containers used in this program have been placed on exterior exposure and will be reevaluated for solar heat reflectance after 1 year. In the interim, tests on the experimental enamel by a missile contractor[3] utilizing a solar chamber confirmed the findings of this laboratory. Their work indicated a 2 - 3°F. advantage for the experimental enamel and arrangements have been made through the missile system project office for field testing.

III. DISCUSSION

On the data collected to date, it appears that the experimental low cost solar heat reflecting green enamel can be utilized on missile systems without sacrifice of the required performance characteristics. Should the weathering and field tests further confirm these findings a specification will be prepared to cover its procurement. In the interim it is planned to continue work on other solar heat reflecting coatings in efforts to more nearly approach the heat reflectance obtained with a white color coat, and thereby provide a higher margin of operational reliability for electronic components of missile systems subjected to solar heating without sacrifice of tactical visibility requirements.

IV. ACKNOWLEDGEMENT

The author wishes to acknowledge the contributions of Mr. Merrill Cohen in conduct of this program.

V. REFERENCES

(1) Final Report Engineering Services Memorandum BN-51 "Investigation of the Effect of Missile Camouflage Paint on the Operation of the Nike Hercules Guidance Set", Messrs. R. G. Simpson and C. M. Thompson, Bell Telephone Laboratories, Inc.

(2) CCL Report No. 75, 17 April 1959 "Heat Reflecting and Insulating Coatings for Rocket Motors", M. H. Sandler.

(3) CCL Contact Report No. 176, 8 February 1965, Telephone Call Mr. Gaffney, Raytheon Co. and M. H. Sandler.

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APPENDIX A

TABLE I

SOLAR HEAT REFLECTING ENAMELS

Parts by Weight	MIL-E-46061 (MO)	CCL Exp. Green
Cobalt titanate	455.0	--
Chrome oxide green	--	118.5
Antimony sulfide	12.0	18.5
Red iron oxide	4.5	3.3
Lead chromate	--	3.3
Calcium carbonate	20.1	--
Magnesium silicate	50.0	225.5
Barytes	--	41.0
Organo-montmorillonite gellant	3.43	--
Styrenated alkyd resin (60% N.V.)	382.5	--
Styrenated alkyd resin (50% N.V.)	--	456.0
Xylene	273.5	338.0
Ethyl alcohol	1.2	--
Diethylamine	2.3	0.6
Cobalt napthenate (6%)	1.3	1.6
Manganese napthenate (6%)	1.3	--
Antiskinning agent	1.4	1.2
Total solids	61	53
Pigment volume	38.9	37
Viscosity (Krebs Units)	70	70
Hiding power (1 mil dry film)	0.98	0.98
Gloss	8	3

TABLE II

REFLECTANCE SPECTRA

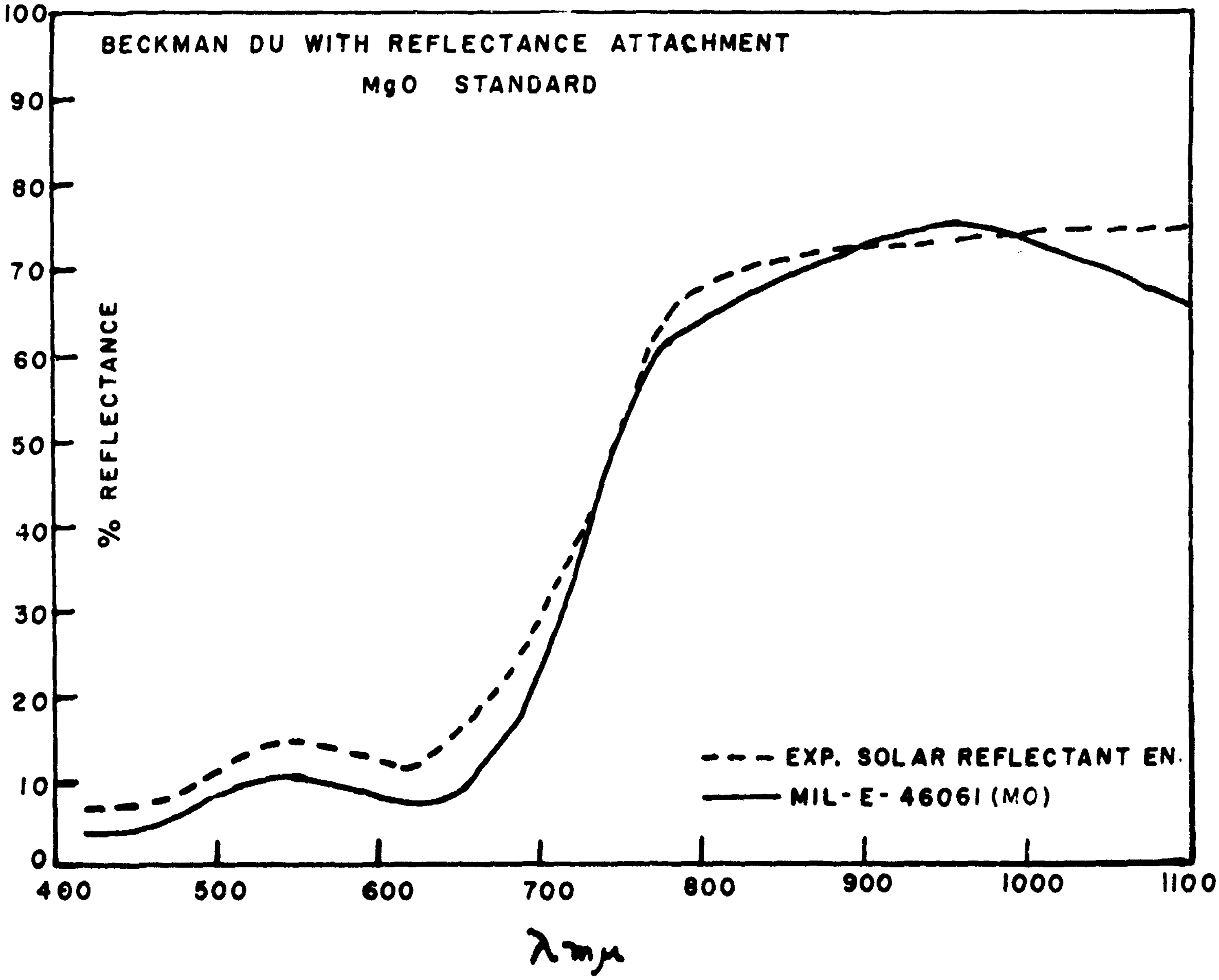

TABLE III

SOLAR EXPOSURE PAINT SYSTEMS

System No.	System*	Dry Film Thickness (Mils)
1	TT-E-529 Semi-gloss white	1.0
	MIL-E-46061 Solar heat reflecting green	1.0
2	TT-E-529 Semi-gloss olive drab	1.0
	MIL-E-46061 Solar heat reflecting green	1.0
3	TT-E-529 semi-gloss white	1.0
	Exp. solar heat reflecting green	1.0
4	TT-E-529 Semi-gloss olive drab	1.0
	Exp. solar heat reflecting green	1.0
5	TT-E-516 lustreless olive drab enamel	1.0
6	TT-E-516 lustreless white enamel	1.0

* All systems over wash primer MIL-P-15328 applied at a dry film thickness of 0.3 - 0.4 mil.

TABLE IV

SKIN TEMPERATURES (°F)

		System					
		White Base Spec Green	O.D. Base Spec. Green	White Base Exp Green	O.D. Base Exp. Green	O.D. Paint	White Paint
Day	Time	1	2	3	4	5	6
1	0930	143	147	139	145	155	105
	1250	93	93	91	91	95	83
	1405	93	91	90	90	94	81
	1545	119	119	117	118	121	99
2	0910	139	144	135	140	156	100
	1045	139	144	136	141	154	102
	1310	105	104	103	105	107	90
	1425	155	158	156	162	171	123
	1600	154	162	149	156	179	120
3	0930	90	91	90	91	92	85
	1040	92	95	94	96	92	89
	1145	92	92	93	93	92	86
	1320	127	132	126	132	132	112
	1420	154	155	148	154	162	120
	1545	105	106	102	104	108	92
4	0915	140	142	132	138	148	88
	1020	141	147	140	145	160	94
	1130	133	134	129	139	150	91
	1305	165	166	156	163	170	110
	1420	158	162	152	161	170	106
	1545	158	161	151	162	174	102
5	0910	134	139	130	133	150	99
	1005	144	150	141	145	155	106
	1120	138	147	137	145	146	106
	1300	148	155	150	153	150	117
	1425	131	134	126	129	140	102
	1600	146	152	140	146	160	110
6	0920	89	93	89	93	95	85
	1015	134	138	128	135	141	106
	1130	136	139	133	137	149	110
	1300	159	161	156	159	163	125
	1400	162	167	159	165	175	128
	1530	168	170	162	167	184	136

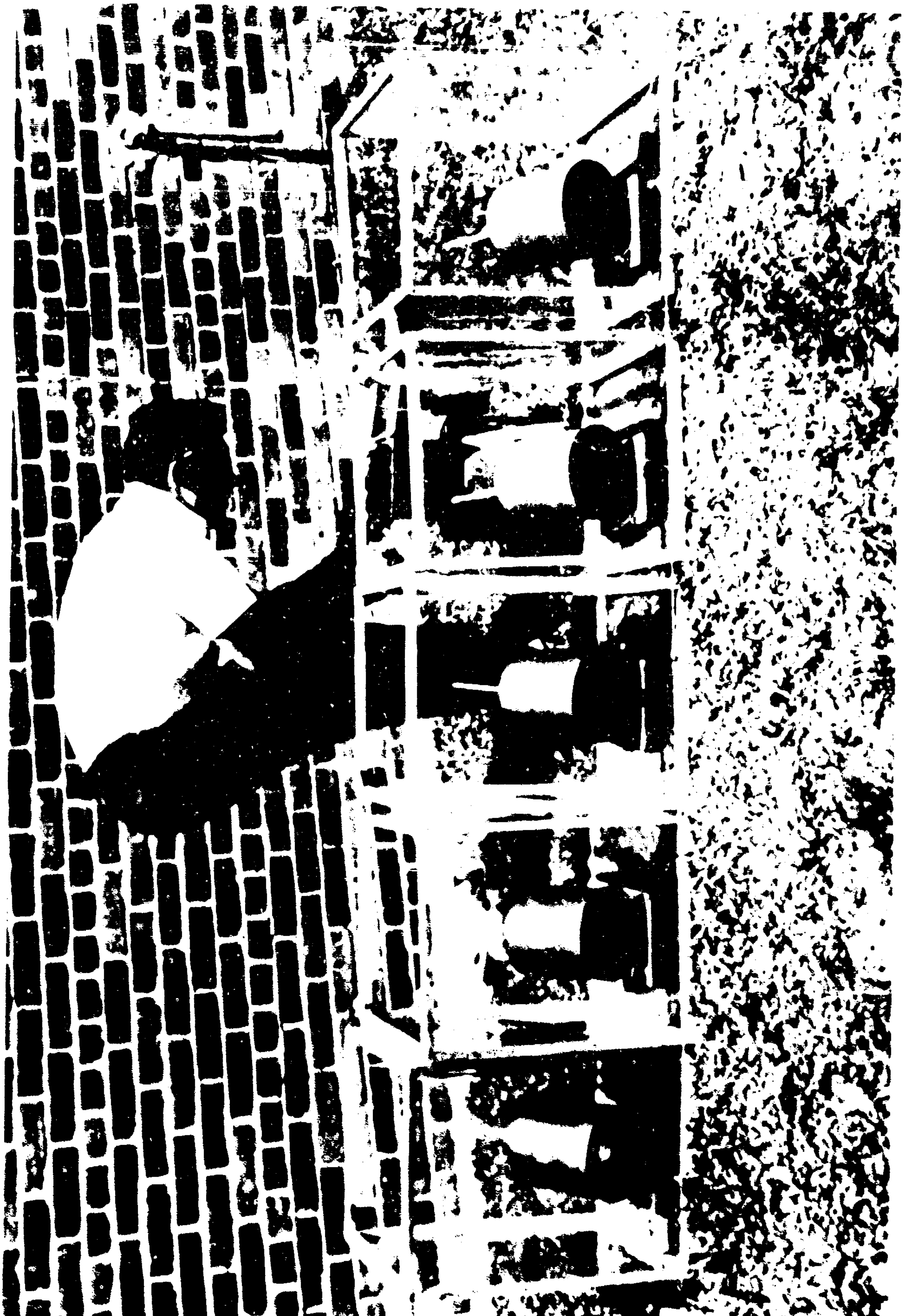

Photo 1

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PROGRESS REPORT

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SANDLER, MELVIN H.

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