NATIONAL BUREAU OF STANDARDS REPORT

6389

PERFORMANCE TESTS OF PROTECTED METALS, SERIES 1959, COLOR PROTECTED METALS

by

William C. Cullen
Edward W. Bender
Edgar H. MacArthur

Sponsored by

Office of the Chief of Engineers
Bureau of Yards and Docks
Department of the Air Force
Washington 25, D. C.

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U. S. DEPARTMENT OF COMMERCE
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1. INTRODUCTION

As part of a building materials investigation at the National Bureau of Standards under the sponsorship of the Tri-Service program, a series of simulated performance tests were made on samples of color protected metals submitted by three manufacturers. The series of tests to which the samples were subjected was designed to simulate actual service conditions as far as practicable in the laboratory. The test procedures employed in the series were as follows:

(a) Accelerated Weathering.

(b) Low-Temperature Impact at:

  1) 0°F.
  2) -30°F.

(c) Salt Spray:

  1) Before Impact
  2) After Impact

(d) Abrasion-Resistance to Air-Blown Sand.

It should be stressed that the laboratory tests are most useful in making a general evaluation of color protected metals when adequate service histories are lacking. However, if the service history of a product is known to be at variance with a test result, naturally the service history should be given the most weight.

2. MATERIALS

Samples of the color protected metals were submitted by the respective manufacturers in response to a letter request of the Office of the Chief of Engineers. It is understood that a representative of the Pittsburgh District Engineers Office was present at each factory when the samples were selected.

Unless otherwise stated, the samples submitted were 24-gauge siding sheets with standard corrugations (max. 2-5/8 in.) and grey in color. In cases where a field coat was recommended, the coating was applied at N.B.S. using manufacturer's application instructions.

The materials that were tested under the project are listed alphabetically and the descriptions were taken verbatim from the manufacturer's literature.

2.1 Color Galbestos, Manufactured by the H.H. Robertson Company, Pittsburgh, Pa.

Description: "First the steel core is pickled and dipped into a bath of molten zinc. Immediately a layer of asbestos felt is applied under great pressure. When the zinc hardens the felt is gripped in an absolute metallic bond. The asbestos felt is then given an asphaltic impregnation, then a tough thick waterproof outer coating in one of six colors is applied to one or both sides".

2.2 Color Clad Plasteel, Manufactured by Plasteel Products Corporation, Washington, Pa.

Description: Regular Plasteel - "The treated steel core shall be coated with an asphaltic rust inhibitive bond coat, after which two mastic coats of water repellent, corrosion-resistant bituminous material shall be rolled on under heat and pressure. Into this coating shall be imbedded a surface coating of mica. The plasteel sheet shall be coated with a chemically inert, emulsified acrylic resin which is resistant to corrosive industrial atmospheres and which is compounded

with durable light-stable pigments. This coating shall not be subject to oxidation and shall remain flexible."

Description: Plasteel CP-400 - No description is available for this except that it is made on a zinc-coated metal sheet.

2.3 Color Steelbestos, Manufactured by American Steel Band Company, Pittsburgh, Pa.

Description: "In manufacturing Color Steelbestos, a thoroughly cleaned steel core is etched and primed with a rust-preventive coating that simultaneously deposits a corrosion-resistant, tightly-knit phosphate coating plus a chemically bonded thin organic film which at once protects the phosphated surface from corrosion and provides an ideal surface for the adhesive. The exclusive synthetic resin bonding agent is then applied. Long-fiber white asbestos felt is immediately put on this adhesive and the sheet is then oven-cured. An asphaltic saturant impregnates the white asbestos felt. These steps create a homogeneous envelope that thoroughly protects the steel core against corrosive atmospheres. After the asbestos felt has been cured and impregnated with an asphaltic saturating compound, it is uniformly covered with two layers of American's special Vinol plastic sealer, which prevents bleeding of the asphalt and is itself water-repellent and corrosion-resistant. Then the surface is given two coats of water-repellent, corrosion-resistant American Alkol plastic color coating, in the color selected by the customer. One coat is shop-applied, the second coat is applied in the field after erection to give a better, smoother appearance."

3. TEST PROCEDURES

3.1 Thickness Determinations

The thickness determinations of the protective coating, felt and metal core were made with a micrometer caliper which was equipped with a 1/4-in. diameter head.

3.2 Accelerated Weathering Tests

Duplicate 10-in. X 12-in. specimens of each sample were exposed in a low-intensity, enclosed carbon arc unit, "Weather-Ometer", manufactured by the Atlas Electric Devices Company, Chicago, Illinois. Only one arc lamp, centrally located, was used as a source of radiation. The unit was operated approximately 23 hours per day, 5 days a week. The cycle used was 51 minutes of light and 9 minutes of light and water. The water was essentially mineral and metal free and was kept at a temperature of 80 ±5°F.

A plot of the time-temperature curve of a typical cycle is reproduced in Figure 1. The temperature measurements were made with a black-bulb mercury thermometer at the panel surface.

Visual inspections were made periodically and significant changes were recorded.

3.3 Low-Temperature Impact Tests

Triplicate, 10-in. X 12-in. corrugated specimens of each sample were subjected to the impact test at 0°F. and at -30°F. The specimens were conditioned at the specified temperatures for a minimum of one hour and placed on a firm support (concrete floor covered with 1/4-in. linoleum) with the exposure side up. A 760 gram (1.68 lb.) steel ball was dropped from a height of 7 ft. and was controlled to strike the specimen on the crest of a corrugation at a point approximately at the center of the specimen.

After impact the specimens were brought to room temperature and two of the specimens were examined. The third specimen (-30°F. only) was set aside for exposure to the salt spray test.

The protective coating and/or felt which was removed by the impact was considered as shatter while that which could be easily removed by probing with a knife blade or

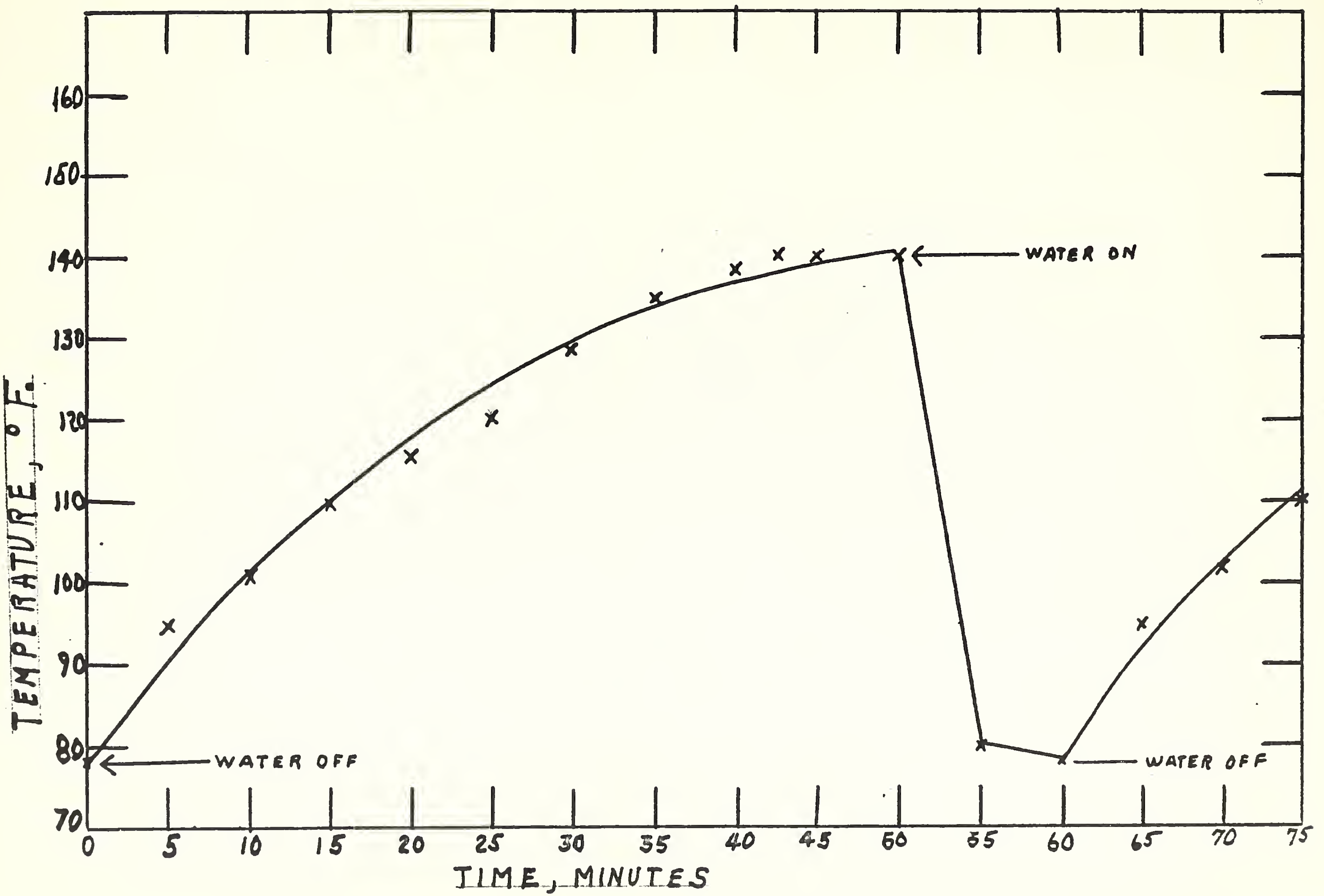

FIGURE 1. BLACK BULB TEMPERATURE DURING WEATHERING TESTS.

similar instrument was classed as loosening. The shatter plus the loosening were taken as the total area on which a loss of adhesion occurred and was recorded as such.

3.4 Salt Spray Tests

Two 10-in. X 12-in. corrugated specimens of each sample were exposed to the salt spray test. One specimen was in the "as received" condition while the other had been subjected to the impact test at -30°F. The salt spray tests were conducted essentially in accordance with the method described in ASTM Designation: B 117-44T, Tentative Method of Salt Spray (Fog) Testing. The specimens were exposed continuously for 45 days and were inspected at weekly intervals and at the completion of the exposure period.

3.5 Abrasion Tests

The abrasion tests were designed to study the influence of the type of material (Test A) and the thickness of the protection (Test B) on the abrasion resistance of the entire coating system. An abrasion apparatus, employing an unsupported abrasive, was developed and constructed for the study. A photograph showing the apparatus is presented in Figure 2.

Flat specimens (4-in. X 4-in.) were exposed in triplicate to both Test A and Test B. Test A determined the abrasion resistance of the protective coating while Test B determined the time which was required for the abrasive to penetrate through to the base metal under the standard conditions of the test.

The test conditions employed in the abrasion tests were as follows:

(1) Abradant - Standard Ottawa Silica Sand.

(2) Position of Test Specimen - Angle of 45° inclination.

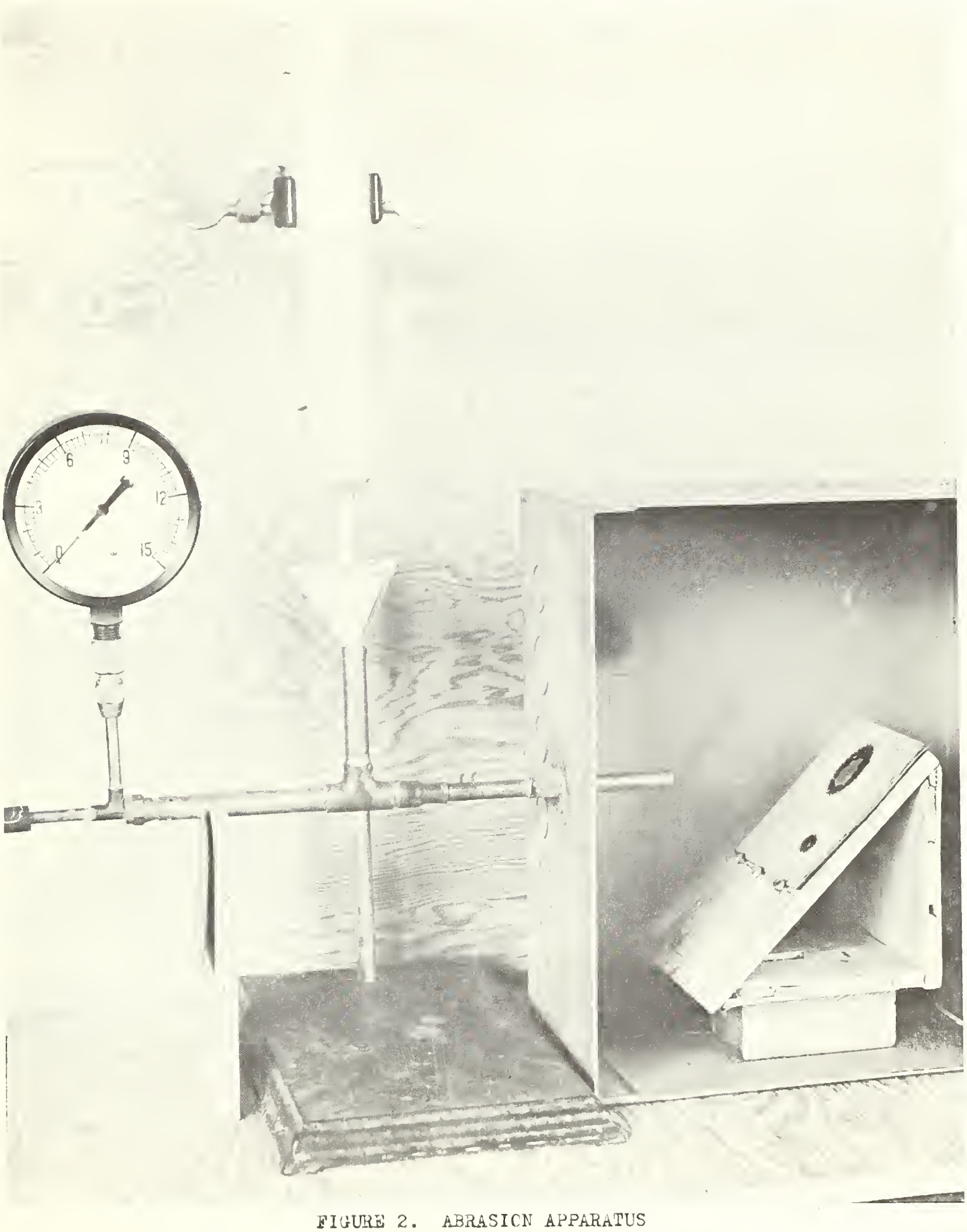

FIGURE 2. ABRASION APPARATUS

(3) Distance of Specimen from Nozzle:

Test A - 4 in.
Test B - 1-1/2 in.

(4) Air Pressure - 3 psi.

(5) Abradant, rate of flow - 144 grams/minute.

(6) Exposure Times:

Test A - 10 minutes in 5 intervals of 2 minutes each.
Test B - Time to penetrate through coating and expose metal.

3.6 Flammability Test Methods

The materials were tested by two different flame-spread methods, an inclined tunnel test and a radiant panel test.

The inclined tunnel test, which has been used in many previous tests of this type of product, involved placement of the specimen as the cover or upper enclosing surface of a tunnel 12 ft. long, and about 40 in. wide, and 9 in. deep. This tunnel was inclined at a slope of 5 in. vertical to 12 in. horizontal. The three fixed sides of the tunnel were of sheet metal lined with asbestos-millboard. The igniting flame was applied to the under surface of the specimen at the lower end.

All specimens for this test were so assembled as to have one joint running the 12-ft. length, and they were placed with the surface intended for interior exposure facing downward and exposed to the igniting flame. The flame was applied for 35 minutes, and was produced by burning gas with a calorific value of approximately 1100 BTU/cu ft, at a rate of 3 cu ft/min for 30 minutes followed by a rate of 5 cu ft/min for 5 minutes. The length of the igniting flame, measured with an unprotected sheet metal cover in place of the test specimen, was about 2-1/2 ft. Two specimens of each material were tested.

The radiant panel method has been described in the article, "A Method for Measuring Surface Flammability of Materials Using a Radiant Energy Source", Proc. ASTM, Vol. 56, 1956. It provides a means for exposing small specimens in a standard fashion to a radiant heat and ignition source. Measurements are made of the rates of flame spread and heat release. These factors are combined to produce a flame-spread index which provides a numerical means for classification of material flammability. Smoke production by the specimen is reported in terms of the weight of material deposited on a glass filter disk.

For some of the tests made by this radiant panel method, the corrugations in the materials were flattened out as much as feasible before the test specimens were cut. In other cases the test specimens were cut with the corrugations running lengthwise of the specimen. From two to four specimens of each material were tested.

3.7 Fuel Potential

This test method is currently under development at the NBS. It is intended to furnish a quantitative measurement of the heat of combustion of which might be released on exposure of the materials to conditions similar to a building fire. A simplified form of this test method was used to provide an indication of the fuel potential of the coating materials used. Standard Parr bomb calorimeter equipment was used for measurement of the heat of combustion of the interior coating of one sample of each of the three types of coated metals.

4. TEST RESULTS

4.1 Thickness of Components

The thicknesses of the various components of the color protected metals are given below. In cases where the coatings are veined, the thicknesses given are maximum.

4.1.1 Color Galbestos (Veined Coating)

Total Thickness	-	.083 in.
Metal Core	-	.027 in.
Felt, Exposure Side	-	.010 in.
Coating, Exposure Side	-	.018 in.
Felt, Reverse Side	-	.010 in.
Coating, Reverse Side	-	.018 in.

4.1.2 Color Clad Plasteel (Coated Both Sides)

Total Thickness	-	.055 in.
Metal Core	-	.024 in.
Bituminous Coating, Exposure Side	-	.012 in.
Color Coating, Exposure Side	-	.004 in.
Bituminous Coating, Reverse Side	-	.011 in.
Color Coating, Reverse Side	-	.004 in.

4.1.3 Color Clad Plasteel (Coated One Side)

Total Thickness	-	.052 in.
Metal Core	-	.024 in.
Bituminous Coating, Exposure Side	-	.012 in.
Color Coating, Exposure Side	-	.004 in.
Bituminous Coating, Reverse Side	-	.012 in.

4.1.4 Color Steelbestos

Total Thickness	-	.054 in.
Metal Core	-	.027 in.
Felt, Exposure Side	-	.009 in.
Coating, Exposure Side	-	.006 in.
Felt, Reverse Side	-	.009 in.
Coating, Reverse Side	-	.003 in.

4.2 Accelerated Weathering

The accelerated weathering test is a laboratory tool for determining in a relatively short time the resistance of an organic material to the factors encountered during normal weathering, as heat, ultraviolet light and moisture. It has been shown that a test of this type will produce the principal types of failure, such as fading, blistering, cracking, embrittlement and shrinking, that a material may exhibit during a longer period of natural weathering. It is stressed, however, that no conversion factor for relating the accelerated weathering test to weathering under natural conditions has been established.

The results of exposure up to 1000 hours are described below. The accelerated weathering test will be continued until the specimens have a total exposure time of 2000 hours, and the final results will be reported in a supplementary report.

4.2.1 Color Galbestos - Rating: Fair.

The "Fair" rating was based on the cracking which appeared between 500 and 1000 hours of exposure and on the separations (approximately 1/4 in.) of the coating from the metal in the valleys. The break was within the asbestos felt and was observed after 600 hours of exposure. It was apparently caused by a shrinkage of the color coating.

4.2.2 Color Clad Plasteel - Rating: Excellent.

The material was rated "excellent" in this test because no appreciable change has occurred in any specimen after 1000 hours of exposure.

4.2.3 Color Steelbestos - Rating: Poor.

The "poor" rating is based on the severe blistering and moderate cracking that occurred within the 1000-hour exposure period. As in the case of Color Galbestos, there

is a separation of the coating from the metal in the valleys which is apparently caused by a shrinkage of the color coating.

4.3 Low-Temperature Impact Test

In practice, color protected metal sheets can be subjected to impact or shock during transportation and/or installation. This can occur in handling the sheets while unpacking and readying them for installation or when they are being fastened to the structural frame. After installation, impact can occur at the lower siding courses or from hail or other missiles. Damage to the protective system is not likely to be serious when the temperature is moderate. However, at low temperatures, damage can be serious.

The low temperature impact tests were designed to give an indication of the ability of a protected metal to resist damage from impact or shock at low temperatures. Tests were made at 0°F. for installations in temperate climates and at -30°F. for installations in colder climates.

The tests were made on materials that were prepared on a 24-gauge base metal which experience has shown to be the least resistant to the low-temperature impact test.

For comparison purposes, the results of the low-temperature impact tests are presented in Table 1.

4.3.1 Color Galbestos - Rating: <u>Excellent</u>.

The damage to Color Galbestos at both 0°F. and -30°F. was slight. Figures 3 and 4 show the extent and type of failure that occurred on this product. In each case the adhesion was lost between the coating and the felt or within the felt itself. Slight to moderate hairline cracking was observed around the point of impact and on other areas of the panel.

TABLE 1. RESULTS OF LOW-TEMPERATURE IMPACT TESTS

Material	Area Showing Loss of Adhesion, sq. in.			
	0°F.		-30°F.	
	Exposure Side	Reverse Side	Exposure Side	Reverse Side
1. Color Galbestos	3.1	0.4	2.4	0.3
2. Color Steelbestos	3.0	3.0	5.8	7.0
Color Clad Plasteel:				
3. CP-400, Coated 1 Side	8.3	1.1	12.7	1.4
4. CP-400, Coated 2 Sides	8.4	15.3	7.1	14.5
5. Regular, Coated 1 Side	11.8	1.3	23.4	2.0
6. Regular, Coated 2 Sides	12.2	11.8	26.6	24.0

4.3.2 Color Steelbestos - Rating: Good.

The damage that occurred to Color Steelbestos was slight to moderate. As expected, the effect of the impact was more severe at -30°F. than at 0°F., both on the exposure and the reverse sides of the specimens. Figures 5, 6, 7 and 8 indicate typical failures that occurred with this product at both 0°F. and -30°F. In every case the loss of adhesion occurred between the felt and the metal core.

4.3.3 Color Clad Plasteel, CP-400 - Rating: Fair.

The damage that occurred to this material was classed as moderate to severe. The type and extent of the damage that occurred is shown in Figures 10, 12 and 14. As expected, the most severe failures occurred at -30°F and on the specimens which were coated both sides.

Cracking of the coating and actual shatter on an area of about one square inch was observed in the vicinity of the point of impact.

4.3.4 Color Clad Plasteel, Regular - Rating: Poor.

This material was rated as poor because of the severe loss of adhesion and of the actual cracking and shatter that occurred on all specimens at both 0°F. and -30°F. The types of failures that were observed were similar to those described for the CP-400 type, but to a greater extent as shown in Figures 9, 11 and 13.

4.4 Salt-Spray Tests

The salt-spray test is a laboratory procedure by which inherent weaknesses in a protective system may be revealed. It is also used to measure the continuity of a coating and to indicate the ability of a coating system to afford protection in a humid atmosphere where corrosive agents may be present.

FIGURE 3. COLOR GALBESTOS, FRONT, 0°F & -30°F, 3.6 SQ. IN.

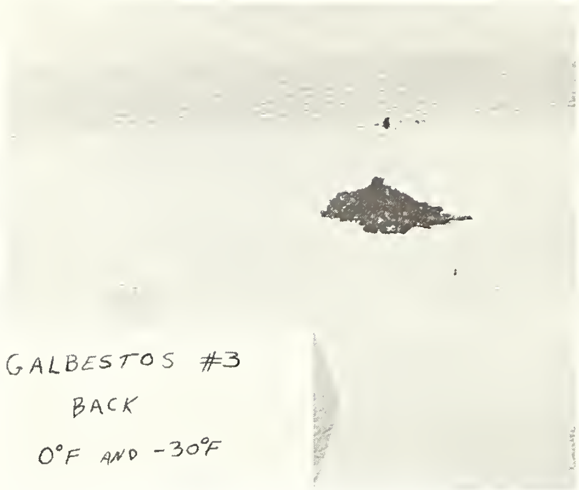

FIGURE 4. COLOR GALBESTOS, BACK, 0°F & -30°F, 0.7 SQ. IN.

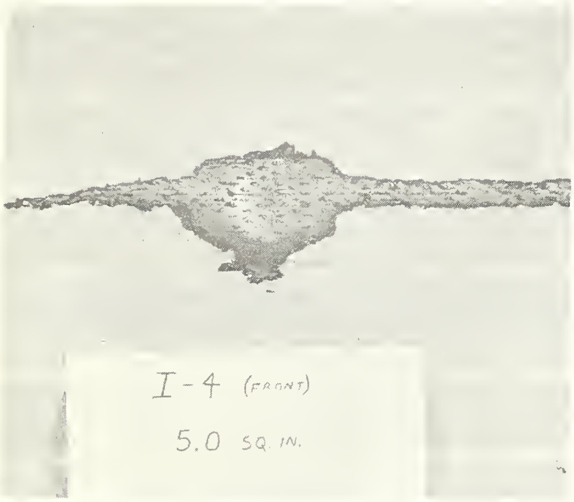

FIGURE 5. COLOR STEELBESTOS, FRONT, -30°F, 5.0 SQ. IN.

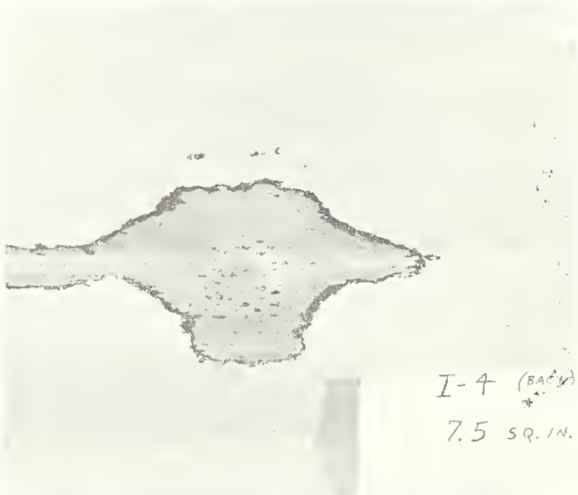

FIGURE 6. COLOR STEELBESTOS, BACK, -30°F, 7.5 SQ. IN.

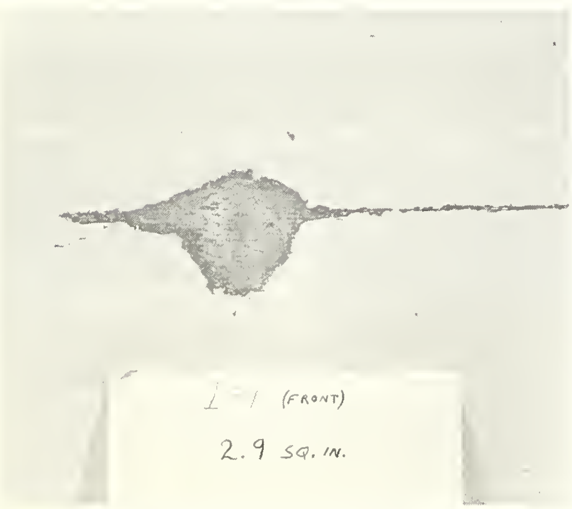

FIGURE 7. COLOR STEELBESTOS, FRONT, 0°F, 2.9 SQ. IN.

FIGURE 8. COLOR STEELBESTOS, BACK, 0°F, 3.6 SQ. IN.

FIGURE 9. COLOR PLASTEEL, REGULAR, FRONT, 0°F, 12.9 SQ. IN.

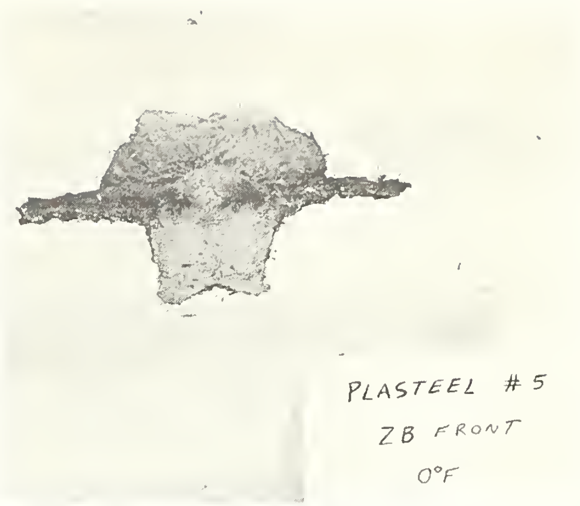

FIGURE 10. COLOR PLASTEEL, ZB, FRONT, 0°F, 7.8 SQ. IN.

FIGURE 11. COLOR PLASTEEL, REGULAR, FRONT, -30°F, 24.8 SQ. IN.

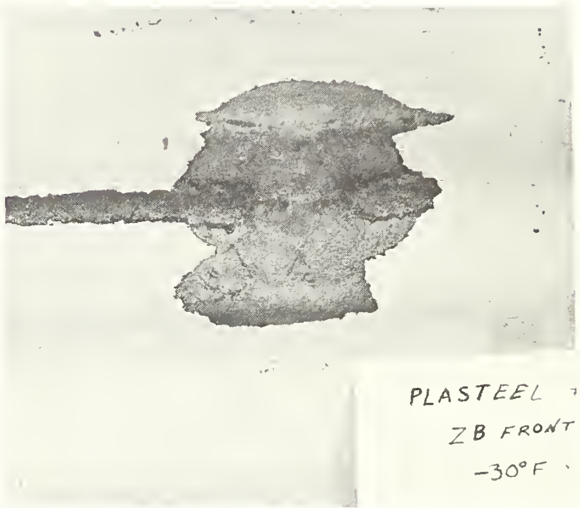

FIGURE 12. COLOR PLASTEEL, ZB, FRONT, -30°F, 12.7 SQ. IN.

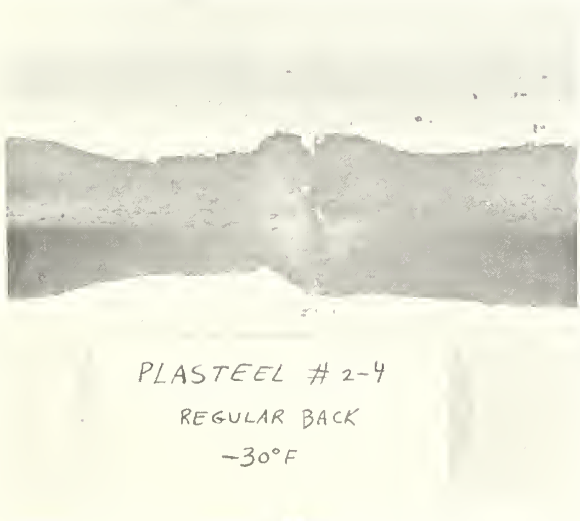

FIGURE 13. COLOR PLASTEEL, REGULAR, BACK, -30°F, 24.0 SQ. IN.

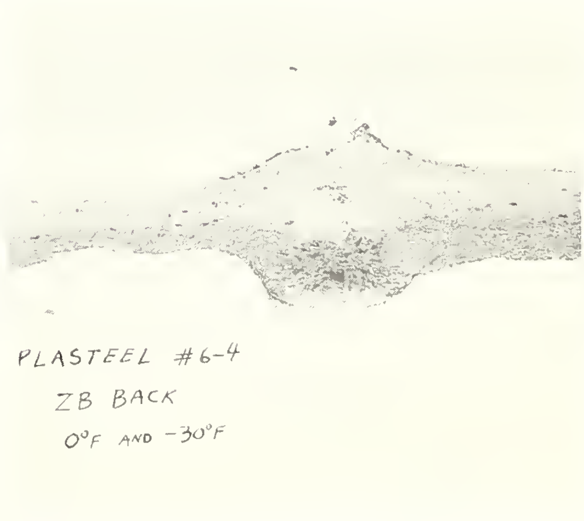

FIGURE 14. COLOR PLASTEEL, ZB, BACK, 0°F & -30°F, 16.2 SQ. IN.

Where the salt-spray tests were performed on specimens subjected to the impact test, the purpose was to provide information as to the ability of a material to withstand corrosive agents after damage to its protective system.

4.4.1 Color Galbestos - Rating: Excellent.

The condition of the Color Galbestos specimens during and after the test was excellent. A number of pin holes, perhaps 50 to 100, as evidenced by rust deposits were the only deteriorative effects noted during the 45-day exposure period. The specimen subjected to the impact test evidenced numerous hairline cracks over the entire surface, especially noticeable around the point of impact. However, there was no evidence of corrosion at the cracks or in the area of the point of impact. The adhesion of the entire protective system appeared intact and no corrosion of the base metal was noted.

4.4.2 Color Clad Plasteel, Regular - Rating: Poor.

The condition of all specimens of Regular Plasteel was rated as poor regardless of whether the material was coated one side or two, or whether the specimens were previously subjected to the impact test or not.

Numerous pinholes and blisters were observed on this product during the test. Severe rusting was observed which resulted from pin holes, cut edges, and, in the case of the specimen subjected to the impact test, from the area beneath where the protective coating was damaged.

The final examination revealed that 100% of the adhesion between the coating and the metal was lost on the exposure side of both specimens and somewhat less (60% to 90%) on the reverse sides. The metal cores showed evidence of corrosion (rust stains) on more than 50 areas ranging in size from pin point to 3/4 in. in diameter. More severe corrosion was noted on the metal core of the specimen after the impact test on both sides in the areas near the point of impact.

4.4.3 Color Clad Plasteel, CP-400 - Rating: Fair.

This material was rated a step better than Regular Plasteel, based on its better performance in regard to adhesion of the protective coating and in corrosion resistance of the base metal. The failures which occurred were similar in nature to those that occurred on Regular Plasteel, but to a lesser degree.

The final examination revealed a loss of adhesion of 50% to 80% on the exposure surfaces and less than 5% on the reverse surfaces. There was evidence of corrosion either in the form of rust or zinc salts on the base metal on the areas where the adhesion was lost.

4.4.4 Color Steelbestos - Rating: Poor.

The poor rating is based on such failures as pin holes, blistering, and apparent embrittlement of the coating, which were observed during the exposure, and the severe loss of adhesion (100%) on both sides of each specimen. Corrosion in the form of rust was observed on an estimated area of 35% on the control specimen and a much larger area of the specimen subjected to the impact test.

4.5 Abrasion Tests

In military construction many building materials are exposed to the abrasive forces of air blown sand or other abradants, especially when they are located in windy, arid areas or in the vicinity of airfields.

Studies of the effects of abrasion were designed to determine the resistance of a respective coating system to the abrasive effects of airblown sand. The study was divided into two phases to determine the following:

1) The abrasive resistance of the coating material and, 2) the influence of coating thickness of a specific material on its abrasion resistance.

The results of the abrasion tests are presented numerically in Table 2 and graphically in Figures 15 and 16. The abrasion resistance of the coating material in terms of weight loss per unit time, reported in Table 2, is equal to the slope of the respective curve in Figure 15.

The bituminous (black) protected metals were included in the abrasion test for comparison purposes.

Adjective ratings have been omitted in the abrasion tests because of the lack of criteria to differentiate between an excellent rating and a poor rating.

TABLE 2. RESULTS OF ABRASION TESTS

Material	Weight Loss	Time to Remove Color Coat	Time to Metal
	mg/min	Seconds	Seconds
Color Galbestos	30.0	80	290
Black Galbestos	21.0	--	330
Color Clad Plasteel	11.5	30	128
Black Plasteel	29.1	--	285
Color Steelbestos	12.6	45	280
Black Steelbestos	19.9	--	290

4.6 Flammability Tests

The flammability tests were originally developed to measure the relative flammability of the finish involved. The tunnel method has been in use for evaluation of coated metals for a period of more than ten years. The radiant panel method, rather recently developed, has only recently been applied for study of flammability of these materials. It provides a means for measurement in a quantative fashion of a much wider range of surface flammability than is possible with the tunnel method. It was originally believed that this latter test method would only be suitable for measurements on flattened sheets of material. Recently,

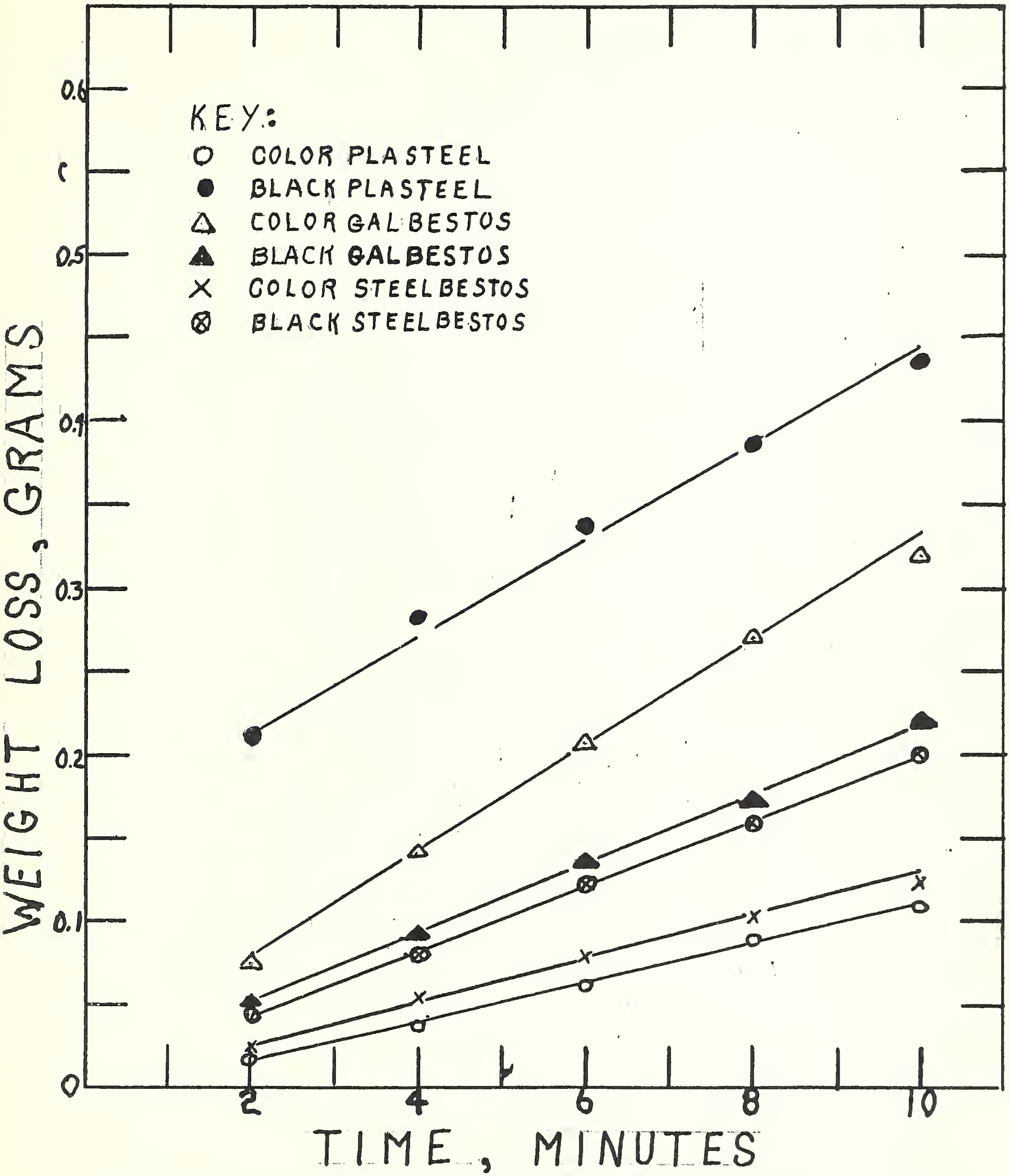

FIGURE 15. RESULTS OF ABRASION TESTS

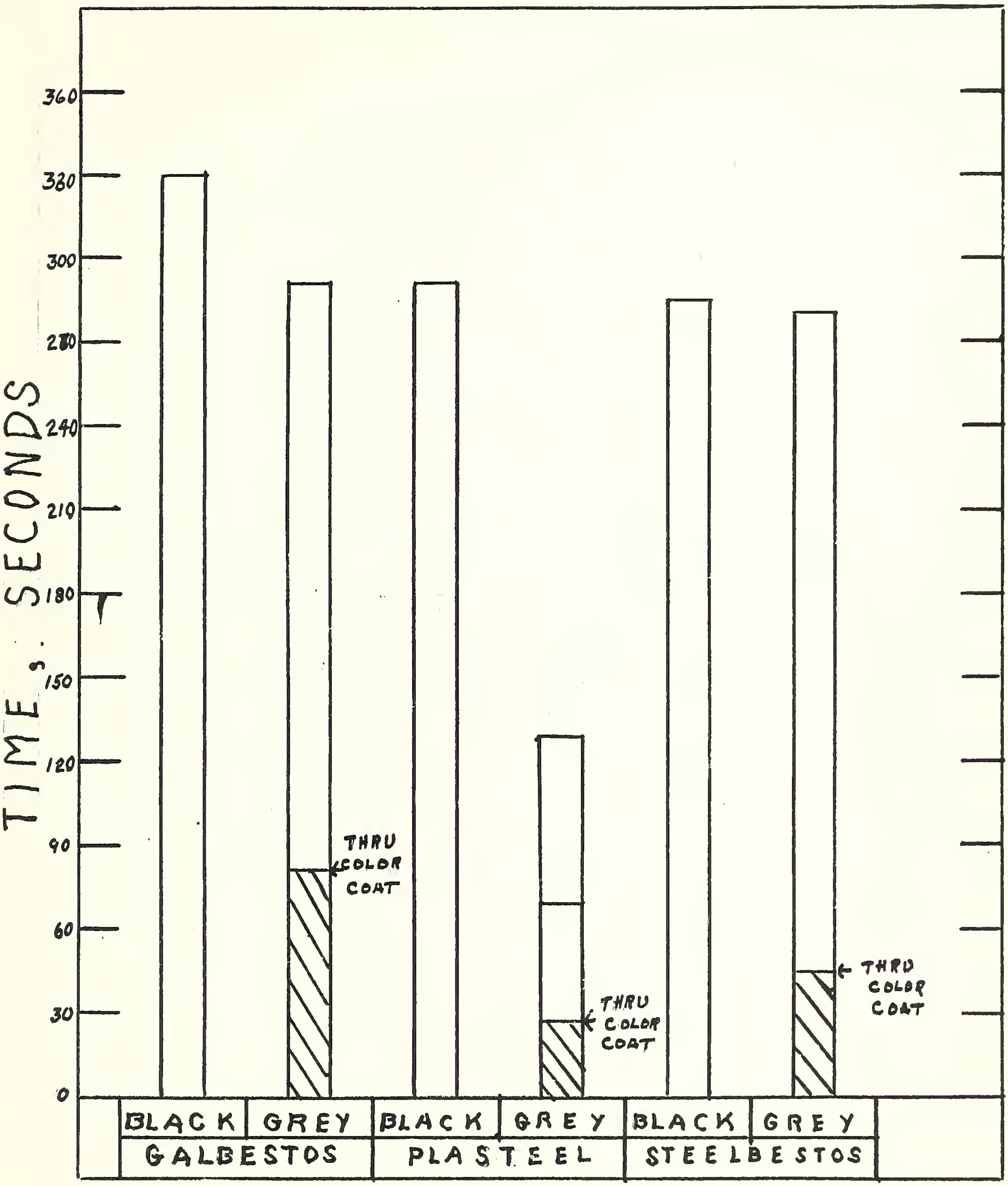

FIGURE 16. TIME TO REMOVE COATING DURING ABRASION TESTS.

however, experiments have been made in which corrugated material was tested. The results obtained seem to indicate greater flammability in this form and it is considered desirable to make all future tests of this type of material in the corrugated form in which it is manufactured.

The results of the flammability tests are presented in Table 3.

The columns headed Interior and Exterior refer respectively to, tests in which the interior uncoated material of coated one-side-stock, and either the exterior coated side of the same stock or one side of stock coated on two sides were tested.

On the basis of the data developed there appears to be little to choose between the three materials on the basis of flammability. The Plasteel product however was consistent in its evidence of the formation of molten bituminous drippings. In many instances these were flaming as they fell and continued to burn after coming to rest.

There was considerable difference in the flammability of the grey colored material as tested by the two different flammability test methods. In the tunnel there was evidence of coking of the coating material ahead of the flame front which seemed to have the effect of limiting flame spread. This effect was not noticed in the radiant panel test results which seemed to indicate much higher flammability. We at present have no way of predicting which test method is more indicative of the hazard which might result from use of a material in a building.

TABLE 3. RESULTS OF FLAMMABILITY TESTS

Color	Trade Name	Radiant Panel		Tunnel			
		Interior	Exterior	Interior		Exterior	
				30 min.	30-35 min.	30 min.	30-35 min.
		Index I_s	Index I_s	ft.	ft.	ft.	ft.
Black	Galbestos	0*	2.5*	1/2	3	1	>12
	Plasteel	--	3.1*	1/2	4 1/2	1/2	4 1/2
	Steelbestos	--	9*	3	7	-----	-----
Maroon	Galbestos	--	1.1*	1 1/2	3 1/2	3 1/2	12
	Plasteel	--	5.0*	1 1/2	12	1 1/2	12
	Steelbestos	9*	12.2*	1 1/2	6 1/2	4	12
Grey	Galbestos	0*	57	1 1/2	6	3 1/2	7
	Plasteel	16	85	5	6 1/2	5	7 1/2
	Steelbestos	23	98	2	2 1/2	-----	-----

*Tests on flattened material; all others tested in corrugated form.

Underlined entries indicate that specimen surface melted and dripped during test.

4.7 Fuel Potential Results

The simplified calorimetric method used for measurement of the heat of combustion of the interior coating of three coated metals provided the following results:

Galbestos	-	304 BTU/ft^2
Plasteel	-	790 "
Steelbestos	-	450 "

Only one specimen of each of the coated metals was used in determining these results. In each case the interior coating of a nominally coated-one-side sheet was used for study.

The results seem to indicate that the fuel potential on the interior surface of the Plasteel product is significantly larger than that of the other two products studied.

5. CONCLUSIONS

The performance ratings, based exclusively on the results of the accelerated weathering, impact and salt-spray tests, described in this report are given below. The adjective ratings are based on the overall performance of each material in a given test.

5.1 Accelerated Weathering Tests (1000 Hours Exposure)

Plasteel, CP-400	-	Excellent
Plasteel, Regular	-	Excellent
Galbestos	-	Fair
Steelbestos	-	Poor

5.2 Low-Temperature Impact Test (0°F. and -30°F.)

Galbestos	-	Excellent
Steelbestos	-	Good
Plasteel, CP-400	-	Fair
Plasteel, Regular	-	Poor

5.3 Salt-Spray Before Impact

Galbestos	-	Excellent
Plasteel, CP-400	-	Fair
Steelbestos	-	Poor
Plasteel, Regular	-	Poor

5.4 Salt-Spray After Impact at -30°F.

Galbestos	-	Excellent
Plasteel, CP-400	-	Fair
Steelbestos	-	Poor
Plasteel, Regular	-	Poor

5.5 Abrasion Resistance

No adjective ratings can be made. The material listed first has the best rating in the respective test.

5.5.1 Abrasion Resistance of Coating

Plasteel, Regular and CP-400
Steelbestos
Galbestos

5.5.2 Abrasion Resistance in Terms of Time to Remove Coating

Galbestos
Steelbestos
Plasteel, Regular and CP-400

5.6 Surface Flammability

There appears to be little basis for selection of one product over others so far as flammability is concerned. There is however some evidence that the color coatings used may have the effect of increasing surface flammability over those of maroon and black coating materials. This effect was only observed with specimens tested by the radiant panel method.

The Plasteel product exhibited a greater tendency to form molten bituminous drippings and might be considered inferior to the others on this score.

5.7 Fuel Potential

Only a few tests of the calorimetric type were performed. These, however, seemed to indicate the following ordering of the various products:

Galbestos
Steelbestos
Plasteel.

6. SUMMARY OF THE RESULTS OF FOUR SERIES OF TESTS ON PROTECTED METALS

For reference and convenience, Table 4 is presented to summarize the results obtained during four series of tests on various samples of protected metals. The results are reported in detail in N.B.S. Reports Nos. 1808, dated 8/21/52; 4963, dated 12/14/56; 5148, dated 2/5/57; and in this report.

The adjective ratings used in the table are, of necessity, quite broad and we would expect others might interpret the results of some of the tests differently.

TABLE 4. SUMMARY OF TESTS ON PROTECTED METALS.

TEST	1952 SERIES BLACK			1956 SERIES BLACK			1957 SERIES MAROON			1957 COLOR	1959 SERIES COLOR			
	G	P	S	G	P	S	G	P	S	G	G	P CP-400	P Reg.	S
Accelerated Weathering	F	E	P	F	E	G	P	E	F	G	F	E	E	P
Low Temp. Impact 0°F.	E[1/]	F	F	E	P	G	--	--	--	--	E	F	P	G
Loss of Adhesion in.^{2}	0	1.8	1.2	0.8	7.7	1.2	--	--	--	--	3.1	8.3	11.8	3.0
Low Temp. Impact -30°F.	--	--	--	E	P	G	E	P	G	E	E	F	P	G
Loss of Adhesion in.^{2}	--	--	--	1.1	12.6	2.1	0	12.0	1.2	0	2.4	12.7	23.4	5.8
Salt-Spray	E	G	P	G	P	P	--	--	--	--	E	F	P	P
Salt-Spray After Impact	--	--	--	--	--	--	E	P	P	E	E	F	P	P
Abrasion (Rating)	--	--	--	2	3	1	--	--	--	--	3	1	--	2
Wt. Loss, mg/min.	--	--	--	21.0	29.1	19.9	--	--	--	--	30.0	11.5	--	12.6
Abrasion (Rating)	--	--	--	1	2	3	--	--	--	--	1	3	--	2
Time to Metal, secs.	--	--	--	330	290	285	--	--	--	--	290	128	--	280

KEY: G = Galbestos
P = Plasteel
S = Steelbestos

PERFORMANCE: E = Excellent
G = Good
F = Fair
P = Poor
-- = No Test

1/ Flat specimens tested.

U. S. DEPARTMENT OF COMMERCE
Lewis L. Strauss, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major laboratories in Boulder, Colo., is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside front cover.

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Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Engine Fuels. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer.

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Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Anolog Systems. Application Engineering.

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Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering. Radio-Meteorology.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Electronic Calibration Center. Microwave Physics. Microwave Circuit Standards.

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