NATIONAL BUREAU OF STANDARDS REPORT

7109

PERFORMANCE OF COATING SYSTEMS WHEN APPLIED TO SURFACED BUILT-UP ROOFS TO FACILITATE THE REMOVAL OF ATOMIC FALLOUT

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U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

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NBS PROJECT **NBS REPORT**

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NBS

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Based on these data, it can be concluded that the early removal of a radioactive contaminant from a surfaced built-up roof will not be possible.

Obviously, a roof which presents a smooth, even surface can minimize the hazard due to the accumulation of radioactive fallout, because the probability of its ultimate removal by the conventional decontamination methods will be greatly increased. In the case of new construction, this can be partially accomplished by the specification of smooth-surfaced roofs at the sacrifice, of course, of some durability, since mineral-surfaced roofs generally out-perform their smooth-surfaced counterparts.

Existing slag- or gravel-surfaced roofs must be treated in some manner to render their surface smooth. The application of coating or topping systems to fill the voids between the surfacing particles has been suggested as a possible method. If such a system is to perform adequately, it should possess many, if not all, of the following attributes:

1. Be economical and easy to apply.
2. Provide good coverage, i.e., present a smooth, dense surface even after extended periods of exposure.
3. Provide good adhesion to the base on which applied.
4. Be compatible with the base on which applied.
5. Possess desirable weathering characteristics.
6. Resist flow at roof temperatures.
7. Easy to maintain.

At the request of the Atomic Energy Commission, the National Bureau of Standards carried out a program to study the performance of a number of coating systems employed as surface preparations for built-up roofs surfaced with slag or gravel. Ten organic coating systems were selected for inclusion in the program and they may be placed in one or more of the following categories:

(1.) Asphalt Base.
(2.) Coal-tar Base.
(3.) Resin Base (epoxy, polyvinyl acetate).
(4.) Rubber Base.

Each of the coatings was intended for cold application by brush and/or spray in either a solvent or emulsion form.

The performance of the coating systems was studied during a series of simulated service tests carried out in the laboratory. In addition, outdoor exposure tests were conducted on a slag-surfaced, coal-tar pitch, built-up roof located at the Atomic Energy Commission site at Germantown, Md.

2. COATING SYSTEMS

Ten coating systems were selected for inclusion in the program and were obtained directly from the manufacturers by the Atomic Energy Commission in response to a letter request. Table 2 lists the NBS Sample Number (assigned in the order of the receipt of the sample), manufacturer, trade name, weight per gallon and the spreading rate as applied, both in laboratory and outdoor exposure tests. Cost data were not available.

3. SIMULATED SERVICE TESTS

A laboratory investigation was carried out to study the performance characteristics of the various systems when subjected to environments simulating actual exposure conditions. Whenever possible, existing methods of test were employed, but in some cases existing methods had to be modified or new methods devised to obtain the type of test data which were desired. The following characteristics of the coating systems appeared to be worthy of consideration in the laboratory phase of the study:

1. Resistance to accelerated weathering tests.
2. Resistance to flow at elevated temperatures.
3. Adhesion of materials simulating fallout from a nuclear explosion.

3.1 Accelerated Weathering Tests

The accelerated tests which were employed were designed to simulate exposure on dead-level roofs where there are no run-offs and standing water evaporates in place.

One specimen of each sample was prepared by depositing a uniform film of the coating material over the bottom of a 90 mm by 20 mm petri dish. A second specimen was similarly prepared except that the bottom of the dish was covered with glass beads (5 mm in diameter) to simulate a roughened surface.

The specimens were exposed in a horizontal position in a low-intensity, single, enclosed carbon-arc accelerated weathering machine.[3/] They were exposed 23 hours per day to light only. The petri dishes were filled

[3/] Available from the Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago 13, Illinois.

TABLE 2.

Coating Systems

NBS Sample No.	Manufacturer	Trade Name	Wt/Gal (lb.)	[1/] Spreading Rate (ft^2/gal)
1	Gates Engineering Co.	Hypalon H-2	8.1	18
2	do.	Gacote NA-62	8.0	15
3	Lewis Asphalt Engineers	Karnak	7.7	21
4	Amercoat Co.	Amercoat 78	11.7	13
5	Brooklyn Paint and Varnish Co.	Copon Arocoat	10.2	14
6	Pittsburgh Coal and Coke Co.	Tarset	10.7	19
7	Flintkote Co.	Levelkote	9.0	10
8	Koppers Co.	Bituplastic 33	10.1	10
	do. (2nd coat)	do. (2nd coat)	10.1	15
9	do.	Roof Sealer	9.3	9
	do.	do. (2nd coat)	11.6[2/]	7
10	Tri-Delta Products Co.	Gravel Grip	15.2	13

1/ Computed on the basis of 21 ft^2, except #1 and second coats of #8 and #9. The entire one-gallon sample of #1 was applied to approx. 18 ft^2. The second coats of #8 and #9 were applied to approx. 8-3/4 ft^2.

2/ Includes 5 lbs of sand per gallon.

three-quarters full with distilled water after each 100 hours exposure and were then reexposed to the radiation of the arc allowing the water to evaporate in place, which required from 4 to 6 hours. The temperature of the specimens during exposure varied from 50 to 60°C.

The results of the accelerated weathering tests after 1000 hours exposure are given in Table 3.

3.2 Flow Tests at 60°C.

The flow test was employed to indicate the stability (ability to remain in place after set) of the coating material after it had been applied to the roof surface.

Two specimens of each sample were prepared by applying the material by brush to a 70 mm. by 150 mm. aluminum panel at the spreading rate recommended for application. The specimens were conditioned at room temperature (25°C.) for 24 hours and then placed in a vertical position for 5 hours in an oven maintained at a temperature of 60°C. The amount of flow was noted and recorded.

The results of the flow tests indicated that none of the specimens showed flow at 60°C for 5 hours.

3.3 Dust Retention Test

The dust retention test was developed to determine the ease of removal of simulated fallout particles from the surfaces of the various coating systems, originally and after predetermined periods of exposure to the accelerated weathering test.

The specimens were prepared as described in Section 3.1 and allowed to condition at room temperature (25°C.) for at least 48 hours.

Each specimen was dusted with a mixture of 3 parts U.S.P. talcum powder and 1 part of fluorescent powder[4/] (zinc salt of 8 hydroxyquinoline) and then inverted and tapped gently to remove the excess material. The specimen was then flushed with water maintained at a flow rate of 1500 ml. per minute through a 3/16-in. orifice, while being slowly revolved at an angle of 45°. After flushing with 500 ml. of water, the specimens were examined under a black light[5/] to indicate

[4/] Trade name "Glo-Craft", obtained from Switzer Bros., Inc., Cleveland 15, Ohio.

[5/] The Burton Twin Fluorescent Illuminator, No. 1920, equipped with two Sylvania black light, blue bulbs (4W).

TABLE 3.

Results of Accelerated Weathering Tests (Rating)[1/]

NBS No.	Substrate	Blistering	Cracking	Holes or Pits	Alligatoring & Checking	Shrinkage	Coverage	Adhesion	Durability
1	Smooth	0	0	0	0	0	2/	G	G
	Rough	0	0	0	0	0	P	G	G
2	Smooth	0	0	1	0	3	2/	P	P
	Rough	0	0	2	0	0	F	G	F
3	Smooth	0	0	0	2	1	2/	G	F
	Rough	0	2	0	0	1	P	G	F
4	Smooth	0	0	0	0	2	2/	F	G
	Rough	0	0	0	0	0	G	F	G
5	Smooth	0	0	0	0	0	2/	G	G
	Rough	0	3	0	0	2	G	G	F
6	Smooth	0	0	0	1	0	2/	G	G
	Rough	0	1	0	0	0	G	G	G
7	Smooth	0	0	2	3	0	2/	G	F
	Rough	0	0	1	0	0	F	G	G
8	Smooth	0	0	0	0	0	2/	G	G
	Rough	0	3	1	0	0	F	G	F
9	Smooth	0	0	0	0	0	2/	G	G
	Rough	0	1	0	0	0	G	G	G
10	Smooth	0	0	0	0	0	2/	G	G
	Rough	0	0	0	0	0	F	G	G

1/ 0 = None, 1 = Trace, 2 = Evident, 3 = Pronounced. G = Good, F = Fair, P = Poor.

2/ Not applicable.

the degree of removal of the fluorescent powder. The amount of fluorescence (brilliant light green color) was noted and recorded.

The dust retention tests were performed on specimens prepared on a smooth substrate after 0, 1000, and 2000 hours of exposure. The results are presented in Table 4. In addition, similar tests were made on the specimens prepared on the roughened surface after 2000 hours exposure and the results are given in Table 5.

4. OUTDOOR EXPOSURE

The outdoor exposure tests were conducted to study the performance of the ten coating systems on actual slag-surfaced, coal-tar pitch, built-up roofs. The roof selected as the test site was located on the Radio Building at the Atomic Energy Facility, Germantown, Md.

Prior to the application of the coatings, the roof surfaces were prepared as follows:

(a) The loose slag was removed by sweeping with a stiff-bristle broom.

(b) The deck was washed down thoroughly with a hose to remove dirt, dust and other fines which may have affected the adhesion of the coating system.

(c) The surface was allowed to dry thoroughly prior to the application of the coating.

On 6 June 1960, each coating system was applied by brush to an area of 21 sq.ft. of prepared surface. In the case of the emulsion-type coating, the roof surface was dampened slightly prior to the application of the material. The test applications were made by Atomic Energy Commission personnel and were witnessed by a number of manufacturer's representatives (all were invited) and members of the staffs of the Atomic Energy Commission and the National Bureau of Standards. Inspections of the exposures were made periodically, the latest being made on 13 January 1961 after approximately 6 months exposure. During the inspections, particular attention was directed not only toward the durability of the system, but also to those aspects which would contribute to the retention of fallout particles, such as alligatoring, checking, cracking, blisters, and pitting of the surface.

The results of the outdoor exposure tests after six months exposure are presented in Table 6.

TABLE 4.

Results of Dust-Retention Tests on Smooth Specimens

NBS No.	Rating[1/] after Exposure to Accelerated Weathering Tests for 0 hours	1000 hours	2000 hours
1	2	0	0
2	2	2	3
3	2	3	3
4	0	0	0
5	0	0	0
6	0	1	1
7	3	2	3
8	2	2	2
9	3	3	3
10	1	0	1

1/
Dust completely removed = 0
Trace = 1
Evident = 2
Pronounced = 3

TABLE 5.

Results of Dust-Retention Tests on Coatings Applied to Roughened (Glass Beads) Surface After Exposure of 2000 Hours to Weatherometer.

NBS No.	Rating[1/]
1	3
2	2
3	3
4	1
5	1
6	1
7	2
8	2
9	3
10	2

1/
Dust completely removed = 0
Trace = 1
Evident = 2
Pronounced = 3

5 DISCUSSION OF RESULTS

The results of the study indicated that two major problems exist in regard to the contamination and subsequent decontamination of a mineral-surfaced, built-up roof from radioactive fallout. The uneven surface of such a roof may permit the accumulation of fine particles and, most important, the difficulties encountered to completely decontaminate such a roof by conventional methods may prove formidable. The obvious solution to the problems appears to be in the conversion of the roughened surface to a smooth, dense surface by the application of a material capable of filling the voids between the granular surfacing. In this connection, the results indicated that 8 of the 10 materials appeared capable of meeting this requirement. However, is should be kept in mind that the protective system must also act as a durable weather surface and retain its desirable characteristics over a number of years of exposure. Surface irregularities resulting from cracks, blisters, holes and pits, alligatoring and checking, would in all probability hold rather tenaciously the fine particles of radioactive fallout. Poor coverage, of course, defeats the purpose of the system, although it does reduce the surface area to some extent. Poor adhesion to the substrate may allow the contaminant to penetrate to the area between the coating and the roof, rendering its removal impossible. Therefore, in the course of the study, particular attention was directed toward these conditions as they occured, in both the simulated service tests and the outdoor exposures.

As expected, the specimens which were applied to smooth bases performed better than those which were applied to the roughened substrate (glass beads) in that five of the ten specimens evidenced cracking to some extent under the latter condition and no cracking was observed under the former condition. It is interesting to note here that 8 of the 10 specimens showed some degree of cracking during the outdoor exposure tests.

The formation of blisters and subsequent pits, holes, and other surface irregularities resulting therefrom, appeared to be much more severe in the outdoor tests, both in the number of systems exhibiting the failure and the degree to which the conditions developed.

Coverage was generally not adequate with coatings of paint-type consistency, as Nos. 1 and 3. These materials, which contain relatively high volatile vehicle contents, flowed between each surfacing particle and deposited a thin film surrounding each granule, but still leaving numerous voids.

Poor adhesion to the substrate was exhibited by coating systems Nos. 4, 5, and 6 in the outdoor tests. This condition was evidenced by the curling of the edges of the test exposures and the presence of water between the old roof surface and the coating system. These failures were not observed during the simulated service tests in the laboratory.

There was no incompatability observed between the coating systems and the base during the outdoor exposure tests.

As expected, the dust retention tests indicated that the removal of the simulated fallout particles could best be accomplished from the specimens presenting a smooth, dense surface. On the other hand, the removal of the fine particles was quite difficult from the specimens on which the coverage was poor or where the surface was marked with irregularities caused by checks, cracks, pits, blisters, or other imperfections. Generally, the ease of removal was related to the degree of surface roughness.

In general, the results of the tests showed the outdoor exposures on actual roofs to be more severe than the simulated service tests conducted in the laboratory.

6. SUMMARY AND CONCLUSIONS

The following conclusions are based on the observations made during the application and subsequent inspections of the outdoor exposure specimens, as well as on the data which were obtained during the laboratory tests:

1. In the outdoor tests, Systems Nos. 2, 7, and 8 appeared to perform the most satisfactory. However, it is felt that the performance of these systems was not sufficiently adequate to justify their use on large roof areas.

2. Coatings which have a paint-type consistency, as Nos. 1 and 3, were not satisfactory due to their poor coverage over the surfacing granules of a built-up roof. These coatings, however, may have use as a protective or decorative covering over suitable systems.

3. Coatings which exhibited poor adhesion to the substrate, as Nos. 4, 5, and 6, are not considered satisfactory

4. Blisters, cracks, pits, alligatoring, and other surface irregularities retained the fine particles which are present in radioactive fallout. Cracking of the coatings appeared to be the most serious defect.

5 Multiple applications of a given coating appeared to give better results than a single, heavy application

6. The data which were obtained in the dust-retention test appeared to give a good indication as to the ease of removal of simulated fallout from a surface.

7. SUGGESTIONS

1. Since the correlation between the laboratory test and the outdoor exposures was generally poor, it is suggested that future weathering tests be restricted to outdoor exposure on existing surfaced roofs.

2. It is suggested that further consideration be given to the use of a plastic or other type of sheet material to facilitate fallout removal. The sheet, sufficiently large to cover a given area of a roof, could be stored in protected rolls along the edge of the roof and could be quickly unrolled in the event of a warning of a nuclear explosion. The entire sheet could be rolled up and removed to a disposal area, along with the contaminant, after the fallout had been deposited This method would be somewhat analogous to the protection afforded to a baseball infield by a plastic or canvas covering during a sudden summer shower. It would appear that a polyethylene sheet or similar material, with a minimum thickness of 4 to 6 mils, may prove satisfactory and economical for this purpose.

8. ACKNOWLEDGMENT

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TABLE 6.

Results of Outdoor Exposure Tests After 6-Months Exposure (Rating)[1/]

NBS No.	Spreading Rate	Blistering	Holes or Pits	Alligatoring & Checking	Cracking	Adhesion to Base	Coverage
	ft^2/gal						
1	18	2	2	0	0	G	P
2	15	2	3	0	0	G	G
3	21	0	0	1	2	G	P
4	13	0	3	0	2	P[2/]	G
5	14	1	3	0	3	P[2/]	G
6	19	1	3	0	2	P[2/]	G
7 Single Coat	10	0	0	0	1	G	F
Double Coat	10	0	0	0	2	G	G
8 Single Coat	10	0	0	0	2	G	G
Double Coat[3/]	15	0	0	0	1	G	G
9 Single Coat	9	0	0	0	3	G	G
Double Coat	7	0	0	0	3	G	G
10	13	0	0	0	3	F	G

[1/] G = Good, F = Fair, P = Poor. 0 = None, 1 = Trace, 2 = Evident, 3 = Pronounced.

[2/] Water between coating and old roof.

[3/] Second coat stabilized with sand.

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METROLOGY. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

HEAT. Temperature Physics. Heat Measurements. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research. Equation of State. Statistical Physics. Molecular Spectroscopy.

RADIATION PHYSICS. X-Ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

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