NATIONAL BUREAU OF STANDARDS REPORT

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MOISTURE-RESISTANT COATINGS FOR WALLS OF STRUCTURES USED FOR STORAGE

by

Edward R. Oglio and William C. Cullen

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Floor, Roof and Wall Coverings Section
Building Technology Division

Sponsored by
Bureau of Yards and Docks
Department of the Navy

NBS

MOISTURE-RESISTANT COATINGS FOR WALLS OF STRUCTURES USED FOR STORAGE

11. APPENDIX B - TABLES AND FIGURES

ABSTRACT

Tests were made to determine some of the pertinent characteristics of a number of commercially available cold-application coating materials proposed for use as water-vapor barrier coatings for the walls of structures used for storage. Standard methods of procedure, or adaptations of such methods, were employed for the most part. Determinations included water-vapor transmission rate, outdoor and accelerated durability, effect of exposure to accelerated test for durability on rate of water-vapor transmission, behavior at elevated (140° F) and at low (32° F) temperatures, adhesion to aluminum foil, tensile breaking strength, and bridging durability.

The results indicated that some coatings would be suitable for use as water-vapor barriers, while others, chiefly because of their high rate of transmission, lack of durability, or poor coverage on coarse masonry surfaces, would not. Two specifications covering three types of coating materials were formulated from the results obtained.

1. INTRODUCTION

The Bureau of Yards and Docks, Department of the Navy, is engaged in an extensive program of preservation of large stocks of military equipment stored in various warehouses throughout the country. Essentially, the method being employed consists in converting the structure into a vast water-vapor resistant package by coating the walls with suitable water-vapor resistant coatings. Inside such a structure humidity is automatically controlled at a level which Navy research has shown to be safe against the corrosion and degradation of materials caused by moisture. This method of preservation, in addition to safe storage, has the advantage that equipment need not be individually packaged or coated with preservatives. In this way such equipment requires but a minimum of maintenance and reconditioning to be made ready for use. Furthermore, items already packaged do not need periodic repacking for long-term preservation.

A satisfactory water-vapor resistant coating when used for the purpose of moisture control should possess, among others, the following characteristics:

1. High resistance to the passage of water-vapor.
2. Flexibility or ductility, which represents the capacity of the coating for elongation or stretching. This characteristic is indicative of the ability of the coating to withstand without rupture, stresses imposed by vibrations, expansion and contraction, or cracking of the sub-strate.
3. Adhesion to various types of building materials, e.g. masonry, metal, wood, glass, etc.
4. Resistance to flow on vertical surfaces with consequent loss in protection.
5. Ability to bridge over and seal surface voids and existing cracks.
6. Good cohesion. This is an indication of the resistance of the coating to tensile forces tending to rupture it.
7. Resistance to weather if the coating is to be used on the exterior.

2. PURPOSE

The purpose of the work was to determine the pertinent characteristics of several types of commercially available water-vapor resistant coating materials and to utilize the data obtained in formulating a purchase specification.

3. SCOPE

Since the ultimate aim was the formulation of a purchase specification covering a water-vapor barrier coating material, determinations were limited to standard methods of procedure or modifications and adaptations of such methods, avoiding wherever possible the use of highly specialized or complex apparatus.

By mutual agreement with the Bureau of Yards and Docks, the investigation covered mainly the various types of bituminous-base, cold-applied coating materials. Also included were a number of other types of coatings such as paints, lacquers and non-bituminous mastics.

4. MATERIALS

Sixty-three coating materials were submitted by various manufacturers through the Bureau of Yards and Docks, Department of the Navy, for inclusion in the test program. Of this number, thirteen were eliminated during the initial stages for various reasons so that, effectively, fifty materials were subjected to the tests.

4.1 Classification of Materials

For convenience, the coating materials were grouped into three general classes as follows:

Class I. "Mastic" Type

These are heavy-bodied materials consisting of organic bases thinned to a workable consistency with a volatile organic solvent and which may contain added stabilizers such as asbestos fiber, mineral flour, flake mica, etc., and pigments such as aluminum powder, red iron oxide, chrome green, etc. The organic bases in this grouping include asphalt, coal-tar pitch, fatty-acid pitch, various resins, rubber, drying oils, etc. The spreading rates of these materials vary from 20 square feet per gallon to 100 square feet per gallon.

Class II. Paint Type

The materials in this class are relatively thin-bodied coatings whose application rates are between 300 and 500 square feet per gallon. Included in this grouping are aluminum paints, light-colored paints, and one lacquer.

3. SCOPE

Since the situation did not lend itself to a performance specification covering a heterogeneous variety of materials, determinations were limited to standard methods of procedure or modifications and adaptations of such methods, avoiding wherever possible the use of highly specialized or complex apparatus.

By mutual agreement with the Bureau of Yards and Docks, the investigation covered mainly the various types of bituminous-base, cold-applied coating materials. Also included were a number of other types of coatings such as paints, lacquers and non-bituminous coatings.

4. MATERIALS

Sixty-seven coating materials were submitted by various manufacturers through the Bureau of Yards and Docks, Department of the Navy, for inclusion in this test program. Of this number, thirteen were eliminated during the initial stages for various reasons so that, ultimately, fifty materials were subjected to the tests.

4.1 Classification of Materials

For convenience, the coating materials were grouped into three general classes as follows:

Class I. Mastic Type

These are heavy-bodied materials consisting of organic bases thinned to a brushable consistency with a volatile organic solvent and which may contain added ingredients such as asbestos fibers, mineral fibers, flake mica, etc., and pigments such as aluminum powder, red iron oxide, carbon black, etc. The organic bases in this grouping included asphalt, coal-tar pitch, fatty-acid pitch, various resins, rubber, drying oils, etc. The spreading rates of these materials vary from 20 square feet per gallon to 100 square feet per gallon.

Class II. Paint Type

The materials in this class are relatively thin-bodied coatings whose spreading rates are between 200 and 400 square feet per gallon. Included in this grouping are aluminum paints, light-colored paints, and the lacquers.

Class III. Emulsion Type

These are dispersions of various materials in water and which may contain various fillers, stabilizers, pigments, etc. Included in this group are asphalt, coal-tar pitch, and several pigmented resin emulsions.

Table 1* lists the various materials according to class, manufacturer, brand name, and also gives some of their pertinent characteristics.

5. DURABILITY TESTING

In order to determine the weathering characteristics of the protective coatings, two methods were employed, namely, (1) exposure to normal weathering conditions (Washington, D.C.) and (2) exposure to accelerated tests for durability.

5.1 Outdoor Weathering Tests

5.1.1 Preparation of Test Specimens

Each coating material was applied to two test surfaces for outdoor exposure; the "Mastic" Type (Class I) and the Emulsion Type (Class III) were applied to cinder block and aluminum panels and the Paint Type (Class II) was applied to asbestos-cement board and aluminum panels.

The surfaces of the cinder block and asbestos-cement board were thoroughly cleaned and brushed free of all foreign matter, before the coating materials were applied. No other treatment was given to the test surfaces except in the case of the Emulsion Type (Class III). Here the surface was moistened with water prior to application of the protective coating.

The surfaces of the aluminum panels were prepared by thorough scrubbing with steel wool and degreasing in carbon tetrachloride.

The materials were then applied to the test surfaces, at the spreading rates recommended by the manufacturers (see Table 1), by brushing or troweling, depending upon the

*All tables and figures are attached to this report as Appendix B.

consistency. In instances where a recommended spreading rate was not available, the coating was applied at a rate comparable to other coatings of the same general type. After air drying in a well ventilated room at 75° - 80°F for a period of ten days, the test specimens were exposed to outdoor weathering.

5.1.2 Exposure Conditions

All specimens for outdoor tests were exposed at an angle of approximately 45° to the horizontal on the roof of the Industrial Building, National Bureau of Standards, Washington, D. C., with the coated surfaces facing South. The coated cinder blocks were placed with their lower edges resting on the faces of other, uncoated blocks, laid directly on the roof deck, while the other test panels (aluminum and asbestos-cement board) were exposed on elevated racks from 4 to 5 feet above the deck.

5.1.3 Results of Outdoor Exposure

The appearance of the coatings, after three years of outdoor exposure, is described in Table 2.

5.2 Accelerated Test For Durability

5.2.1 Apparatus

Exposure to accelerated tests for durability were made in an Atlas Weather-O-Meter consisting of a single, centrally located carbon arc, a cylinder, a water spray and an arrangement for automatic temperature control during the light period. Although the arc lamp operated on a 220 volt line, alternating current, the voltage was reduced by means of a resistance to 130-135 volts while the lamps operated at 15 to 17 amperes. An open aluminum cylinder, 31 in. in diameter and 15 in. in height, equipped with slots to hold the test specimens and connected to a revolving mechanism, encircled the lamp. The cylinder made one revolution in twenty minutes around the enclosed carbon-arc lamp and each test specimen was thoroughly washed by sprays of tap water once in each revolution as it passed the spray nozzles. The spray nozzles were located approximately two inches from the surface of the test specimens.

conditioner. In locations where a thermostatic controller was not available, the heating [illegible] comparable to [illegible] buildings of the same general type, [illegible] air during [illegible] of 70° - 75°F. For a period of ten days, the test specimens were exposed to [illegible].

3.1.2 Exposure Conditions

All specimens for outdoor tests were exposed at an angle of approximately 45° to the horizontal on the roof of the Industrial Building, National Bureau of Standards, Washington, D. C., with the exposed surfaces facing south. [illegible] from 4 to 6 feet above the roof.

3.1.3 Results of Outdoor Exposure

The appearance of the coatings, after [illegible] of outdoor exposure, is described in Table 2.

3.2 Accelerated Test for Durability

3.2.1 Apparatus

Specimens in accelerated tests for durability were exposed in an Atlas Weather-Ometer consisting of [illegible] from the surface of the test specimens.

5.2.2 Test Specimens For Accelerated Durability

The specimens, prepared on the aluminum panels as described in Section 5.1.1, were exposed in this apparatus (Section 5.2.1) to accelerated test for durability.

5.2.3 Exposure Conditions

The specimens were subjected to a weathering cycle consisting of approximately 17 minutes of light and 3 minutes of simultaneous light and wash water in each 20 minutes. During the light period the temperature at the surface of the panels rose to and was maintained at 130 ±5°F. No attempt was made to control the temperature of the tap water used for the washing. Each specimen was changed at intervals to compensate for unavoidable differences of position in relation to the light source.

5.2.4 Results of Exposure

The appearance of the coatings after exposure to this accelerated test for durability is described in Table 2a.

6. WATER-VAPOR PERMEANCE

6.1 Apparatus

6.1.1 Test Cell

In order to eliminate variations caused by unavoidable differences between specimens made from the same material, it was thought desirable in determining the effect of exposure on water-vapor permeance, to employ the same specimens throughout the weathering cycles. The cell (see Figure 1) consisted of a shouldered ring "A" that served as a specimen holder and a bottom or seal plate "B". In practice, the circular specimen, cut to proper size, was placed on and sealed to the shoulder of ring "A" with sufficient hard, water-vapor resistant wax to insure a good vapor-tight bond. The ring, with specimen affixed, was then inverted and charged with desiccant. The bottom plate "B" was also inverted and immediately placed on the desiccant-loaded ring as a cover. Reversion was quickly made of the whole assembly to its correct position and the bottom plate was then sealed (microcrystalline wax) to the specimen holder. The assembled cell with desiccant sealed inside is shown as "C". An aluminum template "D" of accurately known area and a centering ring "E" were used to sharply define and center the test area in the specimen holder.

Additional determinations of water-vapor permeance on the same specimen were made by simply removing the bottom plate and recharging (fresh desiccant) the cell. This manipulation did not disturb the vapor-tight seal between the specimen holder and the specimen nor did it damage the specimen itself.

6.1.2 The Constant Temperature - Constant Humidity Chamber

Determinations of water-vapor permeance require the maintenance of constant conditions of temperature and humidity. To accomplish this a cabinet was designed and constructed which controlled the temperature at 100 ±1°F and the relative humidity at 82 ±2%. Under the conditions, the vapor pressure within the chamber was equivalent to 1.595 in. of mercury (calculated).

6.1.3 Desiccant

It was necessary to employ a desiccant which was chemically inert, in order not to damage the specimen, and still have a large capacity for absorbing and holding water. For these reasons, activated silica gel, 6-16 mesh, supplied by the Davison Chemical Corp., Baltimore, Md., was used.

6.2 Test Surfaces

The coatings were applied to a non-absorptive sheet which had a relatively high rate of water-vapor transmission. Experience has shown, however, that when certain types of coatings are applied to an absorptive base, the resulting water-vapor permeance of the system is somewhat higher than when a non-absorptive base is used. With this in mind, fifteen coatings selected from the three classes were also applied to an absorptive sheet. These two types of test surfaces were:

1. Non-absorptive base. "Mattex" Acetate sheet, 0.01 in. in thickness, one surface having a mat finish. This material was not apparently affected by any of the organic solvents present. The permeance of this material was 175 grams per square meter per day (6.7 perms) under the conditions of test.
2. Absorptive base. Asbestos-cement board, 1/8 in. in thickness, having a smooth surface and capable of absorbing the organic solvents and at least part of the vehicle of the coating materials. The permeance of this material was 538 grams per square meter per day (20.5 perms) under the test conditions.

6.3 Preparation of Test Specimens

Test specimens were prepared by applying the coatings on clean surfaces at spreading rates recommended by their respective manufacturers. One of the following methods was used for each material depending upon its nature:

1. Doctor Blade (Boston-Bradley Adjustable Blade).
2. Brushing.
3. Troweling (with or without a mask).
4. Spraying.

Methods used to apply each coating are presented in Table 3.

6.4 Accelerated Test for Durability and Water-Vapor Permeance

Many investigations have indicated that protective coatings, upon being exposed to ultra violet radiation and water (sunlight and rain during normal weathering) undergo changes in both their physical and chemical characteristics. Some of the changes are advantageous, while others are not. Since low water-vapor permeance is of particular significance in this study, it was desirable to determine what affect weather would have on this property of the coating material. To accomplish this in the shortest possible time, the test specimens were exposed to accelerated tests for durability and the water-vapor permeance determined after selected intervals of exposure. The selected time intervals were 0, 500, 1000, and 2000 hours for those coatings on the non-absorptive sheet (acetate sheet) and 0, 1000, and 2500 hours for those on the absorptive type of sheet (asbestos-cement board).

6.5 Test Procedures

The method used for the determination of water-vapor permeance of the protective coatings was essentially as outlined in "Tentative Method of Test for Water-Vapor Permeability of Paper, Paperboard, and Other Sheet Materials", ASTM Designation D988-48T, except that the area of the specimen tested was 11.46 sq. in. and the determinations were made at 100 ±1° F and 82 ±2% relative humidity. Assuming zero water-vapor pressure inside the cell, the vapor pressure differential across the film was 1.595 in. of mercury (calculated).

6.3 Preparation of Test Specimens

Test specimens were prepared to simulate the coating-as-[illegible] [illegible] to [illegible] [illegible] [illegible] by [illegible] [illegible] [illegible]. One of the following methods was used for each material depending upon the type:

1. Doctor blade (Boston-Bradley adjustable-blade).
2. Brushing.
3. Troweling (with or without a screed).
4. Spraying.

Methods used to apply each coating are presented in Table 3.

6.4 Exposure Test for Durability and Vapor-Permeance

Many investigators have indicated that protective coatings, upon being exposed to ultra violet radiation and heat [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]. Some of the coatings are [illegible], while showing [illegible] [illegible] [illegible] [illegible] [illegible] is of particular significance in this study. It was desirable to determine what effect weather would have on this property of the coating material. To accomplish this in the shortest possible time, the test specimens were exposed to accelerated tests for durability and the water-vapor permeance was determined after selected intervals of exposure. The exposure time intervals were 0, 500, 1000, and 2000 hours [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

6.5 Test Procedure

The method used for the determination of water-vapor permeance of the protective coatings was essentially as outlined in "Standard Method of Test for Water Vapor Permeability of Sheet Materials", [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]. The area of the specimens tested was 11.45 sq. in. and the determinations were made at 100 °F and 90 percent relative humidity. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the vapor pressure difference across the film was 1.93 in. of mercury (calculated).

The specimens were prepared and allowed to dry to constant weight before initial water-vapor permeance determinations were made. After the initial determinations were made, the cells were disassembled, the desiccant removed, and the specimens exposed in accelerated weathering unit (see Figure 2). The unit used was a "Type XWCL-X Weather-O-Meter", manufactured by the Atlas Electric Devices Company, Chicago, Ill. Only one arc, centrally located, was used as the source of radiation and its power consumption was approximately 1.8 kilowatts per hour. In order to eliminate the injurious effects of the wash water wetting the Mattex Acetate backing sheet, the weathering cycle was altered. The altered cycle consisted of 22 hours of exposure to the carbon-arc light followed by a one hour wash with water. This was accomplished by removing the specimens from the weather-ometer and placing them in a horizontal position. Water was then poured on the surface of the coating until it was level with the rim of the specimen holder. After one hour, the water was removed and each surface rinsed three times.

In the case of the coatings applied to the absorptive sheet (asbestos-cement board), the conventional cycle of 17 minutes of light and 3 minutes of light and spray water in each 20-minute period, was used.

The temperature of the wash water, in both cycles, was approximately 77°F and the water was essentially mineral and metal free having passed through a "Filt-R-Still" Demineralizing Unit prior to use.

6.6 Results of Water-Vapor Permeance Tests

In Table 3, the water-vapor permeance of the coating materials, as well as those of the base sheets, are reported in terms of grams of water vapor passing through the coated surface of one square meter in 24 hours and in "Perms". The "Perm" is defined as the amount of water vapor, in grains, that will pass through an area of one square foot in one hour when there is a water-vapor pressure differential of one inch of mercury across the membrane. When test conditions are 100°F and 82% relative humidity, the following formulas may be used to convert

one to the other:

(1) $\frac{\text{Grams x .038}}{\text{Sq. m. x day}}$ = Perms

(2) Perms x 26.32 = $\frac{\text{Grams}}{\text{Sq. m. x day}}$

The unit "Perm" has been used by the Housing and Home Finance Agency in their publication "Condensation Control" to classify coatings into two groups as follows:

> <u>Vapor Barrier</u> - A material capable of preventing or effectively restricting the movement of water vapor from a zone of high vapor pressure to one of lesser vapor pressure and permitting not more than one grain of water vapor to pass through one square foot in one hour, when the water vapor pressure differential is one inch of mercury when tested by a dry cup method.

> <u>Breather</u> - A material capable of preventing air infiltration and permitting the transmission of at least 5 grains of water vapor per square foot, under the conditions just described.

The results of the various determinations of water-vapor permeance are given in Table 3 and 3a.

7. MISCELLANEOUS TESTS

7.1 Behavior at 60°C (140°F)

The tendency of a coating to exhibit flow was determined by a rather simple method widely used in laboratories concerned with testing organic protective and decorative coatings. In essence the method consists in measuring flow of a coating, when exposed vertically, at 140°F.

The coating materials were applied at the manufacturer's recommended spreading rates to clean steel panels (6- by 4- by 0.016-in.) leaving a one-inch uncoated portion along the top edge of each. A piece of thread was carefully embedded

into the surface of the coating, parallel to and at a distance of two inches from the top edge of the panel. The specimens were placed in a horizontal position for one hour in a well ventilated room at 70-80°F. At the end of this conditioning period, the panel was suspended vertically for five hours in an oven maintained at 140 ±2°F. At the end of this exposure period, the panels were removed from the oven, allowed to cool, and examined for flow. This was indicated by rippling of the surface film, drippage of the coating from the panel, or displacement of the thread from its original position. For results of the flow test, see Table 4, Column 1.

7.2 Behavior at 0°C (32°F)

The behavior of the coating when subjected to flexure at 0°C (32°F) was used as an indication of its ability to withstand without rupture stresses imposed by vibration, expansion and contraction, or cracking of the sub-strate.

The same specimens which were used in the Behavior at 60°C (140°F) test (see Section 7.1) were used in this test. When the final inspection of the panels was completed after the Behavior at 60°C (140°F) test, they were placed in an ice bath (0°C, 32°F) for a period of one hour. They were removed and immediately bent 180°, coated side up, over a one-inch mandrel in approximately two seconds. The specimens were examined for cracking of the coating and loss of adhesion to the steel panel.

The results of this test are presented in Table 4, Column 2.

7.3 Adhesion to Aluminum Foil

To be of the greatest significance, the adhesion of the protective coating should be determined when the coating is applied to the surface on which it is to be used. However, since this was impractical for laboratory evaluation, it was decided to measure adhesion when the coating was applied to a smooth, dense surface. Aluminum was chosen since it possesses these requisites.

In each case the coating was applied, at the manufacturer's recommended spreading rate, to 9- by 12-in., clean, 0.004-inch aluminum foil, leaving an uncoated area along both the surfaces of the coating, parallel to and at a distance of one inch from the top edge of the panel. The specimens were placed in a horizontal position for one hour in a well ventilated room at 75-80°F. At the end of this conditioning period, the panel was suspended vertically for five hours in an oven maintained at 140°F. At the end of this exposure period, the panels were removed from the oven, allowed to cool, and examined for flow. This was indicated by slipping of the stained scale, sagging of the coating from the panel, or displacement of the lines from the original position. The results of the flow test, see Table V, Column 1.

7.2 Cracking at 0°F (-18°C)

The toughness of the coating when subjected to flexure at 0°F (-18°C) was used as an indication of the ability to withstand without rupture stresses imposed by vibration, expansion and contraction, or warping of the substrate.

The same specimens which were used in the resistance to 60°C (140°F) test (see section 7.1) were used in this test. When the final inspection of the panels was completed after the exposure at 60°C (140°F) test, they were placed in an ice box (0°F, -18°C) for a period of one hour. They were removed and immediately bent 180°, coated side out, over a one-inch mandrel in approximately two seconds. The specimens were examined for cracking of the coating and loss of adhesion to the steel panel.

The results of this test are presented in Table V, Column 2.

7.3 Adhesion to Aluminum Foil

To be of the greatest significance, the adhesion of the protective coating should be determined when the coating is applied to the surface on which it is to be used. However, since this was impractical for laboratory evaluation, it was decided to measure adhesion when the coating was applied to a smooth, dense surface. Aluminum foil was chosen as possessing these properties.

In each case the coating was applied, at the rate recommended by the manufacturer, to a 3 by 6-inch, 0.005-inch aluminum foil, leaving an uncoated area along one edge measuring 3 in. wide and 12 in. long. After air-drying in a well ventilated room at 70-80°F until constant weight was attained, the coating was carefully cut through to the foil. The cut was made parallel to the 12-inch dimension and one inch from the junction of the coated and uncoated foil. The foil was folded back 180° along this line of cut. A sheet of 15 lb, asphalt-saturated felt, 9- by 12-in., was then cemented to the 5- by 12-in. coated section of the foil with a water-soluble glue conforming to the requirements of Federal Specification C-G-463. To promote good bonding, a 50-lb weight was placed on the specimen and allowed to remain for four hours. Strips two inches wide were then cut parallel to the 9-inch dimension and allowed to age for 24 hours to permit final setting of the glue. In this manner, test strips 2- by 9-in. in size were obtained with a coated and cemented portion measuring 2- by 5-in. and free ends of felt and foil measuring 2- by 4-in.

The aluminum foil was carefully stripped from the coating, by hand, a distance of 1/4 in. from the cut previously made. The free end of the felt was clamped in the upper jaw of a tensile strength machine and the free end of the foil in the lower jaw. The foil was then stripped from the coating to within 1/2 in. of the end of the specimen. The temperature during the test was 77 ±2°F and the jaws moved at a rate of 12 ±1 in. per minute.

The maximum pull, in pounds per two-in. strip, necessary to strip the foil from the coating was determined for each specimen and the results are presented in Table 4, Column 3.

7.4 Tensile Breaking Strength

Tensile breaking strength measurements were made as an indication of the resistance of the coatings to tensile forces tending to rupture them. These measurements were made on free films of the coating materials.

Two methods had to be employed to make free films. For Class I coatings, the materials were applied, at the manufacturer's recommended spreading rate, to the gummed surface of dextrin paper. The coatings were allowed to dry in a well-ventilated room until substantially constant bed with thermometer [illegible] air-drying in a well ventilated room at [illegible] specimen weight was obtained, the specimen was carefully put through to the grip. [illegible] the 12-inch dimension and [illegible] capacity of [illegible] [illegible] specimen [illegible] of the [illegible] with a [illegible] specifications [illegible] weight was placed on the specimen and allowed to remain for four hours. [illegible] parallel to the [illegible] dimension and allowed to dry for 24 hours to [illegible] final setting of the glue. [illegible]

The [illegible] was [illegible] [illegible] [illegible] specimen. [illegible] per minute.

The [illegible] [illegible] [illegible] in Table [illegible], Column [illegible].

7.3 Tensile Breaking Strength

Tensile breaking strength measurements were made as an indication of the [illegible] of tensile forces [illegible]. [illegible]

The specimens had to be [illegible] manufacturer's recommended [illegible] weight was attained. Strips, measuring 2- by 5-in., were cut from the coated and dried sheets and the free films separated from the gummed paper by soaking in water and stripping. The free films thus obtained were thoroughly washed and dried.

The Class II materials were prepared in essentially the same manner except that cellophane sheets, stretched over flat brass plates, were used in place of the gummed dextrin paper.

The 2- by 5-in. free films prepared as above were placed in a tensile strength machine with their long axes parallel to the direction of pull. The temperature during the test was 77 ±2°F and the jaws of the machine moved at a rate of 12 ±1 in. per minute.

The maximum pull, in lb. per 2-in. strip, required to rupture the specimen was taken as the tensile breaking strength and these data are recorded in Table 4, Column 4.

7.5 Bridging

Two aspects of bridging should be considered: (1) the ability to bridge over a gap, hole, space, etc., and (2) the durability of the bridge once formed. The laboratory was not equipped with the heavy-duty spray facilities which were necessary for determining bridging ability; therefore, such tests were not made. It was felt that an "on the job" acceptance test would be more practical. This could be done by applying the coating material, with the equipment that is actually used on the job, to a frame containing a specified number of openings of specified size. A requirement as to the minimum number of openings expressed as a percentage, that are to be bridged at the recommended spreading rate, might be specified for acceptance. For the determination of bridging durability, a test was devised and applied to seventeen of the Class I (Mastic type) coatings. A brief description of this test follows:

7.5.1 Procedure

The material under test was applied to gummed dextrin paper at the manufacturer's recommended spreading rate and air dried for one hour at 70-80°F. A No. 4 galvanized wire screen measuring 3 inches by 6 inches was placed on the

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

partially set coating and a slight pressure, to promote adhesion, applied to the screen. After the coating, with screen in position, had dried thoroughly (two to three days were allowed for this), the gummed dextrin paper was removed in the usual manner and the test specimen dried at 70+10° F for a period of two weeks.

The test specimens were then placed in an Atlas single arc accelerated weathering unit such as described in Section 6.5 and exposed for 1600 hours. The cycle consisting of 17 minutes of arc light and 3 minutes of both water spray and light in each twenty-minute period was used in this test.

7.5.2 Evaluation

The results were determined by inspection of the panels at the expiration of the 1600 hours of exposure. Note was taken of the number of openings in the screen which were no longer bridged over by the coating. This number, divided by the total number of openings in the screen and multiplied by 100, gave the percentage of bridge failures as reported in Table 4, Column 6.

8. SUMMARY OF RESULTS

8.1 Class I Coatings ("Mastics")

8.1.1 Water-Vapor Transmission

As a group, the coatings in this class exhibited low rates of transmission (Tables 3 & 3a) between 0.5 and 5 grams per square meter per day at 100° F and 92% relative humidity. However, a number of exceptions were noted, as follows:

N.B.S.	No. 17	(on asbestos cement)	- 51.6
"	No. 51	(on acetate sheet)	- 9.7
"	No. 53	(" " ")	- 8.3
"	No. 54	(" " ")	- 7.2
"	No. 56	(" " ")	- 6.3

The generally low rates obtained with this class of coatings are typical of those materials known as bituminous cements and coatings (which most members of this class are). This is attributed to the hydrophobic nature of the bituminous vehicles and to the thickness of the coatings as used. The one exception, coating No. NBS 17 on asbestos cement, is probably due to absorption of its vehicle by the board.

Determination of transmission rates after exposure to the accelerated test for durability (Tables 3 & 3a) indicated that generally there were small changes after exposure to 2000 hours on acetate sheet. A number of exceptions were noted, however, especially in instances where exposure caused such disruption to film integrity as alligatoring, cracking, checking, hummocking, etc. Indeed, in a number of instances, the rates decreased slightly.

All seven coatings on asbestos cement showed some rate increase with exposure (2500 hours) to the weathering cycle. However, in only one instance (No. 1) was the increase appreciable.

8.1.2 Outdoor Weathering

Except for coatings 14, 17, 18, 29, 30, 53 and 54, the members of this class did not show good durability on cinder block during the three years of exposure covered to date. A number of the coatings blistered (Table 2) within the first year. This was not totally unexpected since the transmission rates of these coatings were all under 2 grams of moisture per square meter per day under the conditions of test (see Section 6.5) and the cinder blocks were open backed. This condition permitted water to soak into the masonry and migrate behind the coating during rain periods. It is probable that during the day periods, under the influence of a hot, bright sun, this water vaporized and blistered the coating. Figures 3-14 show the coatings after two years of outdoor exposure on cinder block.

Considerable improvement in durability toward outdoor weather was noted when these coatings were exposed on aluminum. In fact, half of them were rated as "Very good" or better on the basis of their performance during the three years this test has covered to date.

8.1.3 Accelerated Test For Durability

The results of exposure to the accelerated test for durability described in Section 5.2 paralleled, with some five exceptions (see Tables 2 & 2a), those obtained in outdoor weathering when exposed on aluminum.

8.1.4 Flow Properties - Behavior at 60°C (140°F)

Of the thirty materials subjected to this test (see Section 7.1), twenty-one performed satisfactorily, showing not more than 1/4" displacement of the indicating thread and no slide or drippage from the test panel. The remainder showed a thread displacement of 0.5 to 1.5 inches and a drippage of 2% to 20%.

Satisfactory performance in this test is an indication that the material is capable of application to vertical surfaces without deleterious flow, drippage, blistering, etc.

8.1.5 Flexibility - Behavior at 0°C (32°F)

Five of the thirty coatings tested were unsatisfactory in this test. All five developed one or more cracks with attendant diminution in adhesion at the area of bend. The remaining twenty-five showed no cracking or any apparent loss in adhesion.

Behavior in this test is considered an indication of the expected performance of a coating when subjected to vibration, expansion, contraction or other stresses caused by changes in the substrate. Satisfactory performance here indicates some ability to withstand, without rupture, the effects of such stresses.

8.1.6 Adhesion

Adhesiveness of a coating material is influenced by the nature of the non-volatile vehicle and the amount of mineral stabilizer, among other factors. The coatings included in this class varied considerably in the amount of stabilizer and to a somewhat lesser extent in the nature of the base material employed in formulation. It was not surprising, therefore, that adhesion as determined in Section 7.3, ranged from 1.0 to 10.8 lb. An interesting sidelight was revealed by the fact that a good correlation existed between adhesion and performance in the test "Behavior at 32°F". Those with the lowest adhesion values (3.5 lb. or less) gave the poor performances (failures) in the "Behavior at 32°F" test.

8.1.7 Cohesiveness (Tensile Breaking Strength)

Cohesiveness can be considered as the force by which molecules of the same substance are held together, and enables the substance to resist forces tending to pull it apart. Furthermore, this property of bituminous substances, from which most members of the Class I coatings were formulated, is a function of hardness. Other things being equal, the harder the coating the greater the tensile breaking strength (cohesiveness).

The results (Table 4) showed that members of this class varied as much in this characteristic as in adhesiveness although no established relationship exists between these two properties of substances. Eleven of the twenty-nine coatings tested,as described in Section 7.4, for cohesiveness gave values lower than 5 lb. with the values for the remaining eighteen ranging from 7.3 to 19.2 lb.

8.1.8 Bridging Durability

A test for Bridging Durability (Section 7.5) was made on seventeen of the coatings in this class. The results indicated (Table 4) that no general trend existed except that the thickest coatings appeared the most durable. It was found that the bridges, in ten of the seventeen coatings, survived 1600 hours of exposure to the accelerated test for durability. Failures of the bridges ranged from 10 to 100% for the remaining seven.

8.2 Class II Coatings (Paint Type)

8.2.1 Water-Vapor Transmission

The coatings of this class exhibited the highest transmission rates (Table 3) of the three groups included in the study. Except for two members of the group, these rates ranged from 10.5 to 67.1 grams per square meter per day. These exceptions were Nos. 23 and 42, and their rates were 1.5 and 4.2 grams per square meter per day, respectively. Undoubtedly, the relatively high permeances shown by these coatings as a group is due to the high spreading rates employed as well as to their formulation.

Exposure to the accelerated durability test (Section 5.5) had a similar effect on the transmission rates (Tables 3 & 3a) of this class as on the Class I coatings. Moderate changes occurred during the cycle in which acetate sheet was the backing for the coating. Here again some were in the direction of an increase in rate while others were in the opposite direction. Somewhat different results were obtained on asbestos cement. In this cycle, all four coatings that were tested showed an increase. This was large for three of the coatings and moderate in the case of the remaining one.

6.2.2 Outdoor Weathering

The coatings of this class were considered too thin for application to the rough-textured surface presented by cinder block. Therefore, for outdoor exposure, application was made on asbestos-cement board as a masonry surface and on aluminum as stated in Section 5.1.1. Seven of the twelve coatings in this class have shown little or no effect (Table 2) from the three years of outdoor exposure reported to date. The seven included five aluminum paints, one synthetic resin base paint and a floor enamel. Three exhibited extremely poor durability during the period, while the remaining two showed a little more than average effect from the weather.

Some decrease in durability toward outdoor weathering was noted when this class was exposed on aluminum. This was apparently caused by a substantial decrease in adhesion and by an increased tendency toward alligatoring of the affected coatings. Actually, four materials exhibited less durability, six showed equal durability, while two appeared to be more durable on asbestos cement (Table 2).

6.2.3 Accelerated Test for Durability

The results of exposure to the accelerated test for durability showed good correlation with the outdoor durability tests. Six of the coatings were rated excellent in behavior, four poor, one very good, and one good. This almost exactly duplicated the ratings (Tables 2 and 2a) for these coatings after three years of outdoor exposure on asbestos-cement board.

8.2.4 Miscellaneous Tests

The high spreading rates and consequent thin films rendered impractical application of the Miscellaneous Tests described in sections 7.1-7.5 to the members of this class.

8.3 Class III Coatings (Emulsions)

8.3.1 Water-Vapor Transmission

All members but one in this group are classed as bituminous emulsions. The rates of water-vapor transmission of these coatings on acetate sheet ranged from 3.3 to 135 grams per square meter per day while averaging 33 grams per square meter per day (Table 3), and were generally intermediate between those of the Class I and Class II coatings.

The rates determined after exposure to the accelerated test for durability (Section 6.5) were generally lower than before exposure. Coatings Nos. 10 and 36 were the only exceptions to this trend.

8.3.2 Outdoor Weathering

The durability of the group appeared to be the best of the three studied. This was true whether exposure was made on cinder block or on aluminum. No coating was rated lower than "good", while most were rated either "very good" or "excellent" in durability after exposure for three years. This superior performance is due to the fact that the majority of the coatings in this grouping are bituminous emulsions, a class of materials noted for their durability. No blistering occurred on cinder block (compare Section 8.1.2) under the severe conditions of exposure. This is attributed at least in part to the moderate rates of water-vapor transmission that appeared to be characteristic of the group.

8.3.3 Accelerated Test for Durability

The behavior of the coatings in the accelerated test for durability (Table 2a) duplicated almost exactly their behavior outdoors. Again, the characteristic durability of the bituminous emulsions was demonstrated by the results of the test.

8.3.4 Flow Properties - Behavior at 60°C (140°F)

All coatings in this group showed satisfactory behavior in this test, there being no displacement of the indicating thread nor any drippage or flow of the coating from the test panel. This behavior indicates that these coatings are capable of application to vertical surfaces without deleterious flow, dripping, blistering, etc.

8.3.5 Flexibility - Behavior at 0°C (32°F)

Only three of the eleven coatings in this group met this test satisfactorily. However, it should be noted that the conditions of test are severer than are ordinarily used in evaluating bituminous emulsion coatings. Usually, the test is performed at a temperature of 77°F. The lower temperature was used in order that comparison could be made with the Class I ("Mastic" type) coatings. On the basis of performance here, the Class I coatings appear to be more ductile than the Class III coatings and might be expected to withstand better the stresses caused by expansion, contraction, vibration, etc., of the sub-strate.

8.3.6 Adhesion

The values obtained for adhesion ranged from 1.4 lb. to 6.9 lb. (Table 4) as tested. It should be noted that half of these coatings gave values below 3.4 lb. This compares with approximately one-third for the Class I ("Mastic" type) coatings. Also, adhesion values averaged 3.5 lb. for this class as compared to a 4.9 lb average for Class I. Here again the results of these tests indicate a superiority of the Class I coatings over the Class III coatings in a property that is considered important.

8.3.7 Cohesiveness (Tensile Breaking Strength)

Tensile breaking strengths (Section 7.4) varied from a minimum of 2.2 lb to a maximum of 27.6 lb with the average at 10 lb for the group. The average is higher then for the Class I coatings. However, it would be the same for the two groups if the value for coating No. 33, which is a vinyl resin emulsion, were not considered.

9. SUGGESTED SPECIFICATIONS

The tests have served as bases for the two specifications covering three types of water-vapor resistant coating materials that are included in Appendix A. Only those tests and requirements that were considered practicable from the standpoint of acceptance testing were included. Nevertheless, it is believed that they are descriptive of materials which would perform satisfactorily as water-vapor barriers. If low water-vapor permeance were not a major consideration, a number of highly decorative coatings suitable for application to masonry would also be available for use. Some of these coatings are described in National Bureau of Standards Report No. 1603 entitled "Protective Coatings for Exterior Concrete Masonry Surfaces".

10. APPENDIX A - SPECIFICATIONS FOR MOISTURE-RESISTANT COATING MATERIALS

SPECIFICATION

FOR

COATING MATERIAL; MOISTURE-RESISTANT (FOR WALLS)

1. SCOPE

The materials furnished under this specification shall be moisture-resistant coatings capable of spray application in relatively thick films for the interior or exterior walls of structures used for storage, and shall be of the following types as indicated in the invitation for bids, contract or purchase order.

Type I - Resin or drying-oil base coating intended for either interior or exterior application.

Type II - Bituminous cut-back type intended primarily for interior application.

2. GENERAL REQUIREMENTS

Type I coating material shall be composed of a resin or drying-oil base, pigments, mineral stabilizers, and a suitable volatile, organic thinner. No water, toxic, or highly inflammable substance shall be used in the formulation. It shall be of the color specified by the purchaser and shall be suitable for brush or spray application, at a spreading rate of 3-4 gallons per 100 square feet, to vertical surfaces of wood, masonry, metal, etc., to give a continuous, adherent coating over the surface.

Where a primer is recommended by the manufacturer, its use shall be mandatory.

Type II coatings shall be composed of a bituminous base material, with added mineral stabilizers, thinned to a workable consistency with a suitable volatile, organic thinner. They shall conform to the same general requirements as the Type I coatings except that there shall be no restriction as to color.

3. DETAIL REQUIREMENTS

The coating material shall conform to the requirements enumerated below.

	Type I Max.	Type I Min.	Type II Max.	Type II Min.
Non-volatile, % by weight	--	55	--	50
Ash, % by weight	55	25	45	10
Water-vapor permeability, perms	1.0	--	0.2	--
Tensile breaking strength, lb	--	--	--	3
Adhesion, lb	--	--	--	3
Behavior at 60°C (140°F)(sagging, drippage, blistering, flow)	1/		1/	
Behavior at 0°C (32°F) (cracking through to metal on bending over 2" mandrel)		----		None
Bridging durability[2], % failure	10			
Increase in permeance[2] after weathering (accelerated) for 2500 hrs., perm	0.2[3]			

[1] Not more than 1/4" sag or displacement of guide string and no blistering of coating or drippage from test panel.

[2] Applies only to coatings for exterior application.

[3] The coating shall show no cracking, checking, alligatoring, or loss of adhesion.

4. METHODS OF TEST

4.1 Non-volatile matter

Weigh about 10 grams of the sample (nearest 0.01 gram) into a tared flat-bottomed metal dish about 5 to 6 centimeters in diameter. Heat the dish and its contents in an oven maintained at 105-110°C (221-230°F) for 24 hours or until successive hourly weighings show a loss of not more than 0.04 grams. Cool and weigh. From the weight of the residue and the weight of the original sample taken, compute the percentage of non-volatile material.

4.2 Ash

Place from 5 to 10 grams (weighed to the nearest 0.001 gram) of the coating material into a previously ignited and tared porcelain crucible and incinerate at not above a dull red heat (550-600°C) until all carbonaceous matter is consumed or until essentially constant weight is attained. Cool in a desiccator and weigh. From the weight of the sample taken and the weight of the residue in the crucible, compute the percentage of ash.

4.3 Water-vapor permeability

Apply the coating at a spreading rate of 3-4 gallons per 100 square feet to at least two circular discs of 1/8-in. asbestos cement of suitable diameter, and conforming to the requirements of Federal Specification SS-S-282, Type I. Care should be exercised in applying the coating so that an essentially uniform film is obtained. Allow the coated discs to condition in a well-ventilated room at 21-27°C (70-80°F) until constant weight is attained. Determine water-vapor permeability in accordance with the method described in "Tentative Method of Test for Water-Vapor Permeability of Paper, Paperboard, and other Sheet Materials", ASTM Designation D988-48T. Calculate permeability and express as perms (grains per square foot per hour per inch of water-vapor pressure differential across the specimen).

4.4 Tensile breaking strength

Apply the coating at a spreading rate of 3-4 gallons per 100 square feet to the gummed surface of at least two 8- by 6-in. sheets of gummed dextrin paper (White Dextrin Paper, No. 502-1/2D, manufactured by the McLaurin-Jones Company, Brookfield, Mass., is recommended for this purpose). Place the coated sheets in a well-ventilated room at 21-27°C (70-80°F) and allow to condition until substantially constant weight is attained.

Cut six strips, 2- by 6-in., from the coated and dried sheets and soak the strips in water to remove the coatings. This can be done by allowing sufficient time for the water to penetrate the back coating of paper and soften the dextrin. When this has occurred, carefully strip the paper from the coating and thoroughly rinse the free film thus obtained. Allow the films to dry and then condition at 73 ±2°F for four hours.

Place the test strips (free films), with their long axes parallel to the direction of pull, in a testing machine of the inclination-balance type. Determine the tensile breaking strength at 73 ±2°F with the lower jaw moving at a rate of 12 ±1 in. per minute. Record the maximum pull in pounds required to rupture the specimen and average the results obtained for the six strips tested.

4.5 Adhesion

Apply the coating uniformly at a spreading rate of 3-4 gallons per 100 square feet to clean, 9- by 12- by 0.004-in. aluminum foil leaving an uncoated area 3 inches wide along one of the long edges. Allow the coated sheets to dry in a well-ventilated room (70-80°F) until constant weight is attained. With a sharp knife or similar implement, carefully cut through the coating to the foil. This cut is made parallel to the 12-in. dimension of the sheet and a distance of one inch from the line of junction of the coated and uncoated foil. Fold the foil back 180° along this line of cut.

Cement a 9- by 12-in. sheet of 15-lb asphalt-saturated felt to the 5- by 12-in. coated section, obtained above, with a water soluble glue conforming to the requirements of Federal Specification C-G-463. (In placing the felt during this operation, it should be positioned on the coated foil so that the 12-in. and 9-in. dimensions of sheet coincide). To promote bond, place a 50-lb weight on the specimen and allow to remain for 4 hours.

Remove the weight and cut the specimen into strips 2 inches wide, making the cuts parallel to the 9-in. dimension. Allow the 2-in. specimens so obtained to age for 24 hours to permit final setting of the glue. In this manner, 6 test strips measuring 2-in. wide and 9-in. long, with a coated and cemented "sandwich" portion measuring 2- by 5-in. and free ends of felt and foil measuring 2- by 4-in., are obtained.

By hand, carefully strip the aluminum foil from the coating a distance of 1/4-in. from the cut previously made. Condition the specimens at 73 ±2°F for 4 hours. Test the strips at this temperature in a machine of the inclination-balance type with the lower jaw traveling at a rate of 12 ±1 inch. with the free end of the felt gripped in the upper jaw and the free end of the foil in the lower jaw of

the machine, the foil is stripped from the coating to within 1/2 inch of the end of the "sandwich" portion of the specimen. The maximum pull (in pounds) required, in each case, to strip the foil from the coating is recorded. The six readings so obtained are averaged and the results taken as the adhesion for the sample.

4.6 Behavior at 60°C (140°F)

Apply the coating at a spreading rate of 3-4 gallons per 100 square feet to a clean, 30-28 gauge (0.0123-0.0164 in. thick) steel panel. A convenient size for the panel is 4- by 6-in. (The steel panel must be capable of being bent uniformly through an arc of 180° over a 1/2 inch mandrel.) Embed a thread in the coating extending across the coating at a distance of 2 inches from the top edge of the panel. Expose the coated panel, in horizontal position, in a well-ventilated room at 21-27°C (70-80°F) for two hours and then suspend it vertically for 5 hours in an oven at 60°C (140°F).

Examine the coating at the end of the test period for sagging, blistering, slippage, and dripping. Sagging and slippage shall be determined by comparing the distance of the thread from the top of the test panel with its distance at the start of the test.

4.7 Behavior at 0°C (32°F)

Immerse the test panel from Section 4.6 in a water bath at 0°C (32°F) and allow to remain 1 hour. Remove the panel from the bath and bend (immediately) through an arc of 180° over a one-inch diameter mandrel. The bend is made in approximately 2 seconds time with the uncoated surface of the panel next to the mandrel.

Immediately after bending, the coating shall be examined for cracking. Small cracks that do not extend to the metal shall be disregarded.

4.8 Bridging durability

Apply the coating to an 8- by 8-in. sheet of gummed dextrin paper, as described in Section 4.4. Allow the coating to dry in a well-ventilated room at 21-27°C (70-80°F) for 1 hour. Place two No. 4 galvanized wire or copper screens, measuring 3- by 6-in. on the partially-set coating and apply

slight pressure to the screen to promote adhesion. Allow to dry two to three days and remove the dextrin paper as described in Section 4.4 and allow an additional week for further drying.

The specimens shall be exposed for 1500 hours in an accelerated weathering unit such as described in Federal Specification TT-P-141b, Method 615.2 except that only one arc, centrally located, shall be used. (Note: The Atlas Electric Devices Co., Chicago, Ill., "Type HVDL-A weatherometer", with one arc removed, is a satisfactory unit for this operation.) The cycle shall be such that during each 20-minute period the specimens are exposed to 17 minutes of light without water spray followed by 3 minutes of light with water spray. The water used for the spray shall contain not more than 0.1 grain total solids per gallon.

At the expiration of the specified period of exposure, the specimens shall be removed from the weathering unit and count taken of the number of openings in each screen that are no longer bridged over by the coating. This number, divided by the total number of openings in the screen and multiplied by 100, shall be taken as the percentage of bridge failures.

4.9 Increase in permeance

The specimens from Section 4.3 shall be exposed for 2500 hours to accelerated weathering as described in Section 4.8 and water-vapor permeability determined as described in Section 4.3. Any increase in permeability over that of the unweathered specimen shall be noted and the results averaged. This figure shall be taken as the increase in permeance for the sample.

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[illegible]

[illegible]

SPECIFICATION

FOR

BITUMINOUS EMULSION; FOR USE AS MOISTURE-RESISTANT COATING FOR WALLS

1. SCOPE

The materials furnished under this specification shall be bituminous-base emulsions suitable for spray application in relatively thick films as moisture-resistant coatings for the walls of structures used for storage.

2. GENERAL REQUIREMENTS

The emulsion shall be homogeneous and show no separation or coagulation of its components that cannot be overcome by moderate stirring. It shall be suitable for brush or spray application, at a spreading rate of 3-4 gallons per 100 square feet, to vertical surfaces of wood, masonry, metal, etc., to give a continuous, adherent coating over the surface coated.

Where a primer is recommended by the manufacturer, its use shall be mandatory.

3. DETAIL REQUIREMENTS

The emulsion shall conform to the requirements enumerated below.

	Max.	Min.
Non-volatile, % by weight	--	45
Ash (based on non-volatile), % by weight	45	--
Water, % by weight	55	--
Water-vapor permeability, perm	1.0	
Behavior at 60°C (140°F)	1/	
Behavior at 0°C (32°F)(cracking through to metal on bending over 1" mandrel)	None	
Increase in permeability 2/ after weathering (accelerated) for 2500 hours, perm	0.2 3/	

1/ Not more than 1/4" sag or displacement of guide string and no blistering of coating or drippage from test panel.

2/ Applies only to coatings for exterior application.

3/ The coating shall show no blistering, cracking, alligatoring or loss of adhesion.

4. METHODS OF TEST

4.1 Non-volatile matter

Weigh about 10 grams of the sample (nearest 0.01 gram) into a tared flat-bottomed metal dish about 5 to 6 centimeters in diameter (a friction-top can cover is suitable for this purpose). Heat the dish and its contents in an oven at 105-110°C (221-230°F) for 24 hours or until successive hourly weighings show a loss of not more than 0.05 grams. Cool and weigh. From the weight of the residue and the weight of the original sample taken, compute the percentage of non-volatile.

4.2 Ash

Place about 3 grams (weighed to the nearest 0.001 gram) of the residue from the determination of non-volatile material (Section 4.1) in a previously ignited and tared porcelain crucible and incinerate at not above dull red heat (500-600°C) until all carbonaceous matter is consumed or until essentially constant weight is attained. Cool in a desiccator and weigh. From the weight of the sample taken for incineration and the weight of the residue in the crucible, calculate the percentage of ash.

4.3 Water

Water shall be determined in accordance with the method described in Federal Specification SS-R-406c, Method 230.01, except that the sample of emulsion for test shall be selected on a weight basis.

4.4 Water-vapor permeability

Apply the coating at the spreading rate of 3-4 gallons per 100 square feet to at least two circular discs of 1/8-in. asbestos cement of suitable diameter and conforming to the requirements of Federal Specification [illegible], Type I. Care should be exercised in application of the coating so that an essentially uniform film is obtained. Allow the coated discs to condition in a well-ventilated room at 21-27°C (70-80°F) until constant weight is attained.

Determine water-vapor permeability in accordance with the method described in "Tentative Method of Test for Water-Vapor Permeability of Paper, Paperboard and other Sheet Materials", ASTM Designation D988-40T. Calculate permeability and express in perms (grains per square foot per hour per inch of water-vapor pressure difference across the specimen).

4.5 Behavior at 60°C (140°F)

Apply the coating uniformly at a spreading rate of 3-4 gallons per 100 square feet to a clean, 30-26 gauge (0.0123 in.-0.0184 in. thickness) steel panel, leaving a 1-in. margin along the top edge. A convenient size for the panel is 4- by 6-inch. (The steel panel must be capable of being bent uniformly through an arc of 180° over a 1/2-in. mandrel.)

Embed a thread in the coating extending across the panel at a distance of 2 inches from the top edge of the panel. Expose the specimen, so prepared, in a horizontal position in a well-ventilated room at 21-27°C (70-80°F) for two hours and then suspend it vertically for five hours in an oven at 60°C (140°F).

Remove the panel from the oven and examine the coating for sagging, blistering, slippage, and dripping. Sagging and slippage may be determined by comparing the distance of the thread from the top of the test panel with its distance at the start of the test.

4.6 Behavior at 0°C (32°F)

Immerse the test panel from Section 4.5 in a water bath at 0°C (32°F) and allow to remain for one hour. Remove the panel from the bath and bend immediately (coating side uppermost) through an arc of 180° over a two-inch mandrel. The bending shall be accomplished in approximately 2 seconds time.

Immediately after bending, the coating shall be examined for cracking. Cracks that do not extend to the base metal shall be disregarded.

4.7 Increase in permeance

The specimens from Section 4.4 shall be exposed for 2500 hours in an accelerated weathering unit such as described in Federal Specification TT-P-141b, method 615.2, except that one arc, centrally located, shall be used. (Note: The Atlas Electric Devices Co., Chicago, Ill., "Type XWL-R weather-ometer", with one arc removed, is a satisfactory unit.) The cycle shall be such that during each 20-minute period, the specimens are exposed to 17 minutes of light without water spray, followed by 3 minutes of simultaneous light and water spray. The water used for spray shall not contain more than 0.1 grain total solids per gallon.

At the end of the 2500 hours, the specimens shall be removed from the weathering unit and allowed to condition in a well-ventilated room at 21-27°C (70-80°F) until substantially constant weight is obtained. Determine water-vapor permeability of the weathered specimens as described in Section 4.4. Any increase over that of the unweathered specimen shall be noted and the results averaged. This figure shall be taken as the increase in permeance for the sample.

11. APPENDIX B - TABLES AND FIGURES

TABLE 1. LIST OF COATING MATERIALS

Class	Ident. No.	Manufacturer	Brand Name	Color	Spreading Rate sq ft/gal	Wt. per Gal. lb	Non-Vol. %	Ash %	Ash of Non-Vol. %	Water %	Nature of Non-Vol. Vehicle 1/
I	1	H.H. Robertson Co.	Black Leathery Coat	Black	50	7.9	56.1	6.4			
I	2	H.H. Robertson Co.	Robertson Everplastic Coat	Maroon	50	9.0	64.9	22.0			Bituminous Resin
I	3	H.H. Robertson Co.	Robertson Everplastic Coat	Black	50	8.0	60.0	10.5			Bituminous Resin
I	8	L. Sonneborn Sons, Inc.	Hydrocide Mastic	Black	25	7.7	76.1	15.0			Asphalt
I	9	Sika Chemical Corp.	Sika Seal, Heavy Consistency	Black	90	11.7	62.4	49.5			Gilsonite & treated petroleum asphalt
I	11	Pioneer Latex & Chemical Co., Inc.	Trowel-On Mastic A-132	Black	25	8.3	75.0	10.9			
I	12	Johns-Manville Sales Corp.	Aertite Coating	Black	25	8.4	83.8	37.3			
I	13	Johns-Manville Sales Corp.	Asbestile Cement	Black	25	9.7	80.6	36.2			
I	14	The Ureo Co.	[illegible] for metals	Alum.	25	8.5	85.8				

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Table 1. List of Coating Materials (Continued)

Class	Ident. No.	Manufacturer	Brand Name	Color	Spreading Rate sq ft/gal	Wt. per Gal. lb	Non-Vol. %	Ash %	Ash of Non-Vol. %	Water %	Nature of Non-Vol. Vehicle 1/
I	17	Insul-Mastic Corp. of America	XX Mica #3911	White	20	11.5	65.0	53.4			Processed Fish Oils
I	18	Insul-Mastic Corp. of America	Gilsonite #4010 Vaporseal	Black	25	7.4	73.4	34.2			Gilsonite & asphalts
I	19	Sika Chemical Corp.	Sika Seal Dampproofing Paint	Black	60	7.5	54.8	0.05			Gilsonite & treated Petroleum asphalts
I	21	The Davison Chemical Corp.	Protek-Coat	Black	25	8.5	65.0	22.7			Asphalt
I	24	Flintkote Co., Inc.	Semi-Mastic #214	Black	50	8.1	65.0	7.0			Asphalt
I	2-25	Flintkote Co., Inc.	Flintkote #201	Black	33	8.4	81.1	30.5			
I	29	Pecora Paint Co.	Pecora Special: Code 153-[illegible]	Black	25	8.2	69.2	12.9			
I	30	Redmont Mfg. & Waterproofing Co., Inc.	RDC #201 Vaporseal	Black	50	7.9	76.4	6.3			Plasticized Asphalt
I	32	A.C. Horn Co., Inc.	Dehydratine #10	Black	25	8.9	76.0	21.6			Asphalt

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Table 1. List of Coating Materials (Continued)

Class	Ident. No.	Manufacturer	Brand Name	Color	Spreading Rate sq ft/gal	Wt. per Gal. lb	Non-Vol. %	Ash %	Ash of Non-Vol. %	Water %	Nature of Non-Vol. Vehicle 1/
I	35	Koppers Co., Inc.	Bitumastic #50	Black	75	10.8	74.1	19.4			Processed coal tar
I	46	Lone Co.	Heavy Duty "Al." Roof Coating	Aluminum	100	8.9	46.3	21.3			[illegible]
I	50	Lone Co.	Heavy Duty Roof Coating	Black	60	7.6	64.8	1.3			
I	51	Southport Paint Co., Inc.	Waterlock	Black	50	7.2	46.0	1.1			Fatty-acid gum
I	52	Southport Paint Co., Inc.	Plasticseal	Black	50	7.9	62.2	15.6			Fatty-acid gum
I	53	Southport Paint Co., Inc.	Plasticseal	Red	50	7.8	65.7	13.6			Fatty-acid gum
I	54	Southport Paint Co., Inc.	Redicoat	Red	50	8.1	57.2	12.8			Fatty-acid gum
I	56	Southport Paint Co., Inc.	Plasticseal	Green	50	8.2	50.6	13.2			Fatty-acid gum

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Table 1. List of Coating Materials (continued)

Class	Ident. No.	Manufacturer	Brand Name	Color	Spreading Rate sq ft/gal	Wt. per Gal. lb	Non-Vol. %	Ash %	Ash of Non-Vol. %	Water %	Nature of Non-Vol. Vehicle 1/
I	58	Rubber & Plastics Compound Co., Inc.	Nerva-Plast	Black	75	7.9	61.1	20.4			
I	59	Acorn Refining Co.	Uniflex Al. Roof Coating	Aluminum	25	8.3	66.6	23.0			Asphalts
I	60	J.W. Mortell	K2479 Mortel Vapor Barrier	Black	25	8.3	72.8	8.6			Asphalt
I	61	Consolidated Paint & Varnish Corp.	Asbestos-Al. Roof Coating	Aluminum	50	8.8	58.6	25.6			
I	62	Consolidated Paint & Varnish Corp.	Liquid Roof Coating	Black	25	8.2	74.8	11.9			
II	15	Benj. Foster Co.	Vinyl Floor Enamel	White	300-500	9.7	46.0				Vinyl copolymer Resins
II	23	Flintkote Co., Inc.	Flintkote Al. Paint	Aluminum	300-500	8.6	50.2				Asphalt
II	26	Foundry Rubber Corp.	Paracrete	Grey	300-500	8.9	39.6				Chlorinated rubber & tung oil

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Table 1. List of Coating Materials (continued)

Class	Ident. No.	Manufacturer	Brand Name	Color	Spreading Rate sq ft/gal	Wt. per Gal. lb	Non-Vol. %	Ash %	Ash of Non-Vol. %	Water %	Nature of Non-Vol. Vehicle 1/
II	27	Benj. Foster Co.	Asph. Al. Paint	Aluminum	300-500	8.6	63.5				Segregated asphalt & reinforcing hard gum
II	28	Pecora Paint Co.	Pecora White Stucco Paint	White	300-500	8.6	53.0				
II	40	Monroe Sci-entific Service	Transealer	Color-less	300-500	7.1	14.4				
II	42	Monroe Sci-entific Service	Silver-sealer	Aluminum	300-500	8.1	55.3				
II	43	Monroe Sci-entific Service	Transealer	Aluminum	300-500	7.4	19.6				
II	44	Monroe Sci-entific Service	Monroecoat	Black	300-500	7.3	46.6				
II	45	Amer. Pipe & Constr. Co.	Amercoat #33	Aluminum	300-500	8.4	32.8				Synthetic resin
II	47	The Zone Co.	New Metal Alum. Paint	Aluminum	300-500	7.8	55.7				
II	49	Redmont Mfg. & Waterproof-ing Co., Inc.	Asphalt Base Alum. Paint	Aluminum	300-500	8.0	32.6				
II	63	The Dasco Co.	Dashide	Color-less	300-500		6.9				

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Table 1. List of Coating Materials (Concluded)

Class	Ident. No.	Manufacturer	Brand Name	Color	Spreading Rate sq ft/gal	Wt. per Gal. lb	Non-Vol. %	Ash %	Ash of Non-Vol. %	Water %	Nature of Non-Vol. Vehicle 1/
III	4	Amer. Bitumuls Co.	Laykold Weathercoat	Black	20	9.3	51.5		38.5	50	Asphalt
III	5	Amer. Bitumuls Co.	Laykold Cement	Black	25		82.0		56.1	10	Asphalt & rubber
III	6	Royal Products Co.	Royalco #20	Black	33	7.9	51.4		19.1	49	
III	10	Royal Products Co.	Pyra-Ro	Brown	33	9.8	30.9		67.1	63	
III	22	Flintkote Co., Inc.	C-13-C4	Black	33	8.4	50.0		9.3	51	Asphalt
III	1-25	Flintkote Co., Inc.	C-13-HPC	Black	33	8.2	62.7		3.4	38	Asphalt
III	3-25	Flintkote Co., Inc.	C-13-E	Black	33	8.4	54.9		8.6	48	Asphalt
III	33	Benj. Foster Co.	#30-36 Sealfas	White	40	11.9	67.0		41.3	29	Vinyl resin
III	34	Benj. Foster Co.	10-16 Asph. Emulsion	Black	75	9.7	60.7		33.1	42	Asphalt
III	36	Koppers Co., Inc.	Bituplastic #28	Black	75	10.1	49.0		34.3	48	Processed Coal-Tar
III	38	Cooper's Creek Chem. Corp.	Bituminous Resin Emuls.	Black	25	9.6	56.6		21.3	37	Coal-Tar Pitch

1/ Information furnished by supplier.

TABLE 2. APPEARANCE OF COATINGS - THREE YEARS OUTDOOR EXPOSURE

Class	Ident. No.	Applied to Cinder Block	Group Rating 1/	Applied to Aluminum	Group Rating 1/	Applied to Asbestos Cement Board	Group Rating 1/
I	1	Coating weathered off 5% area. This developed within two years.	5	A few pits after two years. Some were noticed after 70 days.	2		
I	2	Coating weathered off but not as severe as No. 1, above. Lightened in color.	5	A few pits and a noticeable lightening in color.	2		
I	3	Coating weathered off in high spots. Some lightening in color.	4	Slight checking after two years.	3		
I	8	Severe blisters, 1/4 to 1/2 in. in diameter, over entire surface.	3	No appreciable change.	1		
I	9	Turned to a light gray. Surface covered with cracks.	4	Turned to a gray. No other visible change.	1		
I	11	Moderate surface alligatoring. Blisters 1/8-1/4 in. in diameter over surface.	3	Some alligatoring of surface film.	3		
I	12	Several small blisters on coating.	3	No visible change other than a few pits.	2		

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Table 2. Appearance of Coatings - Three Years Outdoor Exposure (Continued)

Class	Ident No.	Applied to Cinder Block	Group Rating 1/	Applied to Aluminum	Group Rating 1/	Applied to Asbestos Cement Board	Group Rating 1/
I	13	Similar to No. 12.	3	No appreciable change.	1		
I	14	No appreciable change.	1	No appreciable change.	1		
I	17	Whiter in color. No other apparent change.	1	Same as on cinder block.	1		
I	18	Color lightened to a dark gray. No other apparent change.	1	Similar to behavior cinder block.	1		
I	19	Coating weathering off high spots. Hair cracks cover surface.	5	Hair cracks over surface.	4		
I	21	Moderate blistering over entire surface.	3	Blisters up to 1/4 in. in diameter over surface.	4		
I	24	Coating weathering off high spots. A number of small blisters present.	3	Slight alligatoring.	3		
I	2-25	Moderate blistering and slight alligatoring over surface.	3	Some alligatoring over entire surface.	4		
I	29	No appreciable change.	1	Some pitting over surface. No other appreciable change.	3		

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Table 2. Appearance of Coatings - Three Years Outdoor Exposure (Continued)

Class	Ident No.	Applied to Cinder Block	Group Rating[1]	Applied to Aluminum	Group Rating[1]	Applied to Asbestos Cement Board	Group Rating[1]
I	30	A few small blisters. No other appreciable change.	2	No appreciable change.	2		
I	32	Blisters over entire surface.	3	Shrinkage of coating on primer within 3 months.	5		
I	35	Severe cracking over entire area.	5	Shrinkage of coating on primer and alligatoring within 3 months.	5		
I	35A	Same as No. 35	5	Alligatoring within 3 months.	4		
I	50	Slight to moderate blistering. Checking and weathering off in high spots.	4	No appreciable change.	1		
I	51	Coating almost completely weathered off.	5	Hair cracks over surface just barely visible to the eye.	3		
I	52	Coating flaked off in a few places. No other appreciable change.	3	Color lightened to a dark gray. No other apparent change.	2		
I	53	No appreciable change.	1	Some lightening in color. No other apparent change.	1		

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Table 2. Appearance of Coatings - Three Years Outdoor Exposure (Continued)

Class	Ident No.	Applied to Cinder Block	Group Rating 1/	Applied to Aluminum	Group Rating 1/	Applied to Asbestos Cement Board	Group Rating 1/
I	54	No appreciable change.	1	Hair cracks. Some lightening in color.	2		
I	56	Alligatoring, shrinking, and pitting over entire surface.	5	Severe alligatoring and shrinking.	5		
I	58	-----	--	Alligatoring thru to metal after 120 days.	5		
I	59	No appreciable change after 2 years exposure.	--	No appreciable change after 2 years exposure.	--		
I	60	-----	--	Pitting over surface - 2 years exposure.	--		
I	61	No appreciable change - 21 mos. exposure.	--	No appreciable change - 21 mos. exposure.	--		
I	62	Blisters over coating - 21 mos. exposure.	--	No appreciable change - 21 mos. exposure.	--		
II	15			Some chalking. Film is glossy under chalky layer.	2	Same as on aluminum.	2
II	23			No appreciable change.	1	No appreciable change.	1

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Table 2. Appearance of Coatings - Three Years Outdoor Exposure (Continued)

Class	Ident. No.	Applied to Cinder Block	Group Rating 1/	Applied to Aluminum	Group Rating 1/	Applied to Asbestos Cement Board	Group Rating 1/
II	26			Some chalking of the coating.	2	Some chalking and weathering off.	3
II	27			Alligatoring thru to metal. This appeared in first 3 mos.	5	Some alligatoring. Blisters present after 1-1/2 yrs. However, none apparent at 3 yr. inspection.	3
II	28			Severe alligatoring.	5	Checking over entire surface of coating.	5
II	40			Completely gone within two years.	5	Completely gone within 1-1/2 years.	5
II	42			Color turned brighter silver. No other apparent change.	1	Color turned brighter silver. No other apparent change.	1
II	43			Coating peeled from 1/3 of panel. No other change is apparent.	5	No appreciable change.	1
II	44			Some pin point pitting. No other apparent change.	2	Almost completely weathered off panel.	5
II	45			Some of coating peeled from panel. No other apparent change.	3	No appreciable change.	1

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Table 2. Appearance of Coatings - Three Years Outdoor Exposure (Continued)

Class	Ident. No.	Applied to Cinder Block	Group Rating 1/	Applied to Aluminum	Group Rating 1/	Applied to Asbestos Cement Board	Group Rating 1/
II	47			No appreciable change.	1	No appreciable change.	1
II	48			Slight alligatoring and dulling.	3	No appreciable change.	1
II	63			Non-inspectable because of its thin body and transparency.	--	Non-inspectable because of its thin body and transparency.	--
III	4	No appreciable change.	1	Some lightening in color.	2		
III	5	No appreciable change.	1	A few small pits. Some mica showing.	2		
III	6	A little coating weathered off high spots.	2	Some fibers showing and a slight lightening in color.	2		
III	10	Some lightening in color. No other apparent change.	1	Lightening in color to gray. No other apparent change.	1		
III	22	No appreciable change except a weathering off in a few high spots.	2	Pitting over entire surface. However, this was not apparently due to weathering since they also appeared on unweathered panel.	3		

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TABLE 4.—[illegible] (Continued)

Glass	Spec. No.	[illegible]	Change rating	[illegible]	Change rating	[illegible]	Change rating
II	17			No appreciable change.	1	No appreciable change.	1
II	18			Slight glittering and sanding.	2	No appreciable change.	1
II	19			[illegible]	—	[illegible]	—
III	5	No appreciable change.	1	[illegible]	3		
III	7	No appreciable change.	2	A few small [illegible]	2		
III	9	A little sanding [illegible]	2	[illegible]	4		
III	10	Some lightening in color, no other apparent change.	2	Lightening in color, [illegible] no other apparent change.	3		
III	12	No appreciable change [illegible]	3	[illegible]	3		

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Table 2. Appearance of Coatings - Three Years Outdoor Exposure (Concluded)

Class	Ident. No.	Applied to Cinder Block	Group Rating 1/	Applied to Aluminum	Group Rating 1/	Applied to Asbestos Cement Board	Group Rating 1/
III	1-25	No appreciable change.	1	No apparent change except a few pits.	2		
III	3-25	No appreciable change except a weathering off in a few high spots.	2	-----	--		
III	33	Small surface cracks.	3	No apparent change.	1		
III	34	Fine hair cracks in coating.	3	No appreciable change.	1		
III	36	No appreciable change.	1	No appreciable change.	1		
III	38	Some checking and weathering off high spots.	3	Some checking and a few pin point pits.	3		

1/ Group rating numbers are in descending order of comparative merit; number 1 being the best, number 2 next best, etc:

1 - Excellent; no appreciable change.
2 - Very good; slight change.
3 - Good; slight-moderage change.
4 - Fair; moderate-marked change.
5 - Poor; marked change.

TABLE 2a. APPEARANCE OF COATINGS AFTER EXPOSURE TO ACCELERATED TEST FOR DURABILITY

Class	Ident. No.	After 1000 Hours	After 2500 Hours	Group Rating 1/
I	1	No appreciable change.	Slight lightening in color. No other apparent change.	2
I	2	Some lightening in color and a few pits.	Further lightening in color and a few small pits.	2
I	3	No appreciable change other than a graininess developing.	Graininess still present. Some checking and some lightening in color.	3
I	8	No appreciable change.	Slight lightening in color.	1
I	9	Only apparent change appears to be a lightening in color to gray.	Same as after 1000 hours.	2
I	11	Slight checking and some lightening in color.	About same as after 1000 hours.	3
I	12	Slight checking. No other apparent change.	Some lightening in color and a few small pits over surface.	2
I	13	No apparent change.	No apparent change except a lightening in color.	2
I	14	No apparent change.	No apparent chance except a dulling of the color.	1
I	17	No apparent change.	No apparent change except a yellowing of the original white color.	1
I	18	No apparent change except a slight graying in color.	No apparent change except a further lightening in color.	1
I	19	No apparent change.	No apparent change except a slight lightening in color.	2

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Table 2a. Appearance of Coatings After Exposure to Accelerated Test for Durability (Continued)

Class	Ident. No.	After 1000 Hours	After 2500 Hours	Group Rating 1/
I	21	No apparent change.	No apparent change except a slight lightening in color.	1
I	24	Some alligatoring within 240 hrs. This became progressively worse.	Severe alligatoring with hummocks.	5
I	2-25	Slight alligatoring of coating.	Moderate amount of alligatoring over entire surface of coating.	4
I	29	No change except a few pits (approx. 2 mm.).	About the same appearance as after 1000 hours.	2
I	30	A moderate condition of alligatoring on the coating.	Severe alligatoring with some of the cracks penetrating to the metal.	5
I	32	Shrinkage of the coating on the primer.	Even greater shrinkage of the coating on the primer than after 1000 hours of exposure.	5
I	35	Some alligatoring and some shrinkage of the coating on the primer.	More alligatoring and greater shrinkage of the coating on the primer than after 1000 hours of exposure.	5
I	46	No apparent change.	No apparent change except a dulling of of the aluminum finish.	1
I	50	No apparent change.	Slight checking over entire coating.	3
I	51	No apparent change except a few pits after 1500 hrs. of exposure.	--------	3
I	52	Alligatoring of coating through to metal after 1500 hrs. of exposure.	-------	

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Table 24. Appearance of Coatings After Exposure to Accelerated Test For Durability (Continued)

Class	Ident. No.	After 1000 Hours	After 2500 Hours	Group Rating 1/
I	53	Some dulling of finish and lightening in color after 1500 hours.	--------	2
I	54	Some dulling of finish and lightening in color after 1500 hours.	--------	2
I	56	Severe shrinkage of the coating on the panel.	--------	5
I	58	Severe alligatoring through to the metal.	Severe alligatoring with penetration through to metal.	5
I	59	No apparent change.	No apparent change.	1
I	60	No apparent change.	No apparent change.	1
I	61	No apparent change after 600 hours of exposure.	--------	
I	62	No apparent change after 600 hours of exposure.	--------	
II	15	No apparent change.	No apparent change except a slight yellowing of color.	1
II	23	No apparent change.	No apparent change except a slight dulling of the aluminum.	1
II	26	Some chalking and lightening of the color.	Considerable chalking and embrittlement of film.	3
II	27	Severe alligatoring of coating.	Alligatoring has progressed through to the metal.	5
II	28	No apparent change.	Severe alligatoring over entire surface with penetration to the metal in some places.	5

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Table 2a. Appearance of Coatings After Exposure to Accelerated Test For Durability (Continued)

Class	Ident. No.	After 1000 Hours	After 2500 Hours	Group Rating 1/
II	40	Turned opaque and dark brown.	Coating entirely weathered off.	5
II	42	No apparent change except that it turned to a bright silver color.	Same as after 1000 hours of exposure.	1
II	43	No apparent change.	No apparent change.	1
II	44	No apparent change.	Checking over entire surface with penetration through to metal.	5
II	45	No apparent change.	No apparent change.	2
II	47	Slight checking over approximately 1/5 of surface area.	Checking has disappeared. Slight dulling of color.	2
II	48	No apparent change except some dulling of finish.	No apparent change except some dulling of finish.	2
II	63	Non-inspectable because of its thinness and transparency.	Same as at 1000 hours of exposure.	--
III	4	No apparent change except a slight lightening in color.	Finish is lighter in color, some asbestos fibers clearly showing.	2
III	5	A few small pits developed in coating. Some mica flakes showing.	Pits still present. Coating has lightened in color. Mica flakes still showing.	2
III	6	Some asbestos fibers showing. Coating lightened somewhat.	Coating moderately lighter in color. Asbestos fibers and a few small pits showing in coating.	2
III	10	Color turned to a light grey. No other apparent change.	Color has lightened considerably, it now being almost white. A few small pits have developed in the coating.	2

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Table 2a. Appearance of Coatings After Exposure to Accelerated Test for Durability (Concluded)

Class	Ident. No.	After 1000 Hours	After 2500 Hours	Group Rating 1/
III	32	No apparent change except pits that developed when coating dried.	Same as after 1000 hours of exposure.	3
III	1-25	No apparent change except the development of a few small pits.	Same as after 1000 hours of exposure.	2
III	3-25	Not exposed for reason of non-applicability to aluminum.	--------	--
III	33	A number of small blisters and pits developed in the coating during exposure.	The coating appeared to be in approximately the same condition as after 1000 hours of exposure.	3
III	34	No apparent change.	No apparent change except the development of a few small pits.	1
III	35	No apparent change except a lightening in color.	No apparent change except a lightening in color.	1
III	36	No apparent change except the development of small pits in the coating.	No apparent change except the development of small pits in the coating.	2

1/ Group rating numbers are in descending order of comparative merit, number 1 being the best, number 2 next best, etc:

1 - Excellent - No appreciable change.
2 - Very good - Slight change.
3 - Good - Slight-moderate change.
4 - Fair - Moderate-marked change.
5 - Poor - Marked change.

TABLE 3. RATES OF WATER-VAPOR TRANSMISSION ON ACETATE SHEET[1]

Class	Ident. no.	Exposure, hours: 0		500		1000		2000		Manner of Application
		g/sq.m/d	Perm	g/sq.m/d	Perm	g/sq.m/d	Perm	g/sq.m/d	Perm	
I	1	2.8	0.1	5.0	0.2			5.0	0.2	Doctor Blade
I	2	2.5	0.1	2.5	0.1			4.7	0.2	Doctor Blade
I	3	3.1	0.1	3.3	0.1	3.3	0.1	3.2	0.1	Doctor Blade
I	8	1.2	L0.1	1.2	L0.1	1.0	L0.1	0.9	L0.1	Mask
I	9	0.6	L0.1	3.7	0.1					Doctor Blade
I	11	2.4	0.1	2.0	0.1	1.9	0.1	1.7	0.1	Mask
I	12	0.9	L0.1	1.1	L0.1	1.2	L0.1	1.5	0.1	Mask
I	13	1.0	L0.1	1.5	0.1	0.9	L0.1	1.4	0.1	Mask
I	14	5.5	0.2	4.7	0.2	3.4	0.1	4.0	0.2	Mask
I	17	5.3	0.2	3.5	0.1	3.6	0.1	1.5	0.1	Mask
I	18	1.3	L0.1	1.1	L0.1	0.6	L0.1	0.4	L0.1	Mask
I	19	2.2	0.1	6.4	0.2					Doctor Blade
I	21	1.3	L0.1	1.9	0.1			1.3	L0.1	Mask
I	24	1.6	0.1	2.3	0.1			13.3	0.5	Mask
I	2-25	0.4	L0.1	0.5	L0.1	0.4	L0.1	0.3	L0.1	Mask
I	29	2.7	0.1	2.6	0.1	2.8	0.1	1.1	L0.1	Mask

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TABLE 3. RATES OF WATER-VAPOR TRANSMISSION OF ACETATE SHEET[1/] (Continued)

Class	Ident. No.	Exposure, Hours 0		500		1000		2000		Manner of Application
		g/sq.m/d	Perm	g/sq.m/d	Perm	g/sq.m/d	Perm	g/sq.m/d	Perm	
I	30	1.2	<0.1	3.3	0.1	23.0	0.9			Mask
I	32	0.6	<0.1	0.6	<0.1	0.8	<0.1	0.8	<0.1	Mask
I	35	0.9	<0.1	1.3	<0.1	8.5	0.3	26.9	1.0	Doctor Blade
I	46	2.0	0.1	2.0	0.1	2.1	0.1	3.2	0.1	Doctor Blade
I	50	2.7	0.1	2.8	0.1	3.1	0.1	26.8	1.0	Doctor Blade
I	51	9.7	0.4	9.6	0.4	8.5	0.3	8.3	0.3	Doctor Blade
I	52	5.6	0.2	6.6	0.3	8.2	0.3	5.7	0.2	Mask
I	53	8.3	0.3							Mask
I	54	7.2	0.3	7.3	0.3	6.1	0.2	6.5	0.2	Doctor Blade
I	56	6.3	0.2	6.0	0.2	5.3	0.2	5.6	0.2	Mask
I	58	5.5	0.2	4.8	0.2	4.7	0.2	10.9	0.4	Mask
I	59	0.5	<0.1	0.6	<0.1	0.5	<0.1	0.7	<0.1	Doctor Blade
I	60	1.4	<0.1	1.6	0.1	1.3	<0.1	2.4	0.1	Mask
II	15	43.4	1.7							Doctor Blade
II	23	1.5	0.1	3.6	0.1	1.1	<0.1	1.1	<0.1	Doctor Blade
II	26	21.5	0.8	24.2	0.9	21.1	0.8	30.0	1.1	Doctor Blade
II	27	37.2	1.4							Doctor Blade
II	28	37.0	1.4	46.0	1.7					Doctor Blade

(Continued on next page)

TABLE 3. RATES OF WATER-VAPOR TRANSMISSION ON ACETATE SHEET[1] (Continued)

Class	Ident. No.	Exposure, Hours 0		500		1000		2000		Manner of Application
		g/sq.m/d	Perm	g/sq.m/d	Perm	g/sq.m/d	Perm	g/sq.m/d	Perm	
II	40	67.1	2.5							Doctor Blade
II	42	4.2	0.2	4.5	0.2	3.6	0.1	4.4	0.2	Doctor Blade
II	43	10.5	0.4	8.8	0.3	9.3	0.4	17.7	0.7	Doctor Blade
II	44	15.0	0.6	29.1	1.1	31.7	1.2			Doctor Blade
II	45	15.0	0.6	10.5	0.4	15.3	0.6	10.6	0.4	Doctor Blade
II	47	20.1	0.8	23.7	0.9	26.3	1.0	17.0	0.6	Doctor Blade
II	48	25.6	1.0	28.7	1.1	28.9	1.1	21.2	0.8	Doctor Blade
II	63[2]	76.8	11.6							Brushed
III	4	75	2.9							Mask
III	5	32.5	1.2	16.6	0.6					Mask
III	6	7.2	0.3	3.3	0.1	3.5	0.1	2.2	0.1	Mask
III	10	135	5.1	153	5.6	170	6.5			Mask
III	11	8.3	0.3	2.3	0.1	1.5	0.1	2.3	0.1	Mask
III	1-25	9.2	0.3							Brush
III	3-25	3.3	0.1							Mask
III	33	35.5	1.3	32.9	1.3	20.8	0.8	16.7	0.6	Mask
III	34	3.6	0.1	1.9	0.1	1.4	0.1	2.1	0.1	Mask

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TABLE 1. RANGE OF HYDRO-STATIC DETERMINATIONS ON SELECTED SOILS (continued)

[illegible]	[illegible]	[illegible]									[illegible]
		0		300		1000		3000			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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TABLE 3. RATES OF WATER-VAPOR TRANSMISSION ON ON ACETATE SHEET[1] (Concluded)

Class	Ident. No.	Exposure, Hours								Manner of Application
		0		500		1000		2000		
		g/sq.m/d	Perm	g/sq.m/d	Perm	g/sq.m/d	Perm	g/sq.m/d	Perm	
III	36	7.1	0.3			12.0	0.5	10.0	0.4	Mask
III	38	24.5	0.9	16.2	0.6	18.5	0.7	15.3	0.6	Mask

1/ Rate of water-vapor transmission = 175 g/sq.m/d (6.7 perms).

2/ Determination made at 73 ±1°F and 50 ±2% R.H.

TABLE 3a. RATES OF WATER-VAPOR TRANSMISSION OF ASBESTOS CEMENT[1/]

Class	Ident. No.	Exposure, Hours 0 g/sq.m/d	Perm.	1200 g/sq.m/d	Perm	2500 g/sq.m/d	Perm	Manner of Application
I	1	1.6	0.1	1.7	0.1	19.5	0.7	Brushed
I	2	2.4	0.1	2.0	0.1	4.8	0.2	Brushed
I	12	1.2	<0.1	0.9	<0.1	3.2	0.1	Troweled
I	17	51.6	2.0	48.3	1.8	52.5	2.0	Troweled
I	30	1.7	0.1	1.7	0.1	5.5	0.2	Troweled
I	53	3.8	0.1	3.9	0.1	8.2	0.3	Brushed
I	61	0.9	<0.1	1.1	<0.1	1.5	<0.1	Troweled
II	15	38.5	1.5	54.2	2.1	60.5	2.3	Brushed
II	26	15.7	0.6	260.0	9.9			Brushed
II	27	255	9.7	327	12.4			Brushed
II	28	37.7	1.4	75.4	2.9	116.0	4.7	Brushed
III	22 & 23	2.6	0.1	1.3	<0.1	4.7	0.2	Brushed
III	1-25	17.5	0.7	5.1	0.2	4.4	0.2	Troweled
III	33	16.8	0.6	16.4	0.6	46.5	1.8	Troweled

[1/] Rate of water-vapor transmission = 538 g/sq.m/d (20.5 perms).

TABLE 4. RESULTS OF MISCELLANEOUS TESTS

Class	Ident. No.	Behavior at 60°C (140°F), 5 hrs. Drippage %	Behavior at 60°C (140°F), 5 hrs. Flow in.	Behavior at 0°C (32°F), 180° bend over 1-in. mandrel	Adhesion lb.	Tensile Breaking Strength, lb.	Bridging Durability, % of squares failing
I	1	0	11/4	Satisfactory	1.8	11.4	10
I	2	10	3/4	Satisfactory	3.5	3.2	0
I	3	15	1	Satisfactory	5.5	2.1	35
I	8	0	0	Satisfactory	5.4	2.9	--
I	9	0	0	Cracked	1.0	18.0	90
I	11	0	0	Satisfactory	9.3	3.0	0
I	12	0	0	Satisfactory	5.0	11.9	0
I	13	0	0	Satisfactory	4.4	8.5	0
I	14	--	--	-----	3.4	15.5	--
I	17	0	0	Cracked	1.0	7.9	--
I	18	0	0	Satisfactory	2.8	16.0	0
I	19	10	1-1/4	Cracked	3.0	7.3	100
I	21	0	0	Surface cracks at bend	3.3	19.2	0
I	24	15	11/4	Satisfactory	10.8	1.5	35
I	2-25	0	0	Satisfactory	6.3	11.4	0
I	29	20	1/2	Satisfactory	4.2	3.4	5
I	30	5	0	Satisfactory	7.2	2.4	35

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Table 4. Results of Miscellaneous Tests (Continued)

Class	Ident. No.	Behavior at 60°C (140°F), 5 hrs. Drippage %	Behavior at 60°C (140°F), 5 hrs. Flow in.	Behavior at 0°C (32°F), 180° bend over 1-in. mandrel	Adhesion lb.	Tensile Breaking Strength, lb.	Bridging Durability, % of squares failing
I	32	0	0	Satisfactory	4.7	16.9	----
I	35	0	0	Hair cracks at bend	2.9	10.3	65
I	46	0	0	Cracked	2.8	2.6	----
I	50	20	3/4	1 Crack	2.8	2.5	----
I	51	0	0	Satisfactory	---	8.5	----
I	52	0	0	Satisfactory	8.5	9.9	----
I	53	0	0	Satisfactory	9.3	9.5	0
I	54	0	0	Satisfactory	7.8	9.5	----
I	56	0	0	Satisfactory	9.0	4.3	----
I	58	0	0	Satisfactory	2.9	1.3	----
I	59	0	0	Satisfactory	4.2	9.2	----
I	60	20	1-1/4	Satisfactory	4.4	4.4	----
I	61	0	0	Satisfactory	---	---	----
I	62	2	1.1/4	Satisfactory	---	---	----
III	4	0	0	Satisfactory	3.2	12.6	----
III	5	0	0	Cracked	3.5	9.3	----
III	6	0	0	Cracked	3.6	9.2	----

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Table 4. Results of Miscellaneous Tests (Concluded)

Class	Ident. No.	Behavior at 60°C (140°F), 5 hrs. Drippage %	Behavior at 60°C (140°F), 5 hrs. Flow in.	Behavior at 0°C (32°F), 180° bend over 1-in. mandrel	Adhesion lb.	Tensile Breaking Strength, lb.	Bridging Durability, % of squares failing
III	10	0	0	Satisfactory	1.4	11.0	----
III	22	0	0	Cracked	6.5	2.9	----
III	1-25	0	0	Cracked	6.9	2.2	----
III	3-25	0	0	Cracked	---	2.8	----
III	33	0	0	Satisfactory	4.5	27.6	----
III	34	0	0	Cracked	1.7	14.8	----
III	36	0	0	Cracked	2.4	10.9	----
III	38	0	0	Cracked	1.4	6.5	----

Figure 1. Test cell assembly for determination of water-vapor permeability.

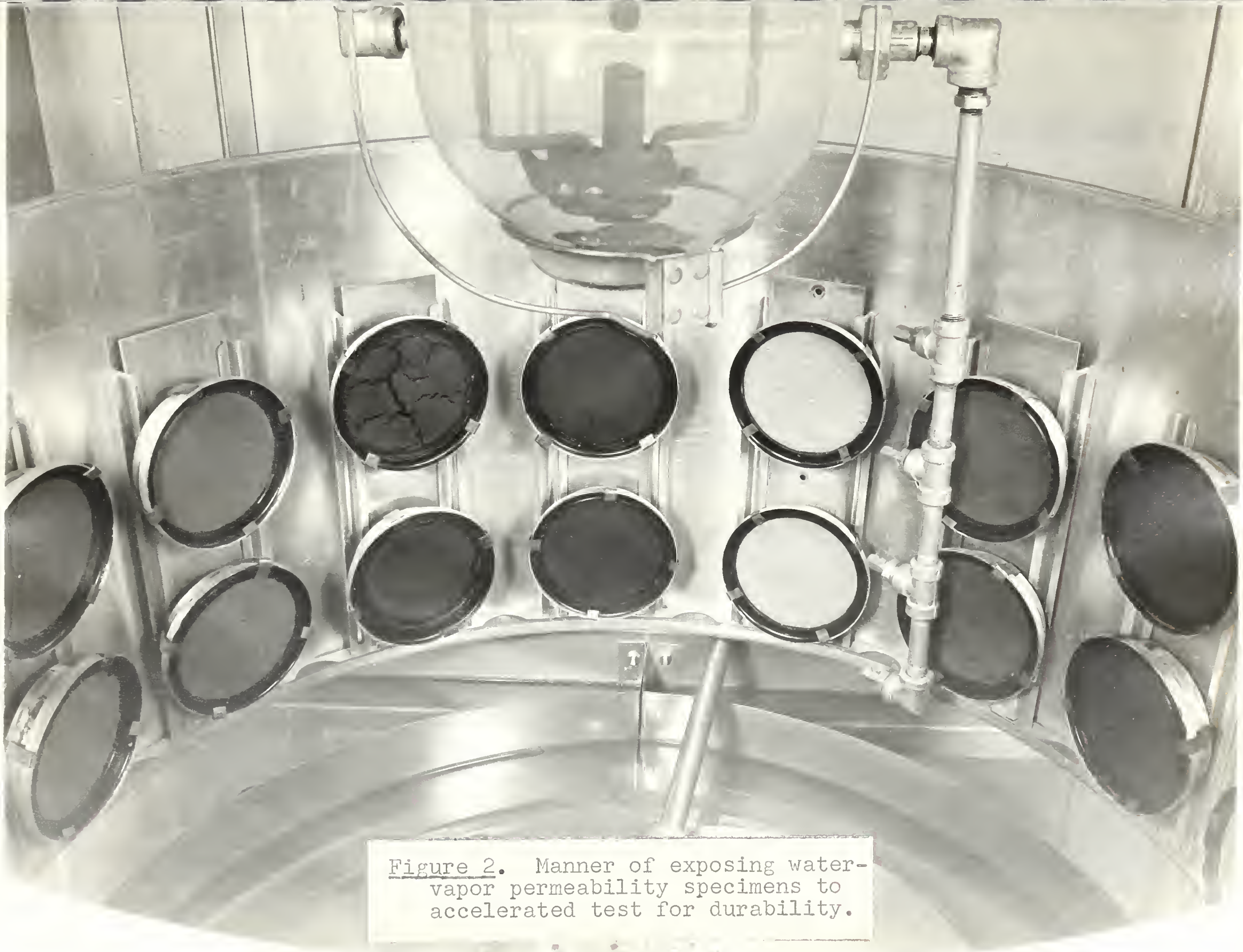

Figure 2. Manner of exposing water-vapor permeability specimens to accelerated test for durability.

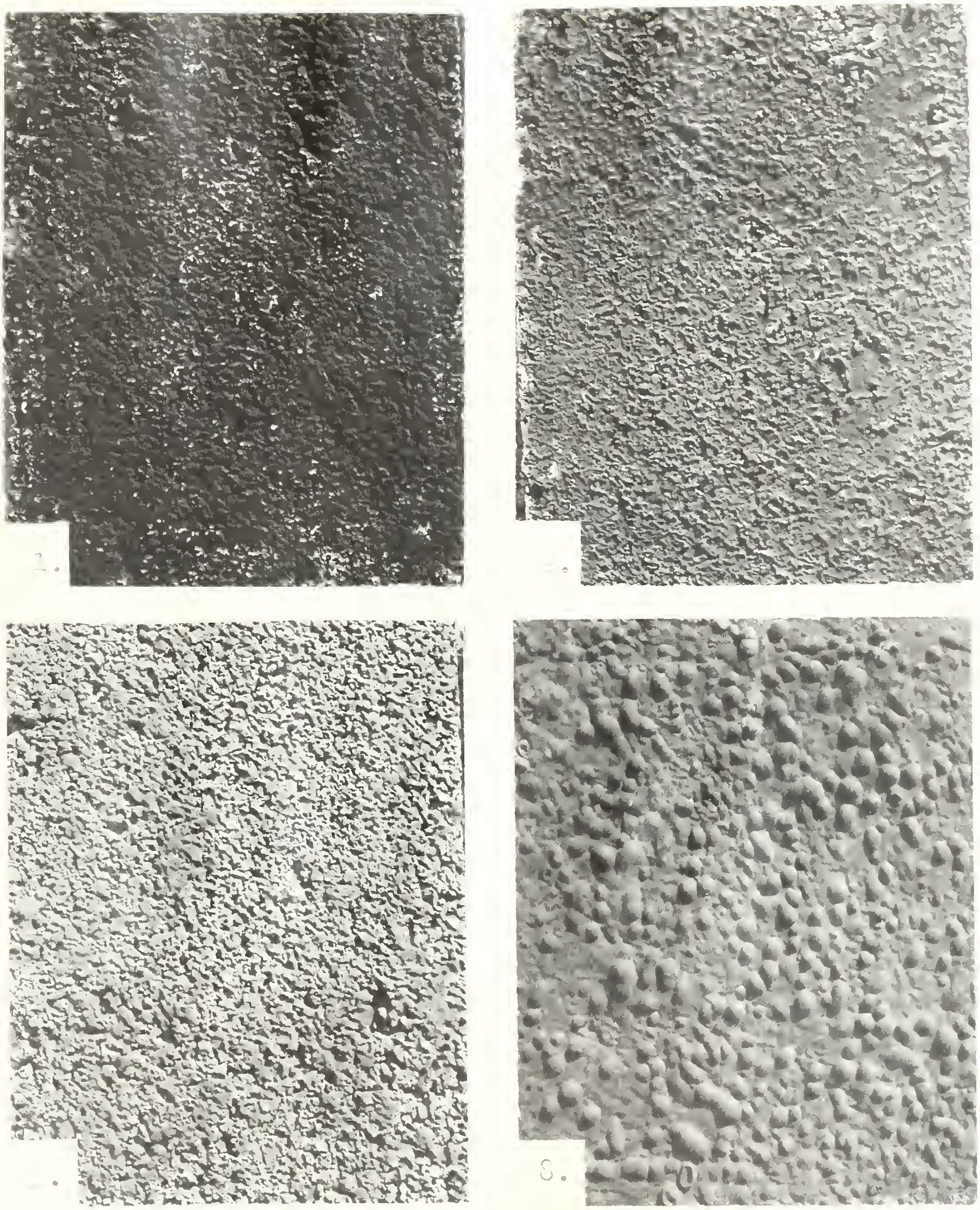

Figure 3. Class I coatings on cinder block - 2 years outdoor exposure.

NBS

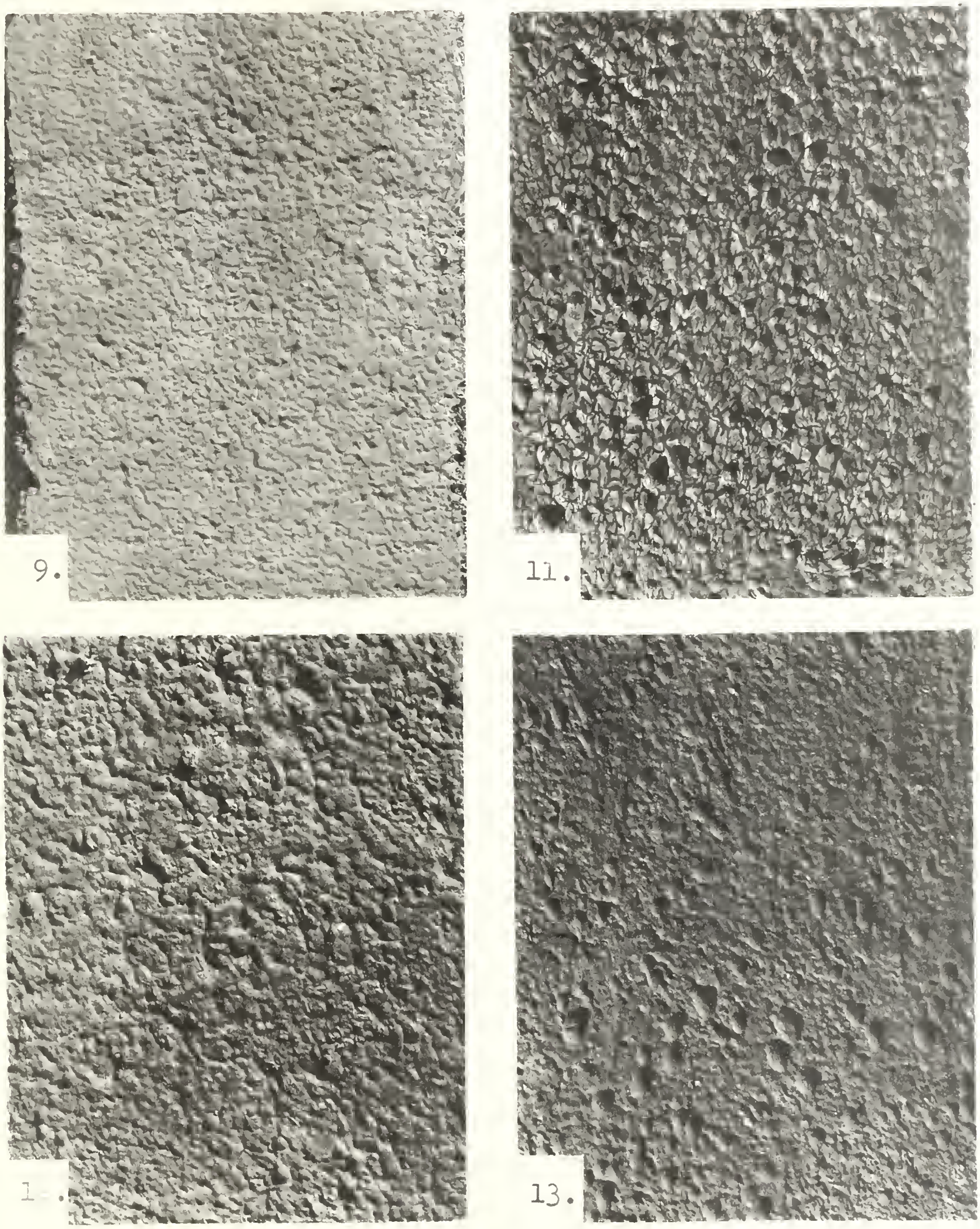

Figure 4. Class I coatings on cinder block - 2 years outdoor exposure.

NBS

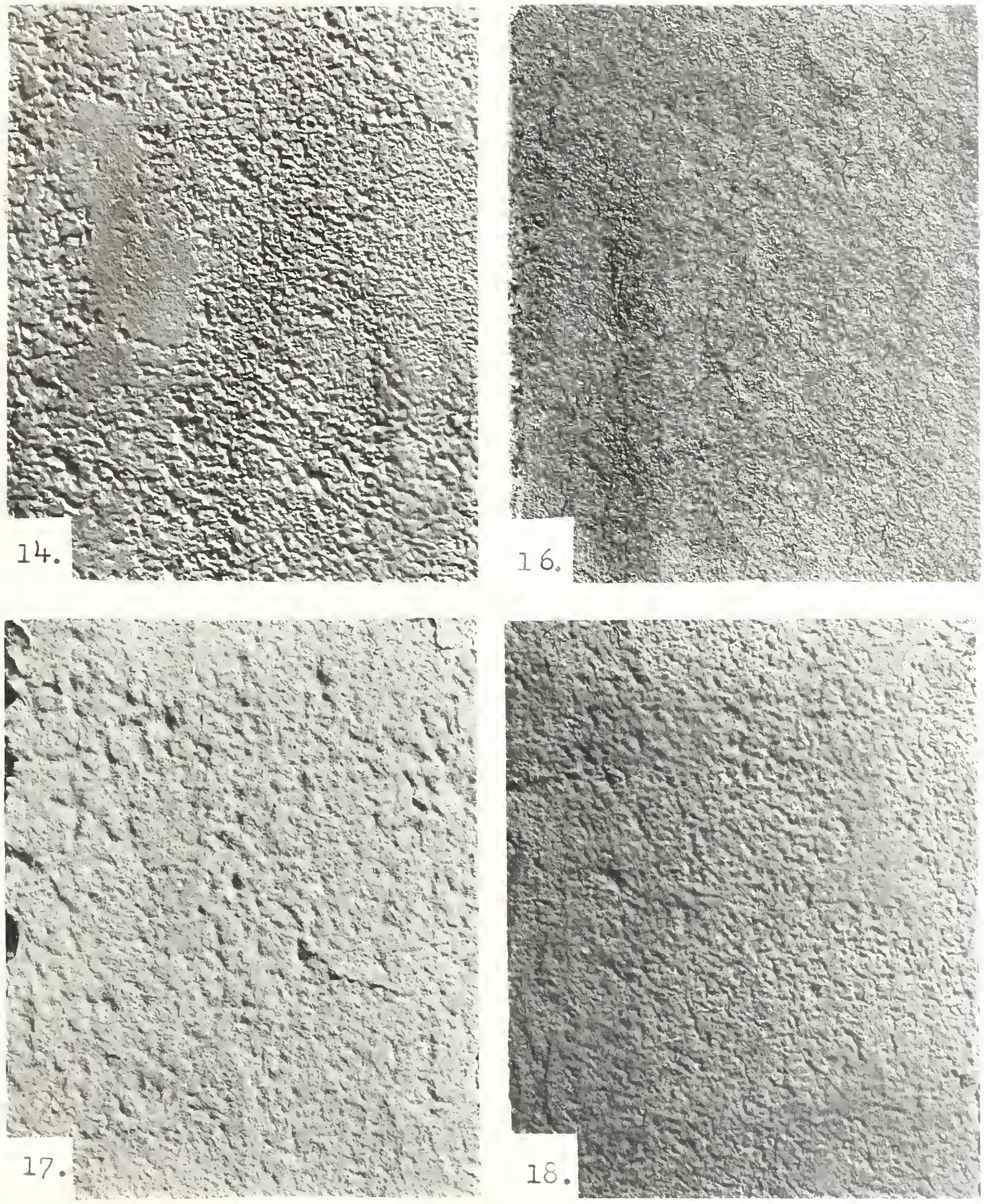

Figure 5. Class I coatings on cinder block - 2 years outdoor exposure.

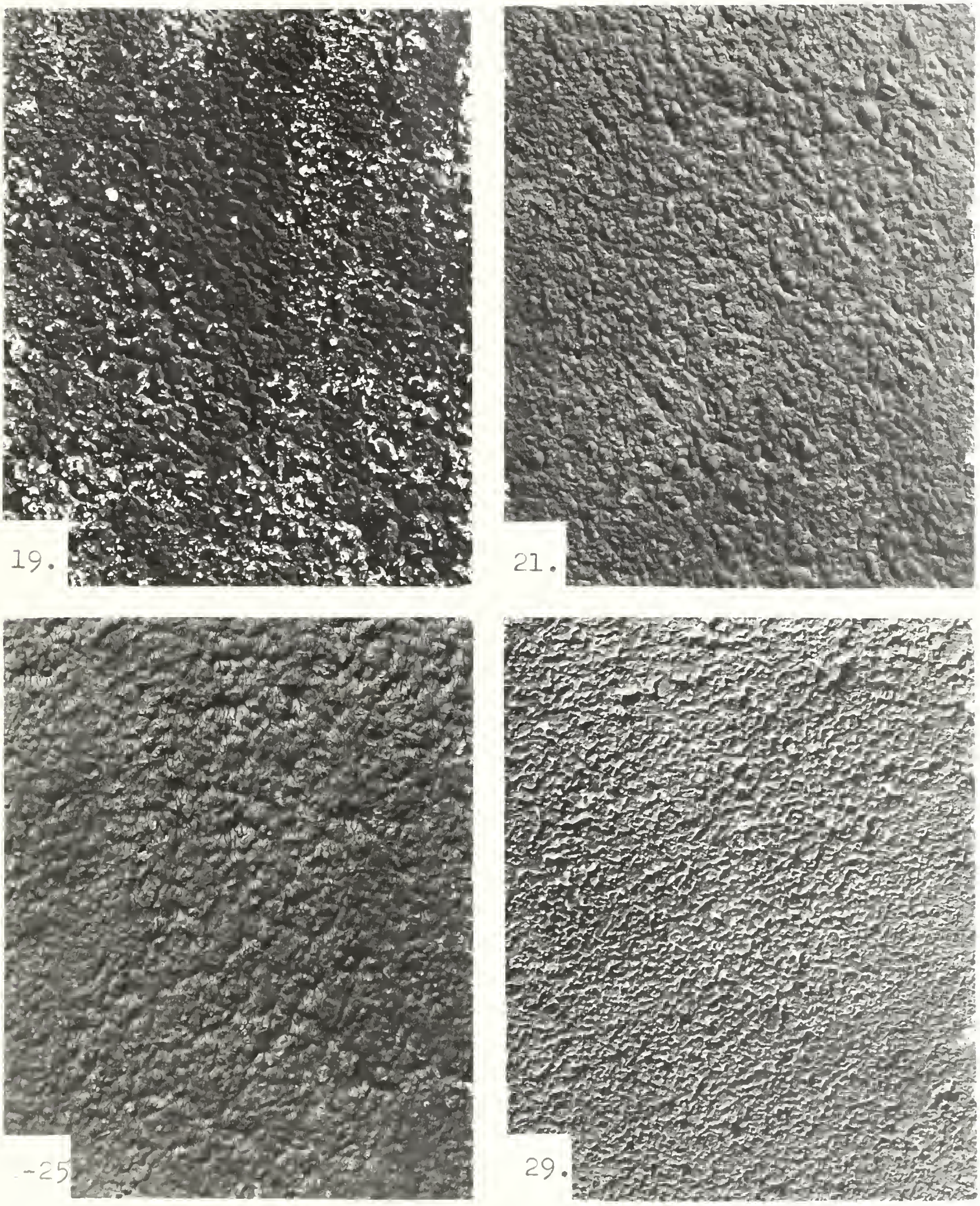

Figure 6. Class I coatings on cinder block - 2 years outdoor exposure.

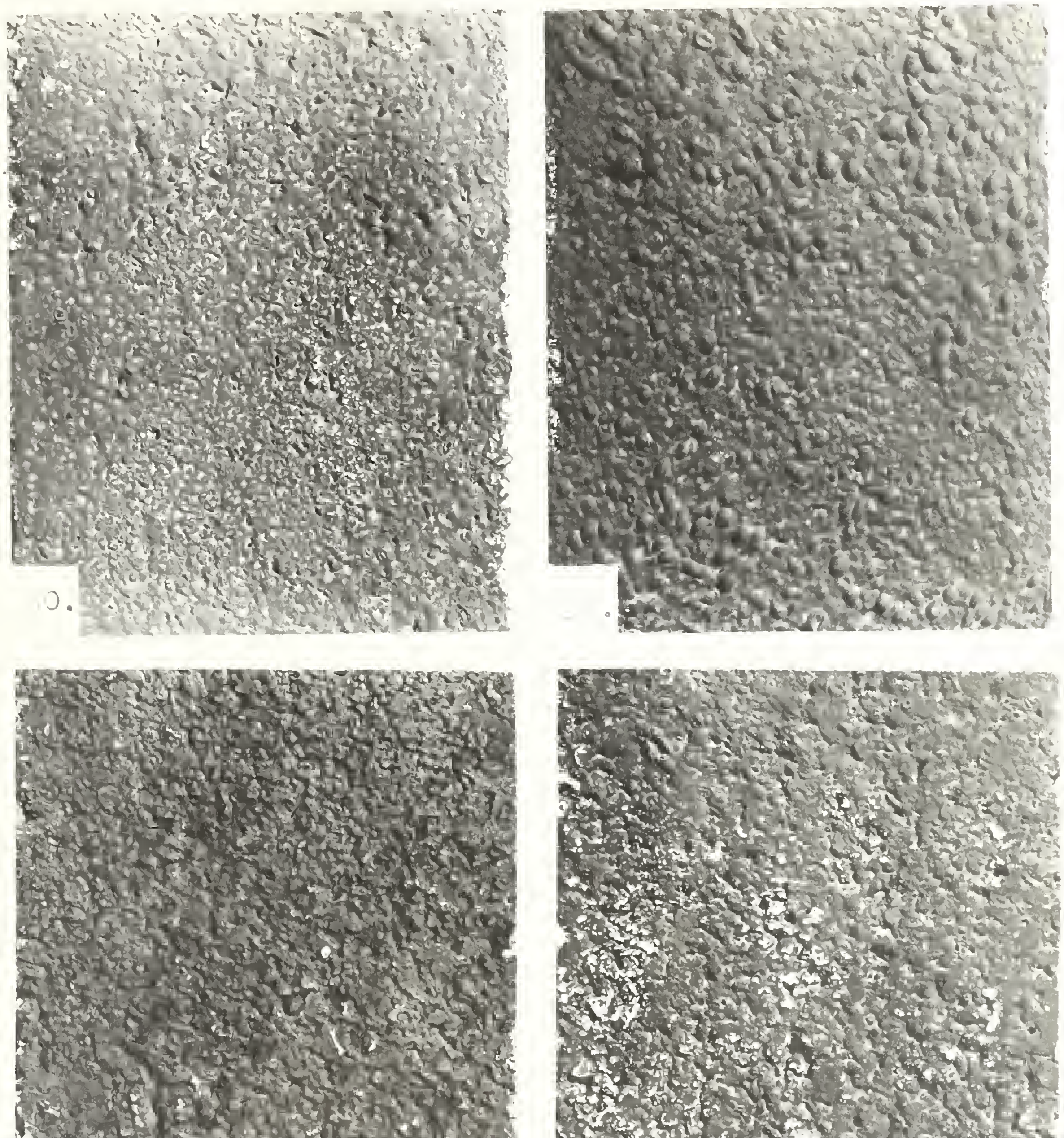

Figure 7. Class I coatings on cinder block - 2 years outdoor exposure.

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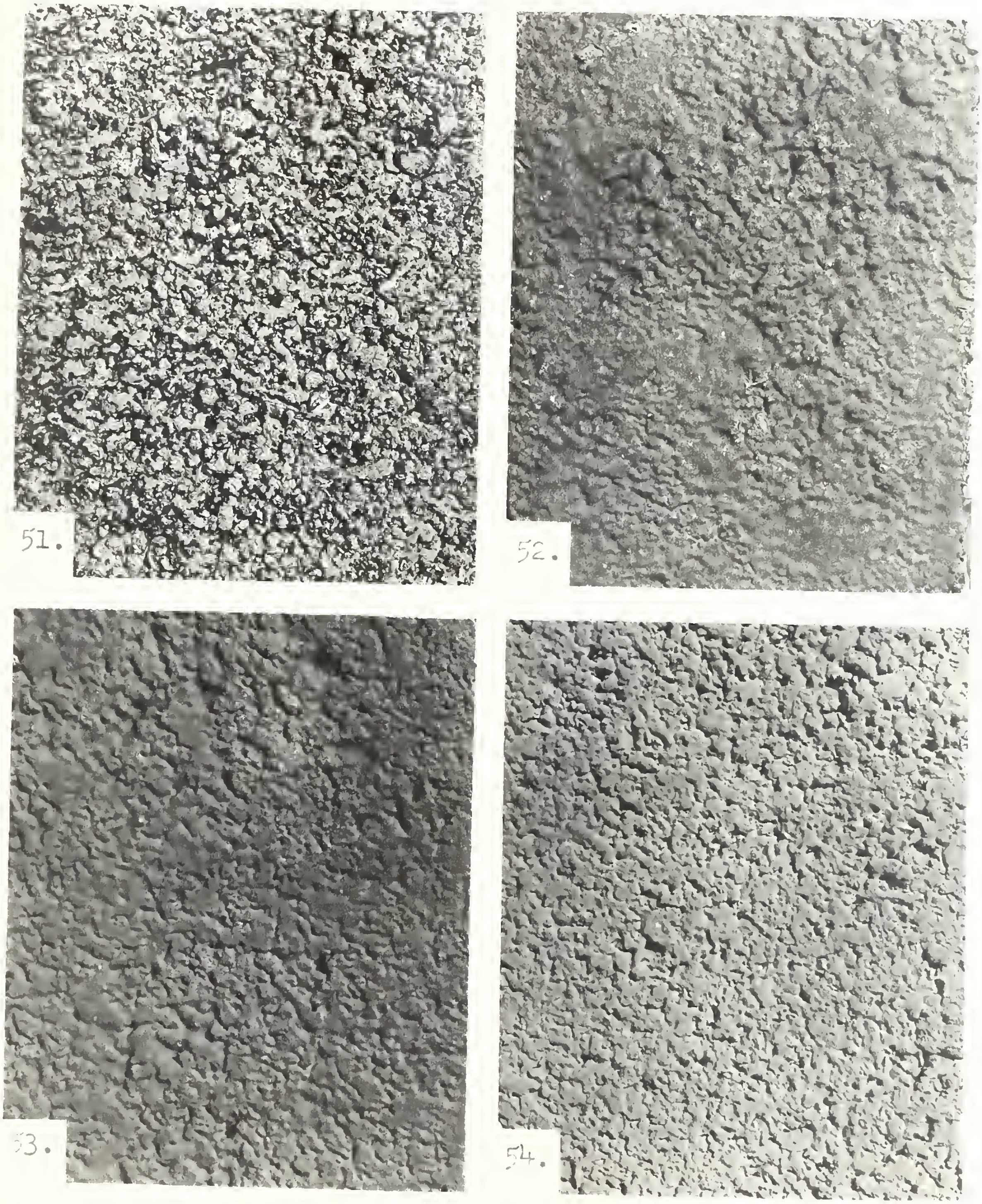


Figure 8. Class I coatings on cinder block - 2 years outdoor exposure.

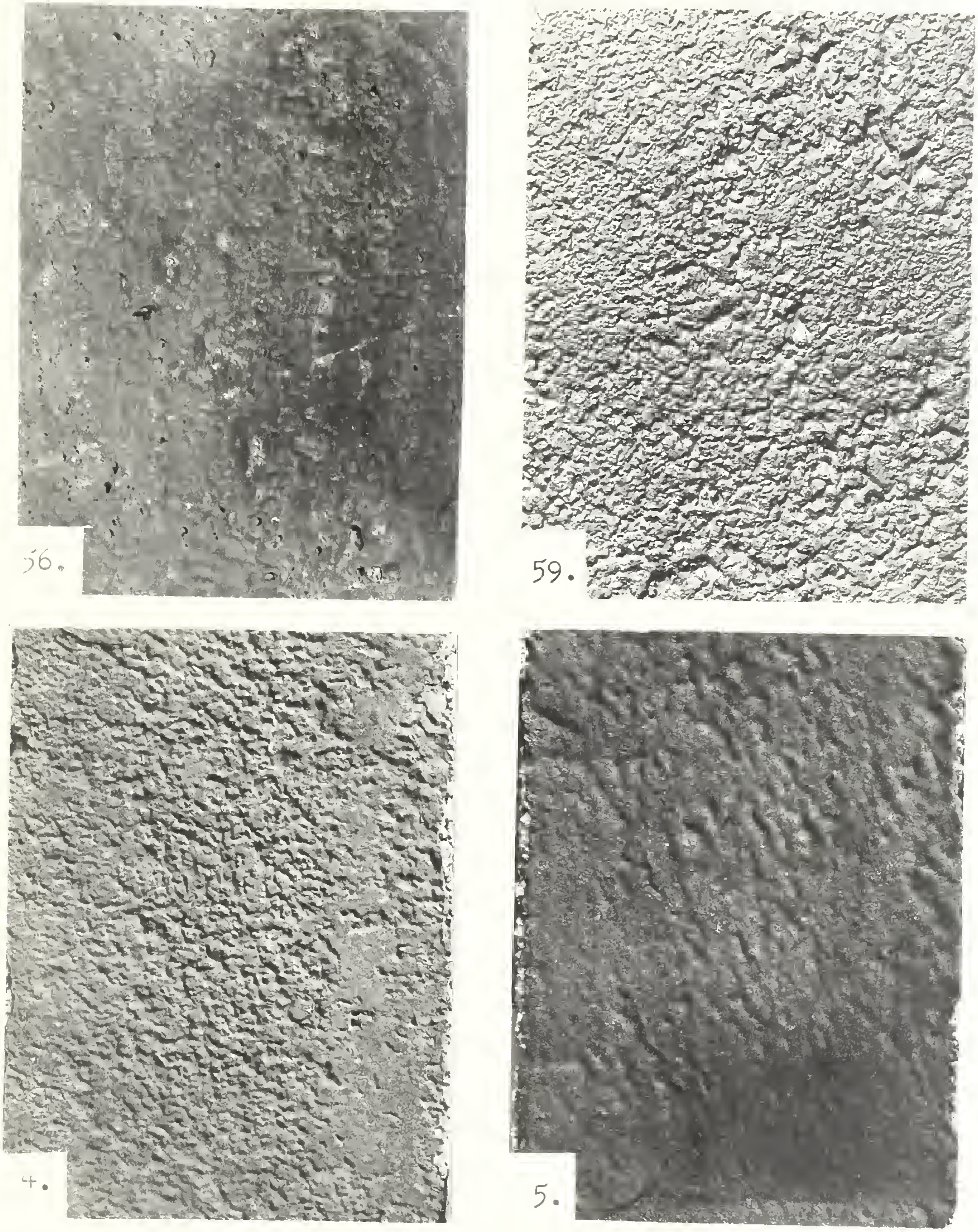


Figure 9. Coatings on cinder block - 2 years outdoor exposure.
56 & 59, Class I coatings; 4 & 5, Class III coatings.

NBS

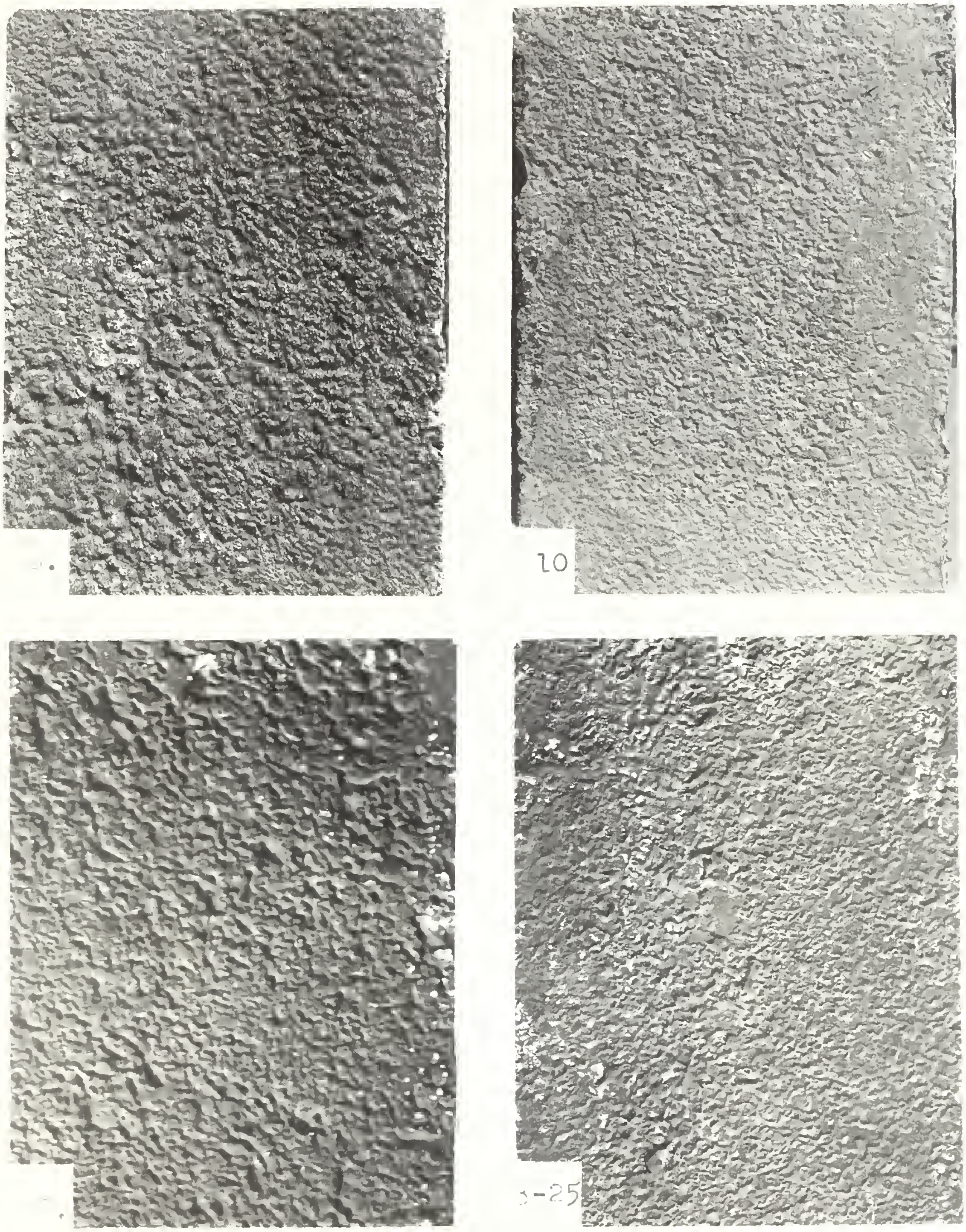
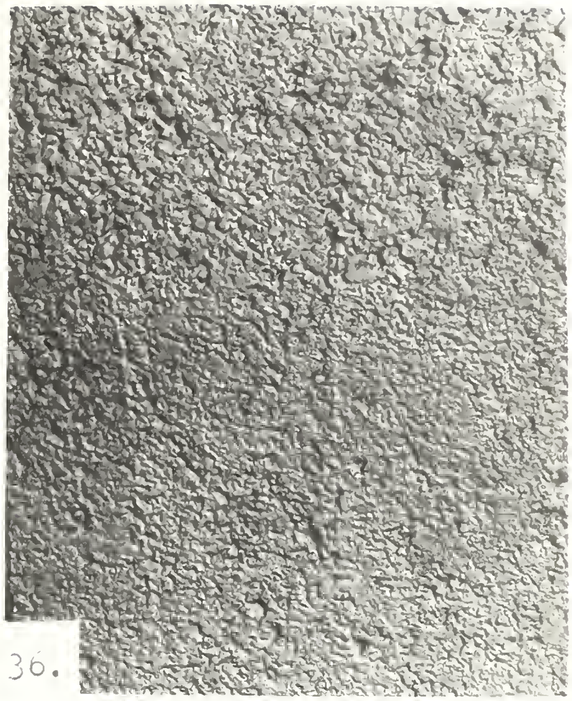


Figure 10. Class III coatings on cinder block -
years outdoor exposure.

34.



36.

38.

Figure 11. Class III coatings on cinder block - 2 years outdoor exposure.

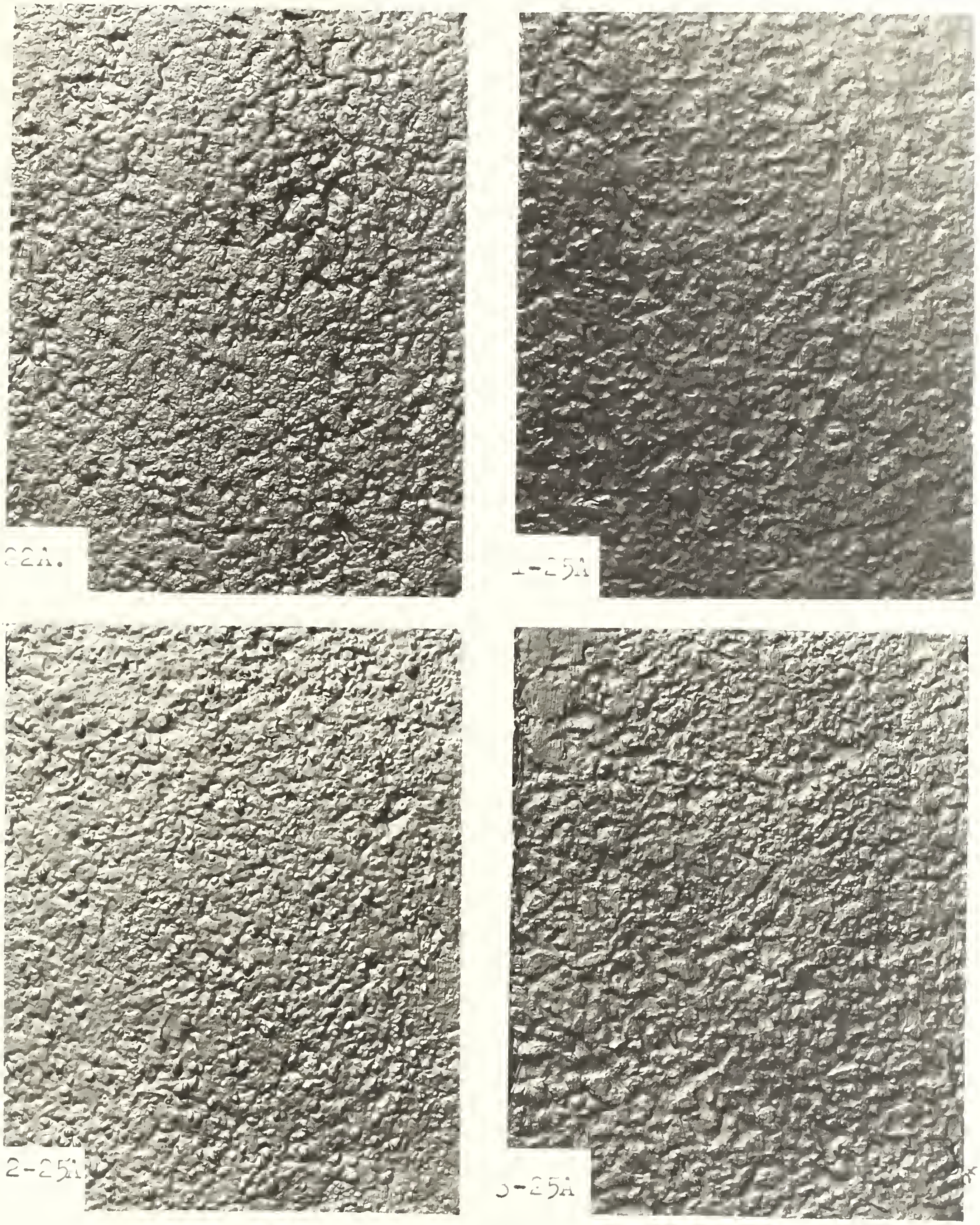


Figure 12. Aluminum paint (coating no. 23) applied to various base coats on cinder block - 2 years outdoor exposure.

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THE NATIONAL BUREAU OF STANDARDS

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