A STUDY OF MEMBRANE CURING COMPOUNDS

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A Study of

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by

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THESIS

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INTRODUCTION

The coming of the war has brought about many changes in the lives of the people of this nation! Many luxuries have been dispensed with; even some of those articles which were once looked upon as necessities are now disappearing. In every field of endeavor it has become necessary to take short cuts which will involve the use of less and less of certain critical materials which either are unobtainable because of the war or are being used in enormous quantities by the Army and the Navy and by those involved directly in the furnishing of materials to the armed forces. Rubber became precious and nearly unobtainable; steel reinforcement for buildings became rare and steel shapes for any purpose whatsoever were greatly limited in both variety and quantity; other materials similarly were limited.

The need for new construction, however, didn't decrease with the same degree of rapidity as did the supply of construction materials. New buildings had to be built to hold the industries and to house the families of the workers; new roads were essential for the transportation to and from the growing industries; new air bases were needed to provide for the training of pilots to fly the hundreds of planes pouring out of the new industries; and, in turn, new roads had to be built to the bases. Thus, the need rose for the materials while the supply of these goods was decreasing. The engineers and industrialists of the United States soon recognized the problem before them and immediately started the development of substitutes for the no longer obtainable products. The huge roof trusses of aircraft hangars, previously made of steel, were successfully fabricated out of wood; concrete slabs for roadways, instead of being reinforced with steel, were redesigned to eliminate that essential material; and similarly, all over the industrial nation, substitutes and new methods were found which took the place of the old--and did the job!

One of the problems which soon appeared in connection with the construction of new buildings and roads was that of the maximum strength and durability must be cured for a period of time under controlled conditions of moisture and temperature. Of the several methods used, the most satisfactory, or at least the most widely used, was the use of burlap sacks, sprinkled and kept wet for a period of from seven to ten days. Burlap, however, disappeared from use for the curing of concrete soon after the opening of the war. Cotton material and paper can still be used to some extent, but their use is limited for certain classes of work and in some localities. Bituminous curing materials are no longer available at all in the East and the restrictions are spreading to other sections of the country.

Of the methods yet remaining for the curing of concrete slabs, the best has not definitely been decided. Ponding and coverings of wet earth undoubtedly retain the water in the concrete during the curing period, but it isn't possible to apply wet earth to the surface of freshly-poured concrete without ruining the finish of the concrete; thus, the curing isn't applied until set occurs and by that time, much of the water has been drawn out of the concrete and the damage has already been done.

Paper, still used in some cases, also has its problems. As with burlap, a definite period must elapse before application, and during the period, valuable water is lost. Also, water must be sprinkled onto the paper during the curing period, since drying out of the paper will cancel its effectiveness. This continual spraying introduces the human element, which is often apt to introduce error.

Another curing method, not entirely new but being promoted extensively since the shortage of other materials, makes use of a thin membrane, supposedly quite impervious to water, to secure retention of moisture during the curing period. It is this group of compounds which we have chosen to investigate.

The so-called membrane curing materials were used a decade before the development of the colorless membranes of today. Even as recently as 1938, when membrane curing compounds were mentioned, the bituminous compounds such as coal-tar, pitch, cutback asphalt, and asphalt emulsion, were usually understood. The first patent on membrane curing was granted to Paul Lechler of Stuttgart, Germany (German Patent No. 337,134) in 1921. The first American patent (No. 1,684,671) was issued in 1928. These first products differed greatly from the colorless compounds used today. It is quite natural that these compounds were first used in the semi-arid regions of the West, where it would be difficult to obtain sufficient water for curing purposes.

> Investigations conducted in various laboratories and corroborated by use, demonstrate that certain of the coal-tar and asphalt cutback materials were

quite effective for the retention of concrete mixing water and, in some respects, a satisfactory substitute for water curing.[1]

There were many disadvantages however, to these bituminout coatings. First, a bituminous coating is very objectionable for use on surfaces where the natural appearance is desirable; for example, highways. Secondly, the black bituminous coating causes very high heat absorption which, in time, produces excessive cracking when it is exposed to the sun's rays.[2] Often these bituminous materials would be put on too heavily and would leave a slick black surface, which was dangerously slippery when wet.

Emulsified asphalt by its very nature will not form an impervious membrane. Since emulsified asphalt is asphalt suspended by a water solution, when the water dries, there are millions of small openings through which the moisture can escape from the concrete. Another disadvantage of bituminous materials is that the material remains tacky for weeks after its application, even in the summer months.

The first clear membrane curing compounds had such low water retention properties that engineers insisted that wet burlap or cotton mats be used for the initial twenty-four or even seventy-two hour period. Of course, this destroys one of the basic advantages of membrane curing compounds, because it is claimed that they may be applied immediately after fin-

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[1]Technical Progress Section, Journal of the American Concrete Institute, Vol. 14, No. 4, p. 377.

[2]H. S. Meissner and S. E. Smith, "Concrete Curing Compounds" Journal of the American Concrete Institute, Vol. 9, May-June 1938, p. 549.

ishing, while wet burlap cannot be applied for the first several hours, The product sold in the West was a paraffin-vegetable oil base cut with a petroleum solvent.[1] These initial products, besides failing to maintain a sufficient amount of water also imparted a blotched discoloration which is ascribed to the reaction of calcium bydroxide with the fatty acids of the compounds, resulting in the formation of calcium salts of the fatty acids.[2] Besides giving an unsightly appearance to the surface, this reaction was detrimental to the concrete. Since the early compounds failed to give the desired results, further research was instigated with the following purposes in mind:

1. Immediately and effectively seal the surface against surface dehydration, and provide maximum retention of the original mixing water within the concrete.

2. Be chemically inert to any constituents of concrete.

3. Produce concrete having compressive and flexural strengths equal to 14-day water curing.

4. Produce concrete surfaces having erosion and abrasion resistance equal to 14-day water curing.[3]

In several of these purposes the manufacturers have made considerable progress. The water retention properties have been improved, chemically inert compounds are used, and the compression and abrasion resistance are comparing favorably

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[1]Technical Progress Section, Journal of the American Concrete Institute, Vol. 14, No. 4, p. 378.

[2]Ibid, p. 378

[3]Deacon, Wm., President of Solvents and Plastics Co. Taken from a reply to letter requesting information.

with water curing. Here are some of the advantages now claimed by the producers for their type of product:

1. High early water retention. The fact that the compound may be applied immediately after finishing (no waiting for concrete to set) gives it at least one to three hour's start on other curing methods such as burlap or cotton mats.

2. Eliminates the burden and expense of prolonged supervision.

3. Its method of application is easy. A spray gun, hand or pressure type, may be used. It may be applied to vertical surfaces, the under side of concrete bridges, and other places where other curing methods cannot be used.

4. Keeps work area dry and prevents all delay incident to sloppy working conditions.

5. Avoids the possibility of decompaction through wet subgrade.

6. Effects definite economics in cost and adds materially to the speed of construction.

7. No after expense. After the material is applied, the job is completed with no expense of recleaning and storage of the materials.

8. It produces concrete of high strength with a maximum performance expectancy.

Not all of the above claims of manufacturers are to be taken as established facts, for when the shortage of essential materials necessitated a substitute, every manufacturer producing a compound which might, by remote chance, find a market as a curing agent, started to promote it. Many of the claims made for the various compounds were doubtful, and at best only the hopeful dreams of manufacturers expressed in print to serve as come-ons for unwary buyers.

In this study, we propose to test some of the better known commercial compounds and to establish, at least in our own minds, which of them best fulfills the requirements of a good curing compound; and incident to this determination we hope to find a suitable method for testing in the laboratory any new compounds which may be brought out in the future, so that they may be evaluated by the same standards as their forerunners.

That is, in general, our purpose in this study.

WATER RETENTION TEST

THE WATER RETENTION TEST

Since it has long been recognized that the strength of Portland Cement Concrete is greatly affected by the hydration of the cement, a Water Retention Test seems a logical and fair method of testing the efficiency of various curing materials. The ideal concrete mix is the mix with the least water in relation to cement and yet providing a mix which is thoroughly plastic and workable. Abrams' water-cement-ratio law is usually stated as follows: "With given concrete materials and conditions of test, the quantity of mixing water used determines the strength of the concrete, so long as the mix is of a workable plasticity."[1] After this mixing water is once added, everything possible should be done to retain it, for this retention of water during the formation period of the concrete is the greatest factor affecting the resultant concrete. This, in brief, is the purpose of curing.

Water retention is necessary, or the highly complicated chemical reactions taking place during the hydration of the cement will necessarily be retarded due to a lack of sufficient water. All the mixing water in the concrete, however, does not chemically combine; therefore these five classifications have been used:

1. There is free water that is only enclosed in the hardened cement and whose vapor pressure is somewhat reduced as a result of dissolved substances, but which is otherwise practically identical with pure water.

2. A certain amount of the water is fixed by the dis-

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[1] Abrams, D.A., "Design of Concrete Mixtures", Materials Research Laboratory, Lewis Inst. Bull. 1.

solved and solvated substances and more or less firmly attached to these.

3. Further, a part of the water functions as capillary-bound water with a vapor pressure varying according to the degree of dryness of the cement and the size of the capillaries.

4. A certain amount of the water is further bound by adsorption at the surfaces of the solid phases and is found engaged in varying degrees according to its nearness to the surfaces and the nature of these.

5. Finally, there is chemically bound water engaged in the chemical structure of the solid elements.[1]

The water available for evaporation is affected by the rapidity with which these chemical reactions take place, for the gypsum in the cement ties up water in ten to fifteen minutes, the tricalcium silicate, tricalcium aluminate and the tetracalcium alumino ferrite bind the water in chemical combination in twenty-four hours and the dicalcium silicate may continue to bind water for several years.

If an evaluation of the quality of various membrane curing compounds is desired, a fair and equitable water retention test seems to be the logical solution. The problem at the first casual glance seems to be only a matter of laboratory technique, but in the ultimate analysis there are so many factors acting to influence the solution, that many variables have to be studied and analyzed, and others converted to laboratory controlled constants.

As the American Society for Testing Materials is usually considered the authority in matters of testing procedure, a

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[1] Staff of Research Division, Michigan State Highway Dept., Membrane Curing Report, May 28, 1942

study of their Tentative Method of Test for the Efficiency of Materials for Curing Concrete (C 156-40T) is of primary importance. This tentative test procedure, however, is looked upon by many laboratories with disfavor. They usually explain that it was disregarded by their laboratory because it was not definite enough on several important points, that it requires too large specimens, and that uniformly consistent results cannot be obtained. Perhaps this test procedure does need more clarification. Its inadequacy is probably due to the fact that it was not specifically designed for membrane curing materials, and such a broad test cannot give the required results. This has led to a confusing array of testing procedures. Diversity is the rule rather than the exception. To give only a few examples: Battenfield's Laboratory suggests slight modification of A.S.T.M. C 156-40T; Truscon Laboratory uses greater variations from A.S.T.M.; The War Department, represented by the Cincinnati and Mount Vernon Testing Laboratories, and also the Bureau of Reclamation, have still more variations.

With this labyrinth of diversity the only logical way that an analysis of such testing procedure can be made is to consider the factors that influence the test, and then point out how the different testing laboratories have tried to control these factors. In my opinion the most important of these are:

1. Proportioning of mix
2. Aggregate grading
3. Shape of moulds

4. Size of specimens

5. Methods of finishing
   (a) Strike-off
   (b) Troweling
   (c) Wood float
   (d) Brushing

6. Time of application of membrane

7. Rate of application

8. Methods of applying membrane

9. Storage of specimens--Control cabinet
   (a) Temperature
   (b) Humidity
   (c) Air flow

The following discussion will center about these points, and taken up in the order necessary in the organization of the test.

It is generally recognized that the storage of the specimens during the test will greatly affect the water lost. However, several laboratories do not seem to take a sufficient interest in the matter of developing a test that may be repeated time after time with the same results. By this, I mean that they have tests which may compare various materials at the same time, but the results are not reproducible, because the conditions are not held constant. The three conditions that must be held constant are the temperature, the humidity, and the air flow. The A.S.T.M. Test specifies that these conditions must be as follows: "Immediately after moulding, the mould and the specimen shall be weighed to the nearest gram and placed in an atmosphere maintained at a temperature of one hundred degrees Fahrenheit (100°F.) plus or minus five degrees (5°F.) and at a relative humidity controlled within the limits of thirty to thirty-five percent (30-35%). Means shall be provided for circulating the air."[1] If a test is to be designed that may be used in every laboratory in the country at different times with as nearly as possible comparable results, the conditions must be controlled more closely than this.

We will consider first the temperature. Since this is easily regulated, it seems careless for several laboratories to fail to attempt more accurate control. Truscon has improved on the A.S.T.M. Test in this respect by stating in their test that the temperature must be regulated to plus or minus five-tenths degree (.5° F.).[2] The War Department specifies that the temperature of the cabinet should be ninety degrees plus or minus two (90 ± 2° F.). The control range is satisfactory, but I see no reason why the temperate should be changed from the 100° F. of the A.S.T.M. procedure. The Bureau of Reclamation's procedure is probably the easiest to comply with, and one which would give only a comparison test under varying conditions. They use no cabinet, but state: "The room temperature should be operated on a 24 hour cycle, alternating between 120° F. maximum and 75° F. minimum."[3] It is presumed that this variation is to similate the temperature

[1]Tentative Method of Test for Efficiency of Materials for Curing Concrete, American Society for Testing Materials, 1940 Supplement, p. 264.

[2]Truscon Laboratory uses an incubator as for hatching eggs, as their control cabinet and endorses its use (Brower Cabinet No. 42-600).

[3]Bureau of Reclamation Specifications for 45-Percent Solids Clear Curing Compounds.

range of the desert regions of the West, but since the specimens lose moisture much more rapidly the first few hours, it would be necessary to mix the specimens at exactly the same time each day or comparable results between different tests would not be obtained.

The next important factor that must be controlled in the storage of the specimens is the humidity. Again various laboratories differ. As noted before, the A.S.T.M. Test designates that the relative humidity should be 30 to 35%. Truscon Laboratory specifies 30% plus or minus 3%. The Cincinnati Testing Laboratory states it should be 45% plus or minus 5%. It is said that the Bureau of Reclamation has done considerable research in the membrane curing field, yet their test seems worthless to me. Their specification reads as follows: "The relative humidity range shall be approximately 15 to 35%."[1] (The word "approximately" is added, I presume, in case the relative humidity should ever stray from this 20% range.) Needless to say, a specification like this is useless if the purpose of the test is to obtain reproducibility. A control cabinet seems to be an absolute necessity if the relative humidity must be controlled very accurately.

The third important factor, the air flow over the specimens, is not definitely specified in any proposed test. The A.S.T.M. Test merely states that, "Means shall be provided for circulating the air." The Truscon Test states the same. The Bureau of Reclamation and the War Department tests do not

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[1] Bureau of Reclamation Specifications for 45-Percent Solids Clear Curing Compounds.

even mention this item. The Battenfield Laboratory, Manufacturers of Satisfaction curing compound, specify: "The incubator shall have a small fan which slowly causes air movement, rather than a large fan that causes excessive evaporation, or air movement."[1]

In considering the design of a control cabinet, a fundamental question is, "Shall the air flow be an open or closed system?" Perhaps a satisfactory control cabinet can be designed with either type, but it seems as if the easier and better control method would be the closed system. This appears logical, since after the conditions are once stabilized, the air must be conditioned only slightly each time that it passes the conditioning agent. However, if an open system is used, there is continually new and unprocessed air passing over the conditioning agent and the conditioning agent has only one chance to regulate the air before it passes over the specimens. This would be a more expensive method and more difficult to control, since the entering air may vary greatly according to conditions outside the cabinet. In a closed system, however, if the conditioning agents are adequate for the size of the cabinet, a stabilized condition is not difficult to maintain.

Following this line of reasoning, the control cabinet designed for this thesis was of the closed system type. It was designed to accomodate six specimens of the A.S.T.M. type with sufficient additional space for the conditioning agents.

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[1] Concrete Curing Compound Specifications in Use and Recommended, published by the Battenfield Grease and Oil Corp., p. 2

CONTROL CABINET

Of course, the size, expense, and the time element involved, controlled the design; but it was recognized that the larger the cabinet, the smoother and more regular the air flow would be. A cabinet 3' - 7 1/2" wide, 2' - 3 3/4" in depth, and 2' - 3 1/2" high was built, with structural wood frame and a celotex covering. To obtain as nearly as possible an air-tight cabinet, a double celotex covering was used with an air pocket between the layers of celotex. It was desired that building paper be placed between the celotex layers, but this was not done, and it later proved satisfactory without it. The doors were of rabbitted construction and sufficiently air-tight for the purpose. The Carpenter Shop on the Campus constructed the cabinet from the sketches furnished them.

While the cabinet was under construction, the wiring arrangement was designed. The most satisfactory control of temperature is of course, obtained electrically. A resistance coil or electric lights were considered, but it was decided that light bulbs controlled by a thermostat would be the most satisfactory. The lights were wired in two banks, one bank of lights being controlled only by a switch on the outside of the cabinet, while the other bank was controlled by a thermostat within the cabinet and by a switch on the outside. It was intended that the one bank be used constantly and the other to regulate the temperature as close to 100° F. as possible. After the cabinet was completed, however, it was found that the thermostat-controlled bank, while working only infrequently, was sufficient to keep the temperature at the desired value. An outlet was needed inside the cabinet to connect an electric fan, which might also be controlled by a switch on the outside. To take temperature and humidity readings, a reading light, controlled by another switch on the exterior, was placed in the top of the cabinet, to be used only infrequently.[1]

An inexpensive electric thermostat, taken from a water bath, was used in series with the light bulbs to regulate the temperature and, after the proper adjustment, controlled to 100° plus or minus 1° F. Since this method is very simple and inexpensive, it appears to me that every laboratory in the country should run its tests with the smallest control range possible, instead of the wide ranges (10° F.) specified at present.

As stated previously, the only comment in connection with the amount of air flow over the specimens was that it should be sufficiently small to prevent excessive evaporation.[2] In line with this reasoning, a small Sterling electric fan with an eight-inch blade was used. The Air movement in the cabinet was first measured without using air baffles. This was done by the use of a Velometer (Boyle system).[3] It was found that the air movement was greater near the top. At Mr. Reuling's[4]

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[1] The wiring for the cabinet was done by the Electrical Shop of the college from the sketches furnished them.

[2] Battenfield Laboratory, op. cit., p. 2.

[3] This Velometer was borrowed from the Power Lab., Olds Hall.

[4] A professor in the Michigan State College Mechanical Engineering Department.

suggestion, air baffles were designed for the corners of the cabinet. After these were installed, the air flow was again tested and proved satisfactory, being approximately two feet per second (1.36 m.p.h.).[1] It is said that the Cincinnati Testing Laboratory is using a wind tunnel costing approximately $15,000 to regulate the air flow to 15 m.p.h..[2] This air flow seems excessive as even field conditions would rarely be so severe. Truscon Laboratory is using an air flow slightly less than our own.[3] Controlling the humidity to the desired range is the most difficult. It was not until the middle of the testing period before it was solved satisfactorily. During the tests under Series I, calcium chloride or water was placed in pie tins (10 1/2" dia.), according to the regulation desired. It was necessary under this method to watch the humidity of the cabinet rather carefully, especially during the initial stage of the test, when the specimens were losing moisture rapidly. However, an error caused the control range to be lower than desired. There are five methods of measuring humidity, but the one simplest and most generally used depends upon the lowering of temperature of a wet bulb thermometer due to evaporation. This method was used and the relative humidity was controlled as close to 33% as possible. It was discovered later however, that this was not actually

[1]See datum on Measurement of Air Flow in the Control Cabinet.

[2]From a discussion with Mr. Fairbrother of Truscon Lab., Jan. 19, 1943.

[3]From a discussion with Mr. Fairbrother, of Truscon Lab., April 19, 1943.

giving the correct humidity reading, because the air flow over the wet bulb thermometer was not sufficient to obtain accurate results. To obtain accurate readings the air velocity must be three meters per second. Since it was much less than this, the actual humidity was approximately 22%. The necessary correction was obtained by use of a Dew Point Apparatus.[1] After the error was discovered, it seemed best to continue with these conditions until all the materials were tested, so that a comparison between the compounds could be obtained. However, by the time that Series II was started, a better method of controlling the humidity had been found.[2] Any aqueous solution which has a vapor pressure close to 0.649 inches of mercury at 100° F. will work satisfactorily if a sufficient surface is exposed to the air. For our test an area of 628 square inches of saturated magnesium chloride was used for a cabinet of 12.35 cubic feet. The solution of magnesium chloride must have some excess crystals at the bottom of the container, but any excess salt above the solution will cause the humidity to drop below 33%.

In connection with the variations that will be caused in water loss by changes in humidity, Test B, Series I, furnishes a good example. After the first several days a specimen will lose moisture in approximately equal amounts each day. (This may be seen from the graphs on Percent Water Loss in the con-

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[1]The Dew Point Apparatus was borrowed from the Physics Department of the college.

[2]Mr. Cecil Rhodes was the first to suggest and try this method of humidity control in the cabinet.

clusion.) The fourth day of the test the relative humidity was 22% and the average water loss was 5 1/4 grams. The next day the humidity was only 2% lower, yet the average water loss was 11 3/5 grams. This may not be a quantitative approach to the problem, but it does illustrate the fact that every attempt should be made to control the humidity as finely as possible.

Each laboratory has again adopted its own ideas in the proportioning of the mix for the specimens. The A.S.T.M. Test states:

> The mortar for making the test specimens shall be of plastic consistency and gaged to a definite water-cement ratio. The proportions of cement and sand shall be determined by adding to a paste having a water-cement ratio of 0.40 by weight, a sufficient quantity of saturated, surface-dried sand to produce a flow of 50 percent as measured on the 10 inch flow table using thirty one-eighth inch drops in thirty seconds.[1]

Truscon Laboratory uses exactly the same words in its procedure, except for the fact that they substitute a 15% flow in place of the 50%. The Cincinnati Testing Procedure is, in effect, the same as the A.S.T.M., but the Bureau of Reclamation uses a concrete made of well rounded, sound, natural aggregate (3/4" max.) and modified portland cement in a mix proportioned by weight of 1:2.65:2.65 with a w/c of 0.55. A 50% flow is objected to because of the great amount of finishing water brought to the surface before a smooth surface is obtained. This finishing water forms a laitance on the surface of the specimen, which, after the application of the

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[1]A.S.T.M. C 156-40T, op. cit., p. 264.

membrane, may dry further and crack, leaving small openings for the water to escape. Reducing the amount of mixing water may remedy this somewhat, but the finishing operation still brings up water which may form a surface laitance.

The grading of the sand used in preparing the mortar may also affect the water retention of the specimen. The A.S.T.M. Test states that an approximate grading should be:

Sieve	Percent Passing
No. 4 (4760-Micron)	100
" 16 (1190- "	60
" 50 (297- "	15
" 100 (149- "	2

In order to make sure that the grading was not affecting the results, the sand for every specimen in both series of tests was sieved and then recombined exactly to the desired proportions. After recombining, the sand was saturated and then surface-dried. While the sand is in a saturated, surface-dried condition it has a tendency to segregate, which may again cause variations in specimens; therefore for future tests I would recommend that the sand be oven-dried, sieved, and then recombined separately for each specimen or each mix. (By oven-drying the sand the amount of additional mixing water needed to correct to a surface-dried condition may be obtained.)

The size of the specimen is another feature over which there has been much discussion. The larger specimen (approximately 12"x6"x2") of the A.S.T.M. Test is not very widely used. Instead the Truscon and Cincinnati Laboratories use a specimen with a top diameter of 5 3/8", a bottom diameter of 4" and 15/16" thick (approximately one-tenth of the size of the larger specimens). It is said that the larger specimen is objectionable in several respects.

1. The specimen is so thick that the water loss is not a true measure of the surface dehydration.

2. Accurate balances cannot be used with such large specimens.

3. The larger specimens require much more work and only a few specimens may be run at the same time.

The last reason seems to be the most logical basis for changing the size of the specimen. Our cabinet would allow the use of six A.S.T.M. specimens or sixteen of the smaller ones. This means that if two blanks were used as controls only two curing materials (two specimens per curing material) could be tested at the same time, while with the smaller specimens four blanks and four curing materials (three specimens per curing material) could be tested simultaneously. In the tests under Series I the large specimens were used, but the smaller specimens were tested under Series II. Smaller variations were obtained with the larger specimens, but this will be discussed in greater detail later. The A.S.T.M. moulds are further objected to because of the one-half inch ridge projecting above the surface of the specimen. It is quite logically claimed that this causes a dead air space above the specimen, which is not affected by the movement of air in the cabinet.

Another variable affecting water retention is the type of finishing used. In this it seems the manufacturing laboratories have experimented until they found the finish which gave the greatest water retention, and then used it in their tests. The first question is, "Should the laboratory finish similate field conditions?" In my opinion this is not neces-

FINISHING WITH STRIKE-OFF

SERIES I

SPRAYING MEMBRANE

FINISHING WITH WOOD FLOAT

SERIES II

APPLYING MEMBRANE

sary, for this test is artificial in many respects, and if the finish in the laboratory were similar to that in the field, it would not yet prove that the concrete slab in the field would lose water in the same proportion as the laboratory specimen. Therefore a finish which is simple and reproducible is sufficient for the purpose. It might be worthwhile to discuss the effect of the different methods of finishing on the water retention properties. The membrane applied to a brushed surface will give the least water loss. A steel troweled surface will lose the greatest water, and a wood float finish gives it an intermediate value.[1] In Series I the strike-off method as specified by the A.S.T.M. was used, while in Series II the surface was finished with a wood float and later brushed, as is done in the Truscon Procedure. A finish to the specimen which has distinct ridges and low spots is to be avoided, because the membrane when applied is quite fluid and the low spots get an excess amount of material, which is definitely detrimental to the water retention properties.

Nearly all the water retention tests now used specify that the membrane should be applied after the surface moisture has disappeared. The A.S.T.M. Test, however, specifies that the membrane should be applied after a storage period in the cabinet corresponding to the time the concrete in the field would be exposed without curing. Since in the field there is not much moisture brought to the surface when finishing, the membrane may be applied immediately. The speci-

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From a discussion with Mr. Fairbrother, Jan. 19, 1943.

mens in the laboratory are, however, in a closed mould and when the specimens are finished a great deal of water comes to the surface, especially with the wetter mixes. Several of the curing compounds, if sprayed on this surface water, form very poor membranes.[1] With a drier mix, Series II, the compounds Aquastatic 1-C-Red, Klearcure 60, Truscon 203, and Satisfaction 45 were tested, applying the membrane immediately. The water retention qualities were comparable with the results obtained when applying the membrane after the surface moisture disappeared.[2] If the curing material is not applied soon enough, the membrane will penetrate the surface of the mortar and the resulting membrane will be very poor. This is especially true of the more viscous materials. In some specifications, if the concrete has dried too much, it is specified that the concrete must be sprinkled before the membrane may be applied. In the laboratory it seems best to wait until the surface moisture disappears, but in the field the best practice indicates that it should be applied immediately.

The present specifications usually indicate that the membrane should be applied at the rate of two hundred square feet to the gallon. In Series II, Test P, the specimens were sprayed at the rate of 100, 200, 400, and 600 square feet to the gallon. The graph on the following page clearly indicates that two hundred square feet to the gallon is the most logical coverage. However, if the coverage is not uniform, the con-

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[1]A notable exception is Klearcure 60, which forms a strong, dense film over this surface water.

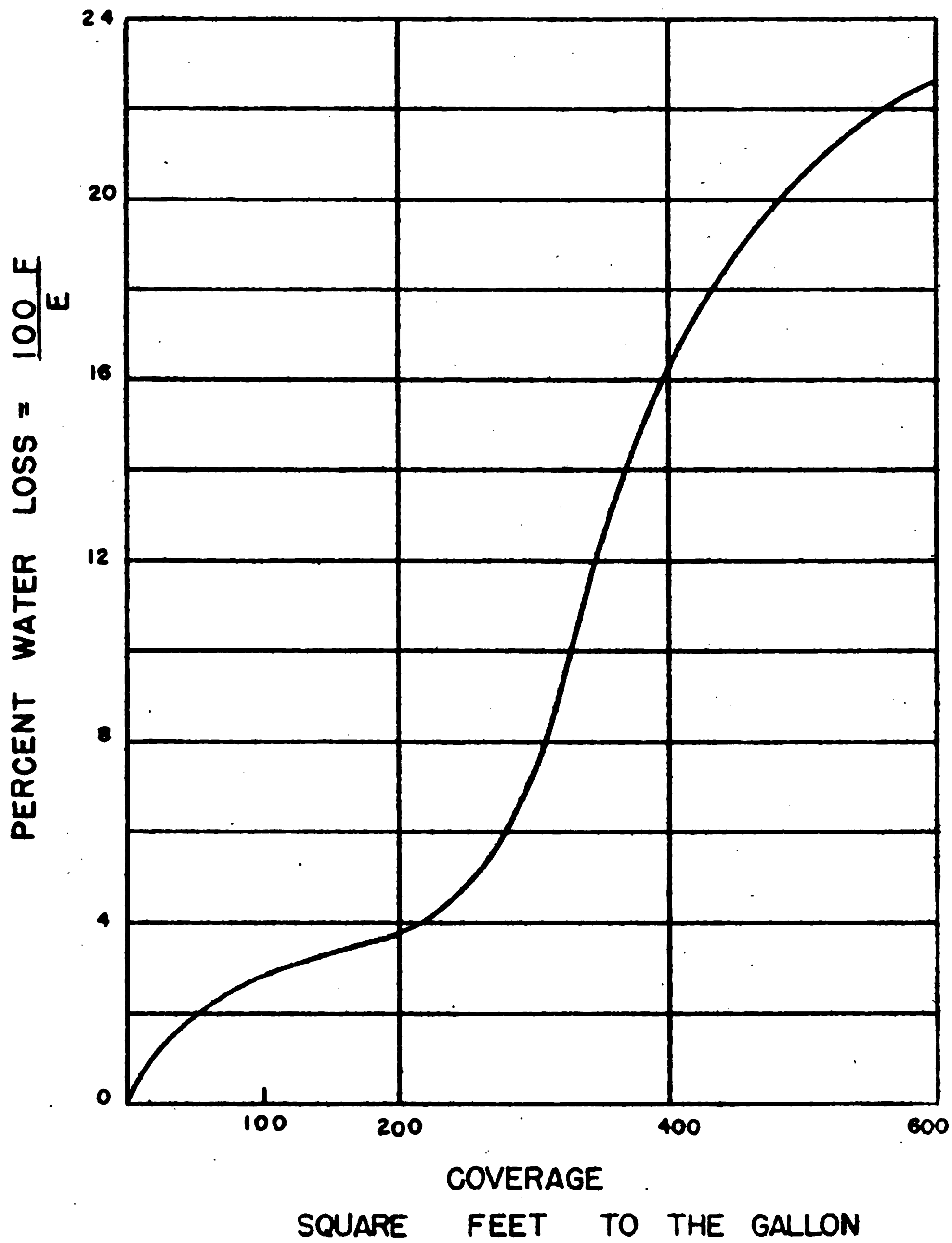
[2]See data on Series II, Test N.

MEMBRANE CURING STUDY

WATER RETENTION TEST

SERIES II — TEST P

PERCENT WATER LOSS VARIATION WITH RATE OF COVERAGE



crete will also vary in strength and durability. A rate substantially greater than that specified does little in improving the water retention, but a rate substantially less is very harmful. In the field a uniform coverage with the old type of spraying equipment was very difficult, but the Truscon Laboratory has, during the winter, developed a new type of spraying equipment which should give much better results.

On large jobs the most efficient method of applying the membrane curing material is, of course, by power-spray equipment, but if necessary, on small jobs the membrane may be applied by brushing. Spraying with an atomizer seems to be the best method of applying the membrane on the laboratory specimens, as the amount applied may be measured quite accurately. If the atomizer is connected to a low pressure air line, a steady, uniform spray can be obtained. This method was not used in any of the tests, but it appears to be the best method so far developed for laboratory specimens.

The Truscon Laboratory has dispensed with the idea that the edges of the specimen must be sealed with a foreign material to prevent water loss other than through the membrane. Instead they use the membrane itself as the sealing for the edges. This may be satisfactory under certain conditions, but in the wetter mixes the specimens shrink slightly, pulling away from the mold and leaving a small crack through which water may escape. As a precautionary measure, it seems best to use some other material to seal these edges. In Test Q, Series II, two specimens with sealer and two without were tested using the same curing material. The specimens without sealer lost about twice as much water as those with sealer placed on the edges.

The next few pages will take up the procedure used in the tests under Series I and II; a summary of the results and conclusions will follow.

LABORATORY PROCEDURE[1]
Water Retention Test
Series I

Scope - This method is intended for laboratory use in testing the efficiency of membrane curing products for the curing of concrete.

Apparatus - Cabinet - The cabinet has been described previously.

Moulds - Moulds shall be water-tight. They shall be rigidly constructed so as not to distort when the specimens are handled at early ages. The moulds shall be 2 1/2" in depth (1/2" deeper than the thickness of the specimen in order to allow for proper sealing of the curing material), and the sides shall be beveled in order that the specimens may be readily removed.

Test Specimens - Test specimens shall be approximately 12" in length, 6" in width and 2" thick.

Proportioning and Mixing Mortar - (a.) Proportioning - The mortar for making the test specimens shall be of plastic consistency and gaged to a definite water-cement ratio. The proportions of cement and sand shall be determined by adding to a paste having a water-cement ratio of 0.40 by weight, a sufficient quantity of saturated, surface-dred sand to produce a flow of 25 percent[2] as measured on the ten-inch flow table using thirty one-eighth inch drops in thirty seconds.

(b.) Mixing - Cement and water in quantities which will give a water-cement ratio of 0.40 by weight shall be placed in an appropriate vessel and the cement permitted to absorb water for one minute. The materials shall then be mixed with a trowel[3] into a smooth paste. Saturated surface-dried sand shall be added to the mixture until the mortar is at the desired consistency (25 percent flow).[4]

Moulding Specimens - After the mortar is thoroughly mixed, it shall immediately be placed in the mould and puddled

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[1]This procedure is almost identical with A.S.T.M. C156-40T.

[2]The A.S.T.M. Test states 50% flow; reasons for changing this have already been discussed.

[3]The A.S.T.M. Test designates a spoon, but this minor matter will not affect results and a trowel is much handier for larger mixes.

[4]The A.S.T.M. Test states that a final mixing with the hands for two minutes should be used, but this was considered superfluous if the mortar was thoroughly mixed with a trowel; however, it was used in the tests under Series II.

with the trowel. It shall then be struck-off with a wooden template.

Storage of Specimens - Immediately after moulding, the mould and specimen shall be weighed to the nearest gram and placed in an atmosphere maintained at a temperature of 100° plus or minus 1° F. and at a relative humidity of 20 to 25%.[5] The air flow over the specimens shall be approximately two feet per second.

Procedure - (a.) Application of Curing Material - After a sufficient period has been allowed for the disappearance of the surface moisture (approximately 3 hours) the specimens shall again be weighed. The liquid curing material shall then be sprayed on the specimen uniformly with an atomizer at the rate of 200 square feet to the gallon. (This was measured as follows: the atomizer was partially filled with curing material and sprayed until no more could be exhausted. Then the desired amount, 9.5 ml. for 72 sq. in., was measured in a glass graduate and placed in the atomizer. The specimen was then sprayed until the atomizer was again exhausted. An additional check was used in that, the atomizer and contents were weighed before and after spraying the specimen.) After the application of the curing material, the specimen shall be weighed and replaced in the storage cabinet. After approximately 1/2 hour the specimen shall be taken from the cabinet, weighed, and the edges of the specimen sealed to the mould with a latex material. The specimen is again weighed and replaced in the control cabinet.

(b.) Determination of Water Loss - The specimen shall be weighed daily for the duration of the test. In determining the water loss, corrections shall be made for the loss in weight of the curing material and the sealer compound. At the end of seven days the specimen shall be taken from the cabinet and the final weighing made.

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[5] The reason why the humidity range was 20 to 25% was explained previously under the humidity control of the cabinet.

LABORATORY PROCEDURE[1]
Water Retention Test
Series II

Scope - This method is intended for laboratory use in testing the efficiency of liquid materials for curing concrete.

Apparatus - Moulds - Moulds shall be made of metal and shall be water-tight. They shall be rigidly constructed so as not to distort when the specimens are handled at early ages. The moulds shall be in the shape of a frustum of a right cone having a top diameter of 5 3/8", bottom diameter of 4" and depth of 15/16".

Test Specimens - Test specimens shall be of a size which completely fills a mould to its upper rim.

Proportioning and Mixing Mortar - (a.) Proportioning - The mortar for making the test specimens shall be of plastic consistency and gaged to a definite water-cement ratio. The proportions of cement and sand shall be determined by adding to a paste having a water-cement ratio of 0.40 by weight, a sufficient quantity of saturated surface-dried sand to produce a flow of 25%[2] as measured on the ten-inch flow table using thirty one-eighth inch drops in thirty seconds. This flow test is described in the Standard Method of Test for Flow of Portland-Cement Concrete by Use of the Flow Table (A.S.T.M. Designation C124) of the American Society for Testing Materials. The sand to be used in the proportioning and mixing of the test specimens shall be sieved through U.S. Standard Sieves. After sieving and separating the retained portions, the sand shall be re-combined in the following exact proportions:

Sieve	Percent Passing
No. 4 (4760-Micron)	100
" 16 (1190- "	60
" 50 (297- "	15
" 100 (149- "	2

(b.) Mixing - Cement and water in quantities which will give a water-cement ratio of 0.40 by weight shall be placed in a non-absorbent vessel and the cement permitted to absorb water for one minute. The materials

[1]Truscon Procedure with only slight modifications.

[2]Truscon Laboratory uses a 15% flow.

shall then be mixed with a spoon into a smooth paste. Saturated surface-dried sand shall be added to the mixture until the mortar shall be of 25% flow. Final mixing shall be accomplished by continuous squeezing and kneading with the hands for two minutes. Rubber gloves shall be worn during the mixing operation.

Moulding Specimens - The specified moulds shall be weighed to the nearest 0.1 gram. Portions of the batch of mortar shall be placed in weighed moulds, tamped and leveled off even with the rim of the moulds with a wood float. The edge of the specimen shall be grooved slightly so that the sealer may be applied later in this groove. The rim of the mould shall be wiped to remove any excess mortar.

Storage of Specimens - Immediately after wiping, each mould and specimen shall be weighed to the nearest 0.1 gram and placed in a storage cabinet. The storage cabinet shall be maintained at 100° plus or minus 1° F. and 33% plus or minus 1% relative humidity. The air flow shall be approximately two feet per second.

Procedure - (a.) Application of Curing Compound - After approximately 1 1/4 hours, the specimens shall be removed from the cabinet, weighed, and the surface of the specimen brushed to remove any laitance. The specimen shall be weighed after brushing, and a latex sealer applied to the grooved edge of the specimen to prevent any water loss, other than through the membrane.[1] The specimen shall be reweighed and placed in the cabinet for an additional thirty minutes. It should then be removed, weighed, and the liquid curing material applied uniformly by spraying on the specimen at the rate of 200 square feet to the gallon. (The amount of curing material applied to the specimen shall be measured by weighing the atomizer and contents before and after spraying the specimen.) The specimen shall then be replaced in the cabinet.

(b.) Determination of Water Loss - The specimen shall be weighed at 24 and 48 hours after the curing material is applied. In determining the water loss, corrections must be made for the changes in weight of the curing material and the sealing compound.

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[1]Truscon Laboratory uses no additional sealer other than the membrane itself.

The results of these tests indicate that the quality of the commercial membrane curing products varies a great deal. (Please refer to the tabulated data and graphs which show the results obtained much more clearly than they can be stated). The product manufactured by the Horn Company is practically useless in retaining the mixing water. It was found upon analysis to be sodium silicate, a material previously discarded because of its inefficiency. The results of the tests under Series I were probably affected by a relatively poor control of humidity. In Series II the tests were run with much better control and laboratory technique. It will be noted that the Percent Variation of the Percent Water Loss is much smaller in Series I. Considering the fact that these tests were run over a longer period and there were more variables to effect the results, I believe the conclusion may be drawn that the larger specimens will give more uniform and consistent results for the same material. The smaller specimens lose so little water and the better materials are so closely bunched that it is quite difficult to determine the relative efficiencies. The tests under Series II have the advantage in that more samples may be run in a given length of time, but the fact that wider variations in results were obtained is a definite disadvantage.

The data was not conclusive enough to prove that one certain material is definitely better than all others as variations may be noted between Series I and II. However, two materials, Satisfaction 45 and the Horn product, may be regarded as definitely inferior, even though their manufact-

MEMBRANE CURING STUDY

WATER RETENTION TEST

Averaged Results

Series I (7 day period)

	Percent water loss = $\frac{100\ F}{E}$	Percent efficient = $\left(100 - \frac{100\ F/E}{F/E\ (blank)}\right)$
Aquastatic 1-C-Red	16.6 %	63.7 %
Klearcure 60	21.0	53.2
Aquastatic Slab Cure Red	22.7	52.3
Truscon 203	23.1	47.6
Truscon 223	29.8	32.6
Satisfaction 45	39.5	16.30
Horn	44.2	1.20
Blank	45.5	_____

Series II (2 day period)

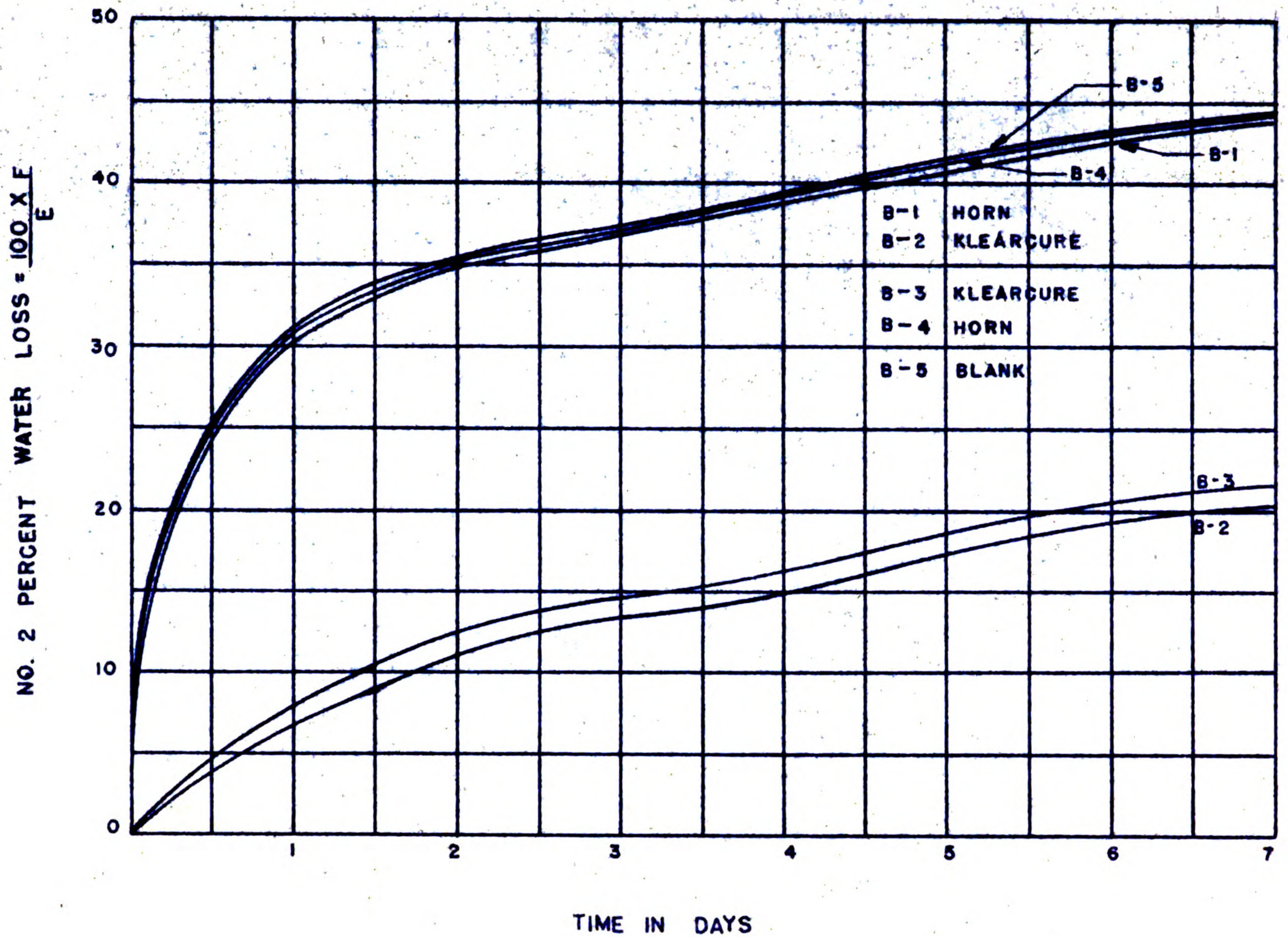
Truscon 203	2.22	96.10
Klearcure 60	3.64	93.66
Aquastatic Slab Cure Red	4.09	93.14
Truscon 223	4.35	92.22
Aquastatic 1-C-Red	5.72	90.05
Satisfaction 45	17.74	69.1
Blank	57.60	_____

Percent Variation of Percent Water Loss from that of average specimen of each material

Series I - 6.66 %

Series II - 11.73 %

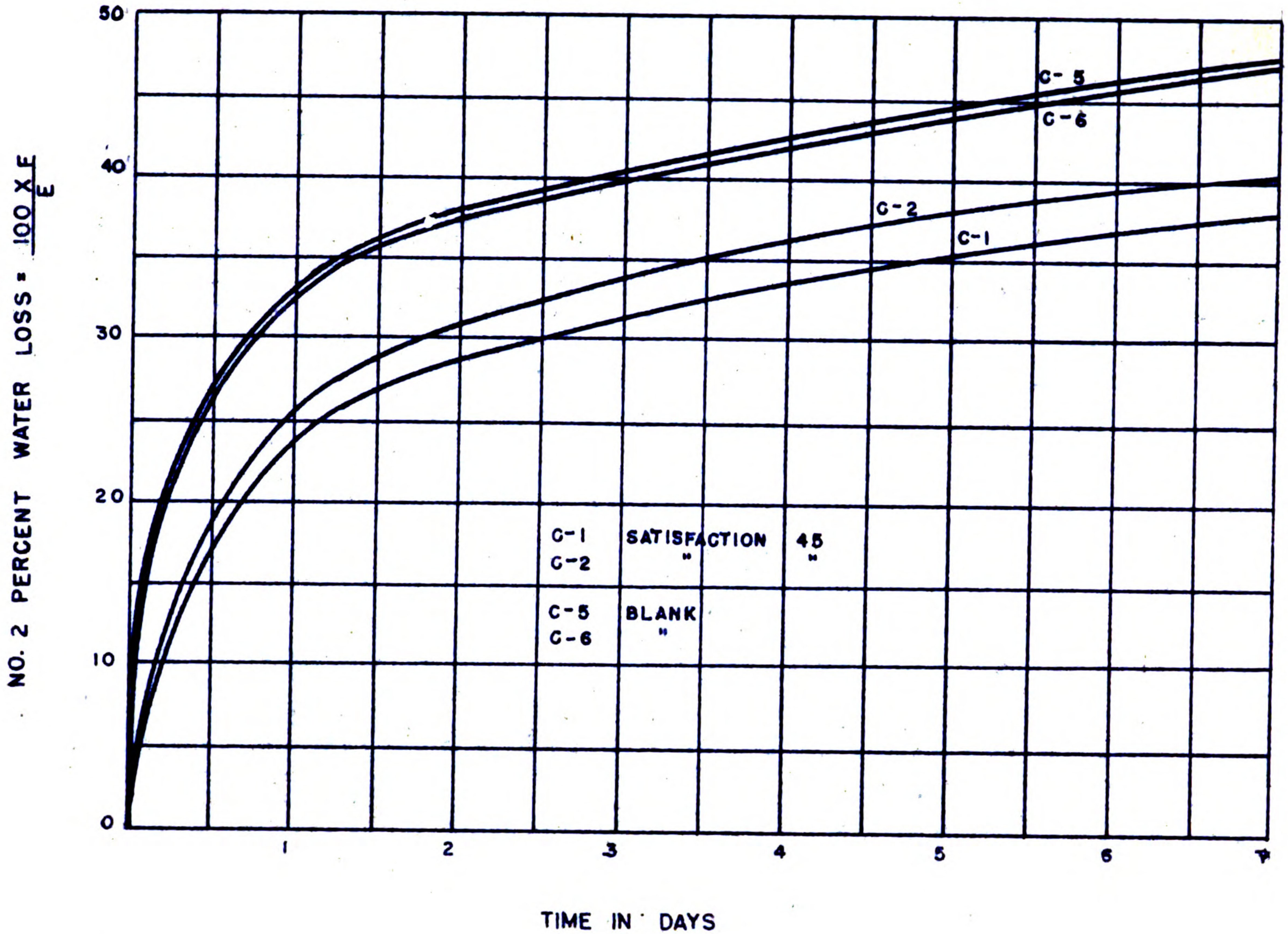
MEMBRANE CURING STUDY
WATER RETENTION TEST
SERIES I TEST B



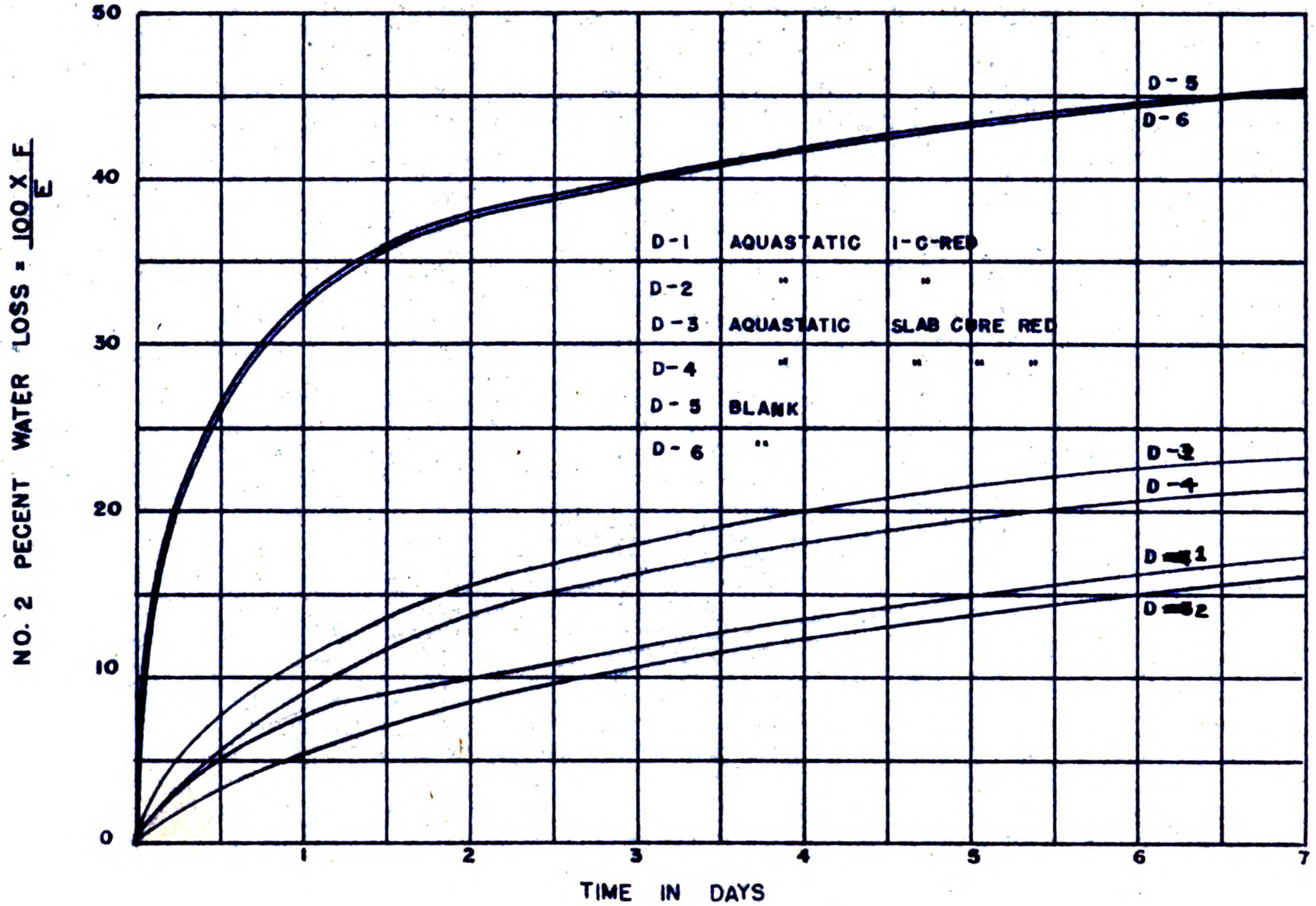
MEMBRANE CURING STUDY

WATER RETENTION TEST

SERIES I TEST C



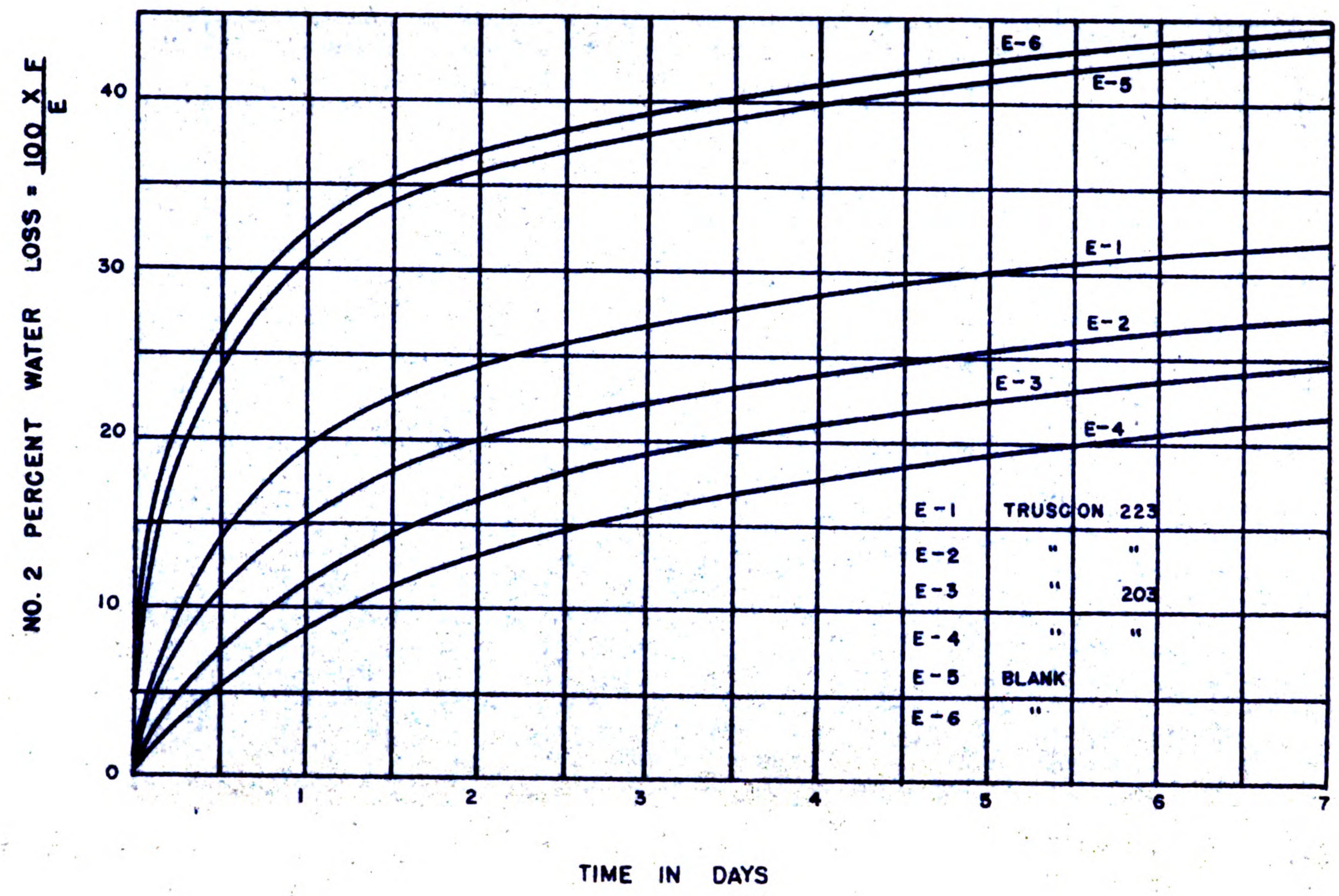
MEMBRANE CURING STUDY
WATER RETENTION TEST
SERIES I TEST D



MEMBRANE CURING STUDY

WATER RETENTION TEST

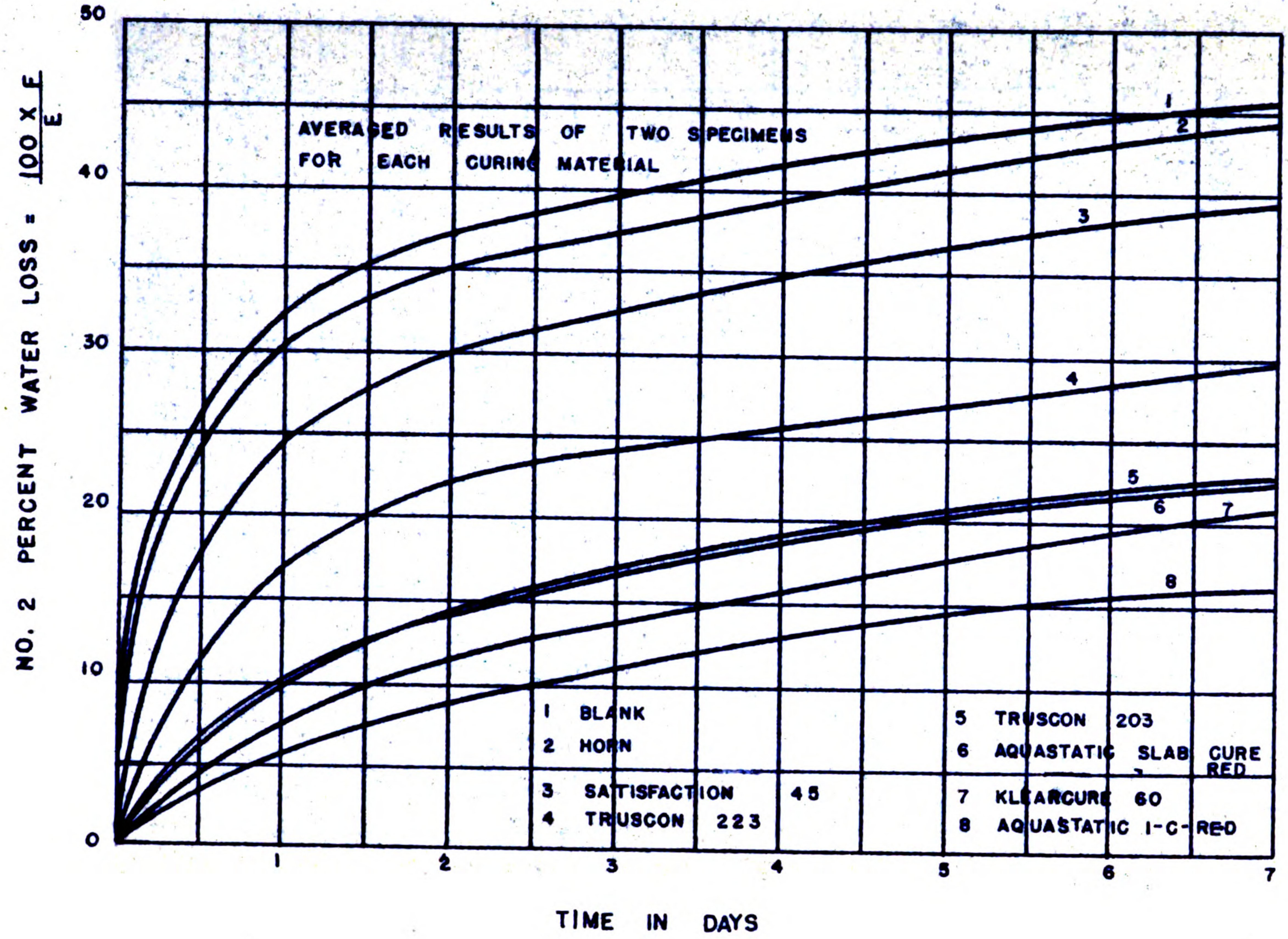
SERIES I TEST E



MEMBRANE CURING STUDY

WATER RETENTION TEST

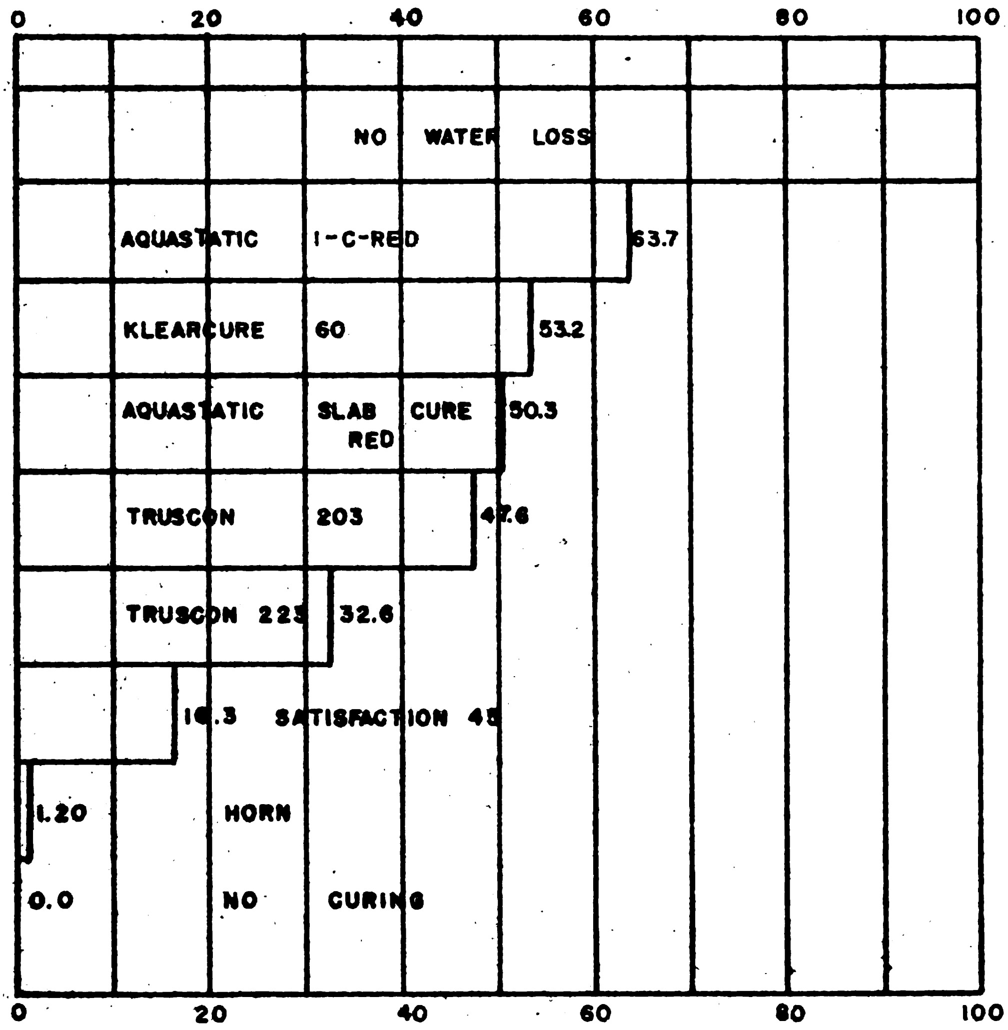
SERIES I



MEMBRANE CURING STUDY
WATER RETENTION TEST

SERIES I

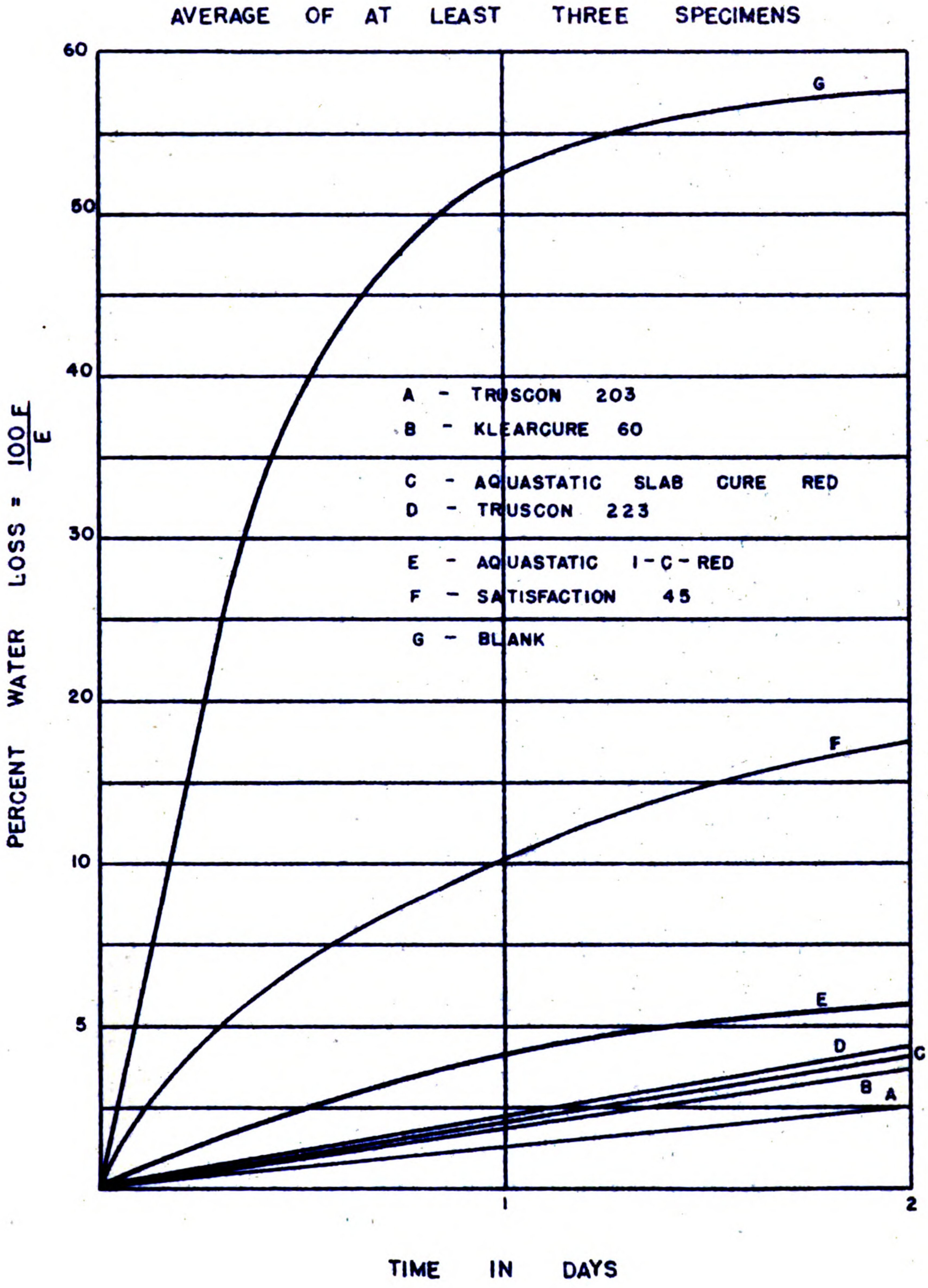
WATER RETENTION EFFICIENCY OF VARIOUS MEMBRANE CURING MATERIALS



PERCENT EFFICIENT

AVERAGE OF TWO SPECIMENS FOR EACH COMPOUND

MEMBRANE CURING STUDY
WATER RETENTION TEST
SERIES 2

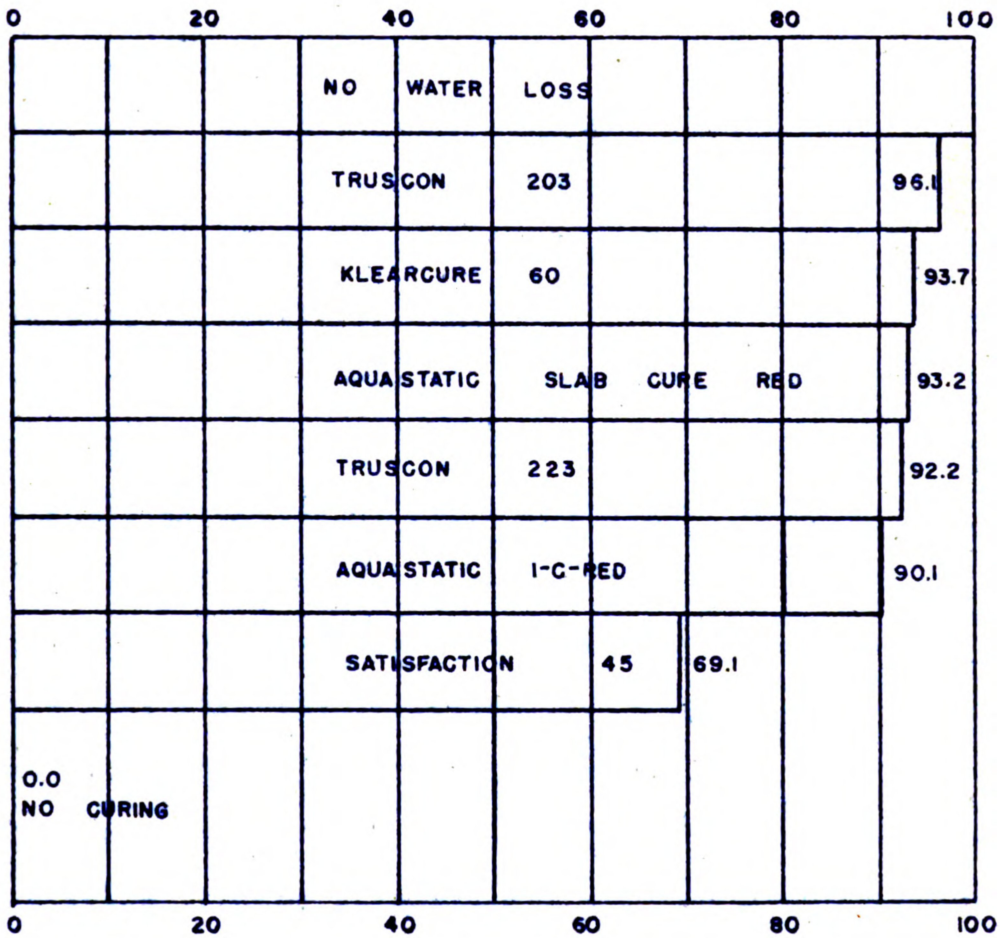


MEMBRANE CURING STUDY

WATER RETENTION TEST

SERIES 2

WATER RETENTION EFFICIENCY OF VARIOUS MEMBRANE CURING MATERIALS



PERCENT EFFICIENT

AVERAGE OF THREE SPECIMENS FOR EACH COMPOUND urers claim results comparable with the better curing materials. In fact, a better product such as Truscon 203 can be applied at the rate of 400 square feet to the gallon with a Percent Water Loss of 16.5%, while Satisfaction 45 applied at twice the coverage, or 200 square feet to the gallon has a water loss of 17.7%. The better curing compounds tested, Truscon 203 and 223, Aquastatic 1-C-Red and Slab Cure Red, and Klearcure 60 are close enough together to make it difficult to predict which is the best material to use. The individual characteristics of the different materials must be investigated before the best all-purpose curing compound may be found. For example, Truscon 223, if applied at the right time, will give good results; but if it is applied too soon the efficiency is greatly reduced.

The War Department specifies that materials may be used which equal Klearcure (No. 70), Sealkure, Trucure (No. 199 or 203), or Aquastatic (1-C, 1 FMST, or Black) in laboratory tests or field performance. The specifications as to the Percent Water Loss allowable are still in a formative stage due to the fact that the variation in testing procedure of different laboratories makes uniform results impossible. As soon as a Standard Test can be developed which every laboratory will abide by, the sooner a definite allowable Percent Water Loss can be specified. From the data obtained from these tests, a few recommendations in regard to the development of an authoritative water retention test will be attempted.

1. The storage conditions of the test specimens must be very carefully regulated.
   Recommended ranges.
   (a.) Temperature $100^{\circ} \pm 1^{\circ}$ F.
   (b.) Relative Humidity 33% $\pm$ 2%, but finer regulation if possible.
   (c.) Air Flow - A definite specification as to the amount, preferably less than 4 m.p.h.

2. The proportioning of the cement and sand should be reduced from 50% to a lower value; further investigation is necessary to determine the best value.

3. An exact grading of the sand should be specified, or further investigation should be made as to the effect of this variable.

4. The larger specimen (A.S.T.M.) is, in my opinion, the best, because more uniform results may be obtained from it.

5. The A.S.T.M. mould should be changed in that the 1/2" projection above the surface of the specimen should be removed, and a flat rim substituted, for sealing purposes.

6. Every material should be tested by applying the material at different intervals after finishing, so that the effect of the moisture of the surface upon the water retention properties of the membrane may be determined for various compounds.

If a standardized test is not developed quickly so that the inferior materials may be eliminated from the market, poor results in the field may cause engineers throughout the country to distrust this new type of product. The sooner these inferior materials are exposed and condemned, the greater will be the chance for the better products to compete successfully with the older methods of curing.

SURFACE DEHYDRATION ANALYSIS

The results of poor curing are most apparent in the upper surface of a concrete slab. In many respects, the strength of this surface is the most important element in the concrete slab. If it is not properly cured, the surface will suffer from scaling and abrasion. A test which would evaluate the surface dehydration of the specimen with different methods of curing would be very useful to correlate with other tests, such as the Water-Retention Test and the Abrasion Test.

In order to analyze the amount of surface dehydration that took place, the specimen, after being broken in the Flexural Test, was immediately sprayed along the fractured surface with phenolphthalein. This indicator gave a reddish color to the surface which contained moisture, but the areas which had been dehydrated remained a natural color. The specimen was then photographed - the surface dehydration is indicated on the print by the lighter color. This procedure was originated by the Truscon Laboratory.

The results of this study show clearly that the better membrane curing compounds successfully retard surface dehydration, while the inferior membranes show a distinct line of surface dehydration which is almost as deep as those of uncured specimens. (Please refer to the photographed specimens on the following pages).

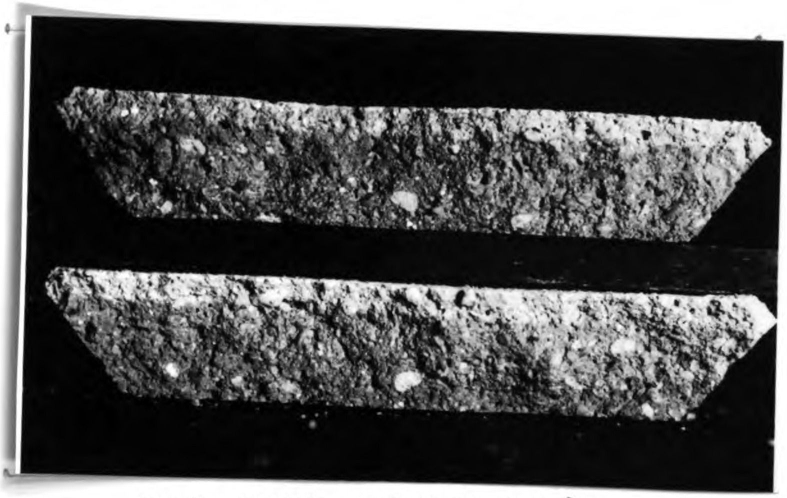
SERIES I

WATER LOSS SHOWN PICTORIALLY

TOP - NO COMPOUND - CURED IN MOIST ROOM

CENTER - AQUASTATIC I-C-RED

BOTTOM - NO COMPOUND - CURED IN CABINET



NO COMPOUND - CURED IN CABINET
WATER LOSS - 31.3 GRAMS

HORN COMPOUND - CURED IN CABINET
WATER LOSS - 25.5 GRAMS

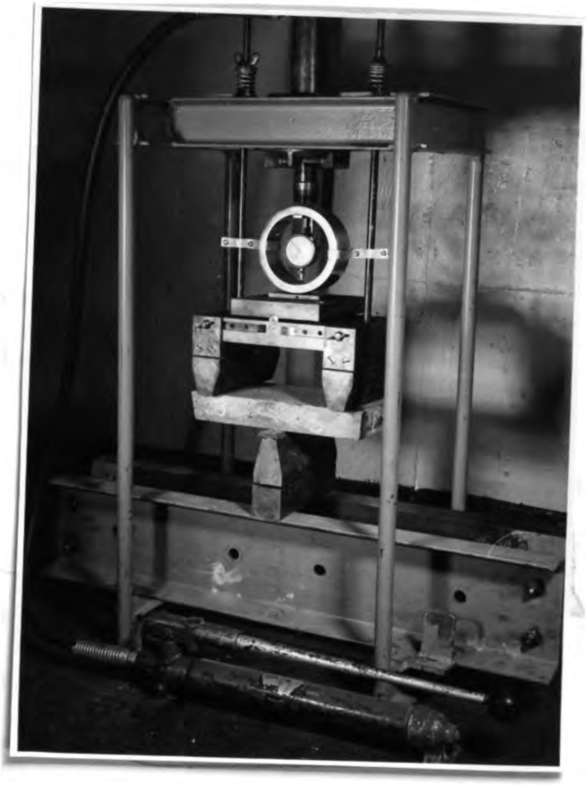
AQUASTATIC I-C-RED - CURED IN CABINET
WATER LOSS - 5.4 GRAMS

FLEXURAL TEST

In an effort to determine what relation the curing compound used bore to resistance to a flexural force, we have included in this study a flexural test, to be used on the larger A.S.T.M. specimens. Concrete placed in slabs, as well as in various members of concrete building structures is continually being subjected to flexural stress, and since the makers of the various membrane curing preparations advocate the use of their individual and collective products in the curing of buildings and slabs, it is of importance just what effect, if any, the various types of curing have on the flexural strength. Very little has been done regarding flexural strength of membrane-cured concrete, and of the specifications recommended up to this time, none, to our knowledge, refer to any flexural tests which have been conducted as aids to evaluation of compounds.

The specimens used are the same ones as used in Series I for the water retention test and later used in the abrasion test. They have a top surface of 72 square inches, being 12 inches long and 6 inches wide; they are 2 inches thick, and the edges are slightly beveled to enable the finished specimen to be easily removed from the molds.

The apparatus used in the test for breaking the specimens is pictured in an accompanying photograph. The pressure was applied through the steel ring, transmitted to the two knife edges and thence through the specimens to the lower knife edge. Pressure was applied by means of the hydraulic jack. The distance between the two upper knife edges was nine inches with the lower knife edge being 4½ inches from



FLEXURAL TEST APPARATUS

each of the two upper ones. Before starting the test, the steel dynamometer ring was calibrated using the Olsen testing machine in the Olds Hal testing laboratory. A Federal dial, sensitive to the variation of one-ten thousandth of an inch was mounted in the ring and adjusted to zero; known loads were then applied and the vertical compression of the ring, as registered on the dial, was noted and recorded. After two cycles of application and releasing of the test load, a calibration curve for the dynamometer ring was drawn, to be used in the flexural test on our specimens.

This test was run on each specimen seven days after removal from the test cabinet or the moist room, as the case might be, and in all cases, this was fourteen days after preparation. Since concrete is weakest in tension and any variation which might be present between the various specimens would occur in the surface region due to varied curing methods, the test was run so that the surface would be put in tension on application of the load. After the specimen was broken and results recorded, the two halves remaining were marked and kept for the running of the abrasion tests.

The results obtained in this test are shown on the following page in tabular form; the modulus of rupture was computed from the formula,

$$s = \frac{M c}{I}$$

in which s = stress in the extreme fiber of the specimen

c = distance from neutral axis to extreme fiber

M = bending moment at the section

I = moment of inertia of the section about its neutral axis

FLEXURAL TEST RESULTS

	Curing	Load at rupture	Modulus of rupture
A-1	No compound-cured in moist room	925 pounds	529 lb./in.^{2}
A-2	No compound-cured in moist room	925	529
B-4	Horn-cured in cabinet	970	554
B-1	Horn	1050	600
B-2	Klearcure 60	1150	656
B-3	Klearcure 60	1225	700
B-5	No compound-cured in cabinet	925	529
C-5	No compound-cured in cabinet	925	529
C-6	No compound-cured in cabinet	925	529
D-1	Aquastatic 1-C-Red	1075	614
D-2	Aquastatic 1-C-Red	1210	690
D-3	Aquastatic Slab Cure	1200	685
D-4	Aquastatic Slab Cure	1125	642
D-5	No compound-cured in cabinet	850	485
D-6	No compound-cured in cabinet	1000	570
E-1	Truscon 223	1025	585
E-2	Truscon 223	1125	642
E-3	Truscon 203	1075	614
E-4	Truscon 203	1063	607
E-5	No compound-cured in cabinet	775	442
E-6	No compound-cured in cabinet	813	464
F-1	No compound-cured in moist room	975	556
F-2	No compound-cured in moist room	925	529
F-3	No compound-cured in moist room	975	556
F-4	No compound-cured in moist room	813	464
F-5	No compound-wet burlap curing	1100	627
F-6	No compound-ponded	813	464

Compound used	Modulus of rupture in pounds / square inch
Klearcure 60	678
Aquastatic Slab Cure	664
Aquastatic 1-C-Red	652
No compound-cured under burlap	627
Truscon 223	614
Truscon 203	610
Horn	577
No compound-cured in moist room	527
No compound-cured in cabinet	507

The values in the above table are the averages for all specimens cured by like methods or compounds.

DISCUSSION

The results given here for the performance of specimens cured by the use of several different curing compounds and methods are in no way intended to represent the flexural strengths of concrete used in construction work. Structural concrete contains not only the mortar but also aggregates of various size and composition, and since the purpose of this test was to evaluate the efficiency of the membrane tested in retaining the water necessary for the cement to properly hydrate and develop full characteristics of strength, coarse aggregates were omitted and merely a mortar of cement, graded sand,[1] and water was used.

It will be seen that the results obtained are not entirely consistent; for example, of the tests run on Klearcure 60, one specimen had a modulus of rupture of 700 pounds per square inch and the other broke at 656 pounds per square inch. This variation may be caused by several different factors:

1. The arrangement of the aggregates may be such as to cause differences.

2. The curing may not be the same for all specimens. This idea is substantiated by the fact that on the water retention test, specimens cured at the same time under identical conditions did not lose identical amounts of water.

3. Variations in surface smoothness will alter the results.

4. Variations in thickness or other dimensions, including effect of shifting of the mortar in the pan before set occurs, or sagging of the bottom of the pan due to weight of mortar.

5. Differences in temperature between the cabinet

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[1]For the gradation of the sand, see Water Retention Test.

(100 F.) and the moist room (70 F.) may cause a variation in curing. If this is true, the moist room cured specimens could not be compared fairly with the membrane cured ones.

Of the above, probably the last two are relatively insignificant, and the most important is probably the second. Even with exactly identical conditions of curing, however, it is probable that results would vary. Concrete acts inconsistently at times, and in the testing of beams, cylinders, briquets, and other similar samples of concrete, the individual result cannot be taken as representative, but a series of specimens must be made up and the average result taken. The Bureau of Reclamation suggests the use of one hundred specimens in a compression test,[1] conclusions to be made only from the composite results of all these specimens. The use of one hundred specimens of each curing compound is of course out of the question in this study, but we feel that the test does give an indication of the relationship existing between cured and uncured specimens.

On examination of the results given in the foregoing table, it will be seen that, as would be expected, the poorest results were obtained on those specimens which were exposed to drying without the benefit of burlap, compound, or moist room curing. The best results were shown by the specimens that were cured by compound and the one cured under burlap; this last result must be taken lightly, however, since only one such specimen was tested and the use of further tests might bring this average result up or down somewhat. Enough

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[1]Concrete Curing Compound, a publication of the Battenfeld Grease and Oil Co. p. 6

tests were run on the specimens with no compound (seven in number) and those cured in the moist room (six) to compare these with the various membrane cured specimens, and when this comparison is made, it will be seen that the compounds are far superior in results to no compounds whatever, and it would appear that the specimens cured by membrane are also superior to moist room cured specimens, although the heat element mentioned before may alter this result.

It must be remembered, also, that the above results are for 14 day tests and the water cured specimens might, on further curing, continue to gain in strength to a greater degree than those cured under the membrane.

ABRASION TEST

INTRODUCTION

It is a generally assumed fact that the value of a membrane curing compound lies in its ability to retain, during the curing period, that water which was used in the preparation of the concrete. However, the value of a concrete structure is not measured by the amount of water that was retained during curing, but rather by the performance of the concrete after it is put into use. For example, in highways, sidewalks, floors, and other structures making use of concrete slabs, the resistance to certain flexural stress and abrasive force is the yardstick by which the value of the concrete is measured.

Thus, before it can be said conclusively that the membrane is effective as a curing agent, the resistance of membrane cured concrete to some outside force must be compared with the resistance of specimens cured by some other method when subjected to the same force. One of the tests used to compare the qualities of various concretes is the flexural test, the results of which are given in another section of this study. The other test being used to evaluate various curing compounds is the abrasion test; this test also measures an important property of concrete. Although a compound may very effectively retain the water during the curing period, it is very possible that it also might react unfavorably with the cement constituents, thus producing a finished concrete product of inferior quality with little resistance to wear.

The abrasion test has been used to some extent in previous studies to measure the quality of concrete produced by different methods of curing. The Bureau of Reclamation, one of the earliest experimenters in the field of curing compounds, made use of an abrasion test which utilized steel grit. The grit was blasted from a nozzle at an angle of 45 degrees with the surface of the specimen and 4 inches away from it. After a given period, the blasting was stopped, the surface brushed, and the loss of weight was determined.[1]

Another wear test of a different type is used by the Cincinnati Testing Laboratory of the War Department. A special tool fastened in the chuck of a drill press is run for three two-minute intervals. After each interval, the specimen is brushed, and the loss in weight is measured; the result is the average loss in weight for the three intervals.

Other experimenters have devised other abrasion tests but they operate, in general, on the principles of the two outlined above, and they all have the same object-to evaluate the abrasive properties of the curing compounds being produced. This, along with an attempt to gain some idea of the correlation between water loss and wear in concrete, is the purpose of this abrasion test.

APPARATUS

The apparatus used in the abrasion test was built up using the drill press as the basis. Two photographs are included on the following page which illustrate the set-up. The wear tool itself was constructed as follows. The shaft was

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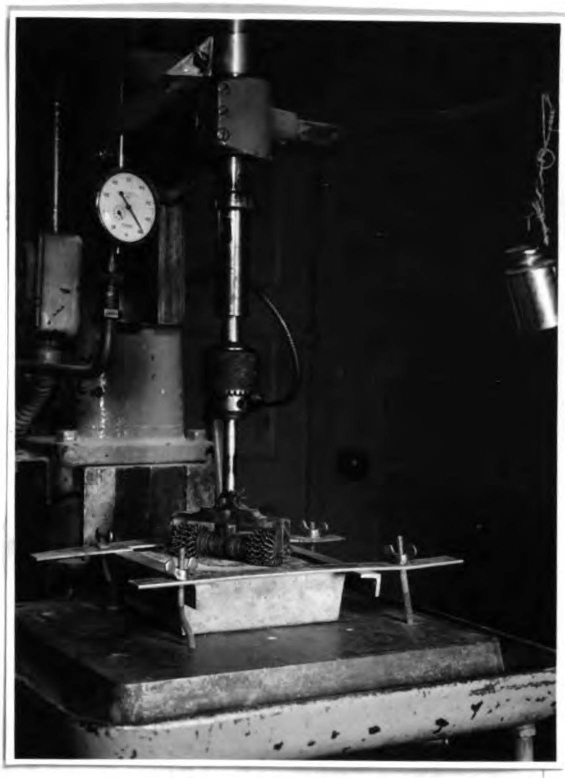
H. S. Meissner and S. E. Smith, "Concrete Curing Compounds", Journal of the American Concrete Institute, Vol. 9, May-June 1938, p. 555.



ABRASION TEST SET-UP

CLOSE-UP OF WEAR TOOL

made of such a size that it could be mounted in the chuck of the drill press; to this shaft was hinged the main part of the tool, the hinge permitting uniform transfer of the load to the specimen being tested. The pointed wheels which were in contact with the concrete surface are No. 0 Huntington emery wheel dresser cutters, and ordinary washers were used to keep the wearing wheels in the proper position. During the preliminary tests, some difficulty was encountered with the shaft on which the wheels rotated, due to the fact that the shaft wore nearly as fast as the concrete. After substituting a case-hardened shaft, however, the trouble was completely remedied.

For measuring the amount of wear, several methods were considered. The one finally adopted made use of the Federal dial with calibrations to the thousandths of an inch. The dial was mounted from a stationary part of the drill press frame and an arm was secured to the main drill-press shaft sleeve. This arm moved downward as the specimen became worn, and the end bearing against the dial shaft caused the amount of wear to be registered on the dial.

The drill press operating arm was twelve inches long and a weight of one pound was suspended twelve inches from the center of rotation of the arm. This caused a force of approximately 24 pounds to be transmitted to the specimen through the wheels. The speed of operation of the press for this test was about 375 revolutions per minute, varying slightly at the different periods of the test; that is, as the tool wore down slightly into the specimen, a slight amount of binding between the tool and the specimen occured, and the speed was slightly reduced. This reduction, however, was small and thus was neglected.

PROCEDURE

In this test, as well as in the water-retention test, there are two main series of specimens, logically known as Series I and Series II. The specimens in Series I were made according to A.S.T.M. specifications--they are 6 inches wide, 12 inches long, and 2 inches thick--and two tests were run on each specimen. In Series II, the specimens were made in the small round molds, as explained in the water-retention test, and only one test was run on each. The procedure was practically the same for both Series I and Series II, and the following explanation will apply for both unless otherwise stated.

In Series I, the various specimens were cured in the cabinet under controlled conditions[1] for a period of 7 days and were allowed to cure further in the laboratory for another 7 days, at which time they were subjected to the flexural test and then tested to determine abrasion resistance. The specimens in Series II were cured for two days in the cabinet and the abrasion test was run immediately except in two cases. Thus the large specimens of Series I were cured 14 days before testing, and the smaller specimens of Series II were cured 2 days.

At the start of the test, the specimens were clamped securely to the table of the drill press and leveled, using a small carpenter's level. The abrasion tool was then brought

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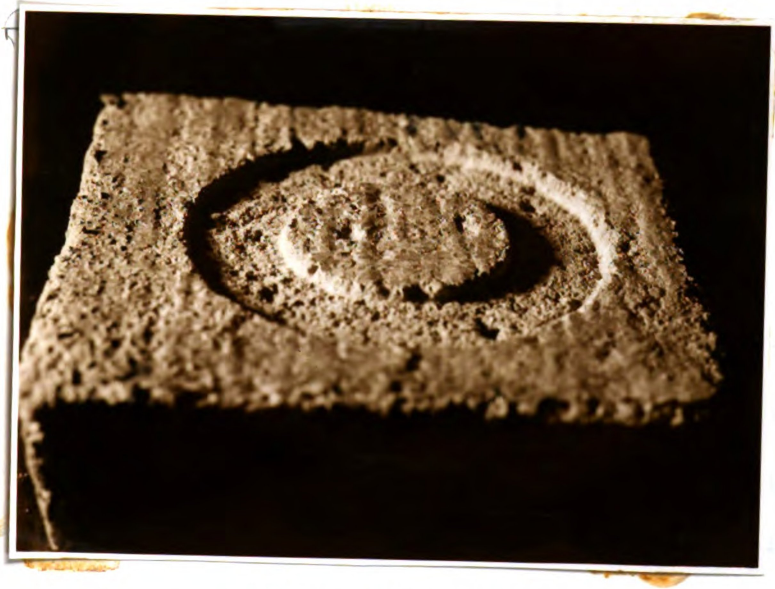
[1] See Water Retention Test for the exact conditions.

down onto the specimen and the table was adjusted so that the drill press arm formed an angle of about 10 degrees with the horizontal. As the specimen wears, the arm drops, and this slight elevation is to allow for the drop; the 10 degrees will cause a difference of only 1.5 percent in the horizontal lever arm, and this will be reduced since the arm swings through the horizontal as the specimen wears.

The next step in the procedure is to take the initial dial readings. The tool was rotated one complete revolution and readings were taken at each of the four quarter points; the average result is that used. As soon as preliminary readings were taken, the drill press was started. An Eastman timer was used to time the test and readings were taken at the one, three, five, and ten minute points in Series I and the one, three, five, and eight minute points in Series II. These readings were taken in exactly the same manner as at the beginning of the test, and were recorded for use in plotting the result curves.

Because the emery wheel cutters used in the test showed a tendency to wear, after each test, the tool was dismantled and the worn cutters were replaced. Since the outer cutter showed the greater wear, this cutter was removed each time and a new cutter put at the inside. This kept the cutters working from inside to outside and insured uniform conditions for each test.



SPECIMEN AFTER WEAR

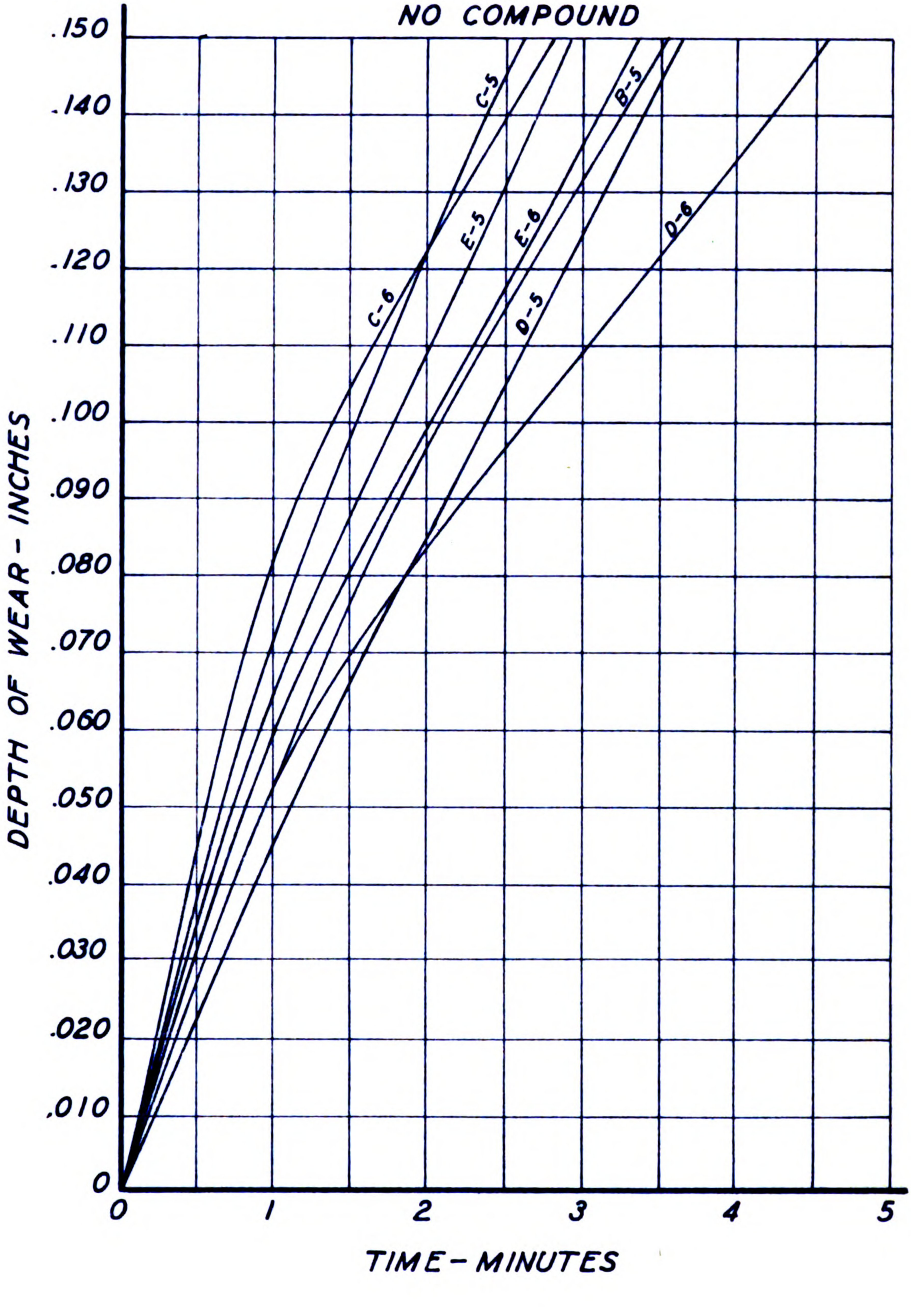
RESULTS

The results of both Series I and Series II tests are shown by the graphs which are drawn up on the following pages. For each specimen, there is a separate curve, and also a summary graph is given which shows the average curves of all of those specimens cured under the same conditions.

Before drawing any final conditions from the curves, certain factors must be considered. The fact that, during the five minute interval, one specimen suffered a slightly greater depth of wear than another does not necessarily prove that it is less resistant to wear than the other, because on the surface of every specimen, there is a certain amount of laitance and irregularities which may wear off rapidly. After these irregularities are worn off, however, the abrasion resisting qualities may be of the highest order. So, besides noting the total wear of each specimen, the slope of the wear curve should be examined when final evaluation of the various curing methods is made.

MEMBRANE CURING STUDY

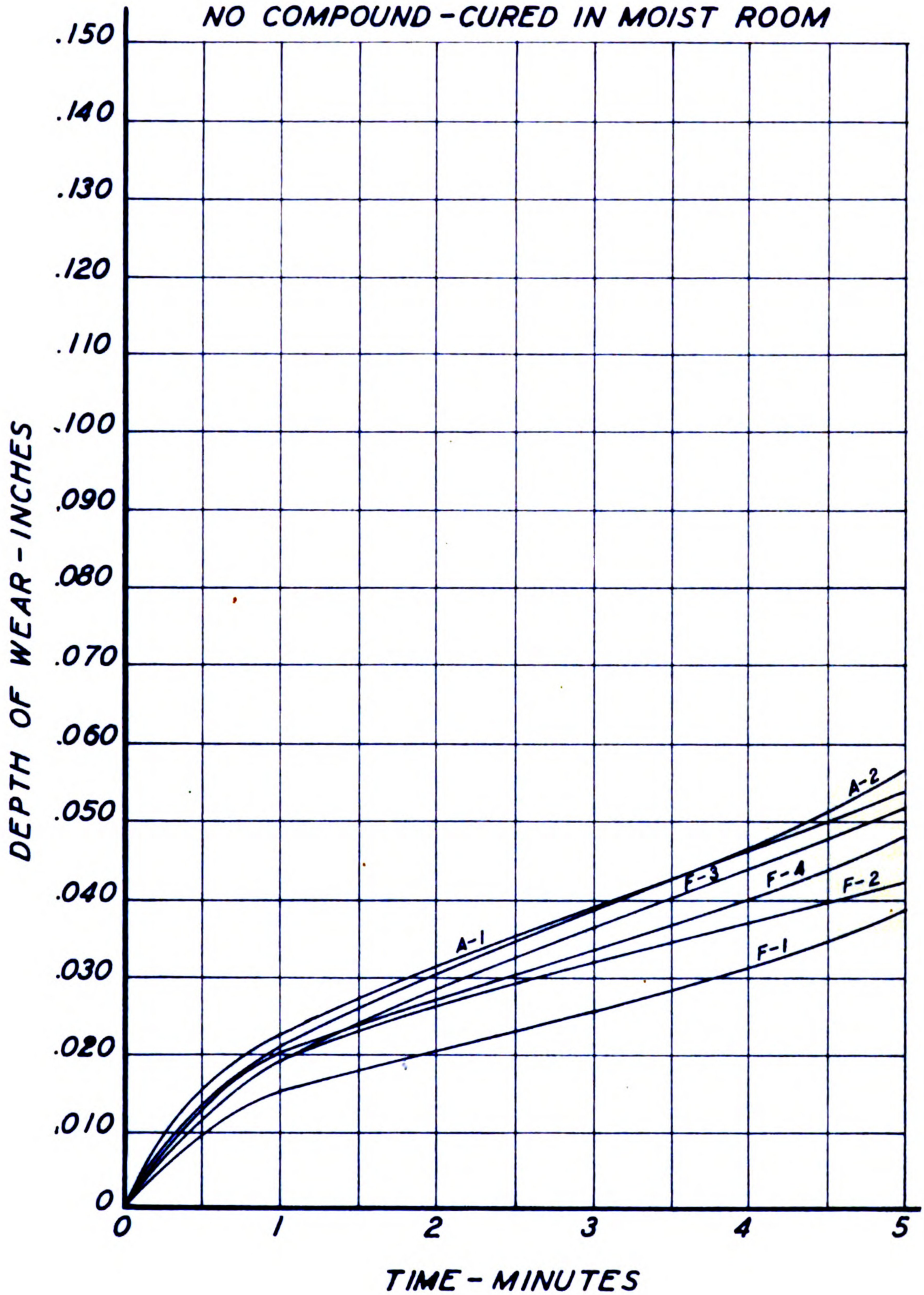
ABRASION TEST
SERIES I

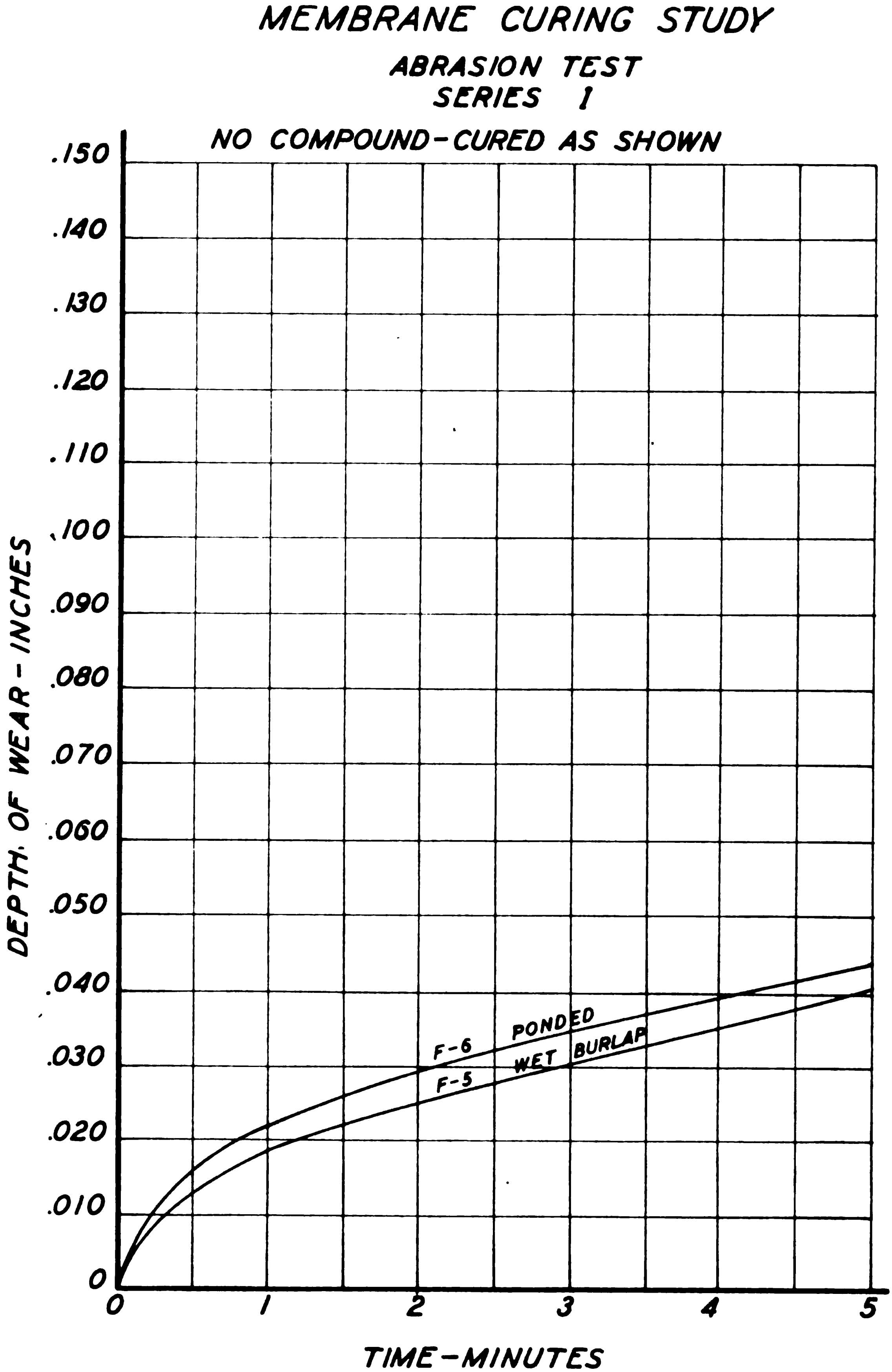


MEMBRANE CURING STUDY

ABRASION TEST
SERIES I

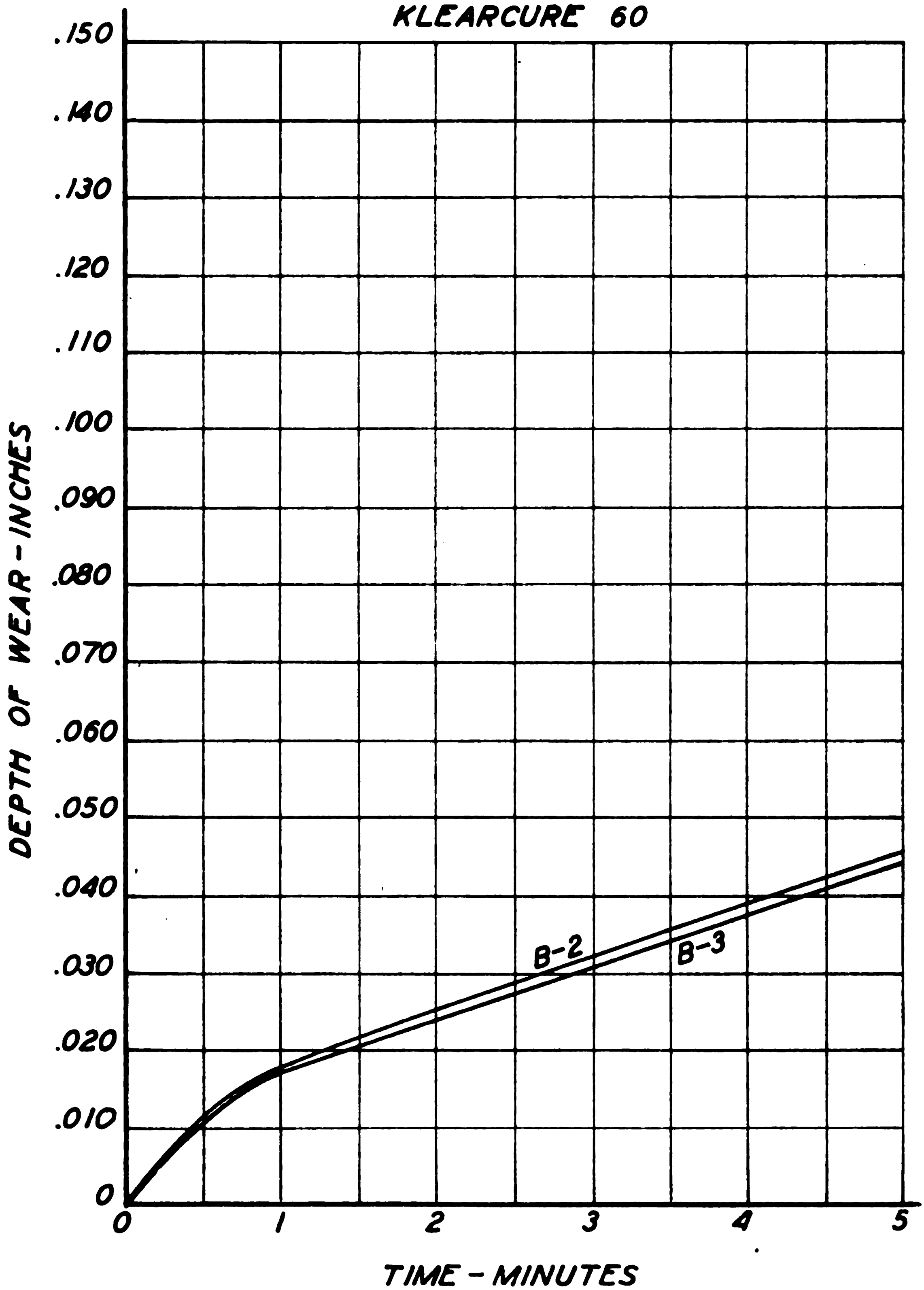
NO COMPOUND - CURED IN MOIST ROOM




MEMBRANE CURING STUDY
ABRASION TEST
SERIES 1
NO COMPOUND-CURED AS SHOWN
DEPTH OF WEAR - INCHES
.150
.140
.130
.120
.110
.100
.090
.080
.070
.060
.050
.040
.030
.020
.010
0
F-6 PONDED
F-5 WET BURLAP
0
1
2
3
4
5
TIME-MINUTES

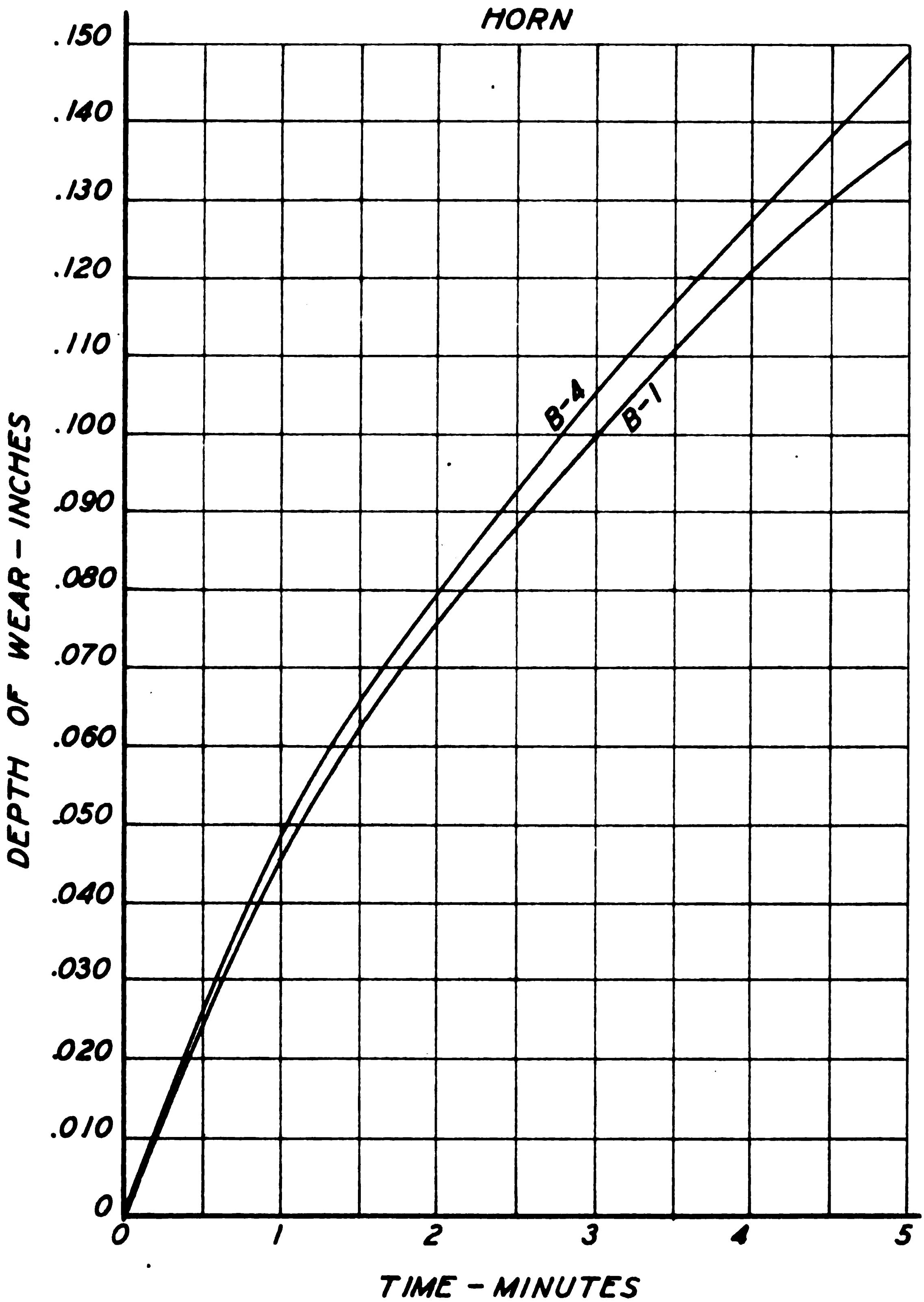
MEMBRANE CURING STUDY

ABRASION TEST
SERIES I



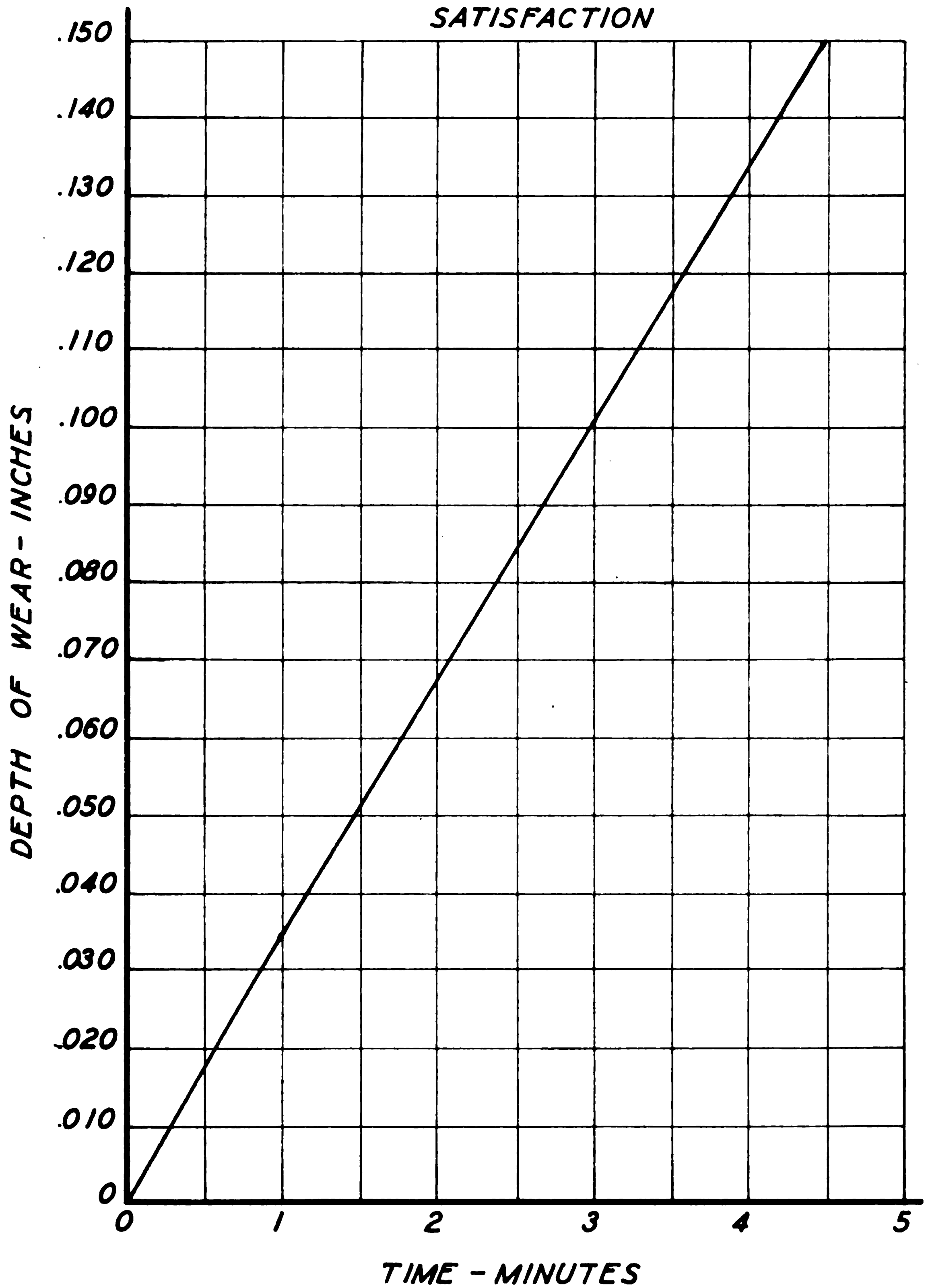
MEMBRANE CURING STUDY

ABRASION TEST
SERIES I



MEMBRANE CURING STUDY

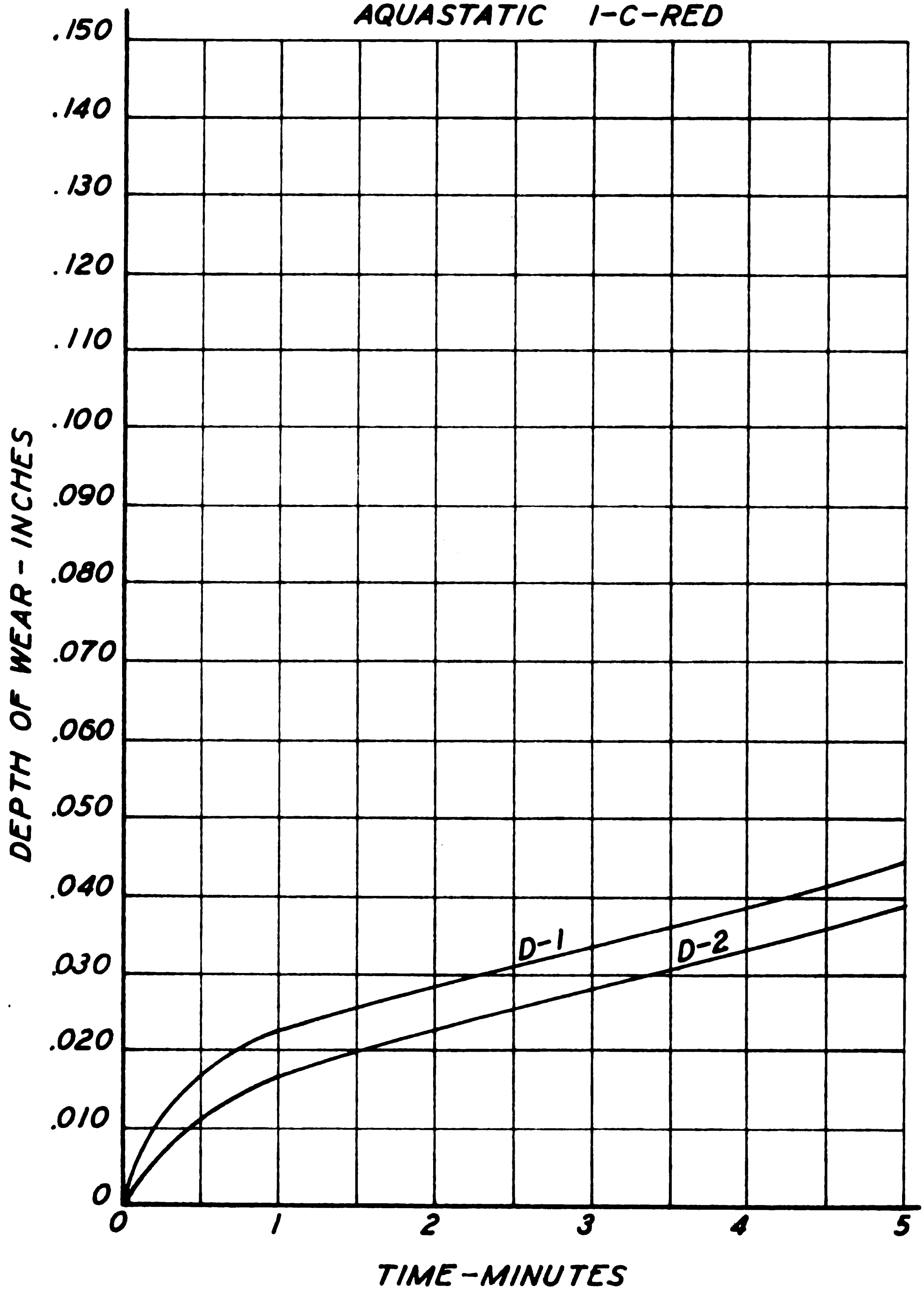
ABRASION TEST
SERIES I



MEMBRANE CURING STUDY

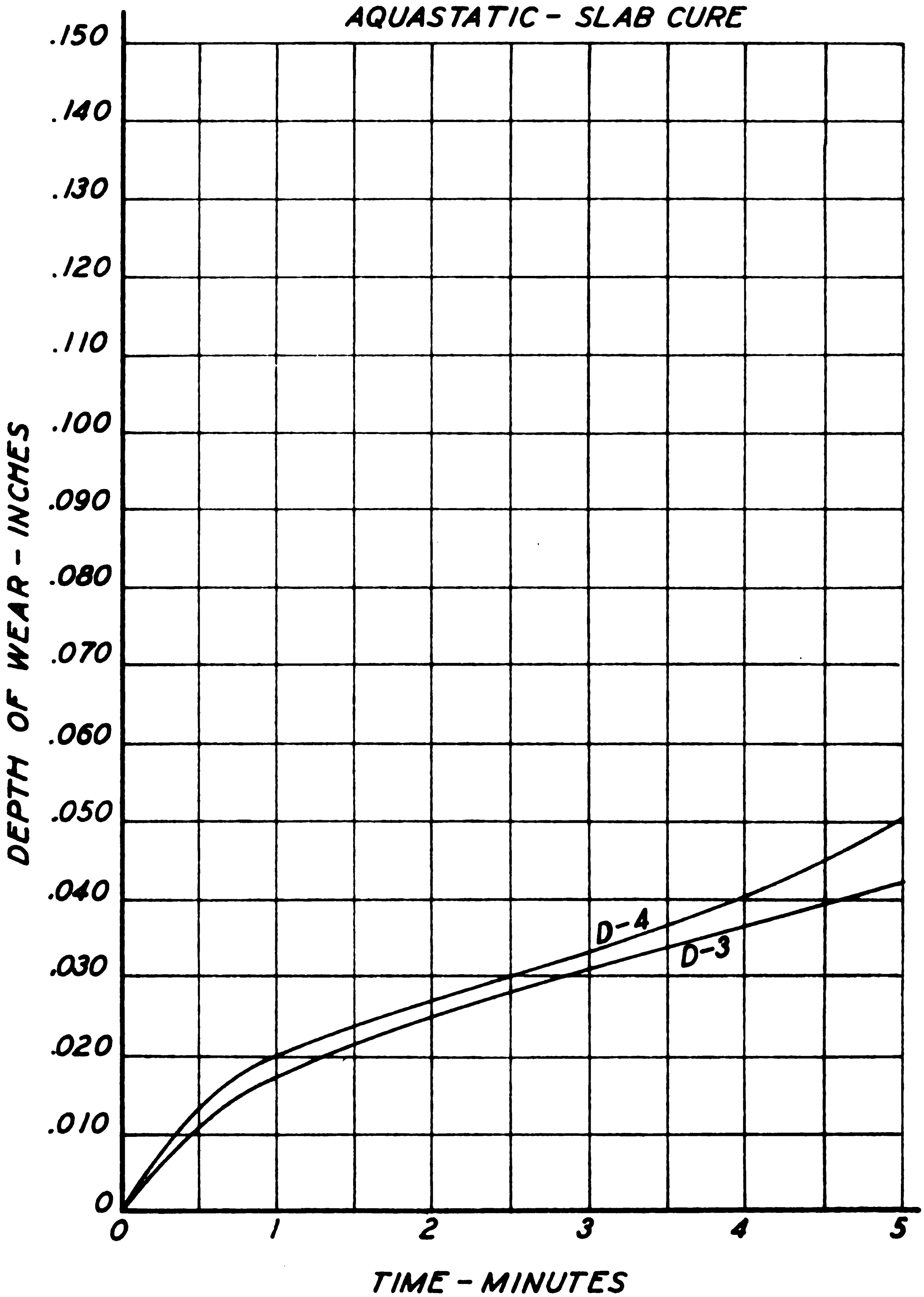
ABRASION TEST
SERIES I

AQUASTATIC I-C-RED



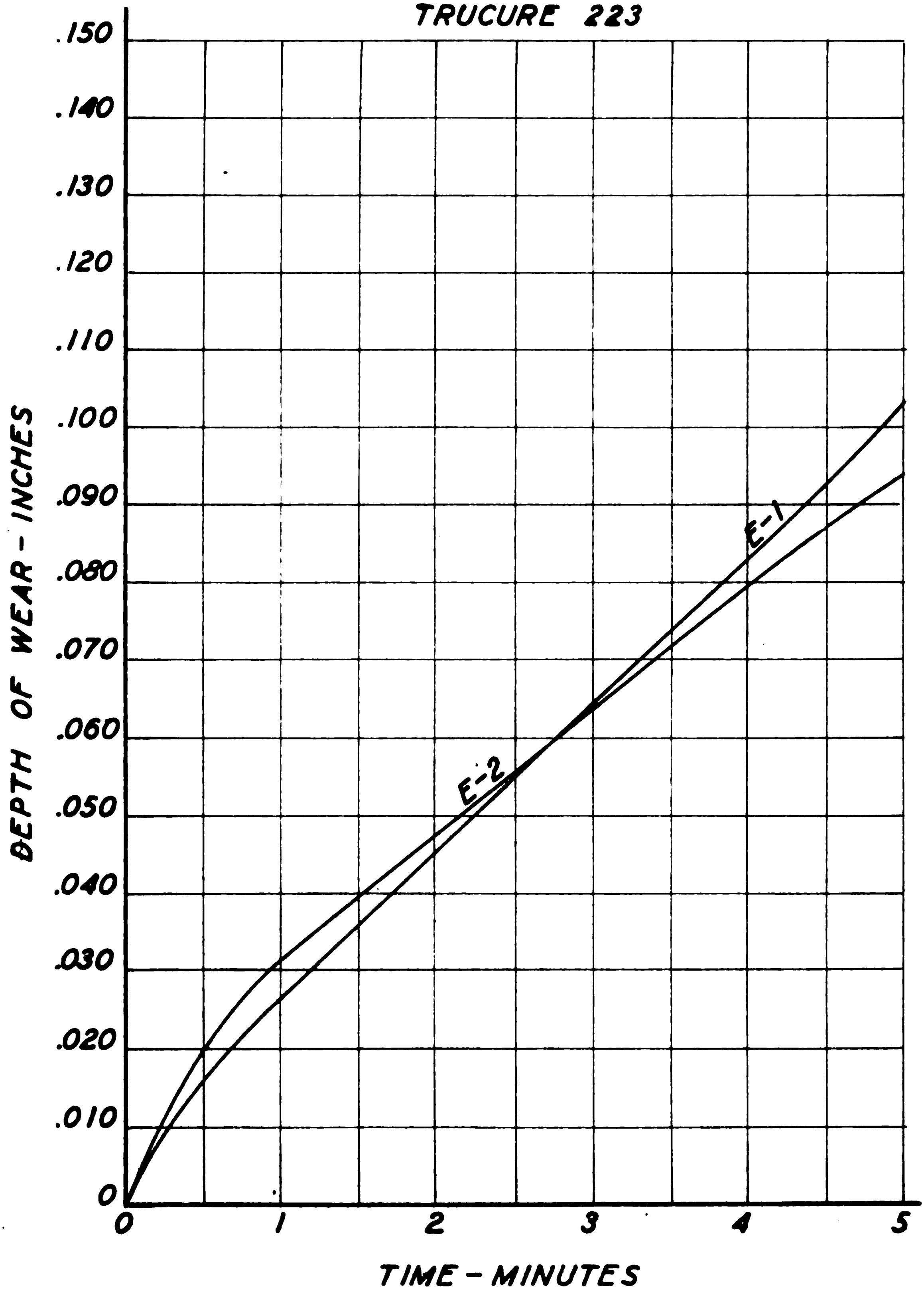
MEMBRANE CURING STUDY

ABRASION TEST
SERIES I



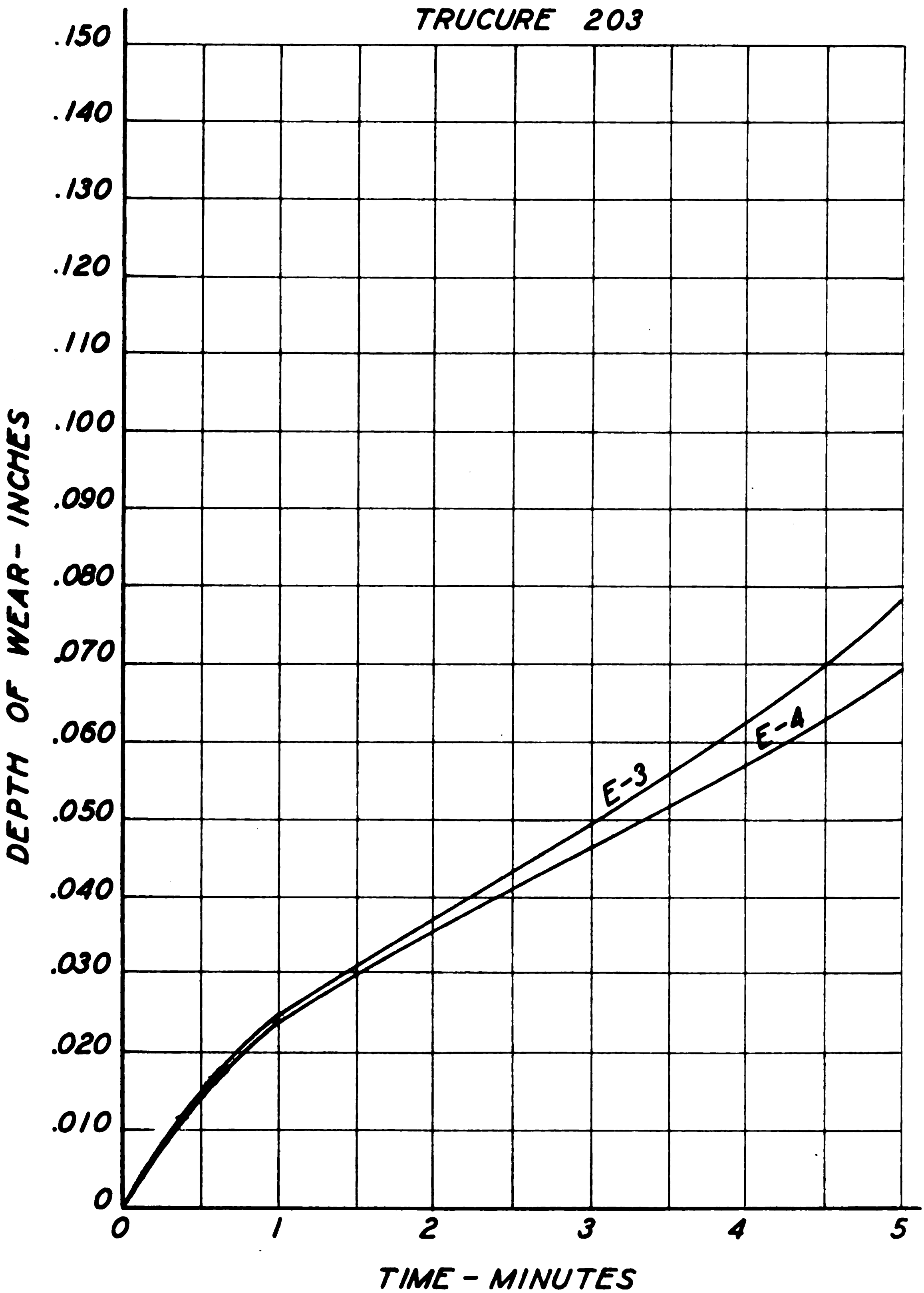
MEMBRANE CURING STUDY

ABRASION TEST
SERIES I



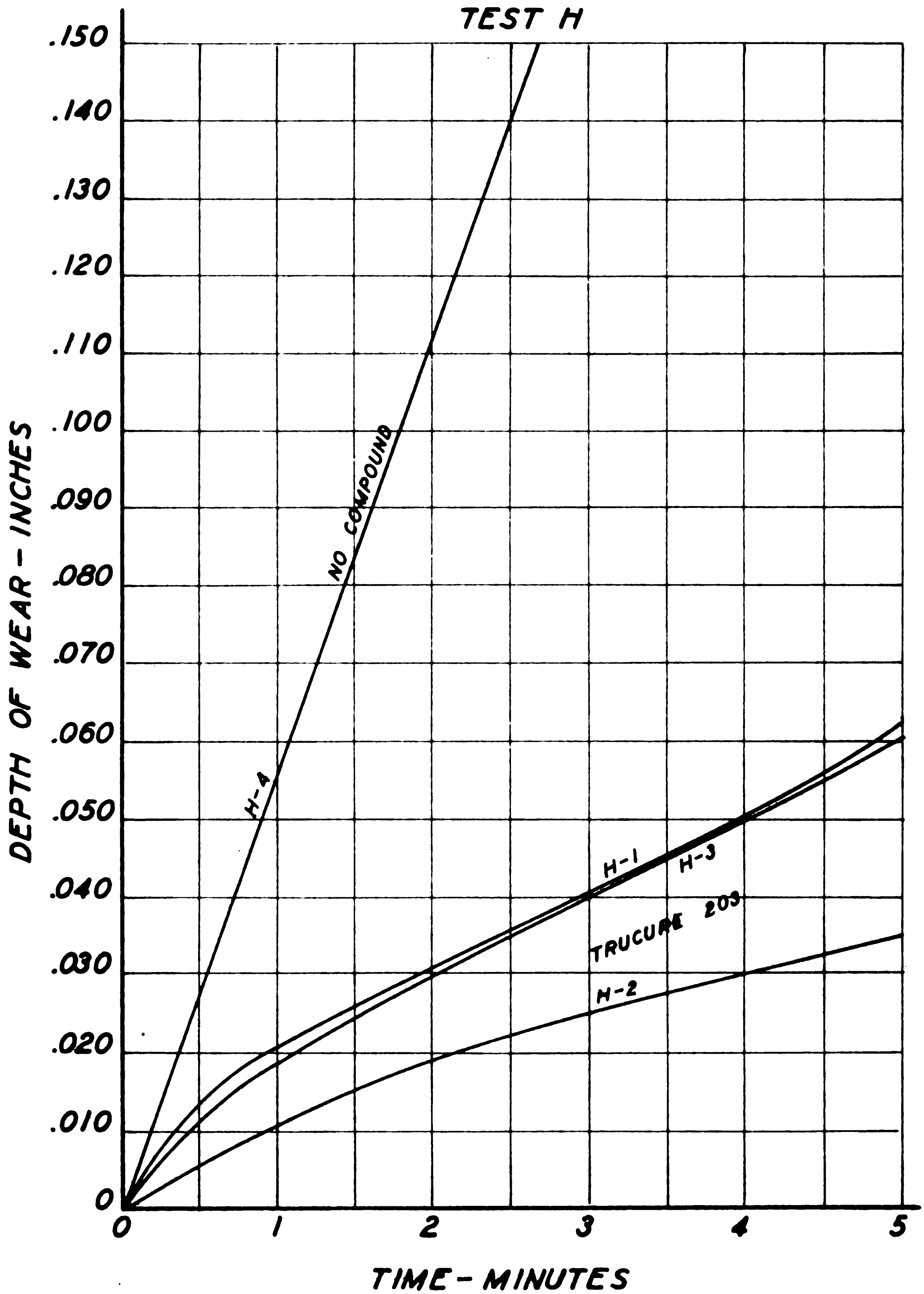
MEMBRANE CURING STUDY

ABRASION TEST
SERIES I



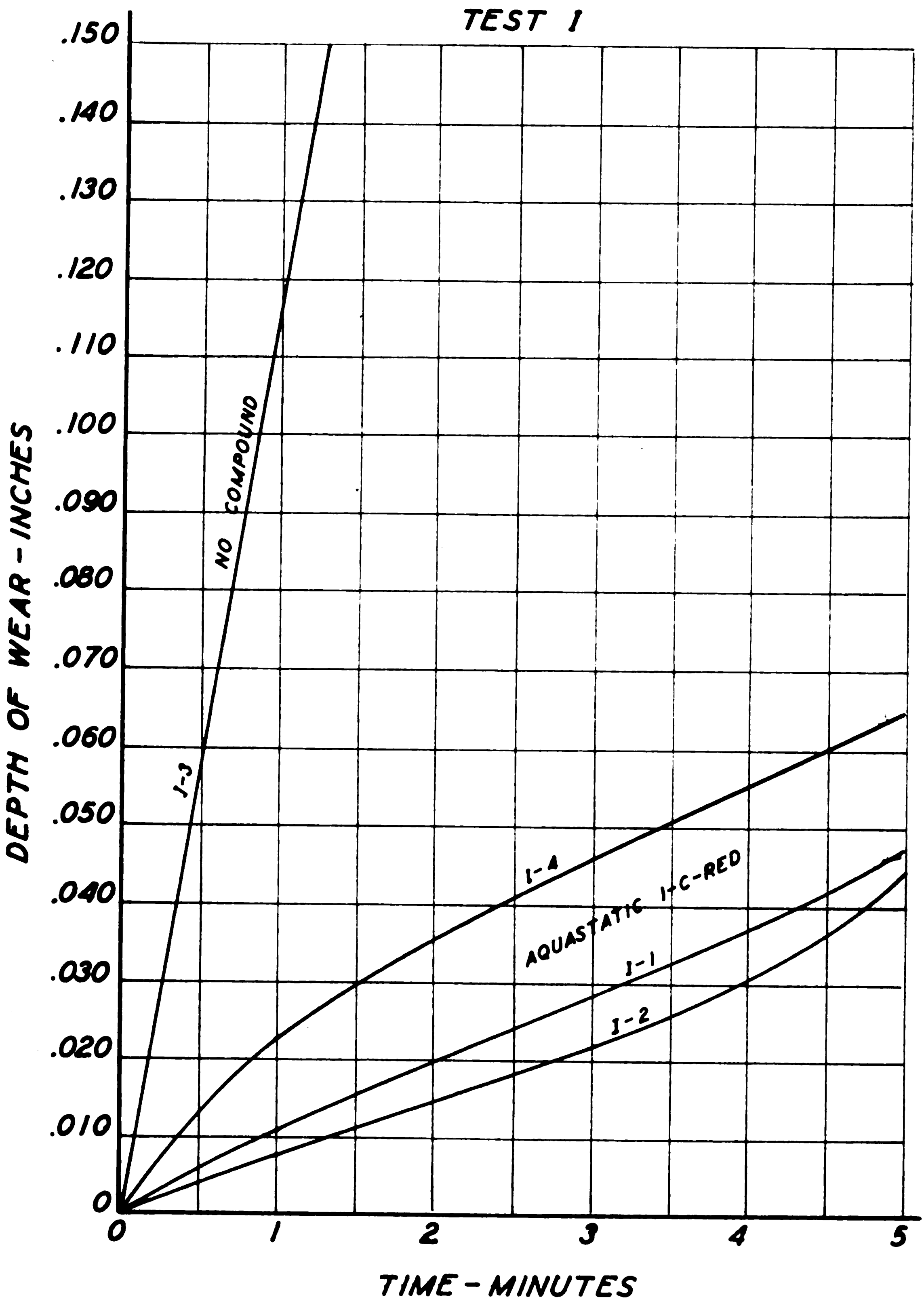
MEMBRANE CURING STUDY

ABRASION TEST
SERIES II



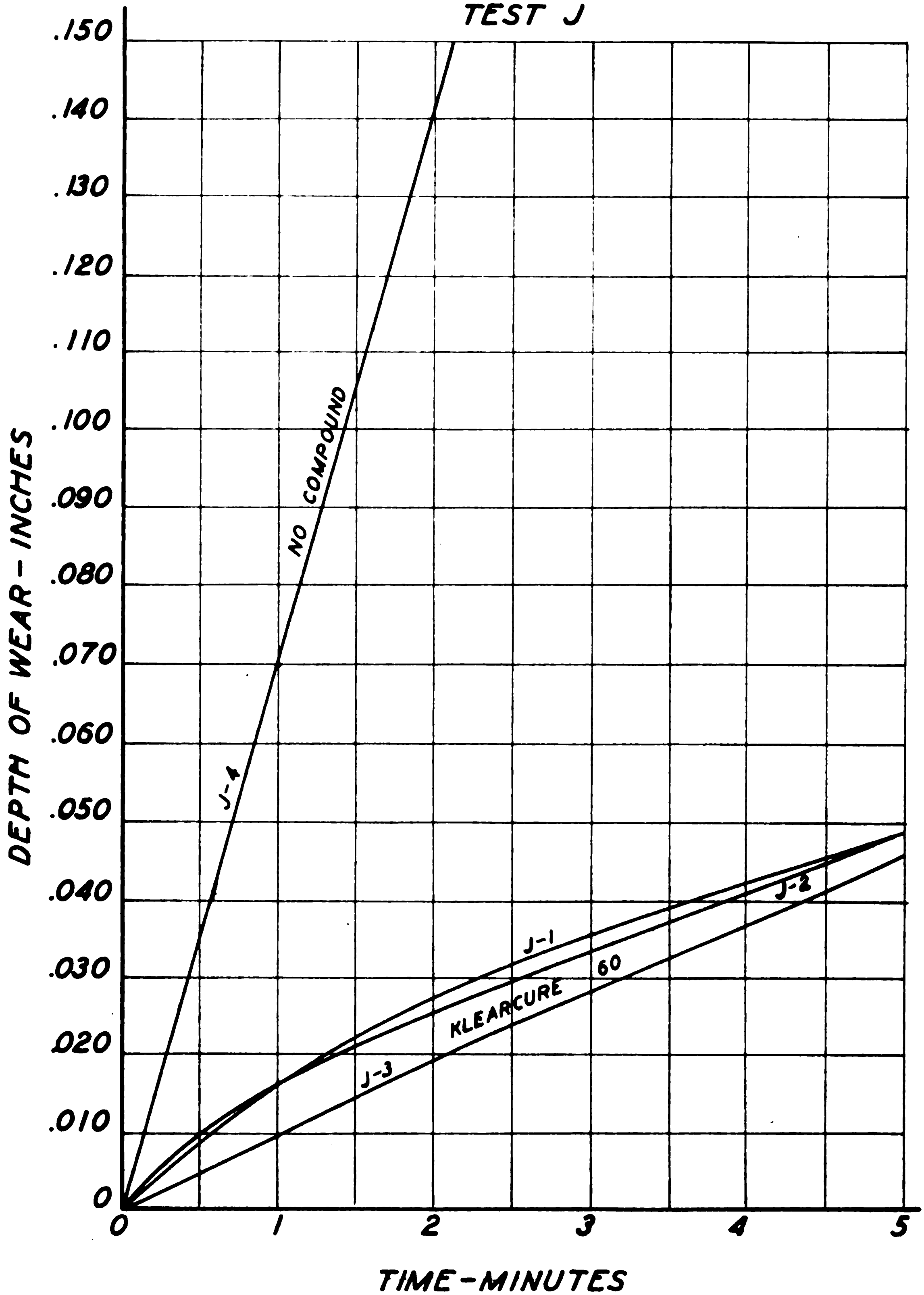
MEMBRANE CURING STUDY

ABRASION TEST
SERIES II



MEMBRANE CURING STUDY

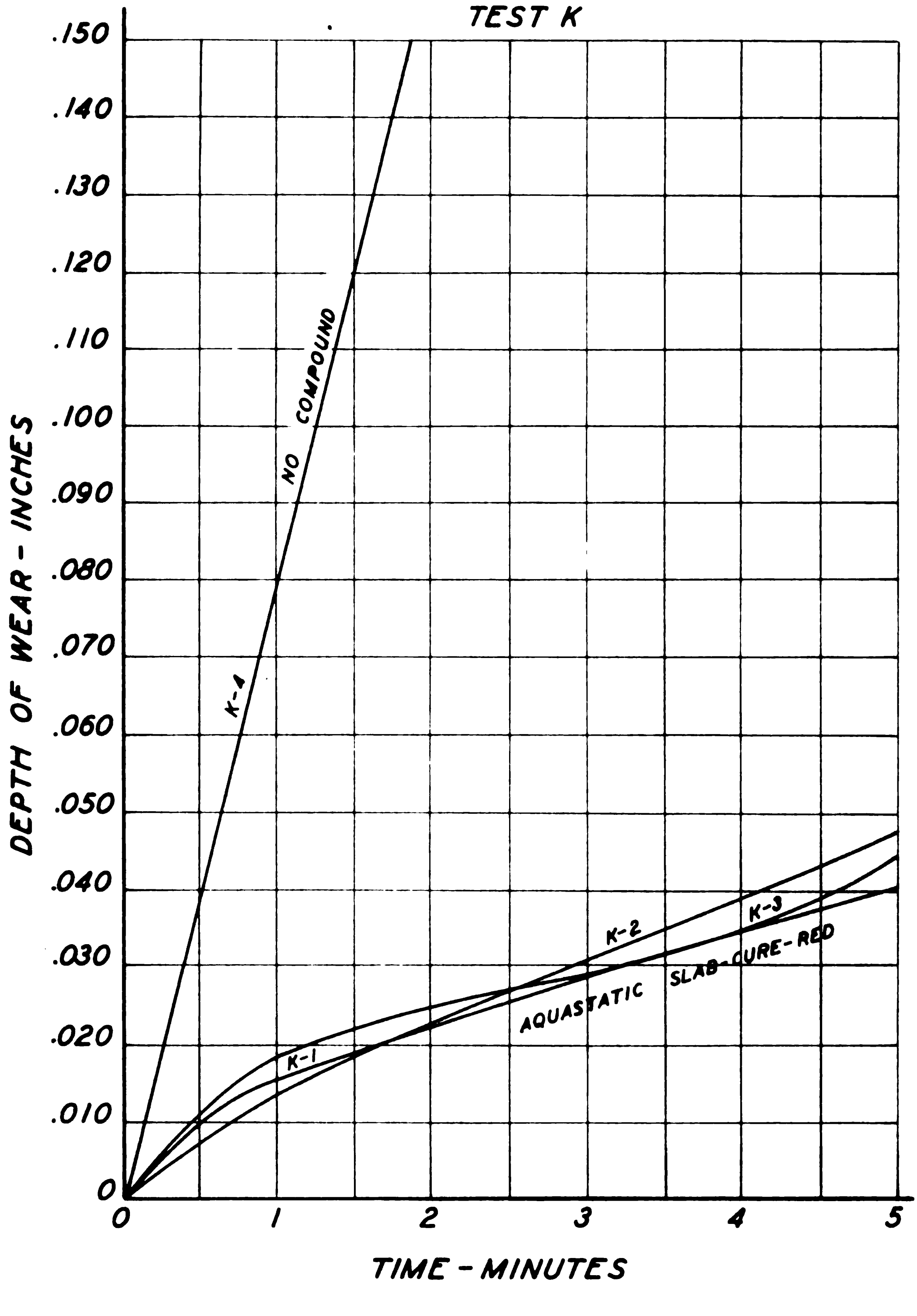
ABRASION TEST
SERIES II
TEST J



MEMBRANE CURING STUDY

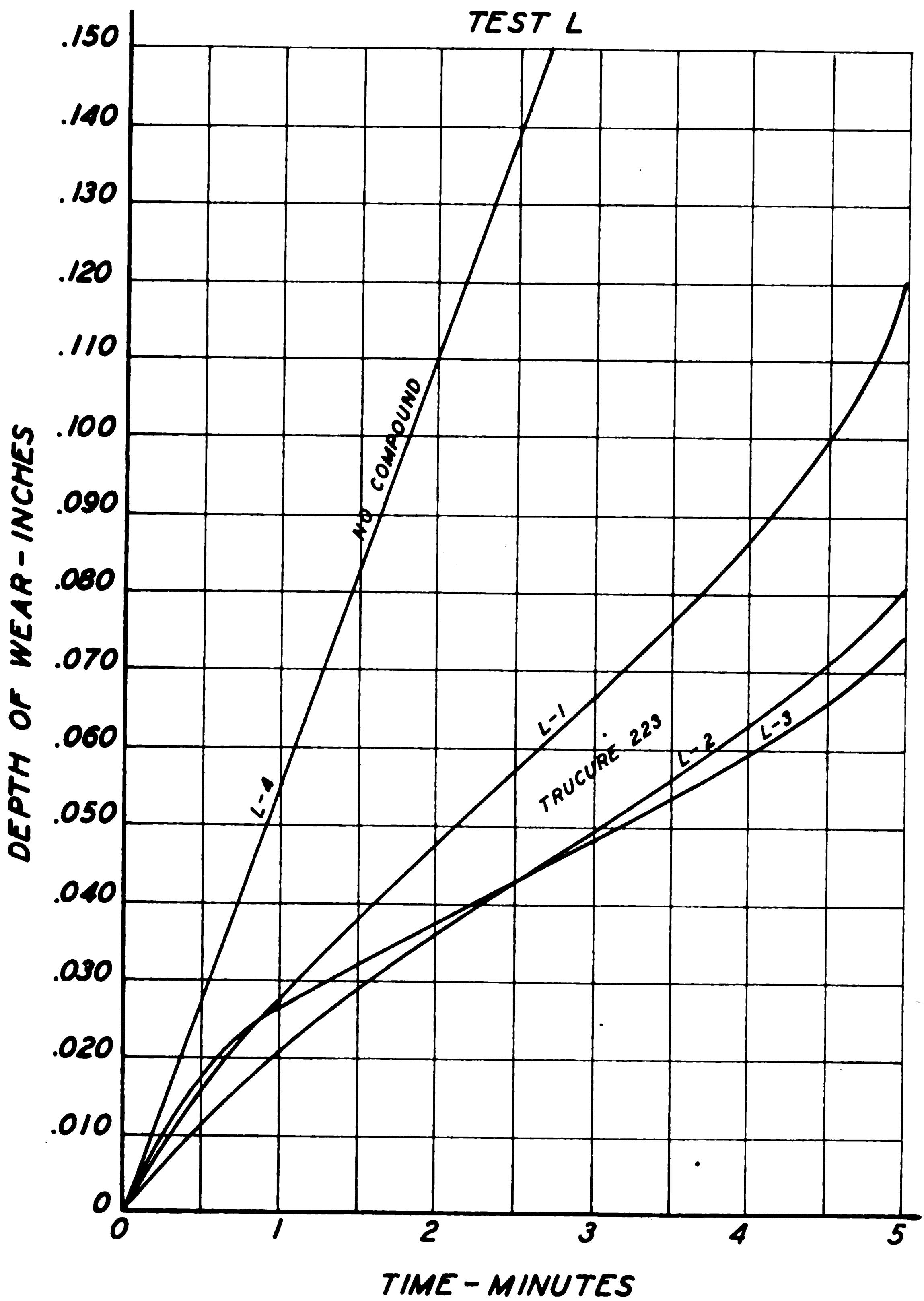
ABRASION TEST
SERIES II

TEST K



MEMBRANE CURING STUDY

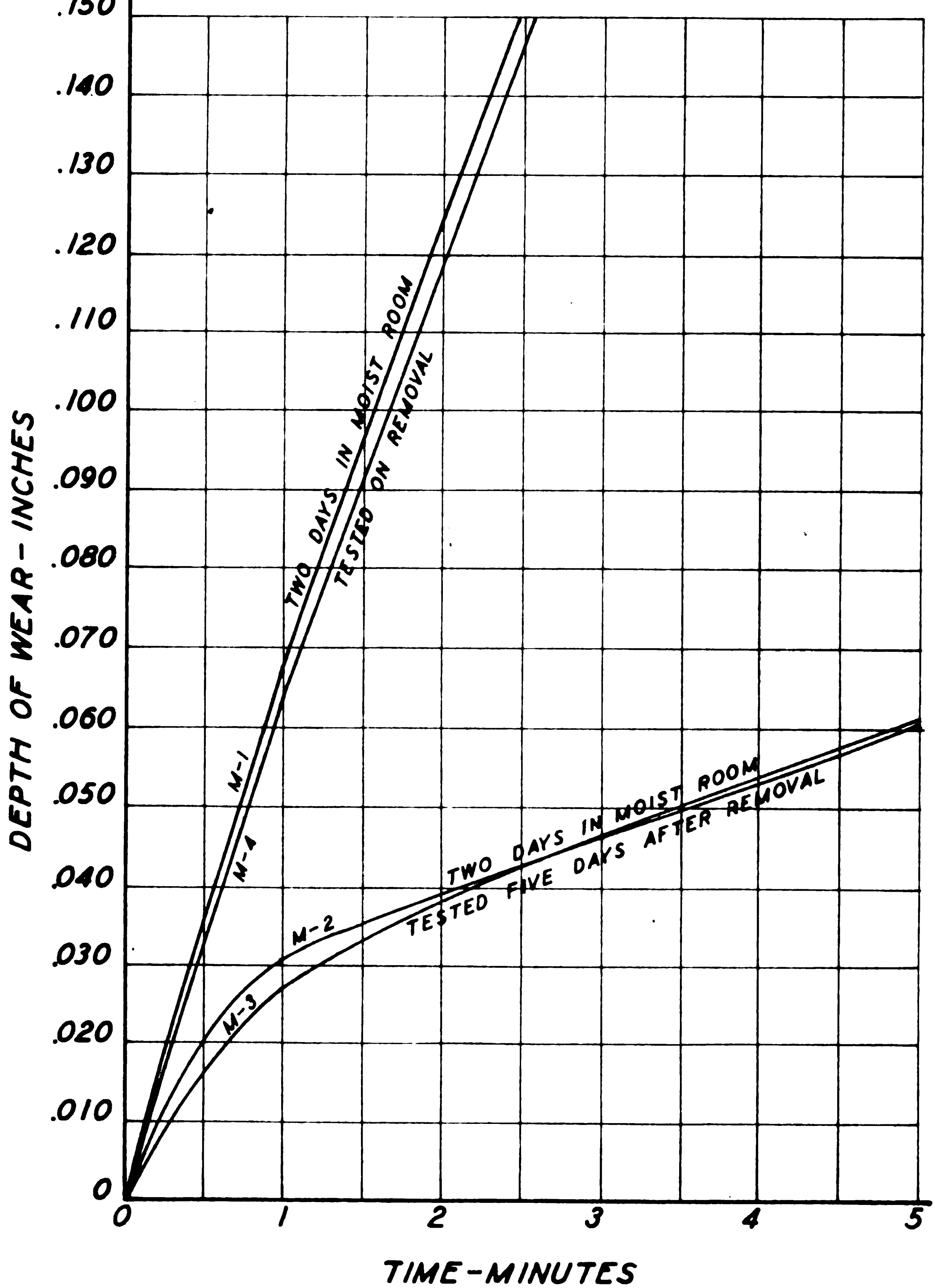
ABRASION TEST
SERIES II

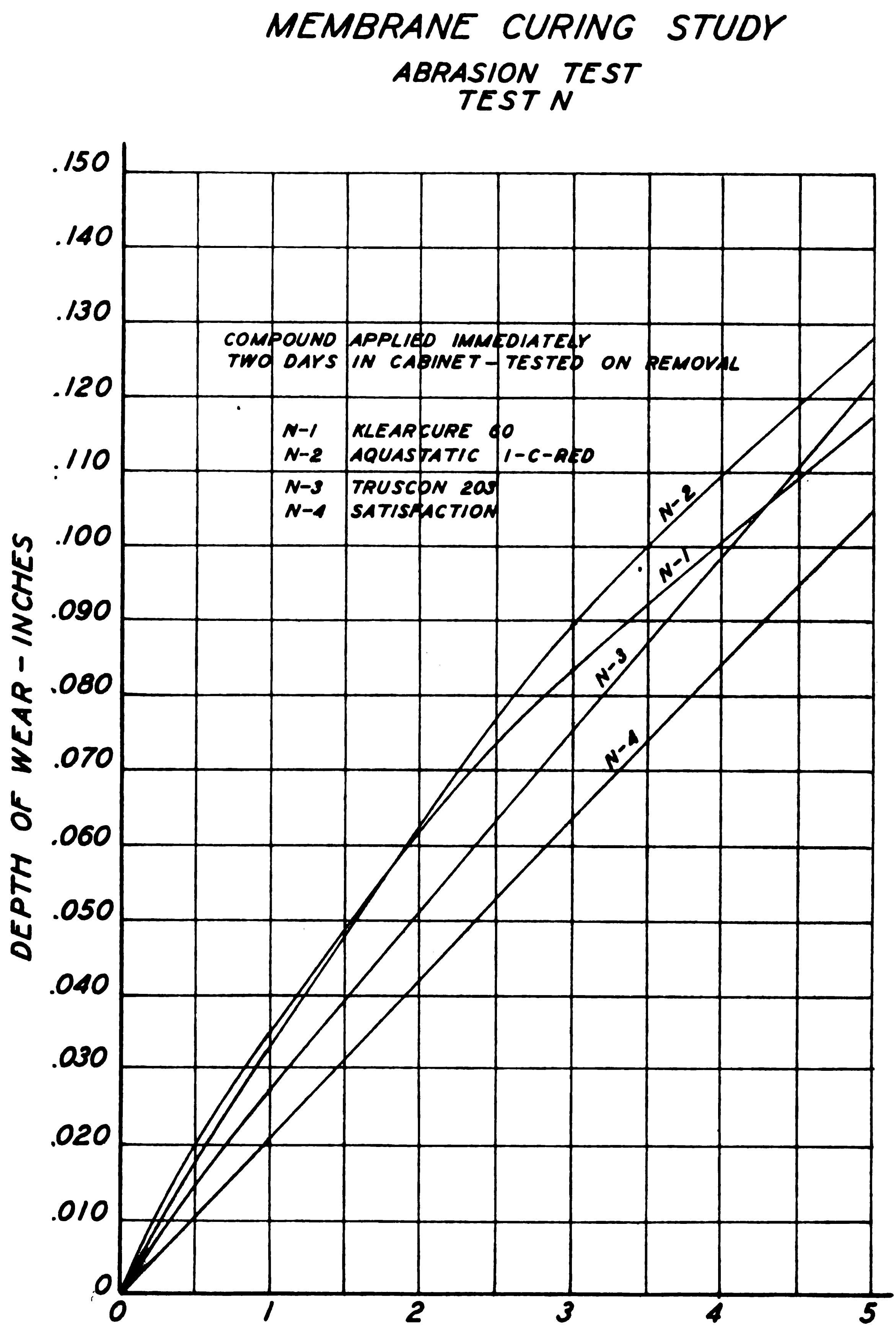


MEMBRANE CURING STUDY

ABRASION TEST
SERIES II

TEST M

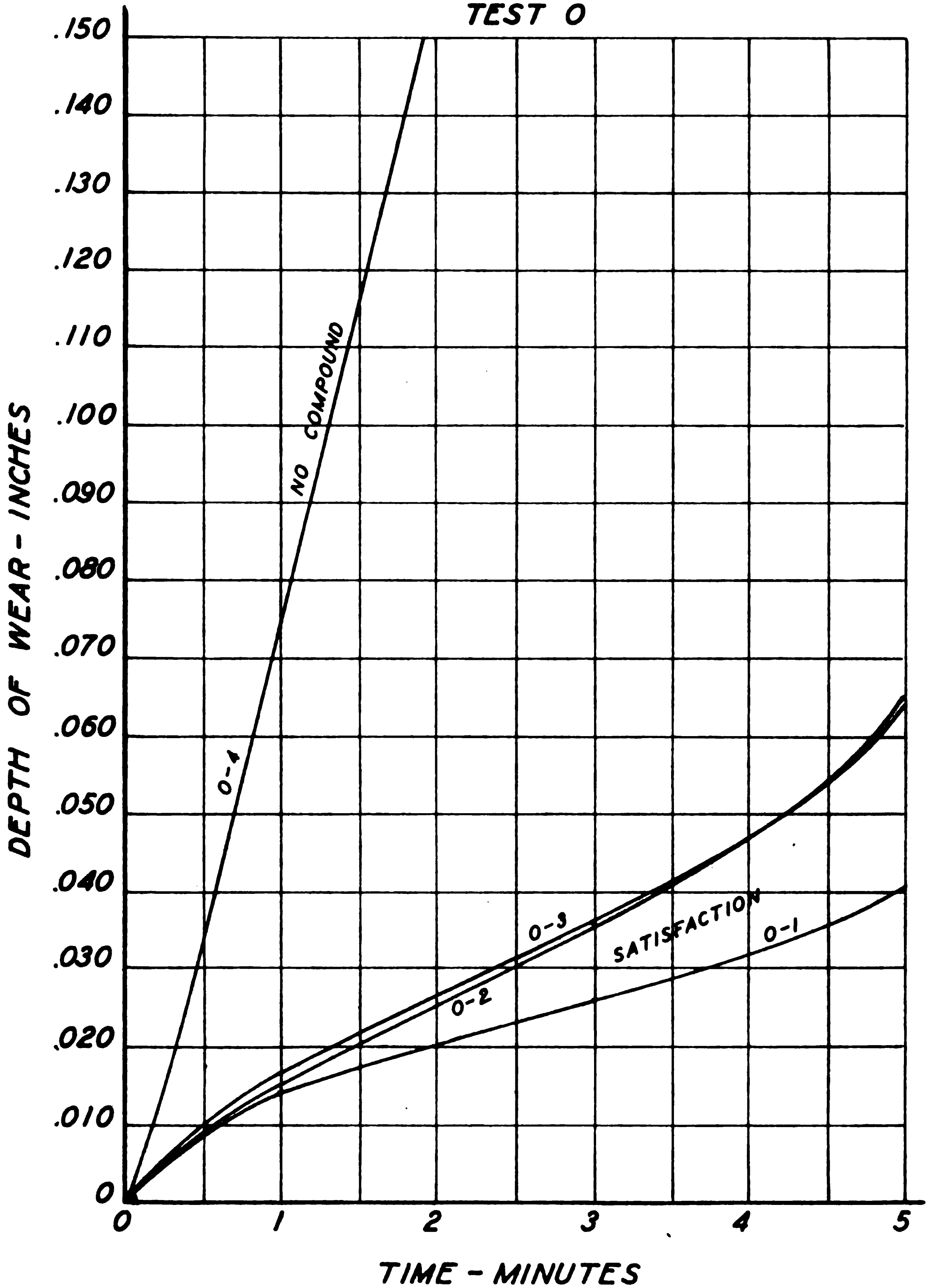



MEMBRANE CURING STUDY
ABRASION TEST
TEST N
COMPOUND APPLIED IMMEDIATELY
TWO DAYS IN CABINET - TESTED ON REMOVAL
N-1 KLEARCURE 60
N-2 AQUASTATIC 1-C-RED
N-3 TRUSCON 203
N-4 SATISFACTION
N-1
N-2
N-3
N-4
DEPTH OF WEAR - INCHES
.150
.140
.130
.120
.110
.100
.090
.080
.070
.060
.050
.040
.030
.020
.010
.0
0
1
2
3
4
5
TIME - MINUTES

MEMBRANE CURING STUDY

ABRASION TEST
SERIES II

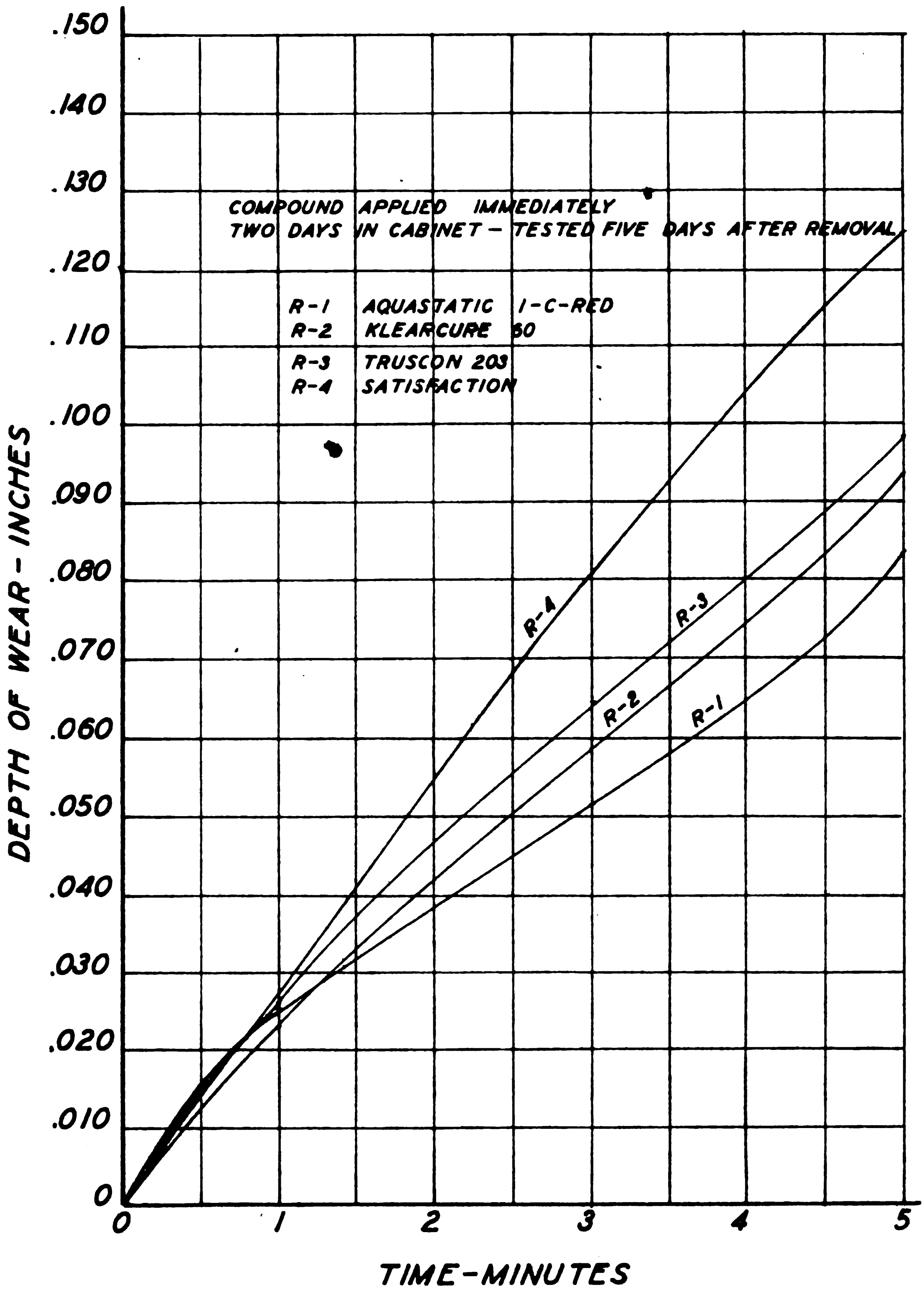
TEST O

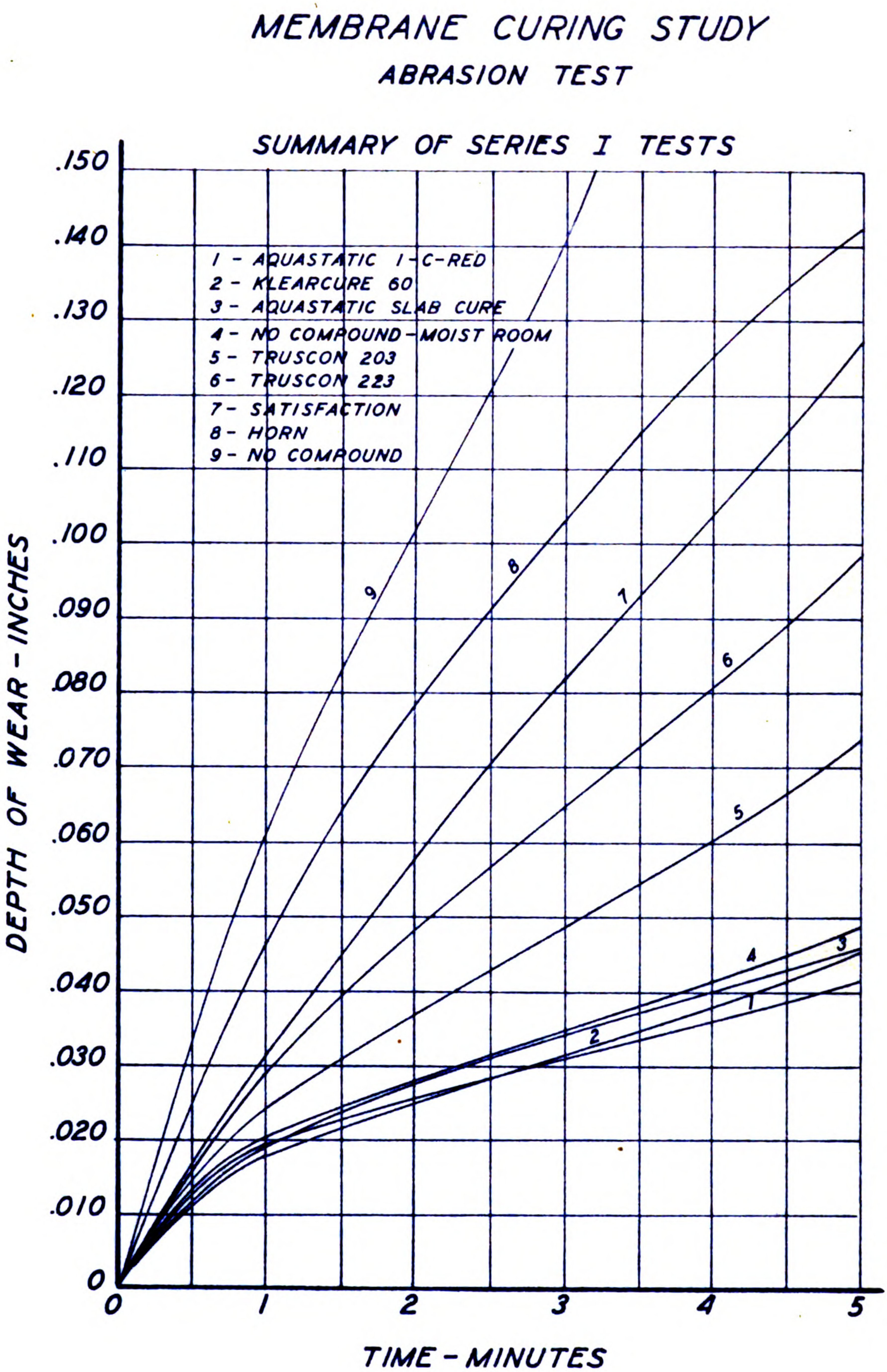


MEMBRANE CURING STUDY

ABRASION TEST

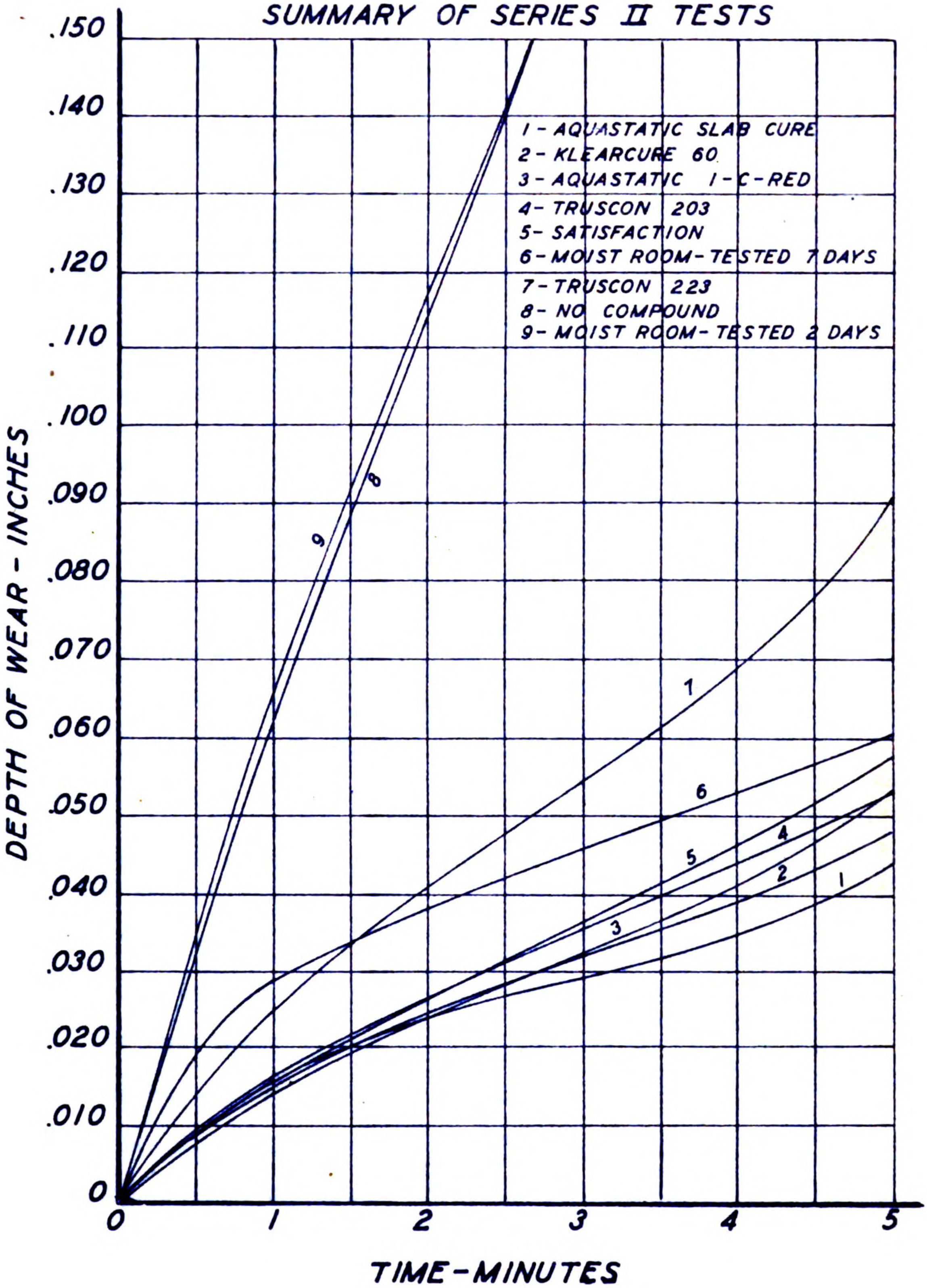
TEST R




MEMBRANE CURING STUDY
ABRASION TEST
SUMMARY OF SERIES I TESTS
1 - AQUASTATIC 1-C-RED
2 - KLEARCURE 60
3 - AQUASTATIC SLAB CURE
4 - NO COMPOUND - MOIST ROOM
5 - TRUSCON 203
6 - TRUSCON 223
7 - SATISFACTION
8 - HORN
9 - NO COMPOUND
DEPTH OF WEAR - INCHES
.150
.140
.130
.120
.110
.100
.090
.080
.070
.060
.050
.040
.030
.020
.010
0
0
1
2
3
4
5
TIME - MINUTES
9
8
7
6
5
4
3
2
1

MEMBRANE CURING STUDY

ABRASION TEST



UNCERTAINTIES

In this test, as in any other, there are certain uncertainties introduced during the test which must be considered. These are not due necessarily to any fault of the tester (although there may be error introduced by the carelessness of operation,) but are caused rather by the nature of the elements being tested and the testing apparatus. In the abrasion test, some of the uncertainties arising are as follows:

1. Variations in the specimens themselves due to non-uniform water loss on curing. If the membrane is not evenly applied, one part of the specimen may lose more water than another part, and therefore, wear faster.

2. Differences in the surface characteristics of the various specimens. Irregularities, such as roughness, will cause a variation of the results.

3. Variations in the speed of the drill press operation. This error is small.

4. Aggregate in a specimen will introduce error since most aggregates will not wear as fast as the mortar itself will. Although fine aggregate was used in the preparation of the specimens for this study, in a few cases the arrangement was such as to cause uneven wear.

5. Impact effect of the tool. On a rough specimen, the tool showed a tendency to bounce; this might cause accelerated wear.

The results as shown in the accompanying graphs seem to be quite consistent; for example, the curves representing the wear of the specimens cured with Klearcure 60 vary only a little over one per cent. The widest variation is shown on the specimens which had no compound, and on these, the results are in close enough agreement to show a very definite trend.

Since the results do seem quite consistent, we feel that it is safe to proceed to draw definite conclusions from the test results.

CONCLUSIONS

From the results of the abrasion test, the following can be safely concluded, we believe:

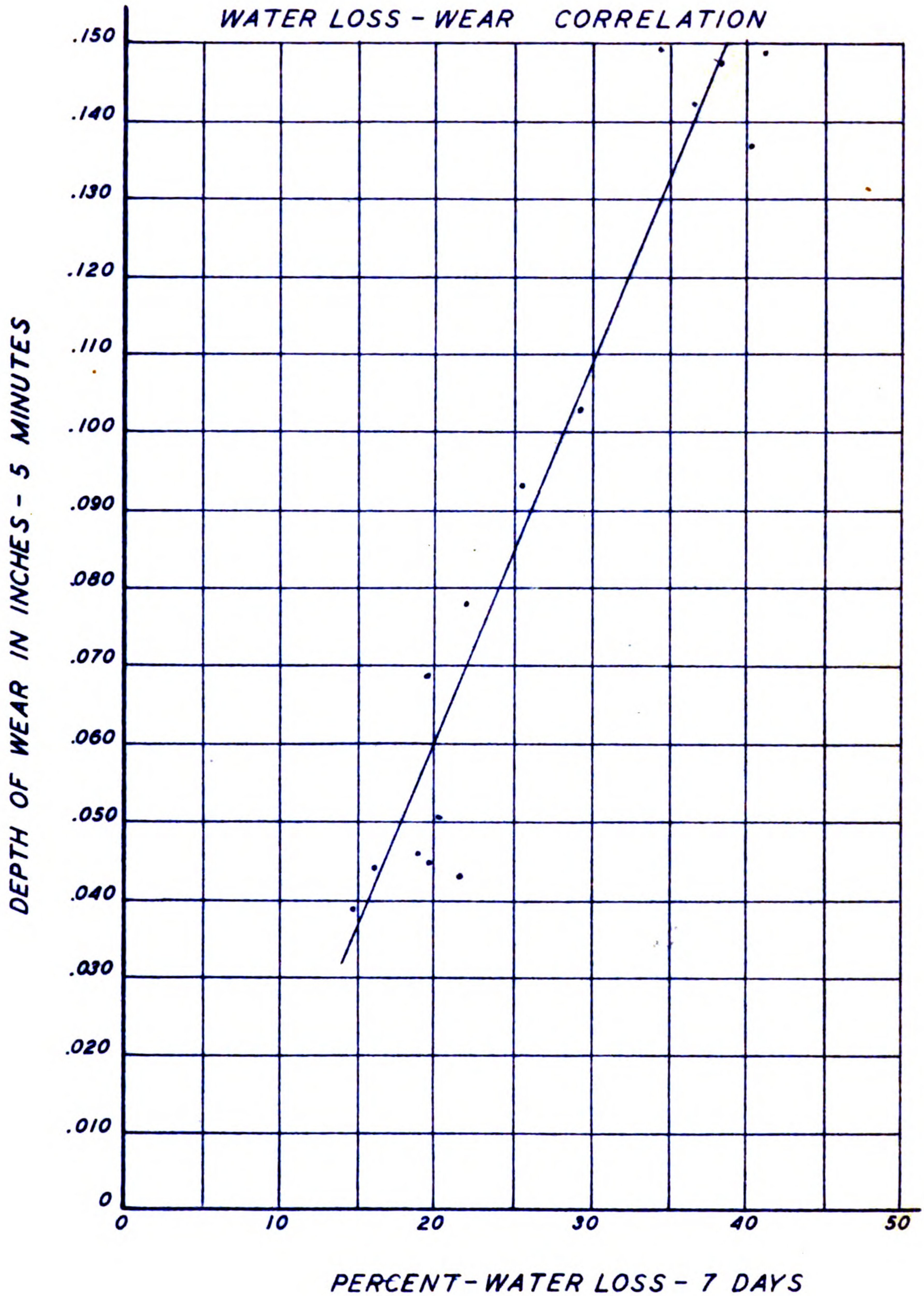
1. Membrane cured concrete can be depended on to give good wearing qualities to approximately the same degree as water cured concrete. This does not apply, of course, to all of the membranes, but to only the more efficient preparations.
2. Not all membranes are effective. In Series I, Horn curing compound and Satisfaction gave results which are but little better than those obtained with no special curing. Truscon 223 is somewhat better and Truscon 203 gave fairly good results. The best results were given by Aquastatic 1-C-Red, Klearcure 60, and Aquastatic Slab Cure, all of which gave nearly the same results as the moist room cured specimens. In Series II, the order of merit was changed slightly, as shown on the summary graph. For a graphic picture of the relative effectiveness of the various compounds, see the summary graphs included with this test.
3. The wear of a mortar which receives no special curing will be about four times that of water-cured or good membrane cured mortar.
4. There is a definite correlation between the water loss and the resistance to wear in a membrane cured specimen. Using the statistical method of least squares, a correlation coefficient of .74

was obtained for this relationship. The graph on the page following also illustrates this correlation.

5. Membranes should not be applied immediately upon molding. Tests N and R in Series II were those in which the membrane was applied immediately after the specimen was molded; in the other tests, a period of about three hours elapsed between mixing and application of the compound. The increased wear on those specimens which were sprayed immediately may be due to chemical reaction between the compound and the cement in the mortar. Whatever the cause, however, a definite weakening of the surface is indicated.

6. Membrane cured specimens develop their wear-resisting qualities in a shorter period of time than the water cured specimens. Test M in Series II shows the wear curves of specimens cured in the moist room with no compound. Those specimens tested at two days gave results practically the same as for specimens cured in the cabinet with no compound. When tested at seven days, however, the water cured specimens gave the same results as the two day membrane cured specimens. It may be claimed that the specimens cured in the cabinet with no compound would show good wear resisting qualities at seven days just as the moist room cured specimens did. The results of Series I

MEMBRANE CURING STUDY



show that this is not true.

Of the six points stated, the first two contain the most important findings of the abrasion test, and from these, it seems that membrane curing compounds are not merely manufacturer's dreams, but on the contrary, have a definite place in concrete work, and if the results of this study can be taken as an indication (and we naturally believe it can) the future of membrane curing materials is anything but gloomy.

CONCLUSION

In this report, even though we have made several definite conclusions, we do not wish to convey the idea that the investigation was as extensive as we might have desired. The time element hindered our investigation of many important items in connection with the relative merits of membrane curing compared with the older types of curing. The Abrasion Test, in particular, has opened up new possibilities in the testing of various curing methods. The cycle of testing, Water-Retention Test, Flexural Test, Surface Dehydration Analysis, and the Abrasion Test, has many advantages and we heartily recommend its use in future testing. By running several different tests on the same specimen, the correlation between tests is obtained, and the several tests may substantiate the validity of results. We realize that many important items have been touched only lightly, but we feel that this study might form a basis for future work and a suggestion for more thorough investigation in the future.

APPENDIX A - WATER RETENTION TEST DATA

APPENDIX A - WATER RETENTION TEST DATA

Table of Contents of Data

MEMBRANE CURING STUDY
WATER RETENTION TEST

Humidity Control of Cabinet

March 23, 1943

Trial	Dew Point (Going down)	Dew Point (Going up)	Dew Point Average	Back of Fan Air Temp. (Dry bulb)	Back of Fan Wet Bulb	Front of Fan Air Temp. (Dry bulb)	Front of Fan Wet Bulb
1	8.0°C.	10.0°C.	9.0°C.	100.5°F.	74.8°F.	101°F.	73°F.
1	8.5	9.0	8.75	99.8	74.6	101	73
2	9.0	9.3	9.15	100	74	101	73
2	8.5	9.5	9.0	97	73	98	72
3	8.8	9.5	9.15	100	74.5	101	73
3	8.8	9.4	9.1	97	73.5	98	72

Trial	Dew Point Average	Vapor in Air gr. per cu.ft.	Air Temp. Average	Vapor for Sat. gr. per cu. ft.	Humidity from Dew Point	Wet & Dry Bulb Humid. Back of Fan	Wet & Dry Bulb Humid. Front of Fan
1	48.2°F.	3.871	100.75°F.	20.38	19.0%	29%	25%
1	47.7	3.804	100.4	20.19	18.8	31	25
2	48.5	3.911	100.5	20.25	19.3	29	25
2	48.2	3.871	97.5	18.65	20.8	31	28
3	48.5	3.911	100.5	20.25	19.3	30	25
3	48.4	3.898	97.5	18.65	20.9	32	28

Average correction to be applied to wet and dry bulb apparatus in back of fan is: 10.8 %

Average correction to be applied to wet and dry bulb apparatus in front of fan is: 6.3 %

MEMBRANE CURING STUDY

WATER RETENTION TEST

Humidity Control of Cabinet

April 2, 1943

Trial	Dew Point °C.	Dew Point °F.	Back of Fan Air Temp.	Back of Fan Wet Bulb	Vapor in Air gr./cu.ft.	Humidity from Dew Pt.	Humidity Wet & Dry Bulb	Difference
1	17.8	64	100	80	6.65	34.2	42	7.8
2	17.6	63.7	100	79	6.58	33.8	40	6.2
3	17.0	62.6	100	80	6.35	32.7	42	9.3
4	18.0	64.4	100	80	6.73	34.6	42	7.4
							Average	7.7

Since the dew point apparatus which gives a correct humidity reading cannot be used, as it was borrowed, the humidity will be maintained by correcting the wet and dry bulb reading and then maintaining the humidity at this desired level. Since the humidity should be maintained at 32.5 %, the wet and dry bulb reading to maintain this desired humidity is 40.2 %, or the wet bulb reading should be between 79 and 80° F., if the air temperature is 100° F.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Measurement of Air Flow in Control Cabinet

Instrument - Velometer (Boyle system)
Serial No. 3314
Type No. 3002

Date Tested
2-19-43

Readings taken at 3 1/2" height

Across right edge

Depth from Front of Cabinet	Velocity of Air Feet per Min.
3 "	101
6	101
9	95
12	101
15	101
18	117

Across center

Depth from Front of Cabinet	Velocity of Air Feet per Min.
3 "	101
6	117
9	101
12	90
15	95
18	106

Across left edge

Depth from Front of Cabinet	Velocity of Air Feet per Min.
3 "	143
6	154
9	154
12	148
15	143
18	148

These readings are corrected for temperature.

MEMBRANE CURING STUDY

Minor Test

in Connection with

WATER RETENTION TEST

SPECIFIC GRAVITY OF MEMBRANE CURING COMPOUNDS

Curing Material	Wt. of Flask	Wt. of Flask & 250 c.c. C.C.	Wt. of 250 ml. Curing Compound	Specific Gravity
Truscon 223	97.8 g.	297.7 g.	199.9 g.	.800
Truscon 203	97.8	307.7	209.9	.840
Truscon 214	97.9	312.9	215.0	.860
Truscon 199	97.9	317.8	219.9	.880
Klearcure 60	97.7	330.1	232.4	.929
Satisfaction 45	98.1	315.8	217.7	.871
Horn	97.7	420.5	322.8	1.291
Aquastatic Slab Cure Red	97.8	307.0	209.2	.837
Aquastatic 1-C-Red	97.8	328.5	230.6	.923

MEMBRANE CURING STUDY

MINOR TESTS

in connection with

WATER RETENTION TEST

PERCENT SOLIDS OF CURING MATERIALS

Curing Material	Weight Liquid	Weight Dry Solids	Percent Solids
Klearcure 60	3.3243 g.	1.8916 g.	56.90 g.
Aquastatic 1-C-Red	2.7740	1.3063	47.09
Aquastatic Slab Cure Red	3.3645	1.4693	43.67
Horn	6.0959	2.3452	38.47
Satisfaction 45			45.00
Truscon 203	3.4417	1.5758	45.79
Truscon 223	2.5832	0.6904	26.73
Truscon 199	2.6108	1.1472	43.94
Truscon 214	1.8322	0.8148	44.47

MEMBRANE CURING STUDY

MINOR TESTS

in connection with

WATER RETENTION TEST

WATER CONTENT OF OXFORD SAND AT SATURATED SURFACE DRY CONDITION

Wt. of can	- 78.59 g.		
Wt. of can and sand (moist)	- 614.70	11:00 a.m.	March 12, 1943
Wt. of can and sand (dry)	- 607.73	11:50 a.m.	March 16, 1943

Wt. of sand (moist) = 614.70 - 78.59 = 536.11 g.

Wt. of sand (dry) = 607.73 - 78.59 = 529.14 g.

$$\text{Percent of moisture} = \frac{536.11 - 529.14}{529.14} = 1.1282\ \%$$

PERCENT SOLIDS OF LATEX SEALER

Wt. of can	- 19.88 g.		
Wt. of can and latex (liquid)	- 26.73	4:45 p.m.	3-2-43
Wt. of can and latex (solids)	- 21.93	12:30 p.m.	3-3-43
Wt. of can and latex (solids)	- 21.93	12:30 p.m.	3-4-43

Wt. of latex (liquid)= 26.73 - 19.88 = 6.85 g.

Wt. of latex (solids)= 21.93 - 19.88 = 2.05 g.

$$\text{Percent of solids} = \frac{100 \times 2.05}{6.85} = 30.0\ \%$$

MEMBRANE CURING STUDY

MINOR TESTS

in connection with

WATER RETENTION TEST

Series I

EVAPORATION OF MOISTURE WHILE MIXING

This test is to determine the amount of water lost, due to evaporation while mixing. Mixing takes approximately thirty minutes.

4750 g. sand			
475 g. water			
5225 g.		at 11:30 a.m.	March 16, 1943
- 5204 g.		at 12:00 m.	March 16, 1943
21 g. water evaporated			

Since in each specimen there is approximately 4500 grams of material, excluding water, the allowance for evaporation is 4500 x 21 ÷ 4700 is 20 grams.

Therefore in the computations 20 grams will be subtracted from the mixing water to determine the original water in the specimen.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series I

Data applicable to every specimen under this series.

Mortar Data

Brand of cement - Huron Standard

Sand (a) Source - Oxford, Michigan

(b) Grading - Absolute

Passing No. 4	100 %
16	60 %
50	15 %
100	2 %

(c) Moisture (saturated surface-dried condition - 1.128 %

Proportioning of Mix

Cement 2700 g.
Water 1080 g. (.40 of cement by weight)
Sand 7460 g. (sufficient for 25% flow)
Total 11240 g.
Percent water - 9.60854%
This batch is sufficient for two specimens.

Application of Membrane Curing Compound

After sufficient time had elapsed after finishing the specimens for the surface moisture to disappear (approximately 3 hours), the membrane was applied by spraying with an atomizer at the rate of 200 sq. ft. to the gallon.

Sealing of Edges

The edges where the mortar met the pan were sealed with a Latex material as soon as the membrane had dried. (approximately 1/2 hour after the application of the membrane).

Weighing of Specimens

The specimens were weighed daily to determine the water loss. This weighing was done as close to the time of day of the application of the membrane as feasible.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series I
Test A

Specimen A-1 Date February 6, 1943

Curing Method Moist Room Tested by L. T. O.

TEST RECORD

Remarks	Date	Time	Weight of Specimen	Moist Room Temp.	Moist Room Humidity
	2-6-43	4:00 p.m.	6063 g.	66° F.	100%
First day					
Second day	2-8-43	2:30	6068	"	"
Third day	2-9-43	2:00	6074	"	"
Fourth day	2-10-43	2:00	6081	"	"
Fifth day	2-11-43	4:30	6086	"	"
Sixth day	2-12-43	2:45	6093	"	"
Seventh day	2-13-43	2:00	6099	"	"

Wt. of mortar and pan 6063 g.

Wt. of pan 1066 g.

Wt. of mortar 4997 g.

Original water in specimen 4997 x 9.60854% - 20 = 460.1 g.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series I
Test A

Specimen A-2 | Date February 6, 1943

Curing Method Moist Room | Tested by I. T. O.

TEST RECORD

Remarks	Date	Time	Weight of Specimen	Moist Room Temp.	Moist Room Humidity
	2-6-43	4:00 p.m.	5899 g.	66° F.	100%
First day					
Second day	2-8-43	2:30	5908	"	"
Third day	2-9-43	2:00	5912	"	"
Fourth day	2-10-43	2:00	5916	"	"
Fifth day	2-11-43	4:30	5924	"	"
Sixth day	2-12-43	2:45	5927	"	"
Seventh day	2-13-43	2:00	5938	"	"

Weight of mortar and pan 5899 g.

Weight of pan 1038 g.

Weight of mortar 4861 g.

Original water in specimen 4861 x 9.60854% - 20 = 447.1 g.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series I
Test E

Specimen E-3 Date March 25, 1943

Curing Material Truscon 203 Tested by L. T. C.

Position in Cabinet 3

TEST RECORD

Remarks	Date	Time	Weight of Specimen	Temp. of Cabinet	Wet & Dry Bulb Humidity Reading	Correct Humidity
	3-25-43	10:05 a.m.	6054 g.	100° F.	33%	22%
Before membrane	3-25-43	1:15 p.m.	6009	100	36	25
After membrane	3-25-43	1:20	6014	100	36	25
Before sealer	3-25-43	1:50	6011	100	36	25
After sealer	3-25-43	1:55	6018	100	36	25
First day	3-26-43	4:00	5965	100	31	20
Second day	3-27-43	12:00 m.	5949	99	34	23
Third day	3-28-43	3:30 p.m.	5936	100	33	22
Fourth day	3-29-43	12:00 m.	5929	100	34	23
Fifth day	3-30-43	1:45 p.m.	5923	100	33	22
Sixth day	3-31-43	1:15	5918	100	35	24
Seventh day	4-1-43	1:00	5913	100	35	24

Weight of mortar and pan 6054 g.
Weight of pan 1065 g.
Weight of mortar 4989 g.

Original water in specimen 4989 x 9.60854% - 20 = 459.4 g.

Membrane Application
Exposed area, 72 sq. in.
Amt. of mat'l. applied 9.5 ml.
Sp. Gr. of mat'l. .840
Checking by weight 8.3 g.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series I
Test B

Specimen B-2 — Date February 20, 1943

Curing Mat'l. Klearcure 60 — Tested by L. T. O.

Position in Cabinet 6

TEST RECORD

Remarks	Date	Time	Weight of Specimen	Temp. of Cabinet	Wet & Dry Bulb Humidity Reading	Correct Humidity
	2-20-43	2:58 p.m.	6039 g.	98° F.	36%	25%
Before membrane	2-20-43	6:00 p.m.	6009	100	36	25
After membrane	2-20-43	6:10 p.m.	6016	100	36	25
Before sealer	2-20-43	6:45 p.m.	6008	100	40	29
After sealer	2-20-43	6:50 p.m.	6012	100	40	29
First day	2-21-43	4:15 p.m.	5987	100	33	22
Second day	2-22-43	2:30 p.m.	5967	99	33	22
Third day	2-23-43	2:00 p.m.	5956	99	33	22
Fourth day	2-24-43	2:45 p.m.	5951	99	33	22
Fifth day	2-25-43	12:15 p.m.	5939	100	31	20
Sixth day	2-26-43	2:45 p.m.	5932	100	34	23
Seventh day	2-27-43	2:30 p.m.	5927	99	32	21

Wt. of mortar and pan 6039 g.
Wt. of pan 1041 g.
Wt. of mortar 4998 g.

Original water in specimen 4998 x 9.60854% - 20 = 459.1 g.

Membrane Application
Exposed area, 72 sq. in.
Amt. of mat'l. applied 9.5 ml.
Sp. Gr. of mat'l. .929
Checking by weight 9.0 g.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series I
Test D

Specimen D-2 Date March 13, 1943

Curing Material Aquastatic 1-C-Red Tested by L. T. O.

Position in Cabinet 6

TEST RECORD

Remarks	Date	Time	Weight of Specimen	Temp. of Cabinet	Wet & Dry Bulb Humidity Reading	Correct Humidity
	3-13-43	1:15 p.m.	6079 g.	100° F.	29%	18%
Before membrane	3-13-43	3:50	6045	100	39	28
After membrane	3-13-43	3:55	6052	100	39	28
Before sealer	3-13-43	4:50	6048	100	39	28
After sealer	3-13-43	5:00	6054	100	39	28
First day	3-14-43	4:15	6028	99	34	23
Second day	3-15-43	4:00	6016	100	33	22
Third day	3-16-43	4:00	6006	100	33	22
Fourth day	3-17-43	3:45	5998	100	29	18
Fifth day	3-18-43	10:00 a.m.	5993	100	29	18
Sixth day	3-19-43	10:00	5986	100	27	16
Seventh day	3-20-43	1:30 p.m.	5982	100	35	24

Weight of mortar and pan 6079 g.
Weight of pan 1041 g.
Weight of mortar 5038 g.

Original water in specimen 5038 x 9.60854% - 20 = 464.1 g.

Membrane Application
Exposed area, 72 sq. in.
Amt. of mat'l. applied 9.5 ml.
Sp. Gr. of mat'l. .923
Checking by weight 8.8 g.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series I
Test D

Specimen D-5 Date March 13, 1943

Curing Material none Tested by L. T. O.

Position in Cabinet 5

TEST RECORD

Remarks	Date	Time	Weight of Specimen	Temp. of Cabinet	Wet & Dry Bulb Humidity Reading	Correct Humidity
	3-13-43	2:45 p.m.	6132 g.	100° F.	36%	25%
Before sealer	3-13-43	5:50	6100	100	35	24
After sealer	3-13-43	6:00	6108	100	35	24
First day	3-14-43	4:15	5956	99	34	23
Second day	3-15-43	4:00	5937	100	33	22
Third day	3-16-43	4:00	5927	100	33	22
Fourth day	3-17-43	3:45	5919	100	29	18
Fifth day	3-18-43	10:00 a.m.	5913	100	29	18
Sixth day	3-19-43	10:00	5907	100	27	16
Seventh day	3-20-43	1:30 p.m.	5902	100	35	24

Weight of mortar and pan 6132 g.
Weight of pan 1061 g.
Weight of mortar 5071 g.

Original water in specimen 5071 x 9.60854% - 20 = 467.2 g.

Exposed area, 72 sq. in.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series I
Test E

Specimen E-6 Date March 25, 1943

Curing Material none Tested by L. T. C.

Position in Cabinet 6

TEST RECORD

Remarks	Date	Time	Weight of Specimen	Temp. of Cabinet	Wet & Dry Bulb Humidity Reading	Correct Humidity
	3-25-43	11:10 a.m.	5933 g.	100° F.	36%	25%
Before sealer	3-25-43	2:05 p.m.	5901	100	36	25
After sealer	3-25-43	2:10	5908	100	36	25
First day	3-26-43	4:00	5760	100	31	20
Second day	3-27-43	12:00 m.	5746	99	34	23
Third day	3-28-43	3:30 p.m.	5734	100	33	22
Fourth day	3-29-43	12:00 m.	5727	100	34	23
Fifth day	3-30-43	1:45 p.m.	5720	100	33	22
Sixth day	3-31-43	1:15	5716	100	35	24
Seventh day	4-1-43	1:00	5712	100	35	24

Weight of mortar and pan 5933 g.
Weight of pan 1049 g.
Weight of mortar 4884 g.

Original water in specimen 4884 x 9.60854% - 20 = 449.3 g.

Exposed area, 72 sq. in.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series I
Test F

Specimen F-1 | Date April 1, 1943

Curing Method Moist Room | Tested by L. T. O.

TEST RECORD

Remarks	Date	Time	Weight of Specimen	Moist Room Temp.	Moist Room Humidity
	4-1-43	2:05 p.m.	6007 g.	66^{o} F.	100%
First day	4-2-43	4:30	6032	"	"
Second day	4-3-43	12:00 m.	6038	"	"
Third day	4-4-43	4:30 p.m.	6041	"	"
Fourth day	4-5-43	4:00	6046	"	"
Fifth day	4-6-43	3:30	6047	"	"
Sixth day	4-7-43	3:15	6048	"	"
Seventh day	4-8-43	7:00	6047	"	"

Weight of mortar and pan 6007 g.

Weight of pan 1068 g.

Weight of mortar 4939 g.

Original water in specimen 4939 x 9.60854% - 20 = 454.5 g.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series I
Test F

Specimen F-2 Date April 1,1943

Curing Method Moist Room Tested by L. T.O.

TEST RECORD

Remarks	Date	Time	Weight of Specimen	Moist Room Temp.	Moist Room Humidity
	4-1-43	2:20 p.m.	5932 g.	66° F.	100%
First day	4-2-43	4:30	5965	"	"
Second day	4-3-43	12:00 m.	5978	"	"
Third day	4-4-43	4:30	5984	"	"
Fourth day	4-5-43	4:00	5987	"	"
Fifth day	4-6-43	3:30	5990	"	"
Sixth day	4-7-43	3:15	5990	"	"
Seventh day	4-8-43	7:00	5990	"	"

Weight of mortar and pan 5932 g.

Weight of pan 1040 g.

Weight of mortar 4892 g.

Original water in specimen 450.6 x 9.60854% - 20 = 450.6 g.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series I
Test F

Specimen F-3 | Date April 1, 1943

Curing Method Moist Room | Tested by L. T. O.

TEST RECORD

Remarks	Date	Time	Weight of Specimen	Moist Room Temp.	Moist Room Humidity
	4-1-43	3:50 p.m.	6060 g.	66° F.	100%
First day	4-2-43	4:30	6094	"	"
Second day	4-3-43	12:00 m.	6105	"	"
Third day	4-4-43	4:30 p.m.	6107	"	"
Fourth day	4-5-43	4:00	6113	"	"
Fifth day	4-6-43	3:30	6114	"	"
Sixth day	4-7-43	3:15	6115	"	"
Seventh day	4-8-43	7:00	6117	"	"

Weight of mortar and pan 6060 g.

Weight of pan 1068 g.

Weight of mortar 4992 g.

Original water in specimen 4992 x 9.60854% - 20 = 459.6 g.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series I
Test F

Specimen F-4

Date April 1, 1943

Curing Method Moist Room

Tested by L. T. O.

TEST RECORD

Remarks	Date	Time	Weight of Specimen	Moist Room Temp.	Moist Room Humidity
	4-1-43	3:57 p.m.	5970 g.	66° F.	100%
First day	4-2-43	4:30	6003	"	"
Second day	4-3-43	12:00 m.	6017	"	"
Third day	4-4-43	4:30 p.m.	6022	"	"
Fourth day	4-5-43	4:00	6027	"	"
Fifth day	4-6-43	3:30	6029	"	"
Sixth day	4-7-43	3:15	6030	"	"
Seventh day	4-8-43	7:00	6033	"	"

Weight of mortar and pan 5970 g.

Weight of pan 1040 g.

Weight of mortar 4930 g.

Original water in specimen 4930 x 9.60854% - 20 = 453.7 g.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series I
Test F

Specimen F-5 | Date April 1, 1943

Curing Method Wet Burlap | Tested by L. T. O.

TEST RECORD

Remarks	Date	Time	Weight of Specimen	Laboratory Air Temp.	Laboratory Air Humidity
	4-1-43	4:35 p.m.	6146 g.		
Start of Curing	4-1-43	7:20	6135		
First day	4-2-43	4:30	6158		
Second day	4-3-43	12:00 m.	6160	72° F.	22%
Third day	4-4-43	4:30 p.m.	6166	72	41
Fourth day	4-5-43	4:00	6174	75	24
Fifth day	4-6-43	3:30	6174	75	32
Sixth day	4-7-43	3:15	6170	75	34
Seventh day	4-8-43	7:00	6170	75	38

Weight of mortar and pan 6146 g.

Weight of pan 1063 g.

Weight of mortar 5083 g.

Original water in specimen 5083 x 9.60854% - 20 = 468.4 g.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series I
Test F

Specimen F-6 | Date April 1, 1943

Curing Method Ponding | Tested by L. T. O.

TEST RECORD

Remarks	Date	Time	Weight of Specimen	Laboratory Air Temp.	Laboratory Air Humidity
	4-1-43	4:45 p.m.	6005 g.		
Start of Curing	4-1-43	7:20	5995		
First day	4-2-43	4:30	6033		
Second day	4-3-43	12:00 m.	6041	72° F.	22%
Third day	4-4-43	4:30 p.m.	6045	72	41
Fourth day	4-5-43	4:00	6047	75	24
Fifth day	4-6-43	3:30	6051	75	32
Sixth day	4-7-43	3:15	6052	75	34
Seventh day	4-8-43	7:00	6053	75	38

Weight of mortar and pan 6005 g.

Weight of pan 1050 g.

Weight of mortar 4955 g.

Original water in specimen 4955 x 9.60854% - 20 = 456.1 g.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series I

Explanation of Computations under Tabulated Data

Original Water (A) - This is the water in the specimen at the time of finishing of the mortar. It was computed as follows: weight of mortar times percent water minus 20 grams. This correction is applied, because during the mixing operation, approximately 1/2 hour, the mortar loses moisture. (Please refer to datum under Evaporation Loss While Mixing under Minor Test).

Correction for Curing Material (B) - Because the membrane curing compounds are highly volatile, much of the weight disappears in a few hours. This correction is necessary or this loss of weight would be considered water loss, which is not correct. (Please refer to Percent Solids of Membrane Curing Materials under Minor Tests).

Correction for Sealer (C) - The Latex material used to prevent moisture from escaping around the edges of the pan is also a material which will evaporate considerably. Therefore, a correction should be used to discount this loss of weight, so that it will not be considered water loss. (Please refer to Percent Solids of Sealing Material under Minor Tests).

Water Loss While Blank (D) - This is the water loss from the time of finishing until the time when the mortar was in a condition so that the membrane could be applied. (Approximately 3 hours).

Water at Application of Membrane (E) - This is the water in the specimen at the time the membrane was applied; or in other words, the Original Water minus the Water Loss While Blank.

Water Loss (F) - This is the corrected water loss as determined by the loss in weight of the specimen from the time that the membrane was applied.

Percent Water Loss $= \frac{100\ F}{A}$ - This is the percent water loss as determined by the water loss from the application of the curing material times 100, divided by the original water in the specimen. This was computed for the two-day and seven-day periods.

Percent Water Loss $= \frac{100\ F}{E}$ - This is the percent water loss as determined by the water loss from the application of the curing material times 100, divided by the water in the specimen at the time of application of the membrane. This percent water loss is probably the better one to use in comparing the results of the various curing materials.

Percent Efficiency $= 100 - \frac{100\ F/E}{F/E\ (\text{blank})}$ - This computation is also useful in comparing the various membrane curing compounds. A slight explanation is necessary. If the membrane were absolutely water-tight, the percent efficiency would be 100, while if the membrane were of no use whatever in conserving the water for the hydration of the cement, the efficiency would be 0. The higher the percent efficiency, the more the water is retained in the mortar and, consequently, the more water is available in the hydration of the cement.

MEMBRANE CURING STUDY
WATER RETENTION TEST

TABULATED DATA - Test A

Specimen		A-1	A-2
Curing		Moist Room 66° F. 100 % Rel. Hum.	
Original water	(A)	460.1 g.	447.1 g.
Water gain	(F)		
1 day			
2 days		5. g.	9 g.
3 days		11	13
4 days		18	17
5 days		23	25
6 days		30	28
7 days		36	39

Percent water gain $= \frac{100\ F}{A}$

2 days	1.08 %	2.01 %
7 days	7.8 %	8.7 %

Percent efficiency $= \frac{100\ F/A}{F/A\ (blank)}$

2 days	103.3 %	106.1 %
7 days	118.9 %	121.1 %

MEMBRANE CURING STUDY
WATER RETENTION TEST

TABULATED DATA - Test B

Specimen	B-1	B-2	B-3	B-4	B-5
Curing Material	Horn	Klearcure	Klearcure	Horn	Blank
Original water (A)	466.2 g.	459.1 g.	456.2 g.	475.2 g.	469.7 g.
Correction for curing material (B)	6	4	4	6	0
Correction for sealer (C)	1	1	1	1	1
Water loss while blank (D)	37	30	37	39	36
Water at appl. of membrane (E)	429.2	429.1	419.2	436.2	433.7
Water loss (F)					
1 day	132	27	34	137	136
2 days	150	47	53	155	154
3 days	160	58	63	164	165
4 days	165	63	68	170	170
5 days	177	75	79	182	181
6 days	184	82	86	189	188
7 days	188	87	91	195	194
Percent water loss $= \frac{100\ F}{A}$					
2 days	32.2	10.25	11.61	32.6	32.8
7 days	40.3	18.98	19.92	41.1	41.3
Percent water loss $= \frac{100\ F}{E}$					
2 days	35.0	10.96	12.65	35.6	35.6
7 days	43.8	20.25	21.70	44.7	44.8
Percent efficiency $= 100 - \frac{100\ F/E}{F/E\ (\text{blank})}$					
2 days	1.50	69.2	64.4	0.0	0.0
7 days	2.20	54.8	51.6	0.20	0.0

MEMBRANE CURING STUDY
WATER RETENTION TEST

TABULATED DATA - Test C

Specimen		C-1	C-2	C-5	C-6
Curing material		Satisfaction 45		Blank	Blank
Original water	(A)	459.0 g.	465.3 g.	478.3 g.	469.2 g.
Correction for curing material	(B)	4	4	0	0
Correction for sealer	(C)	4	2	2	3
Water loss while blank	(D)	52	49	51	51
Water at appl. of membrane	(E)	407.0	416.3	427.3	418.2
Water loss	(F)				
1 day		107	100	143	138
2 days		127	120	162	156
3 days		138	131	173	167
4 days		147	139	183	175
5 days		155	147	190	183
6 days		161	153	196	189
7 days		166	159	204	195
Percent water loss $= \frac{100\ F}{A}$					
2 days		27.7	25.8	33.9	33.3
7 days		36.2	34.2	42.7	41.6
Percent water loss $= \frac{100\ F}{E}$					
2 days		31.2	28.8	37.9	37.3
7 days		40.8	38.2	47.7	46.6
Percent efficiency $= 100 - \frac{100\ F/E}{F/E\ (\text{blank})}$					
2 days		17.0	23.4	0.0	0.0
7 days		13.5	19.0	0.0	0.0

MEMBRANE CURING STUDY
WATER RETENTION TEST

TABULATED DATA - Test D

Specimen	D-1	D-2	D-3	D-4	D-5	D-6
Curing material	Aquastatic 1-C-Red		Aquastatic Slab Cure Red		Blank	Blank
Original water (A)	466.6g.	464.1g.	463.7g.	463.1g.	467.2g.	462.2g.
Correction for curing material (B)	4	4	4	4	0	0
Corr. for sealer (C)	2	2	3	3	3	2
Water loss while blank (D)	37	34	35	30	34	34
Water at appl. of membrane (E)	429.6	430.1	428.7	433.1	433.2	428.2
Water loss						
1 day	35	23	47	37	144	142
2 days	38	35	67	59	163	160
3 days	50	45	77	70	173	171
4 days	57	53	86	77	181	179
5 days	63	58	91	83	187	184
6 days	69	65	97	89	193	190
7 days	74	69	103	93	198	195
Percent water loss = $\frac{100\ F}{A}$						
2 days	8.1	7.5	14.4	12.8	34.9	34.6
7 days	15.8	14.9	22.2	20.3	42.4	42.2
Percent water loss = $\frac{100\ F}{E}$						
2 days	8.55	8.1	15.6	13.6	37.6	37.4
7 days	17.2	16.0	24.0	21.5	45.7	45.6
Percent efficiency = $100 - \frac{100\ F/E}{F/E\ (\text{blank})}$						
2 days	77.2	78.4	58.4	63.8	0.0	0.0
7 days	62.4	65.0	47.4	53.0	0.0	0.0

MEMBRANE CURING STUDY
WATER RETENTION TEST

TABULATED DATA - Test E

Specimen		E-1	E-2	E-2	E-4	E-5	E-6
Curing material		Truscon 223		Truscon 203		Blank	Blank
Original water	(A)	458.1g.	463.2g.	459.4g.	457.3g.	463.5g.	449.3g.
Correction for curing material	(B)	2	2	4	4	0	0
Correction for sealer	(C)	2	3	2	3	2	2
Water loss while blank	(D)	40	35	45	44	41	41
Water at appl. of membrane	(E)	418.1	428.2	414.4	413.3	422.5	408.3
Water loss	(F)						
1 day		83	65	50	37	133	134
2 days		98	81	66	53	148	148
3 days		111	94	79	65	161	160
4 days		118	101	86	73	169	167
5 days		123	107	92	79	175	174
6 days		129	112	97	84	180	178
7 days		134	117	102	89	184	182
Percent water loss $= \frac{100\ F}{A}$							
2 days		21.4	17.5	14.4	11.6	32.0	33.0
7 days		29.2	25.2	22.2	19.5	39.7	40.5
Percent water loss $= \frac{100\ F}{E}$							
2 days		23.4	18.9	15.9	12.8	35.0	36.3
7 days		32.0	27.4	24.6	21.6	43.5	44.6
Percent efficiency $= 100 - \frac{100\ F/E}{F/E\ (blank)}$							
2 days		34.5	47.0	55.5	64.2	0.0	0.0
7 days		27.4	37.8	44.2	51.0	0.0	0.0

MEMBRANE CURING STUDY
WATER RETENTION TEST

TABULATED DATA - Test F

Specimen	F-1	F-2	F-3	F-4	F-5	F-6
Curing	Moist Room 66° F.	100% R.H.	Moist Room 66° F.	100% R.H.	Wet Burlap	Ponding
Original water (A)	454.5 g.	450.6 g.	459.6 g.	453.7 g.	468.4 g.	456.1 g
Water gain (F)						
1 day	25	33	34	33	12	28
2 days	31	46	45	47	14	36
3 days	34	52	47	52	20	40
4 days	39	55	53	57	38	42
5 days	40	58	54	59	28	46
6 days	41	58	55	60	24	47
7 days	40	58	59	63	24	48

Percent water gain =

$$\frac{100\ F}{A}$$

2 days	6.8 %	10.2 %	9.8 %	10.4 %	3.0 %	7.9 %
7 days	8.8	13.3	12.8	13.9	5.1	10.5

Percent efficiency =

$$100 - \frac{100\ F/A}{F/A\ (\text{blank})}$$

2 days	116.6	124.9	123.9	125.4	107.3	119.3
7 days	121.5	132.4	131.2	133.9	112.4	125.6

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series II

Data applicable to every specimen under this series

__Mortar Data__

Brand of cement - Huron Standard
Sand (a) Source - Oxford, Michigan
(b) Grading - Absolute

Passing No.	4	100 %
	16	60 %
	50	15 %
	100	2 %

(c) Moisture (saturated surface-dried condition - 1.128 %)

__Proportioning of Mix__

Cement	680 g.	
Water	272 g.	(.40 of cement by weight)
Sand	2030 g.	(sufficient for 25% flow)
Total	2982 g.	

Percent water - 9.1214 %
This batch is sufficient for four specimens.

__Sealing of Edges__

Approximately 1 1/4 hours after finishing the specimens, they were taken from the cabinet, weighed, brushed, and re-weighed. Latex material was then placed in a small groove, formed for the purpose when finishing, sealing the specimen and the mould. This prevented water loss through shrinkage cracks.

__Application of Membrane Curing Compound__

Approximately 35 minutes after the edges had been sealed, the membrane was applied by spraying with an atomizer at the rate of 200 sq. ft. to the gallon.

__Storage of Specimens__

Temperature range - 100 $\pm$ 1° F.

Humidity range - 31 - 35 %

Air flow - 2 feet per second

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series II
Test H

Specimen	H-1	H-2	H-3	H-4
Curing material	Truscon 203	Truscon 203	Truscon 203	Blank
Weight pan & mortar	588.5 g.	591.8 g.	602.2 g.	585.7 g.
Weight pan	43.6	47.2	42.9	45.3
Weight mortar	544.9	544.6	559.3	540.4
Weight before brushing	583.8	587.5	597.9	581.0
Weight after brushing	583.3	587.2	597.6	580.5
Weight after sealer	585.3	588.8	599.3	582.7
Wt. before membrane	583.9	587.4	597.8	581.2
Membrane should be applied	3.12	3.12	3.12	
Membrane was applied	3.09	3.19	3.12	
4-14-43 1:00 p.m.	584.2	587.9	598.1	558.1
4-15-43 1:45 p.m.	583.7	587.5	597.6	555.5

TABULATED DATA - TEST H

Original water (A)	49.7	49.7	51.0	49.3
Water loss while blank (D)	5.3	5.0	5.1	5.3
Water at time of application (E)	44.4	44.7	45.9	44.0
Water loss (F)				
1 day	.5	.5	.6	22.5
2 days	1.0	.9	1.1	25.1
Percent water loss = 100 x F/E				
1 day	1.125%	1.119%	1.309%	51.1%
2 days	2.25 %	2.01 %	2.40 %	57.0%
Percent efficiency = $\left(100 - \frac{100\ F/E}{F/E\ (blank)}\right)$				
1 day	97.8 %	97.82 %	97.44 %	0.0%
2 days	96.05 %	96.47 %	95.79 %	0.0%

Time of finishing	4-13-43	11:45 a.m.
Brushed and sealer applied	4-13-43	1:00 p.m.
Membrane applied	4-13-43	1:35 p.m.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series II
Test I

Specimen	I-1	I-2	I-3	I-4
Curing material	Aquastatic 1-C-Red	Aquastatic 1-C-Red	Blank	Aquastatic 1-C-Red
Weight pan & mortar	596.8 g.	585.5 g.	596.5 g.	569.5 g.
Weight pan	45.4	45.4	52.4	44.0
Weight mortar	551.4	540.1	544.1	525.5
Weight before brushing	593.1	581.5	592.5	565.3
Weight after brushing	592.9	581.3	592.3	565.1
Weight after sealer	594.1	582.9	593.8	567.0
Weight before membrane	592.6	581.3	591.5	565.3
Memb. should be applied	3.44	3.44	0.0	3.44
Membrane was applied	3.57	3.36	0.0	3.38
4-18-43 12:45 p.m.	591.9	580.1	567.4	564.7
4-19-43 10:40 a.m.	591.1	579.4	565.4	563.9

TABULATED DATA - TEST I

Original water (A)	50.4	49.3	49.5	47.9
Water loss while blank (D)	4.7	4.9	5.7	5.1
Water at time of application (E)	45.7	44.4	43.8	42.8
Water loss (F)				
1 day	2.1	2.4	23.6	1.7
2 days	2.9	3.1	25.6	2.5
Percent water loss = 100 x F/E				
1 day	4.60%	5.41%	54.0%	3.95%
2 days	6.35%	7.0 %	58.5%	5.84%
Percent efficiency = $\left(100 - \frac{100\ F/E}{F/E\ (blank)}\right)$				
1 day	91.47%	90.0 %	0.0%	92.68%
2 days	89.14%	88.02%	0.0%	90.03%

Time of finishing	4-17-43	8:50 a.m.
Brushed and sealer applied	4-17-43	10:05 a.m.
Membrane applied	4-17-43	10:40 a.m.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series II
Test J

Specimen	J-1	J-2	J-3	J-4
Curing material	Klearcure 60	Klearcure 60	Klearcure 60	Blank
Wt. pan and mortar	574.1 g.	575.0 g.	592.0 g.	590.4 g
Wt. pan	45.5	44.9	44.9	44.0
Wt. mortar	528.6	530.1	547.1	546.4
Wt. before brushing	568.0	569.3	585.5	583.6
Wt. after brushing	567.7	569.0	585.3	583.3
Wt. after sealer	569.5	571.0	586.7	584.7
Wt. before membrane	568.2	569.8	585.4	583.5
Memb. should be applied	3.46	3.46	3.46	
Membrane was applied	3.45	3.43	3.44	
4-18-43 1:00 p.m.	568.7	570.3	585.0	560.8
4-19-43 1:45 p.m.	568.1	569.8	584.9	558.6

TABULATED DATA - TEST J

Original water (A)	48.2	48.4	49.9	49.8
Water loss while blank (D)	6.7	6.1	7.2	7.5
Water at time of application (E)	41.5	42.3	42.7	42.3
Water loss (F)				
1 day	.9	.8	1.0	22.2
2 days	1.4	1.3	1.9	24.4
Percent water loss = 100 x F/E				
1 day	2.16%	1.89%	2.36%	52.5%
2 days	3.38%	3.08%	4.45%	57.7%
Percent efficiency = $\left(100 - \frac{100\ F/E}{F/E\ (blank)}\right)$				
1 day	95.89%	96.40%	95.51%	0.0%
2 days	94.14%	94.66%	92.28%	0.0%

Time of finishing	4-17-43	9:35 a.m.
Brushed and sealer applied	4-17-43	10:50 a.m.
Membrane applied	4-17-43	11:25 a.m.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series II
Test K

Specimen	K-1	K-2	K-3	K-4
Curing material	Aquastatic Slab Cure Red	Aquastatic Slab Cure Red	Aquastatic Slab Cure Red	Blank
Weight pan & mortar	562.1 g.	574.8 g.	553.8 g.	574.0 g.
Weight pan	44.2	43.5	42.9	50.3
Weight mortar	517.9	531.3	510.9	523.7
Wt. before brushing	558.2	570.4	549.1	569.0
Wt. after brushing	557.9	570.2	548.9	568.8
Wt. after sealer	560.2	572.1	551.2	571.5
Wt. before membrane	558.8	570.5	549.6	568.8
Memb. should be applied	3.12	3.12	3.12	
Membrane was applied	3.24	3.12	3.12	
4-18-43 12:45 p.m.	559.2	570.8	549.4	546.3
4-19-43 12:55 p.m.	558.4	569.8	548.0	543.8

TABULATED DATA - TEST K

Original water (A)	47.3	48.4	46.6	47.7
Water loss while blank (D)	4.2	5.2	5.1	6.0
Water at time of application (E)	43.1	43.2	41.5	41.7
Water loss (F)				
1 day	.4	1.2	1.0	22.0
2 days	1.2	2.2	2.4	24.5
Percent water loss = 100 x F/E				
1 day	.929%	2.78%	2.41%	52.8%
2 days	2.78 %	5.10%	5.80%	58.7%
Percent efficiency = $\left(100 - \frac{100\ F/E}{F/E\ (blank)}\right)$				
1 day	98.24 %	94.74%	95.44%	0.0%
2 days	95.60 %	91.31%	90.12%	0.0%

Time of finishing	4-17-43	1:05 p.m.
Brushed and sealer applied	4-17-43	2:20 p.m.
Membrane applied	4-17-43	2:55 p.m.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series II
Test L

Specimen	L-1	L-2	L-3	L-4
Curing material	Truscon 223	Truscon 223	Truscon 223	Blank
Wt. pan & mortar	561.7 g.	579.0 g.	578.2 g.	580.3 g.
Wt. pan	43.4	47.0	45.3	50.9
Wt. mortar	518.3	532.0	532.9	529.4
Wt. before brushing	556.4	574.3	572.8	575.0
Wt. after brushing	556.2	574.1	572.5	574.8
Wt. after sealer	558.1	576.3	574.7	577.7
Wt. before membrane	556.6	574.8	572.9	576.0
Memb. should be applied	2.98	2.98	2.98	
Membrane was applied	3.07	3.00	3.01	
4-18-43 12:45 p.m.	556.8	574.9	573.0	554.0
4-19-43 3:40 p.m.	555.5	573.4	570.7	551.4

TABULATED DATA - TEST L

Original water (A)	47.3	48.5	48.6	48.3
Water loss while blank (D)	6.0	5.3	6.6	5.8
Water at time of application (E)	41.3	43.2	42.0	42.5
Water loss (F)				
1 day	.1	.2	.1	21.2
2 days	1.4	1.7	2.4	23.8
Percent water loss = 100 x F/E				
1 day	.242%	.463%	.238%	50.0%
2 days	3.39 %	3.94 %	5.72 %	56.0%
Percent efficiency = $\left(100 - \frac{100\ F/E}{F/E\ (blank)}\right)$				
1 day	99.52 %	99.07 %	99.52 %	0.0%
2 days	93.94 %	92.95 %	89.98 %	0.0%

Time of finishing	4-17-43	1:50 p.m.
Brushed and sealer applied	4-17-43	3:05 p.m.
Membrane applied	4-17-43	3:40 p.m.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series II
Test M

Specimen	M-1	M-2	M-3	M-4
Curing method	Moist R.	Moist R.	Moist R.	Moist R.
Wt. pan and mortar	617.2 g.	615.8 g.	599.9 g.	603.7 g.
Wt. pan	52.3	46.6	46.0	45.0
Wt. mortar	564.9	569.2	553.9	558.7
4-21-43 12:35 p.m.	618.3	615.8	600.3	603.8
4-22-43 10:00 a.m.	619.4	617.4	601.1	604.8

Tabulated Data - Test M

Original water (A)	51.5	51.9	50.5	50.9
Water gain (F)				
1 day	1.1	0.0	0.4	0.1
2 days	2.2	1.6	1.2	1.1
Percent water gain $= \frac{100\ F}{A}$				
1 day	2.16%	0.0 %	0.79%	0.20%
2 days	4.27%	3.08%	2.38%	2.16%

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series II
Test N

Specimen	N-1	N-2	N-3	N-4
Curing material	Klearcure 60	Aquastatic 1-6-Red	Trusscon 203	Satis. 45
Wt. pan	47.0 g.	42.8 g.	43.3 g.	50.2 g.
" " & mortar	591.2	592.9	584.3	591.8
Wt. mortar	544.2	550.1	541.0	541.6
4-28-43 2;50 P.M.	591.1	592.5	583.9	587.2
4-29-43 9:30 P.M.	590.2	591.8	583.3	584.1

Tabulated Data - Test N

Original water (A)	49.7 g.	50.1 g.	49.4 g.	49.4 g.
Water loss while blank (D)	0	0	0	0
Water at time of application (E)	49.6	50.1	49.4	49.4
Water loss (F)				
1 day	2.1	2.0	1.8	6.1
2 days	3.0	2.7	2.4	9.2
Percent water loss = 100 x F/E				
1 day	4.23 %	4.00 %	3.65 %	12.35 %
2 days	6.05	5.40	4.86	18.61
Percent efficiency = $\left(100 - \frac{100\ F/E}{F/E\ (blank)}\right)$				
1 day	91.80 %	92.25 %	92.92 %	76.1 %
2 days	89.48	91.61	91.55	67.6

The membrane curing compound was applied immediately after finishing.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series II
Test O

Specimen	O-1	O-2	O-3	O-4
Curing material	Satis. 45	Satis. 45	Satis. 45	Blank
Weight pan	44.1 g.	44.8 g.	46.8 g.	44.4 g.
Wt. pan and mortar	583.5	573.7	574.1	582.7
Weight mortar	539.4	528.9	527.3	538.3
Wt. before brushing	578.0	568.2	568.8	577.4
Wt. after brushing	577.8	567.9	568.5	577.2
Wt. after sealer	579.9	569.7	570.7	579.4
Wt. before membrane	578.2	568.1	569.1	577.8
Wt. membrane to apply	3.37	3.37	3.37	0
Wt. memb. was applied	3.37	3.37	3.37	0
4-28-43 3:00 p.m.	574.9	564.3	566.1	555.0
4-29-43 3:00 p.m.	571.9	561.0	562.8	552.5

Tabulated Data - Test O

Original water	(A)	49.1 g.	48.2 g.	48.0 g.	49.0 g.
Water loss while blank	(D)	6.3	6.3	6.0	6.0
Water at time of application	(E)	42.8	41.9	42.0	43.0
Water loss	(F)				
1 day		4.2	4.8	3.9	22.2
2 days		7.2	8.1	7.2	24.7
Percent water loss = 100 x F/E					
1 day		9.81 %	11.45 %	9.29 %	51.6 %
2 days		16.80	19.32	17.12	57.5
Percent efficiency = $\left(100 - \frac{100\ F/E}{F/E\ (blank)}\right)$					
1 day		81.0	77.8	82.0	0.0
2 days		70.8	66.4	70.2	0.0

Time of finishing	4-27-43	1:50 p.m.
Brushed and sealer applied	4-27-43	3:05 p.m.
Membrane applied	4-27-43	3:40 p.m.

MEMBRANE CURING STUDY
WATER RETENTION TEST

Series II
Test P

Specimen	P-1	P-2	P-3	P-4
Curing material	Truscon 203	Truscon 203	Truscon 203	Truscon 203
Coverage (sq. ft. to the gallon)	100	200	600	400
Wt. pan	49.9 g.	45.2 g.	44.6 g.	43.6 g.
Wt. pan & mortar	590.0	572.7	597.0	586.6
Wt. mortar	540.1	527.5	552.4	543.0
Wt. before brushing	586.0	568.8	594.6	582.8
Wt. after brushing	585.8	568.6	594.0	582.4
Wt. before membrane	584.2	566.7	591.7	579.8
Wt. membrane should be applied	6.24	3.12	1.04	1.56
Wt. membrane was applied	6.24	3.12	1.04	1.56
3:45 p.m. 4-30-43	586.0	567.1	585.2	576.1
3:30 p.m. 5- 1-43	585.7	566.5	582.1	573.4

TABULATED DATA - Test P

		P-1	P-2	P-3	P-4
Original water	(A)	49.2 g.	48.1 g.	50.4 g.	49.5 g.
Water loss while blank	(D)	5.6	5.8	5.7	6.4
Water at time of appl. of membr.	(E)	43.6	42.3	44.7	43.1
Water loss	(F)				
1 day		1.0	1.0	7.0	4.4
2 days		1.3	1.6	10.1	7.1

Percent water loss = $\frac{100 \times F}{E}$

	P-1	P-2	P-3	P-4
1 day	2.29 %	2.36 %	15.7 %	10.2 %
2 days	2.98 %	3.78 %	22.6 %	16.5 %

Percent efficiency = $\left(100 - \frac{100\ F/E}{F/E\ (\text{blank})}\right)$

	P-1	P-2	P-3	P-4
1 day	95.55 %	95.38 %	69.3 %	80.1 %
2 days	94.77 %	93.36 %	60.4 %	71.1 %

Time of finishing	4-29-43	12:40 p.m.
Brushed and sealer applied	4-29-43	1:35 p.m.
Membrane applied	4-29-43	2:10 p.m.

MEMBRANE CURING STUDY
WATER RETENTION TEST

Series II
Test Q

Specimen	Q-1	Q-2	Q-3	Q-4
Curing material	Aquastatic 1-C-Red	Aquastatic 1-C-Red	Aquastatic 1-C-Red	Aquastatic 1-C-Red
Wt. pan	45.2 g.	50.8 g.	43.4 g.	45.3 g.
Wt. pan and mortar	575.5	600.2	598.9	578.9
Wt. mortar	530.3	549.4	555.5	533.6
Wt. before brushing	570.4	595.8	593.9	573.6
Wt. after brushing	570.1	595.6	593.5	573.4
Wt. after sealer	572.7	596.5		
Wt. before membrane	570.6	595.4	593.1	572.8
Membrane should be applied	3.44	3.44	3.44	3.44
Membrane was applied	3.44	3.44	3.44	3.44
4:15 p.m. 4-30-43	570.4	594.7	592.1	570.5
3:30 p.m. 5- 1-43	569.7	593.9	591.1	569.0

TABULATED DATA - Test Q

Original water	(A)	48.4 g.	50.2 g.	50.6 g.	48.6 g.
Water loss while blank	(D)	6.1	5.7	5.4	5.9
Water at time of application	(E)	42.3	44.5	45.2	42.7
Water loss	(F)				
1 day		1.0	1.7	2.6	3.9
2 days		1.7	2.5	3.6	5.4
Percent water loss = $\frac{100 \times F}{E}$					
1 day		2.36 %	3.82 %	5.75%	9.14 %
2 days		4.02 %	5.61 %	7.98%	12.64 %
Percent efficiency = $\left(100 - \frac{100\ F/E}{F/E\ (\text{blank})}\right)$					
1 day		95.38 %	92.56 %	88.78%	82.13 %
2 days		92.95 %	90.15 %	86.0 %	77.80 %

Note: sealer was applied to edges of specimens Q-1 and Q-2, but not to Q-3 and Q-4. The results are quite apparent.

MEMBRANE CURING STUDY

WATER RETENTION TEST

Series II
Test R

Specimen	R-1	R-2	R-3	R-4
Curing material	Aquastatic 1-C-Red	Klearcure 60	Truscon 203	Satis. 45
Weight pan	44.6 g.	44.2 g.	45.3 g.	45.0 g.
Wt. pan and mortar	594.8	584.3	591.6	573.0
Weight mortar	550.2	540.1	546.3	528.0
Membrane should be applied	3.44	3.46	3.12	3.37
Membrane applied	3.44	3.46	3.12	3.37
4:20 p.m. 4-30-43	592.8	584.1	590.1	566.4
3:30 p.m. 5-1-43	591.2	582.6	588.9	562.4

Tabulated Data - Test R

Original water	(A)	50.3 g.	49.3 g.	49.9 g.	48.2 g.
Water loss while blank	(D)	0	0	0	0
Water at time of application	(E)	50.3	49.3	49.9	48.2
Water loss	(F)				
1 day		3.6	2.2	2.9	8.1
2 days		5.2	3.7	4.1	12.1
Percent water loss = 100 x F/E					
1 day		7.16 %	4.46 %	5.82 %	16.80 %
2 days		10.32	7.51	8.23	25.10
Percent efficiency = $\left(100 - \frac{100\ F/E}{F/E\ (blank)}\right)$					
1 day		86.0 %	91.28 %	88.62 %	67.15 %
2 days		81.90	86.82	85.59	56.0

The membrane was applied immediately after finishing.

APPENDIX B - ABRASION AND FLEXURE DATA

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: B-5 Date tested: March 6, 1943

Compound: None Tested by: W. A. B.

Curing: One week in cabinet and one week in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-14	-14	-12	-16	-13.75	0
1	39	39	38	40	39.0	52.75
3	113	110	111	116	112.5	126.25
5	153	159	154	157	155.75	169.50
10	No readings					

Weight before: 2491 Weight after: 2434 Loss: 57 grams

Time in minutes	Dial readings				Mean	Total wear
0	-1	-10	4	-8	-3.75	0
1	50	47	48	48	48.25	52.0
3	132	135	138	131	134.0	137.75
4	160	162	157	161	160.0	163.75
10	No readings					

Weight before: 2340 Weight after: 2284 Loss: 56 grams

Flexural Test

Dial readings 24

Load at rupture 925 pounds

Modulus of rupture 529 pounds per square inch

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: C-1

Compound: Satisfaction 45 .

Curing: One week in the cabinet and one week in lab air.

This speimen was cracked on removal from the mold, and therefore no tests could be run.

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: C-2 Date tested: March 16, 1943

Compound: Satisfaction 45 Tested by: W. A. B.

Curing: One week in the cabinet and one week in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-15	-14	-14	-9	-13	0
1	19	16	21	18	18.5	31.5
3	76	72	75	72	73.75	86.75
5	133	130	130	129	130.5	143.50
10	No readings					

Weight before: 2530 Weight after: 2484 Loss: 46 grams

Time in minutes	Dial readings				Mean	Total wear
0	-10	-10	-14	-10	-11	0
1	30	27	30	21	27	38
3	105	101	103	108	104.25	115.25
5	152	148	146	149	148.75	159.75
10	No readings					

Weight before: 2285 Weight after: 2231 Loss: 54 grams

Flexural Test

Dial reading

This specimen was also cracked on removal from mold; therefore, no flexure test possible.

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: E-1 Date tested: April 8, 1943

Compound: Trucure 223 Tested by: W. A. B.

Curing: One week in cabinet and one week in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-15	-10	-12	-6	-10.75	0
1	16	14	13	14	14.25	25
3	55	55	57	53	55.0	65.75
5	95	95	97	99	96.5	107.25
10	No readings					

Weight before: 2413 Weight after: 2365 Loss: 48 grams at six minutes

Time in minutes	Dial readings				Mean	Total wear
0	-9	-11	-12	-10	-10.5	0
1	17	16	18	16	16.75	27.25
3	56	55	50	50	52.75	63.25
5	91	88	90	88	89.25	99.75
10	No readings					

Weight before: 2347 Weight after: 2308 Loss: 37 grams

Flexural Test

Dial reading 26.5

Load at rupture 1025 pounds

Modulus of rupture 585 pounds per square inch

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: B-3 Date tested: March 6, 1943

Compound: Klearcure 60 Tested by: W. A. B.

Curing: One week in cabinet and one week in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-8	-8	-18	-10	-11	0
1	6	6	4	4	5.0	16.0
3	16	16	15	14	15.25	26.25
5	25	25	28	25	25.75	36.75
10	50	47	50	48	48.75	59.75

Weight before: 2281 Weight after: 2250 Loss: 31 grams

Time in minutes	Dial readings				Mean	Total wear
0	-12	2	-8	0	-4.5	0
1	11	16	16	17	15.0	19.5
3	34	34	34	34	34.0	38.5
5	48	50	52	49	49.75	54.25
10	92	92	92	95	92.75	97.25

Weight before: 2506 Weight after: 2463 Loss: 43 grams

Flexural Test

Dial reading	32
Load at rupture	1225 pounds
Modulus of rupture	700 pounds per square inch

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: B-4 Date tested: March 6, 1943

Compound: Horn Tested by: W. A. B.

Curing: One week in cabinet and one week in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-6	-3	-10	-6	-6.25	0
1	47	42	47	47	45.75	52.0
3	107	104	111	114	109.0	115.25
5	150	150	156	153	152.25	158.50
10	No readings					

Weight before: 2394 Weight after: 2342 Loss: 52 grams

Time in minutes	Dial readings				Mean	Total wear
0	-10	-8	-15	-12	-11.25	0
1	34	34	33	34	33.75	45.0
3	85	87	85	83	85.0	96.25
5	125	135	125	130	128.75	140.00
10	No readings					

Weight before: 2495 Weight after: 2448 Loss: 47 grams

Flexural Test

Dial reading 25

Load at rupture 970 pounds

Modulus of rupture 554 pounds per square inch

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: E-2 Date tested: April 8, 1943

Compound: Trucure 223 Tested by: W. A. B.

Curing: One week in cabinet and one week in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-28	-32	-24	-30	-28.5	0
1	3	3	1	3	2.5	31.0
3	29	28	28	28	28.25	56.75
5	60	55	57	55	56.75	85.25
10	108	105	107	105	106.25	134.75

Weight before: 2555 Weight after: 2510 Loss: 45 grams

Time in minutes	Dial readings				Mean	Total wear
0	-15	-13	-9	-6	-10.75	0
1	22	20	24	19	21.25	32.0
3	63	57	63	60	60.75	71.5
5	92	90	93	91	91.5	102.25
10	144	144	143	144	143.75	154.40

Weight before: 2295 Weight after: 2244 Loss: 51 grams

Flexural Test

Dial reading 29

Load at rupture 1125 pounds

Modulus of rupture 642 pounds per square inch

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: E-3 Date tested: April 8, 1943

Compound: Trucure 203 Tested by: W. A. B.

Curing: One week in the cabinet and one week in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-7	-6	-12	-5	-7.5	0
1	15	17	15	18	16.25	23.75
3	42	40	40	42	41.0	48.5
5	69	66	69	66	67.5	75.0
10	132	130	132	136	132.5	140.0

Weight before: 2481 Weight after: 2435 Loss: 46 grams

Time in minutes	Dial readings				Mean	Dial wear
0	-3	-11	-7	-4	-6.25	0
1	20	18	18	18	18.5	24.75
3	44	43	46	47	45.0	51.25
5	74	78	70	80	75.5	81.75
10	143	146	140	145	143.5	149.75

Weight before: 2321 Weight after: 2270 Loss: 51 grams

Flexural Test

Dial reading 28

Load at rupture 1075 pounds

Modulus of rupture 614 pounds per square inch

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: E-4 — Date tested: April 8, 1943

Compound: Trucure 203 — Tested by: W. A. B.

Curing: One week in the cabinet and one week in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-16	-17	-18	-16	-16.75	0
1	5	4	10	7	6.5	23.25
3	27	29	26	25	26.75	43.50
5	47	51	45	50	48.25	65.0
10	92	90	93	90	91.25	108.0

Weight before: 2502 Weight after: 2470 Loss: 32 grams

Time in minutes	Dial readings				Mean	Total wear
0	-24	-30	-25	-30	-27.25	0
1	-1	-3	-1	-5	-2.5	24.75
3	23	19	24	24	22.5	49.75
5	46	48	46	46	46.5	73.75
10	99	100	103	102	101.0	128.25

Weight before: 2308 Weight after: 2267 Loss: 41 grams

Flexural Test

Dial reading 27.5

Load at rupture 1063 pounds

Modulus of rupture 607 pounds per square inch

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: E-5 | Date tested: April 8, 1943

Compound: None | Tested by: W. A. B.

Curing: One week in the cabinet and one week in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-5	-5	-4	-6	-5	0
1	59	50	55	50	53.5	58.5
3	159	161	160	161	160.25	165.25
5	No readings					
10						

Weight before: 2398 Weight after: 2340 Loss: 58 grams

Time in minutes	Dial readings				Mean	Total wear
0	-13	-16	-13	-18	-15	0
1	52	58	53	58	55.25	70.25
3	152	150	155	150	151.75	166.75
5	No readings					
10						

Weight before: 2232 Weight after: 2175 Loss: 57 grams

Flexural Test

Dial reading 20

Load at rupture 775 pounds

Modulus of rupture 442 pounds per square inch

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: E-6 — Date tested: April 8, 1943

Compound: None — Tested by: W. A. B.

Curing: One week in the cabinet and one week in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-17	-22	-16	-18	-18.25	0
1	28	28	29	28	28.25	46.5
3	90	90	92	93	91.25	109.5
5	144	140	148	151	145.75	164.0
10	No readings					

Weight before: 2311 Weight after: 2255 Loss: 56 grams

Time in minutes	Dial readings				Mean	Total wear
0	-21	-14	-22	-13	-17.5	0
1	52	57	54	56	54.75	72.25
3	143	147	143	146	144.75	162.25
5	No readings					
10						

Weight before: 2454 Weight after: 2403 Loss: 51 grams

Flexural Test

Dial reading	21
Load at rupture	813 pounds
Modulus of rupture	464 pounds per square inch

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: F-1 Date tested: April 15, 1943

Compound: None Tested by: W. A. B.

Curing: One week in the moist room and one week in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-19	-23	-29	-20	-22.75	0
1	-4	-4	-8	-4	-5	17.75
3	1	3	8	3	3.75	26.5
5	21	17	21	22	20.25	43.0
10	58	60	62	64	61.0	83.75

Weight before: 2533 Weight after: 2498 Loss: 35 grams

Time in minutes	Dial readings				Mean	Total wear
0	-6	-6	-6	-3	-5.25	0
1	11	7	7	5	7.5	12.75
3	20	20	21	19	20.0	25.25
5	30	27	30	31	29.5	34.75
10	73	72	70	73	72.0	77.25

Weight before: 2340 Weight after: 2307 Loss: 33 grams

Flexural Test

Dial reading 25

Load at rupture 975 pounds

Modulus of rupture 556 pounds per square inch

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: F-2 Date tested: April 15, 1943

Compound: None Tested by; W. A. B.

Curing: One week in the moist room and one week in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	10	-6	7	-10	.25	0
1	16	16	20	16	17.0	16.75
3	34	29	29	27	29.25	29.0
5	36	37	35	36	36.0	35.75
10	52	57	56	56	55.25	55.00

Weight before: 2533 Weight after: 2506 Loss: 27 grams

Time in minutes	Dial readings				Mean	Total wear
0	-10	-8	-12	-10	-10	0
1	14	12	11	12	12.25	22.25
3	28	25	26	26	26.25	36.25
5	42	36	40	39	39.25	49.25
10	73	75	73	72	73.25	83.25

Weight before: 2289 Weight after: 2252 Loss: 37 grams

Flexural Test

Dial reading	24
Load at rupture	925 pounds
Modulus of rupture	528 pounds per square inch

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: F-3 Date tested: April 15, 1943

Compound: None Tested by: W. A. B.

Curing: One week in moist room and one week in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-3	-7	-3	1	-1.5	0
1¾	20	18	22	21	20.25	21.75
3	35	37	35	35	35.5	37.0
5	45	50	52	50	49.25	50.75
10	90	90	87	89	89.0	90.5

Weight before: 2412 Weight after: 2374 Loss: 38 grams

Time in minutes	Dial readings				Mean	Total wear
0	-9	-4	-9	-6	-7	0
1	12	12	12	13	12.25	19.25
3	28	30	31	28	29.25	36.25
5	44	50	44	46	46.0	53.0
10	87	84	80	87	84.5	91.5

Weight before: 2525 Weight after: 2488 Loss: 37 grams

Flexural Test

Dial reading	25
Load at rupture	975 pounds
Modulus of rupture	556 pounds per square inch

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: F-4 Date tested: April 15, 1943

Compound: None Tested by: W. A. B.

Curing: One week in the moist room and one week in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-6	-6	-9	-7	-7	0
1	12	10	12	13	11.75	18.75
3	27	26	28	27	27.0	34.0
5	47	43	45	45	45.0	52.0
10	89	88	90	91	89.5	96.5

Weight before: 2441 Weight after: 2400 Loss: 41 grams

Time in minutes	Dial readings				Mean	Total wear
0	-20	-18	-23	-14	-18.75	0
1	1	6	1	3	2.75	21.5
3	14	15	16	14	14.75	33.5
5	27	25	25	25	25.5	44.25
10	50	53	50	50	50.75	69.50

Weight before: 2418 Weight after: 2387 Loss: 31 grams

Flexural Test

Dial reading	21
Load at rupture	813 pounds
Modulus of rupture	464 pounds per square inch

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: F-5 Date tested: April 15, 1943

Compound: None Tested by: W. A. B.

Curing: One week under wet burlap and one week in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-8	-13	-8	-13	-10.5	0
1	8	8	11	7	8.5	19.0
3	18	18	20	17	18.25	28.75
5	26	29	28	27	27.5	38.0
10	66	66	62	68	65.5	76.0

Weight before: 2675 Weight after: 2649 Loss: 26 grams

Time in minutes	Dial readings				Mean	Total wear
0	-14	-14	-16	-18	-15.5	0
1	3	3	3	2	2.75	18.25
3	16	17	16	16	16.25	31.75
5	27	30	27	29	28.25	43.75
10	69	68	70	70	69.25	84.75

Weight before: 2341 Weight after: 2311 Loss: 30 grams

Flexural Test

Dial reading 28.5

Load at rupture 1100 pounds

Modulus of rupture 627 pounds per square inch

MEMBRANE CURING STUDY

Abrasion Test

Series I

Specimen: F-6 Date tested: April 15, 1943

Compound: None Tested by: W. A. B.

Curing: Ponded for one week and one week in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-22	-3	-22	-2	-12.5	0
1	4	4	0	10	4.5	17.0
3	19	20	18	22	19.75	32.25
5	23	26	30	28	26.75	39.25
10	49	48	46	48	47.75	60.25

Weight before: 2104 Weight after: 2085 Loss: 19 grams

Time in minutes	Dial readings				Mean	Total wear
0	-3	-12	-12	-7	-8.5	0
1	20	18	18	18	18.5	27.0
3	27	29	32	30	29.5	38.0
5	40	40	45	40	41.25	49.75
10	59	60	60	55	58.5	65.0

Weight before: 2751 Weight after: 2732 Loss: 19 grams

Flexural Test

Dial reading 21

Load at rupture 813 pounds

Modulus of rupture 464 pounds per square inch

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: H-1 Date tested: April 15, 1943

Compound: Trucure 203 Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-13	-12	-17	-16	-14.5	0
1	9	6	4	7	6.5	21.0
3	27	26	26	26	26.25	40.75
5	49	49	47	49	48.5	63.0
8	76	75	75	70	74.0	88.5

Weight before: 583.7 Weight after: 550.3 Loss: 33.4 grams

Specimen: H-2 Date tested: April 15, 1943

Compound: Trucure 203 Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	7	0	1	1	2.25	0
1	12	25	12	13	13.0	10.75
3	29	28	27	27	27.75	25.50
5	38	37	38	38	37.75	35.50
8	60	62	61	60	60.75	58.50

Weight before: 587.5 Weight after: 565.1 Loss: 22.4 grams

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: H-3 Date tested: April 15, 1943

Compound: Trucure 203 Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-33	-34	-38	-31	-34	0
1	-13	-18	-13	-18	-15.5	18.5
3	6	6	6	7	6.25	40.25
5	25	26	27	27	26.25	60.25
8	60	61	61	60	60.5	94.5

Weight before: 597.6 Weight after: 562.3 Loss: 35.3 grams

Specimen: H-4 Date tested: April 15, 1943

Compound: None Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-9	-18	-9	-14	-12.5	0
1	25	23	23	23	23.5	36
3	153	159	161	160	158.25	170.75
5	No readings					
8						

Weight before: 555.5 Weight after: 495.7 Loss: 59.8 grams

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: I-1 Date tested: April 19, 1943

Compound: Aquastatic 1-C-Red Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-6	-7	-8	-5	-6.5	0
1	4	8	3	3	4.5	11.0
3	21	23	20	22	21.5	28.0
5	40	41	38	45	41.0	47.5
8	69	71	69	65	68.5	75.0

Weight before: 591.1 Weight after: 561.2 Loss: 29.9

Specimen: I-1 Date tested: April 19, 1943

Compound: Aquastatic 1-C-Red Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-6	-12	-12	-12	-10.5	0
1	-2	-4	-5	-3	-3.5	7
3	13	10	10	13	11.5	22.0
5	36	35	34	38	35.75	46.25
10	65	70	67	70	68.0	78.5

Weight before: 579.4 Weight after: 547.7 Loss: 31.7

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: I-3 Date tested: April 19, 1943

Compound: None Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-4	-4	-12	-4	-6	0
1	110	114	115	110	112.25	118.25
1½	160	157	156	157	157.5	163.5
5	No readings					
8						

Weight before: 565.4 Weight after: 506.9 Loss: 58.5

Specimen: I-4 Date tested: April 19, 1943

Compound: Aquastatic 1-C-Red Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-7	-11	-7	-11	-9	0
1	15	13	13	15	14	23
3	37	38	40	38	38.25	47.25
5	54	56	56	60	56.5	65.5
8	85	88	85	89	86.75	95.75

Weight before: 563.9 Weight after: 531.4 Loss: 32.5

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: J-1 Date tested: April 19, 1943

Compound: Klearcure 60 Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-1	0	-2	-3	-1.5	0
1	15	16	15	13	14.75	16.25
3	35	35	35	32	34.25	35.75
5	47	49	48	44	47.0	48.5
8	72	71	71	71	71.25	72.75

Weight before: 568.1 Weight after: 543.6 Loss: 24.5 grams

Specimen: J-2 Date tested: April 19, 1943

Compound: Klearcure 60 Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	0	0	-3	1	-.5	0
1	14	18	16	16	16.0	16.5
3	32	33	33	33	32.75	33.25
5	48	53	46	47	48.5	49.0
8	76	75	78	75	76	76.5

Weight before: 569.7 Weight after: 542.0 Loss: 27.7 grams

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: J-3 Date tested: April 19, 1943

Compound: Klearcure 60 Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	7	3	5	7	5.5	0
1	15	14	15	15	14.75	9.25
3	35	33	33	33	33.5	28.0
5	52	52	50	52	51.5	46.0
8	75	73	75	78	75.25	69.75

Weight before: 584.9 Weight after: 560.2 Loss: 24.7 grams

Specimen: J-4 Date tested: April 19, 1943

Compound: None Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-4	-8	-5	-9	-6.5	0
1	67	60	63	64	63.5	70.0
2	135	140	135	130	135.0	141.5
5	No readings					
8						

Weight before: 558.6 Weight after: 510.0 Loss: 48.6 grams

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: K-1 Date tested: April 19, 1943

Compound: Aquastatic Slab Cure Red Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-7	-8	-9	-6	-7.5	0
1	9	10	6	9	8.5	16.0
3	22	23	20	20	21.25	28.75
5	35	33	33	33	33.5	41.0
8	55	54	56	53	54.5	62.0

Weight before: 558.4 Weight after: 534.2 Loss: 24.2 grams

Specimen: K-2 Date tested: April 19, 1943

Compound: Aquastatic Slab Cure Red Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-6	-18	-9	-16	-12.25	0
1	0	-2	2	4	1.0	13.25
3	20	17	18	18	18.25	30.5
5	32	39	35	37	35.75	48.0
8	77	76	81	80	78.5	90.75

Weight before: 569.8 Weight after: 535 Loss: 34.8 grams

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: K-3 Date tested: April 19, 1943

Compound: Aquastatic Slab Cure Red Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-4	14	-3	13	5.0	0
1	25	25	26	25	25.25	20.25
3	36	36	32	30	33.50	28.50
5	54	51	48	48	50.25	45.25
8	72	76	70	73	72.75	67.75

Weight before: 548 Weight after: 520 Loss: 28 grams

Specimen: K-4 Date tested: April 19, 1943

Compound: None Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	0	-6	-1	-6	-3.25	0
1	70	75	70	74	74.75	78.0
2	150	159	156	159	156.0	159.25
5	No readings					
8						

Weight before: 543.8 Weight after: 487.0 Loss: 56.8 grams

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: L-1 Date tested: April 19, 1943

Compound: Truscon 223 Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-10	-16	-13	-18	-14.25	0
1	15	16	11	11	13.25	27.5
3	55	48	52	54	52.25	66.5
5	110	106	104	104	106.0	120.25
8	157	154	156	159	156.5	170.75

Weight before: 556.8 Weight after: 502 Loss: 54.8 grams

Specimen: L-2 Date tested: April 19, 1943

Compound: Truscon 223 Tested by: W. A. B.

Curing: Two days in the cabinet

Time in minutes	Dial readings				Mean	Total wear
0	-6	-16	-9	-9	-10.0	0
1	10	12	12	10	11.0	21.0
3	40	41	38	37	39.0	49.0
5	67	76	71	67	70.25	80.25
8	118	118	120	122	119.5	129.5

Weight before: 573.4 Weight after: 527 Loss: 46.4 grams

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: L-3 Date tested: April 19, 1943

Compound: Truscon 223 Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-30	-28	-27	-27	-28	0
1	1	-3	-2	1	-.75	27.25
3	18	20	20	22	20.0	48.0
5	48	47	48	45	47.0	75.0
8	100	97	97	97	97.75	125.75

Weight before: 569.8 Weight after: 529.5 Loss: 40.3 grams

Specimen: L-4 Date tested: April 19, 1943

Compound: None Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-14	-12	-16	-11	-13.25	0
1	40	41	44	44	42.25	55.5
3	160	158	161	155	158.5	171.75
5	No readings					
8						

Weight before: 551.4 Weight after: 488.8 Loss: 62.6 grams

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: M-1 Date tested: April 22, 1943

Compound: None Tested by: W. A. B.

Curing: Two days in the moist room. Tested on removal.

Time in minutes	Dial readings				Mean	Total wear
0	-26	-34	-32	-38	-31.75	0
1	42	30	34	36	35.5	67.25
3	143	137	140	141	140.25	172.0
5	NO readings					
8						

Weight before: 620 Weight after: 554 Loss: 66 grams

Specimen: M-4 Date tested: April 22, 1943

Compound: None Tested by: W. A. B.

Curing: Two days in the moist room. Tested on removal.

Time in minutes	Dial readings				Mean	Total wear
0	-25	-18	-20	-19	-20.5	0
1	43	43	42	43	42.75	63.25
3	144	142	150	147	145.75	166.25
5	No readings					
8						

Weight before: 605 Weight after: 540 Loss: 65 grams

MEMBRANE CURING STUDY

Abrasiom Test

Series II

Specimen: M-2 Date tested: April 27, 1943

Compound: None Tested by: W. A. B.

Curing: Two days in moist room and five days in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-2	-9	-4	-18	-8.25	0
1	23	22	22	24	22.75	31.0
3	38	35	38	40	37.75	46.0
5	56	50	52	50	52.0	60.25
8	80	83	79	85	81.75	90.0

Weight before: 599.7 Weight after: 568.0 Loss: 31.7 grams

Specimen: M-3

Compound: None

Curing: Two days in the moist room and five daysin lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-5	-17	-15	-12	-12.25	0
1	14	15	14	17	15.0	27.25
3	37	32	36	31	34.0	46.25
5	50	48	48	52	48.5	60.75
8	87	85	84	87	85.75	98.0

Weight before: 583.5 Weifht after: 549.8 Loss: 33.7 grams

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: N-1 Date tested: April 29, 1943

Compound: Klearcure 60 Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-12	-15	-10	-17	-13.5	0
1	19	22	21	22	21	34.5
3	72	67	70	72	70.25	83.75
5	100	107	106	101	103.5	117.0
8	144	142	142	142	142.5	156.0

Weight before: 590.2 Weight after: 532.8 Loss: 57.4 grams

Specimen: N-2 Date tested: April 29, 1943

Compound: Aquastatic 1-C-Red Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-11	-16	-11	-16	-13.5	0
1	19	20	18	18	18.75	32.25
3	75	77	75	78	76.25	89.75
5	110	115	112	118	114.75	128.25
8	151	153	154	152	152.5	166.0

Weight before: 591.8 Weight after: 530.7 Loss: 61.1 grams

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: N-3 Date tested: April 29, 1943

Compound: Truscon 203 Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-15	-15	-14	-12	-14	0
1	11	11	15	15	15	27
3	62	62	64	62	62.5	76.5
5	110	108	107	108	108.25	122.25
8	147	148	148	148	147.75	161.75

Weight before: 583.3 Weightafter: 525.9 Loss: 57.4 grams

Specimen: N-4 Date tested: April 29, 1943

Compound: Satisfaction Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-3	-9	-5	-12	-7.25	0
1	12	15	12	16	13.75	21.0
3	58	57	60	55	57.5	64.75
5	97	95	100	95	96.75	104.0
8	144	144	145	144	144.25	151.50

Weight before: 584.1 Weight after: 530.5 Loss: 53.6 grams

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: 0-1 Date tested: April 29, 1943

Compound: Satisfaction Tested by: W. A. B.

Curing: Two daysin the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-7	-3	-4	0	-3.5	0
1	11	10	10	11	10.5	14.0
3	26	22	21	23	23.0	26.5
5	40	37	39	35	37.75	41.25
8	64	62	66	66	64.5	68.0

Weight before: 571.9 Weight after: 549.3 Loss: 22;6 grams

Specimen: 0-2 Date tested: April 29, 1943

Compound: Satisfaction Tested by: W. A. B.

Curing: Twodays in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	5	-3	2	-4	0	0
1	17	13	16	14	15	15
3	35	37	36	35	35.75	35.75
5	68	65	67	67	66.75	66.75
8	96	100	96	101	98.25	98.25

Weight before: 562.8 Weight after: 525.8 Loss: 37.0 grams

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: 0-3 | Date tested: April 29, 1943

Compound: Satisfaction | Tested by: W. A. B.

Curing: Two days in the cabinet:

Time in minutes	Dial readings				Mean	Total wear
0	-8	-13	-6	-11	-7.0	0
1	9	13	6	12	10.0	17.0
3	28	27	32	30	29.25	36.25
5	61	55	57	59	58.0	65.0
8	87	86	86	89	87.0	94.0

Weight before: 561.0 Weight after: 528.0 Loss: 33.0

Specimen: 0-4 | Date tested: April 29, 1943

Compound: None | Tested by: W. A. B.

Curing: Two days in the cabinet.

Time in minutes	Dial readings				Mean	Total wear
0	-7	-7	-9	-11	-8.5	0
1	66	63	63	69	65.25	73.75
2	144	144	143	148	144.75	153.25
5	No readings					
8						

Weight before: 552.5 Weight after: 498.1 Loss: 54.4 grams

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: R-1 Date tested: May 6, 1943

Compound: Aquastatic 1-C-Red Tested by: W. A. B.

Curing: Two days in the cabinet and five days in the lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-3	-8	-5	-8	-6	0
1	19	17	16	23	19.25	25.25
3	46	46	45	45	45.5	51.5
5	76	78	80	76	77.5	83.5
8	118	117	117	118	117.5	123.5

Weight before: 589.4 Weight after: 547.2 Loss: 42.2 grams

Specimen: R-2 Date tested: May 6, 1943

Compound: Klearcure 60 Tested by: W. A. B.

Curing: Two days in the cabinet and five days in the lab air.

Time in minutes	Dial readings				Mean	Total wear
0	0	-8	-3	-2	-3.25	0
1	18	22	20	19	19.75	23.0
3	54	58	55	55	55.5	58.75
5	85	92	90	90	89.25	93.50
8	137	129	135	131	134.0	137.25

Weight before: 581.0 Weight after: 533.5 Loss: 47.5 grams

MEMBRANE CURING STUDY

Abrasion Test

Series II

Specimen: R-3 Date tested: May 6, 1943

Compound: Truscon 203 Tested by: W. A. B.

Curing: Twp days in the cabinet and five days in lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-19	-14	-18	-14	-16.25	0
1	10	10	10	11	10.25	26.5
3	50	51	45	48	48.5	64.75
5	82	78	84	84	82.0	98.25
8	135	133	131	134	133.25	149.5

Weight before: 587.4 Weight after: 534.3 Loss: 53.1 grams

Specimen: R-4 Date tested: May 6, 1943

Compound: Satisfaction Tested by: W. A. B.

Curing: Two days in the cabinet and five days in the lab air.

Time in minutes	Dial readings				Mean	Total wear
0	-12	-10	-15	-6	-10.75	0
1	15	17	15	15	15.5	26.25
3	70	70	72	70	70.5	81.25
5	112	111	118	114	113.75	124.50
8	160	153	152	154	154.75	165.50

Weight before: 558.8 Weight after: 503.2 Loss: 55.6 grams