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SUBSTITUTES FOR RUBBER BAG MATERIALS IN MAKING MOLDED PLYWOOD

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**UNITED STATES DEPARTMENT OF AGRICULTURE
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Summary

The qualifications of a good bag material for making molded plywood are imperviousness to air, moisture, or both, at bag-molding temperatures and pressures; ease of fabricating into bags; flexibility and toughness; economy in use, and availability in suitable sizes.

The materials tested at the Forest Products Laboratory as substitutes for rubber were first subjected to a pressure bell test to determine their impermeability to air, water, and steam. Promising materials were then tested under actual bag-molding conditions.

The principal materials tested to date in this continuing program fall into four groups:

1. Cellophane films
2. Thermoplastic resin films
3. Thermosetting-resin-coated fabrics
4. Oiled or enameled cloth

The individual materials, together with the results of tests, are listed in table 1. Certain polyvinylidene chloride, vinyl butyral resin, and cellophane films showed considerable promise as bag-molding materials.

SUBSTITUTES FOR RUBBER BAG MATERIALS IN MAKING MOLDED PLYWOOD¹

By HERBERT O. FLEISCHER

Introduction

Rubber is still the most widely used bag material employed in the manufacture of molded plywood. This study was undertaken at the Forest Products Laboratory in an effort to find materials that can be used as substitutes for rubber for this purpose.

A good bag material must be (1) impervious to the fluid used as the heating and pressure medium, either air, inert gases, water, steam, or steam-air mixtures, at temperatures of from 200° to 300° F. and at pressures of 30 to 100 pounds per square inch; (2) capable of being formed or sealed into a fluid-tight bag; (3) flexible enough to withstand folding and bending about corners and edges of the molded object at the temperatures and pressures used; (4) tough enough to withstand rough handling, scuffing, etc., in use, and durable enough not to deteriorate over a suitable period of time; or, if it is to be used only once, cheap enough to be economical; (5) available in suitable sizes.

Materials

In the search for rubber substitutes that would meet the foregoing requirements, cellophane films (6 types), thermoplastic resin films (3 types), so-called "thermosetting"-resin-coated fabrics (4 types), and oiled or enameled cloth (1 type) were obtained from manufacturers and tested to determine their suitability for bag-molding.

Test Procedure

Preliminary Permeability Test

These materials were first tested for permeability to air, water, and steam in a small pressure bell. Samples 4 inches square were inserted in the bell in such a way that the pressure of the fluid medium was exerted from one

¹This mimeograph is one of a series of progress reports prepared by the Forest Products Laboratory to further the Nation's war effort. Results here reported are preliminary and may be revised as additional data become available.

side only against the membrane which was backed up with a suitably reinforced screen. On the opposite side, the bell was vented to the atmosphere.

This pressure bell was found to be most useful in testing materials for permeability to steam. In this case a double membrane was inserted in the pressure bell and a piece of paper with water-sensitive pencil markings on it was inserted between the membranes. A minute amount of moisture penetrating the first membrane moistened the paper and caused the pencil marks to blur.

Materials that were found to be impermeable or only very slightly permeable to air, water, or steam, were subjected to a bag-molding test.

Bag-Molding Test

This test consisted of preparing a bag, approximately 16 by 20 inches in size, and using it in an autoclave under conditions of temperature and pressure assumed to be suitable to the material under test. The details of these tests are given in the discussion that follows.

Results and Discussion of Tests

A list of the materials submitted for testing, together with a summary of the results of these tests, is presented in table 1.

Cellophane Films

Preliminary tests on cellophane films in various thicknesses showed that these materials are air-tight, but that even the so-called moisture-proof varieties tested allowed water and steam to pass through slowly. In certain grades of these films, however, the moisture penetration was sufficiently slow that it was found possible to use them under almost all bag-molding conditions.

In fabricating cellophane bags for use in these tests it was at first found very difficult to seal the edges of the bags. Scotch tape and several glues were tried without success. Rubber cement was satisfactory only when applied very carefully so as to get a light even spread along the edges to be joined, provided that these edges were subsequently placed together without wrinkling. In general, the time and labor consumed were great and the results were unreliable.

Certain types of cellophane films are "self-sealing" under heat, and it was possible to make satisfactory bags from these films quickly by taking advantage of this feature.² Because they did not have this heat-sealing

²Two types of "sealing irons" designed especially for cellophane films and having temperature controls, were used and found to be very fast and efficient. These were Wells Automatic Sealing Iron, Style T.F., Wells Mfg. Co., San Francisco, Calif., and Sealtight Bag Sealing Machine, Model HS, Heat Seal-It Co., Philadelphia, Pa.

feature, two types of regenerated cellulose films, cellophane 600 A Pt and cellophane "Tritect," were eliminated from further tests. Cellophane 600 A Pt is a plain transparent film 0.0016-inch thick. Cellophane "Tritect" is a laminated film 0.0032-inch thick over all, two laminations being sealed together with a wax.

Cellophane 600 A Mst-53 and cellophane 600 A Msat-82 are similar to each other, being 0.0017-inch thick, moisture proof, self-sealing, and transparent, but not laminated. Tests in the pressure bell showed that these materials were not so moisture-proof as the laminated cellophanes used in these tests. However, they are air-tight and were used with complete satisfaction for one cook in hot air at temperatures of 250° and 300° F. They became very brittle and could not be handled after a single use without breaking.

Cellophane 600 A laminated 1657-A and cellophane "Durafilm" are also similar in that they are both 0.0022-inch thick, laminated, moisture-proof, self-sealing, and transparent. Both gave identical results in the bag-molding tests, and were used satisfactorily under all the following conditions:

<u>Heating medium</u>	<u>Pressure</u>	<u>Temperature</u>	<u>Time</u>
	<u>Pounds per square inch</u>	<u>°F.</u>	<u>Min.</u>
Air	3 ¹⁰⁻¹⁵	200-400	15 and 30
Water	50-60	220-240	15 and 30
Steam-air	50-60	240-260	15 and 30
Steam	55	302	15 and 30

These bags also had a life of only one cook under ordinary conditions, although if great care were used in handling them, it might be possible to obtain more than one use. The cooking treatment causes the film to become brittle and hence difficult to handle. The adhesiveness which gives the film its heat-sealing qualities is also lost. These characteristics, combined with the relative cheapness of the film and the ease and rapidity with which the bags are fabricated, indicate that, for practical purposes, these bags will have a life of only one cook.

When using the cellophane "Durafilm" with steam or a mixture of steam and air the bleeder ejected a considerable volume of steam. The molded plywood, however, was not wet. It was assumed, therefore, that the steam passed through the cellophane film, along the surface of the molded plywood, and out through the bleeder without wetting the plywood. Because of this semi-permeable nature of these films, some additional tests were made as follows.

³Tests were made at this low pressure for convenience in heating. Cellophane bags have been used with air at higher pressures but inert gases are recommended for pressures higher than atmospheric at elevated temperatures.

Cellophane "Durafilm" was used in a test to determine the capacity of the bleeder required. A bag 5 feet long and 18 inches wide was used to mold flat plywood on a form approximately 4 feet long, 1 foot wide, and 2 inches thick. The bleeder connection was located near one end of the form, the plywood to be molded was on the opposite side of the form, and the molding was wrapped in one thickness of canvas. The material was molded in the autoclave for 30 minutes at approximately 300° F. and 50 pounds steam pressure. The bleeder steamed during the operation, but no portion of the material in the bag became noticeably wet. From this it appears that a single bleeder outlet is effective in evacuating vapors accumulating over an area of at least 8 square feet.

A second test was designed to determine whether the steam passing through the bag exerted a serious back pressure within the bag. A bag of cellophane "Durafilm" about 20 inches square was equipped with two bleeder connections on opposite sides of the bag. A flat form 12 inches by 15 inches in size was covered with a single sheet of canvas and placed in the bag. The bag was placed in the autoclave with one bleeder connection vented to the atmosphere and the other leading to a pressure gage outside the autoclave. The assembly was subjected to a typical bag-molding cycle of 15 minutes at a pressure of 50 pounds steam-air mixture and a temperature of 250° F. The pressure inside the bag was found to be 10 pounds per square inch after 5 minutes and rose slowly to 13 pounds in 15 minutes. Steam was visible at the bleeder after 10 minutes of cooking. Similar work on rubber bags at the Forest Products Laboratory indicated that a back pressure comparable to this is obtained in a rubber bag punctured by a single hole 1/16-inch in diameter.

A third test was made to compare the moisture content of the plywood produced in cellophane and in rubber bags. Comparable test panels, 5 by 12 inches in size, of 3 plies 1/16-inch yellow birch were bag-molded on flat wooden forms 12 by 15 by 1/2 inch in size in cellophane "Durafilm" and in rubber bags. The glue used was Bakelite XC-16221, a phenolic resin. A steam-air mixture was used, at a temperature of 250° F., and at 55 pounds pressure for a period of 20 minutes. Only one panel was made in each bag and this panel was placed on the form on the side opposite the bleeder outlet. In one cook the veneer in both bags had been conditioned at 80° F., in a 30 percent relative humidity room; in the second cook the veneer had been conditioned in a 65 percent room. Results were as follows:

	<u>Initial</u> <u>moisture content</u>	<u>Final</u> <u>moisture content</u>
	<u>Percent</u>	<u>Percent</u>
Cellophane "Durafilm" bag.....	About 6	About 10
Cellophane "Durafilm" bag.....	" 12	" 12
Rubber bag.....	" 6	" 4-1/2
Rubber bag.....	" 12	" 8-1/2

The moisture content of the wood decreased during the molding cycle when the rubber bag was used, but increased or remained constant when the cellophane bag was used.

In contemplating the use of cellophane film for bags, it may be useful to know that this material can be obtained prefabricated into bags. Cellophane "Durafilm" is available at present in bags 7 feet long and 36 inches in circumference. Other sizes of this and other films can be made by fabricators.

In using bags of this film having a life of only one cook, it is important to have a bleeder connection which can easily and quickly be attached to the bag. An example of such a bleeder connection is shown in figure 1. The bleeder should be properly located in the bag so that it will not cause the production of defective plywood because of uneven heating, pressure, or the accumulation of vapors.

A few suggestions for sealing cellophane bags are given in figure 2.

Thermoplastic Resin Films

Polyvinylidene chloride, plasticized.--Polyvinylidene chloride film, Saran B-115, is said by the manufacturer to have a very low moisture-vapor permeability and seems to have other properties which make it a suitable bag material, but reportedly should not be used continuously at temperatures over 175° F. The film is 0.001-inch thick and is available at the present time in continuous tubes, the largest of which is 24 inches in circumference.

Preliminary tests showed that the film satisfactorily excluded air and water. In a heated autoclave, however, its use was found to be limited by the maximum temperature and the length of the heating period. In one case, the material disintegrated completely after being exposed to a steam-air mixture at a temperature slightly below 260° F. for 15 minutes. Under the action of heat the film shrinks at least 10 percent in length and width and a bag made of it must be large enough to allow for this shrinkage or it will rupture.

A bag of this tubing, 12 inches wide and 18 inches long, made simply by clamping both ends shut, was used twice at a pressure of 50 pounds per square inch and a temperature of 250° F. in a steam-air mixture for periods of 15 and 30 minutes. The bag developed no defects, but because the film is extremely thin, it was difficult to remove it from the form without damage. Until an improved product is available, the life of these bags would have to be considered one or two cooks.

It is understood that efforts are now being made to supply polyvinylidene chloride films up to 0.002-inch thick; it may also become possible to obtain a laminated film. It seems possible that thicker films will be sufficiently strong so that bags can be used repeatedly.

Polyvinyl alcohol film.--A sample of a thermoplastic polyvinyl alcohol film, No. 300 B-15-0, was received for testing, but was found to have no general application for bag-molding. This material is air-tight and presumably could be used in hot air. However, it is extremely sensitive to moisture and disintegrates in water or steam.

This film when dry will shrink upon heating and can thus be used to exert a considerable pressure over a curved form. It is possible that this characteristic might prove valuable in certain applications. However, it must be remembered that the pressure exerted in an application of this kind varies inversely with the radius of the convex curvature over which it is stretched.

Vinyl chloride acetate resin sheet.--A sample of vinyl chloride acetate resin sheeting, Vinylite resin sheet VU-5930D black, 0.020-inch thick, was received for testing. Preliminary tests indicated that this sheet was air tight and moisture proof in water or steam up to 300° F. in spite of the fact that it is a thermoplastic. A bag was, therefore, made of it by simply heat-sealing the edges, and was used first in pure steam at approximately 300° F. for 15 minutes and again in a steam-air mixture at 240° F. for 15 minutes, both times under 50 pounds pressure. After each cook the bag was found to have a number of small holes which developed along the edges of folds in the bag.

Thermosetting Resin-coated Fabrics

Several samples of a so-called "thermosetting" vinyl butyral resin-coated fabric were received for testing. After a bag of this fabric has been prepared and sealed with the liquid resin, the material must be vulcanized at a temperature of 270° F. for 1 hour.

The first materials submitted consisted of thin fabrics coated with 4 ounces of the resin per square yard. These materials, Saflex TS coated fabric No. C-1518 and Saflex fabric No. C-1520 appeared from preliminary tests to be impermeable to air, water, and steam. Bags were made of these fabrics and used at approximately 300° F. with a steam pressure of 50 pounds per square inch. Neither of these fabrics was satisfactory as a bag material. In one case the fabric was double coated and the resin coating inside the bag caused it to stick to the molded object. The other fabric developed many pin holes and minute cracks after three trial cooks. The same manufacturer later submitted samples of Saflex TS coated fabric, research sample D-127, with an 8-ounce coating of resin per square yard. The same difficulty was experienced with this fabric.

A material known as "double-texture fabric" made by assembling and cementing together two layers of the No. D127 fabric with the coated surfaces face to face was made into a bag. The resulting bag exhibited some very desirable qualities in that it was flexible, tough, and durable.

This bag was used nine times under extremely severe bag-molding conditions of about 320° F., at a steam pressure of 80 pounds. Each cook was

50 minutes in duration and the bag was drawn hot each time. During the ninth cook, or after 450 minutes of use, leaks developed in the material wherever it had been sharply folded or wrinkled. The severe usage to which this bag was subjected is not representative of common bag-molding conditions. It is thought that the bag would have a life of at least 30 cooks under less severe bag-molding conditions. A fitted bag to avoid wrinkling would be advisable.

The manufacturer has signified his intention of submitting samples of other improved types of this material.

Oiled and Enameled Cloth

Small samples of 12 oiled cloths were received from one manufacturer. None of these was big enough for testing. However, the pieces were exposed in an oven at 250° F. for 7 hours, at the end of which time they were very dry, brittle, and weak. Pieces were also exposed to steam at 300° F. for 7 hours, which practically decomposed them. None of these materials appeared to be very promising, and no other samples were received from this source.

A heavy black enameled sateen stood up well under the preliminary test with air, water, and steam.

of this material

A bag/was therefore made, using Fairprene cement as the sealing material. This bag was used only once for 15 minutes at a temperature of 290° F., and a pressure of 50 pounds of steam. The bag quickly developed leaks and it was found that the enamel had cracked wherever the material was sharply folded. On flat surfaces, however, the material was not affected.

The manufacturer of this material is submitting a second sample of enameled cloth which is said to have improved qualities.

Additional Tests

Since writing the above report, the question of using paper as a bag material when hot air is used as the pressure medium has arisen and tests on several papers have been made.

Glassine paper 0.0025 inch thick was found to be sufficiently airtight in a flat sheet, but when used as a bag it cracked at the folds. Three other papers, vegetable parchment 0.0040 inch thick, sign paper 0.0125 inch thick, and supercalendered kraft 0.0036 inch thick, were not sufficiently airtight.

Table 1.--Summary of materials tested at the Forest Products Laboratory as substitutes for rubber bag materials in making solid plywood.

Name	Type	Recommended heating and pressure medium	Limitations of temperature bag	Life of notes on flexibility, toughness, etc.	Method of forming bag	Size of sheets	Remarks
Materials that appear to be suitable for bag-making							
1. Cellophane 600 A Wet-53 and cellophane 600 A Wet-52	Regenerated cellulose single film	Air (or inert gas)	Not critical	One cook	Will not stand rough handling	Can be heat-sealed: rolls up to 40" width	Air-tight but not so moisture proof as 1657-A and "Durefil".
2. Cellophane 600 A Laminated 1657-A	Regenerated cellulose laminated film	Air, water, or steam	Not critical	One cook	Will not stand rough handling	Can be heat-sealed: rolls up to 40" width	Steam passes through slightly but does not appear to be a serious disadvantage.
3. Cellophane "Durefil"	Regenerated cellulose laminated film	Air, water, or steam	Not critical	One cook	Will not stand rough handling	Can be heat-sealed: rolls and pre-not appear to be a serious disadvantage.	Steam passes through slightly but does not appear to be a serious disadvantage.
4. Saran B-115 film	Thermoplastic polyvinylidene chloride film	Air, water, or steam	Not over 250° F. for 15-30 min.	One cook (perhaps more)	Very thin and very tough but becomes dry, brittle and easily damaged in re-moving from form	Use in tubular clamp form. Largest in use: 24" circumference	Shrinks 10% in length and width when largest in use.
5. Saflex 93 coated fabric, in "double texture" form	"Thermosetting" vinyl butyral resin between fabrics	Air, water, or steam	Not critical	Many cooks	Resistant to scuffing; pin holes developed in wrinkles after 450 min. at 320° F. (steam)	Resistant to scuffing; pin holes developed in wrinkles after 450 min. at 320° F. (steam)	"Double texture fabric" better than single fabric.
Materials that do not appear to be satisfactory for general bag-making applications							
Cellophane 600 A Pt	Regenerated cellulose single film						Not heat-sealing, almost impossible to seal air-tight with glue, cement, or tape but has been used commercially.
Cellophane "Tritect"	Regenerated cellulose film laminated with wax						When heated, the wax melts and the sheet delaminates.
Polyvinyl alcohol film	Thermoplastic polyvinyl alcohol film						Very sensitive to moisture. Might possibly be used with air. Shrinks upon heating.
Vinylite VU-5930B	Thermoplastic vinyl resin sheet						Has good impermeability but cracks at folds at higher temperatures.
Black smooth glass enamel	Enamel cloth						Tough, durable, and impermeable, but enamel cracks at folds.
M. I. du Pont de Nemours & Co., Cellophane Division, Wilmington, Delaware.							
2. Spodeckum Co., 3301 Monroe Avenue, Cleveland, Ohio.							
3. Dow Chemical Co., Midland, Michigan.							
4. Monsanto Chemical Co., Plastics Division, Springfield, Massachusetts.							

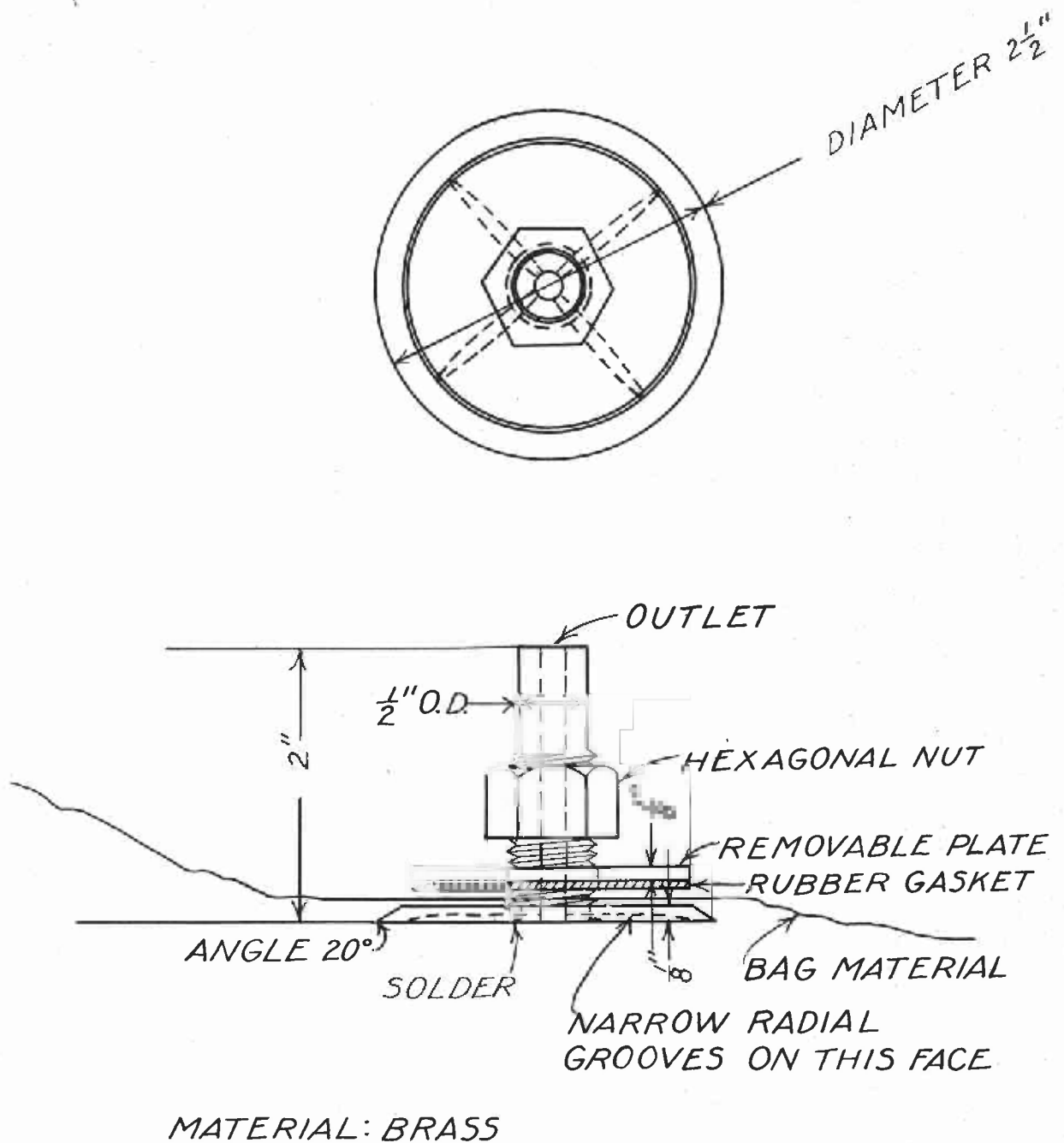


Figure 1.--Metal bleeder connection designed for rapid attachment to bags.

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NOT RECOMMENDED

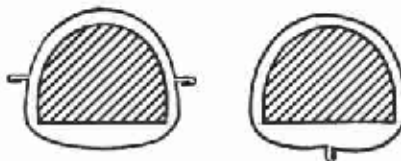


RECOMMENDED

A-FOLD CELLOPHANE OVER BEFORE SEALING EDGES



NOT RECOMMENDED



RECOMMENDED

B-ARRANGE BAG ON FORM SO THAT SEALED EDGES ARE PLACED UNDER NO UNNECESSARY STRESS



NOT RECOMMENDED



RECOMMENDED

C-ARRANGE SEALED EDGES SO THAT WATER CANNOT ACCUMULATE AT THE EDGE.