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PLASTIC SEALING of Tobacco-Storage Warehouses

U.S. DEPARTMENT OF AGRICULTURE
Production and Marketing Administration

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The use of plastics is expanding and the field of application for these materials is practically unlimited.

The fumigation of closed-type tobacco storages has always been seriously complicated by the necessity for adequate sealing. Time has been an important factor and in the past the labor required to do the job has been excessive. If fumigations are to be effective they must be made promptly after the peak of emergence of the insects. Plastic sealing can be applied rapidly and with a minimum of labor. The savings that can be made by the use of this material as compared with other materials are largely attributable to these factors. The cost of material and the equipment necessary for the application do not represent sizable items when over-all cost is considered.

This type of sealing, although tested only on tobacco warehouses, may be found practical in other types of storages for other commodities. Plastic materials are extremely adaptable and the technique of application is simple. Specialized training is not required for their use.

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PLASTIC SEALING OF TOBACCO- STORAGE WAREHOUSES

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INTRODUCTION

Losses Caused by Insect Infestation

One of the many problems faced by the tobacco industry is that of the infestation of leaf tobacco and stored tobacco products by the tobacco moth and the cigarette beetle. These insects appear in varying numbers throughout the tobacco-storage area. Their control has been studied by the industry and by the United States Department of Agriculture.

According to a publication by the Bureau of Entomology and Plant Quarantine, the damage caused by these insects was estimated at 3 1/4 to 10 million dollars annually.2 As the figures were obtained before 1942, the price of leaf tobacco was lower and the cost of processing was considerably less than now. In April 1947 the Bureau found that damage from infestation in flue-cured tobacco amounted to $5 per 1,000 pounds of tobacco stored in open-type warehouses.3 The percentage of damage was in direct proportion to the length of time the tobacco was in storage.

Before World War II domestic manufacturers carried tobacco-leaf inventories for periods up to 30 months. Such periods were required in order to age the tobacco properly. Since the beginning of the war period, however, little tobacco has been carried for more than 2 years. It is believed that the longer aging period will be restored as soon as possible by the manufacturers and as a result the insect-

1 The author is indebted to Elise M. Hanscom for assistance in the preparation of the manuscript. Acknowledgment also is made to Joseph N. Tenhet, Head of the Stored Tobacco Insect Laboratory, Bureau of Entomology and Plant Quarantine at Richmond, Va., Carroll C. Scott, Field Supervisor, Flue-Cured Tobacco Cooperative Stabilization Corporation, Raleigh, N. C., C. W. Gettys, Bureau of Ordnance, Department of the Navy, and A. B. Belmore, of the R. M. Hollingshead Corp., Camden, N. J., for assistance and helpful suggestions.

2 Reed, W. D., and Vinzant, J. P. Control of Insects Attacking Stored Tobacco and Tobacco Products. U. S. Department of Agriculture, Agricultural Research Administration, Bureau of Entomology and Plant Quarantine Circular 635. 40 pp., illus. 1942.

control problem will again become more important. When tobacco is to be exported, any infestation creates a serious problem, and this problem is further complicated if the tobacco is held for a relatively long period before shipment. Tobacco held awaiting export is usually stored in closed-type warehouses similar to those shown in figure 1. It is in this type of building that fumigation is performed if insect infestation exists.

**Insecticides and Fumigants**

In the past, dusting with pyrethrum powder was recommended by the Richmond Stored Tobacco Insect Laboratory of the Bureau of Entomology and Plant Quarantine, for the control of the tobacco moth. The Laboratory’s study of pyrethrum oil sprays developed a more satisfactory control. Sprays have been much more effective than dusting, but fumigation, which has also been used for many years, is still the most widely accepted method of control, particularly against the cigarette beetle.

Several fumigants have been used in the past but at present hydrogen cyanide (HCN) is probably used more extensively than any other gas. The develop-

![Figure 1.—Closed-type storage warehouses at Norfolk, Va., where a part of the tobacco held under the Commodity Credit Corporation loan program is located.](image)

ment of Carbacryl (formerly known as Acrylon) has been studied and its use tested on a commercial scale. Methyl bromide and other gases have also been tested. All these fumigants have their desirable characteristics. In Circular 635 and other publications issued by the Bureau of Entomology and Plant Quarantine, methods of application of these fumigants are discussed. Information as to the effectiveness of these gases and sprays, and safety measures necessary in their application, are also given.

In every instance, however, the sealing of a storage building to be fumigated at atmospheric pressure must be adequate. Over a period of years there has been little change in the methods of sealing employed by the industry. As sealing is essential to fumigation, some study of the methods and materials used in this work seems desirable.
Storage Problems

The tobacco industry, in general, has storage space available for a normal inventory of leaf tobacco and of tobacco products. In some cases, however, commercial storage space adapted for the handling of this commodity is used. Even if the storage buildings are operated by the owner of the commodity, shipping and sampling bring about the necessity for moving the tobacco into sections other than those in which it was originally stored. Because of placing the tobacco in these sections not previously fumigated, a considerable amount of sealing work is necessitated, and as this must be done in a limited period of time, adequate preparation in advance is often impossible. For this reason any development that reduces the amount of labor required and speeds up the preparations for fumigation is of considerable importance and aids in producing better results in insect control.

Sealing Methods

Very little has been written on the subject of sealing closed-type tobacco-storage warehouses for fumigation in connection with the control of insects. In an early publication, the Bureau of Entomology and Plant Quarantine covered in some detail the sealing of warehouse buildings. This information was later summarized in Circular No. 635, Control of Insects Attacking Stored Tobacco and Tobacco Products. In this publication, methods and materials currently used in this type of work are briefly described. Recent studies of commercial fumigation indicate the importance of adequate sealing and the need for an improvement in methods and materials used in this work.

Tobacco Insects and Their Control

The Richmond Stored Tobacco Insect Laboratory (Bureau of Entomology and Plant Quarantine) states that from South Carolina northward both the tobacco moth (Ephesia elutella (Hbn.)) and the cigarette beetle (Lasioderma serricorne (F.)) normally have from two to four generations a year. The time of emergence of adults varies in relation to the climatic conditions existing in the storage area throughout the continental United States. In controlling these insects, it is recommended that fumigation immediately follow the peak of emergence. This time is determined from catches obtained in suction light traps installed as shown in figure 2. The average life cycle of these insects is from 50 to 60 days.

It is essential, therefore, that sealing in warehouses must be maintained for periods up to 7 months in each year. As the cost is high, it is desirable that the type of sealing used be durable and easy to patch at the beginning of the next fumigation season.

Fumigation and Sealing Problems

Hydrogen cyanide (HCN), a fumigant recommended by the Department and used extensively throughout the tobacco industry, is slightly lighter than air. Any very small aperture resulting from inadequate sealing will permit leakage which will reduce the concentration of gas in the building. As the insects to be destroyed are usually not active at temperatures below 60° F. and as fumigants are generally more effective at temperatures above this point, the retention of heat within the building is not an important point. Leakage of gas caused by high winds or other detrimental atmospheric conditions presents a much greater problem due to the effect on the distribution and density of gas within the building.
In warehouses that have been recently sealed prior to fumigation, good results are usually obtained, whereas in warehouses, in which the sealing work was done more than 6 months previously, checking and injury permit cracks to develop and thus the effectiveness of fumigation is correspondingly reduced. The Bureau of Entomology and Plant Quarantine recommends a fumigation period of 72 hours and it is obvious that a perfect seal must be maintained for that period.

The use of paper, mineral asphalt, and other materials has not been entirely satisfactory. Paper has a tendency to dry with age and is easily torn. Drafts and vibration tend to loosen the seal. Some sealing compounds lose their adhesive qualities and become hard and brittle. Careful inspection of the sealing at the beginning of each fumigation season will disclose a certain amount of injury, but it is impossible to ascertain and entirely eliminate the effects of aging and resulting leakage of gas.

Figure 2.—Interior of closed-type tobacco-storage warehouse showing suction light trap and screened door.

**Vinylite Plastic (Strippable) Coating**

The Department of Agriculture, in its study of sealing tobacco warehouses, was anxious to find a material which would retain its elastic and adhesive qualities over long periods of time. Plastic materials were considered and were found to have these characteristics, and, in addition, were readily removable (strippable).

Vinylite plastic strippable film is a material the basis of which is a plasticized vinyl chloride-acetate copolymer resin. It is made sprayable for pressure spray-gun equipment by the addition of volatile solvents, such as methyl ethyl ketone and acetone. The resulting material after the volatile solvents have evaporated, forms a durable, flexible film which is tough and weather-resistant.

In addition to being volatile, the solvents used in plastic are highly inflammable and explosive where a sufficient concentration of fumes exist. Although there
have been no instances recorded where the toxicity of these solvents affected the operator, it is believed that this condition could develop were the fumes sufficiently concentrated. Maximum safe concentrations of these toxic materials are as follows:

<table>
<thead>
<tr>
<th>Material</th>
<th>Parts per million in the air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methyl</td>
<td>200</td>
</tr>
<tr>
<td>Ketone</td>
<td>500</td>
</tr>
<tr>
<td>Ethyl</td>
<td>400</td>
</tr>
<tr>
<td>Acetone</td>
<td>500</td>
</tr>
</tbody>
</table>

Wherever the possibility of excessive density occurs, exhaust fans should be used. It is highly important that all precautions listed under the heading of Safety be followed in the application of plastic sealing.

*Figure 3.*—Pigmented plastic coating in pressure pot. *Note:* Several unsafe practices are shown. Open pressure pot should be kept away from gasoline-operated compressor. Spilled material indicates the importance of performing operation elsewhere, and being careful to prevent spilling.

An especially desirable feature is the toughness and resistance of plastic film to injury. Although tensile strength is not essential, it makes this product more durable and less subject to abrasions when bumped or scraped by the movement of hogsheads. Sharp instruments or nails puncture it easily and for this reason plastic should not be used in sealing the floor of a building unless the work can be done from the lower side.

Plastic coating, when applied without the use of a binding agent, is readily strippable or removable. When a binding agent is applied first, the plastic will then be more or less permanently bound to the surface to be sealed. This type of application adheres satisfactorily to all kinds of building materials, including concrete, steel, wood, brick, and hollow tile.
Pigment may be added to the plastic solution, thus giving it resistance to weathering and the direct rays of the sun. Pigmented plastic is shown in figure 3. When applied either with or without pigment, plastic sealing is less unsightly than sealing with mineral asphalt and paper.

Development of OS–3602 by the Navy

During the war period the Bureau of Ordnance of the Department of the Navy developed a vinylite plastic film known as OS–3602. The development of this plastic has made possible a complete revision of the methods and materials previously used in sealing storage warehouses. All the topside ordnance units, as well as some of the machinery units in vessels of the Reserve Fleet, were sealed by the Navy with strippable plastic to protect them from rust, corrosion, and exposure to the elements and to preserve them in readiness for immediate reactivation. A majority of these plastic covers were later replaced with permanent-type metal enclosures.

Naval Bureau of Ordnance publication OP 1485, Instructions for Application of Strippable Coating (Spray Type) (OS–3602), dated April 2, 1945, gives a detailed description of the manner in which the Navy handled its plastic program. Although the problems discussed are different from those found in the tobacco industry, the publication is of value in training employees engaged in this work.

Navy specifications call for an application of not less than 0.040 inch of film. As a result of this method, the Navy obtained a satisfactory moisture barrier for a period up to 3 years, during which time the barrier or plastic was exposed to average weather conditions but received routine maintenance amounting to a semiannual reworking, or patching, and recoating as found necessary.

Army Specification

The Artillery Division of the Department of the Army also set up production-line usage of plastic. Later it added a top coat of coal tar and bitumastic-type materials. Department of the Army specification dated October 29, 1946, and identified as “AXS–1756—Compound, Protective, Strippable (Sprayable), covers the material currently used by that Department.

Experimental Work by Department of Agriculture

The Tobacco Branch of the Production and Marketing Administration, in its administration of the tobacco-loan programs, for the Commodity Credit Corporation, is required to see that stored collateral is properly protected. Investigation revealed that Navy formula OS–3602 was probably adaptable to the sealing of storage warehouses.

Experiments were conducted at the Army Base warehouses at Norfolk, Va., on December 11 and 12, 1947, in an effort to test the application of plastic under

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4 Pursuant to section 8 of the Stabilization Act of 1942, as amended (October 2, 1942), 56 Stat. 767, as amended June 30, 1944, 58 Stat. 632, and as amended June 30, 1945, 50 U. S. C. App. (sec. 968), Commodity Credit Corporation made loans available on 1946 and 1947 flue-cured tobacco crops. As a result of these programs approximately 265,000 hogsheads of flue-cured tobacco were stored as collateral for nonrecourse loans. A comprehensive insect-control program was considered essential to protect this tobacco from infestation by the tobacco moth and the cigarette beetle. Joseph N. Tenhet, Head of the Stored Tobacco Insect Laboratory (BE&PQ), at Richmond, Va., cooperated in the development of this program. Under it, tobacco was to be fumigated if possible; otherwise it was to be sprayed with pyrethrum oil. The program was carried into effect by the Flue-Cured Tobacco Cooperative Stabilization Corporation at Raleigh, N. C., and a major part of the information contained in this publication is based on results of sealing work performed by this grower cooperative organization.
commercial storage conditions. Sample operations were set up and performed with the use of Navy material and equipment, as shown in figure 4. Test applications which were exposed to weather conditions were examined 60 days later and found to be intact and to have retained their sealing properties. After completion of the sealing on two groups of warehouses, inspections were made 4 months from the date of application and very little deterioration was noted in excess of that shown in the earlier experiments. Industrial fumigation engineers cooperated with the Department in making these tests and suggested methods of application insofar as they applied to fumigation and use of HCN gas.

**Laboratory Tests**

One outstanding difference in the method of application used by the Navy and that developed by the Department of Agriculture is the thickness of the material when applied. Tests of plastic film made at the Richmond Laboratory of the Bureau of Entomology and Plant Quarantine showed that the material effectively prevented the transmission of hydrogen cyanide (HCN) at thicknesses above 0.005 of an inch. This finding made it possible to reduce greatly the quantity of material required and the cost of application as established by the Navy.

![Figure 4](image.png)

*Figure 4.—Experimental truck equipped by the Naval Ordnance Laboratory, Silver Spring, Md., and used by the United States Department of Agriculture in experimental work.*

Penetration of air under pressure on plastic 0.005 of an inch thick resulted in the passage of 1 cubic centimeter of air per square foot in 24 hours. It was also found that the material was not chemically affected by the exposure to hydrogen cyanide.

**Tests of Chemical Effect on Tobacco**

Further investigation revealed that the solvents used in the various types of plastic materials tested were acetone and methyl ethyl ketone. To check the susceptibility and retentive qualities of tobacco to the vapors given off by the plastic, samples were exposed to the fumes under controlled conditions to a point beyond

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8 Material and equipment were obtained from the Atlantic Reserve Fleet at Norfolk, Va., with the cooperation of the Navy Bureau of Ordnance and the Norfolk Naval Supply Depot.
the normal saturation expected in tobacco warehouses. These tobacco samples were tested in the Eastern Regional Research Laboratory of the Department of Agriculture by B. A. Brice, of the Bureau of Agricultural and Industrial Chemistry. In a report dated February 10, 1948, he states in conclusion:

Since the methyl ethyl ketone and acetone contents of the treated samples were the same as those of the untreated samples (controls), it can safely be concluded that the treated samples (R and B) did not retain any methyl ethyl ketone or acetone volatilized from the sealing compounds.

Smoke tests of cigarettes made from the treated and from the untreated tobacco showed no differences. Samples of exposed tobacco were examined by the Tobacco Branch (PMA), and were found to contain no foreign odor. All tobaccos tested were of cigarette and smoking types grown in the flue-cured area. It is believed that tobacco generally would react in a similar manner; however, cigar types have not been specifically tested.

**Results of Tests**

On the basis of these findings, plastic was applied to commercial warehouses at Charleston, S. C., and Norfolk, Va. Fumigation of these sealed sections has been entirely satisfactory and has shown that this method of sealing meets all the requirements of this type of work.

The manufacturers of plastic film have already made changes and improvements in the basic Navy formula. The development of materials adapted to specialized usages in industry has gone forward with the demand, and further improvements can be expected in this field. There is a possibility that a product with a controlled degree of adhesion will be placed on the market in the near future. Such a product should be an improvement from the standpoint of tobacco-fumigation work.

The Department of Agriculture, as a result of the various tests and commercial applications made, finds vinylite plastic (sprayable) adaptable for use in sealing closed-type tobacco-storage warehouses.

**MATERIALS**

**Coating—Webbing—Adhesive**

Vinylite plastic film is a viscous liquid which comes from the manufacturer in sprayable form ready to use. It is shipped in metal containers, or drums, as shown in figure 5. This is the basic material used in plastic spraying and is complete in itself when applied on relatively solid surfaces.

In order to form a foundation for the plastic film on voids, holes, and cracks that are wider than 1/4 inch, it is necessary to add to this basic solution a material known as webbing agent. This webbing compound is added in proportions of approximately 1 part to 3 or 4 parts of the coating solution. A sufficient quantity of the combination should be prepared for each day's operation. The method of adding webbing compound is illustrated in figure 7, page 12.

In cases in which the webbing solution had been mixed for several days it was found that a separation of the two ingredients had occurred. This incomparability can be overcome by agitating the mixture thoroughly at the beginning of each operation and again on succeeding days if necessary.

During cold weather proportionately more webbing agent is needed in the mixture than when higher temperatures prevail. It is advisable to start with a normal mixture and add enough of the webbing agent to obtain the desired solution. With each addition the mixture should be thoroughly stirred or agitated. As a recent development, a complete webbing solution already mixed and
Figure 5.—Vinylite plastic being transferred from shipping container to pressure-pot insert. Work is being performed in the open air as fumes are especially explosive and inflammable during pouring operation.

ready for use has been placed on the market. It is stated that this solution will not separate when allowed to stand.

Neither plastic film nor the combination of plastic and webbing agent adheres permanently to surfaces without prior application of a binding agent. Suppliers of plastic produce a material which can be used for this purpose. Navy specifications list as an adhesive agent, a product known as Pliobond, which the Department of Agriculture used in its experimental work. This product is manufactured by the Goodyear Tire & Rubber Co. and is distributed by the United States Plywood Corp., New York, N. Y.

**Coloring and Pigment**

Where plastic is used on interiors or in protected locations, the addition of a coloring agent makes the application more visible. Although this may be desirable in some cases, it is not essential. In experimental work performed by the Department, a gray pigment was obtained which, when added to the vinylite plastic film, produced a satisfactory color and materially improved the resistance of the compound to heat, weathering, and the direct rays of the sun. Pigment may be added to the plastic material when prepared for use, or it may be included
by the manufacturer in the basic product. It should always be a part of the solution when it is applied on exteriors or in exposed locations. If a pigmented material is purchased, it is desirable, but not essential, to obtain some clear plastic film for use in mixing the webbing compound.

**Thinner or Retarder for Plastic Solution**

Weather conditions affect the application of these materials. When plastic coating is applied during cold weather, it is important that a thinner be used only where absolutely necessary. Evaporation of the solvents is slowed down at low temperatures and additional thinner tends to retard this action further. Excessive thinner tends to allow the materials to run and the resulting thickness of the application varies. It is, therefore, desirable to agitate the material wherever possible in order to avoid the use of a thinner. Whenever plastic is being agitated, the pressure pot should be tightly closed and, if possible, the operation should be performed in the open air.

*Figure 7.—Open spray-pressure pot equipped with agitator and air motor.*

Plastic coating compound has a tendency to become more viscous with age. Where drums have been stored for a considerable time this excessive viscosity may be found. If the solution is too thick for spraying, agitation will remedy this condition in most cases. A pressure pot, equipped with agitator, used in this operation is shown in figure 6. Where a thinner is required, it should be methyl ethyl ketone, acetone, or a product recommended by the maker of the basic plastic solution.

At extremely high temperatures, above 90° F., the addition of a retarder is recommended by the Navy. Methyl iso-butyl ketone, methyl hexyl ketone, and toluene have been used and are satisfactory in slowing down the drying process. There is little likelihood that a condition will be found in which the addition of a retarder is required. In most instances the adjustment of the spray-gun nozzle will allow a sufficiently wet application that will flow properly and form an even
surface to which additional coats may be applied if necessary. When plastic is applied too dry, a pebbly or rough surface is obtained. The use of a retarder is, therefore, not recommended except under extreme conditions.

In cases in which either a thinner or a retarder is used, care should be exercised in the handling of these explosive materials. The operation should be performed in the open air, if possible, and the suggestions listed under the heading of Safety should be carefully followed.

Sources of Supply

All the materials just discussed can be obtained from the manufacturers of the basic vinylite plastic film, who are the authorized suppliers of formula OS–3602 to the Navy. The names of these firms are listed below, together with the trade names of the products, similar to OS–3602, currently being manufactured by them.

<table>
<thead>
<tr>
<th>Name of manufacturer</th>
<th>Trade name of product</th>
</tr>
</thead>
<tbody>
<tr>
<td>R. M. Hollingshead Corp., 840 Cooper St., Camden, N. J.</td>
<td>Cocoon.</td>
</tr>
</tbody>
</table>

It is recognized that this list is not complete and that other manufacturers of plastic materials can supply products similar to OS–3602. It is suggested, however, in view of differences found in the various products tested by the Department that care be exercised in selecting new products and that thorough tests be made in order to determine the adaptability of the product being considered.

When stored in airtight containers, vinylite plastic deteriorates very slowly and may be kept for relatively long periods of time. Unopened material usually will remain in sprayable condition when carried over from one season to the next. It need not, therefore, be purchased in extremely small quantities but can be obtained in sufficient quantities to justify a reduction in price.

EQUIPMENT

Plan for Efficient Application

As a result of its experimental work the Department found that the most efficient application of this material was obtained when two men, working as a team, used equipment supplied by air pressure from one large-type compressor. This permits the use of two sets of three spray guns, one gun out of each set being used more or less continuously. Each gun is connected to a pressure pot by 100 feet of both 5/16-inch air and 1/2-inch fluid hose. The pots are attached to the compressor by 50 feet of 5/16-inch air hose, thus giving a combined working range of approximately 150 feet. This type of operation requires air pressure for long periods of time. A compressor rated at a minimum of 60 cubic feet per minute at 100 pounds pressure was used by the Department.

Compressors

In large operations where spraying work will be performed over a period of several months, it is desirable that an even heavier type of compressor be used. Experiments indicate that a compressor delivering approximately 100 cubic feet per minute is needed in view of the heavy load on this equipment. It is possible that a slightly higher tank pressure might also be advantageous, considering the length of hose used and the corresponding loss in pressure. It is believed that a compressor capable of maintaining a tank pressure of 125 pounds would deliver
a more consistent nozzle pressure and as a result be more effective. However, with the use of a larger diameter hose from the compressor to the pressure pot, the need for additional tank pressure could in all probability be eliminated. This heavy-duty type of equipment need not run continuously in order to maintain tank pressure and could efficiently deliver sufficient compressed air for the operation of a two-man program. As this item represents the largest single investment for the work, it is economical in the long run to purchase a machine which will withstand heavy-duty operation.

**Portable Equipment**

It is advisable to have the compressor, as well as the equipment, mounted on a truck or be otherwise portable, in order to facilitate its movement around the storage warehouses to be sealed. Where groups of warehouses are located at relatively distant points, it is recommended that the compressor be mounted on
the type of truck which can transport at the same time the other items essential to the operation. Figure 7 shows equipment mounted on a Navy truck.

Where operation is confined to a single group of warehouses, or to several groups in a small area, the trailer-type compressor can be used to advantage. This type of equipment can often be moved to positions under the shed roofs of the warehouses or to other more convenient locations, thereby eliminating the need for excessive footage of hose. However, compressors should at all times be placed in the open air outside the building to be sealed.

Where compressed air is available from a stationary unit, it is desirable to have outlets arranged so that the hose will not be more than 100 feet long in any location. Nozzle pressure is important and is difficult to maintain when longer hose is used.

**Spray-Equipment Requirements**

Equipment required for the application of plastic material is basically that used for spraying paint and other viscous substances. Manufacturers of equipment listed by the Navy in their publication on OS-3602 are the DeVilbiss Co., Toledo, Ohio, and Binks Manufacturing Co., Chicago, Ill.

The products of these manufacturers have been thoroughly tested and meet the requirements of this type of spraying. Other manufacturers produce similar equipment. In the selection of these items, however, it should be noted that the material to be sprayed is viscous and of relatively heavy body. Nozzles, spray guns, and pressure pots should be selected on the basis of their adaptability to the use of plastic.

All of the spray equipment tested in the experiments by the Department was of a standard type and readily obtainable. The equipment required for the twoman operation recommended is shown in the following list:

- Four 10-gallon pressure feed tanks, 2 equipped with agitator (2 for plastic coating and 2 for webbing solution).
- Two 2-gallon pressure feed tanks (for adhesive or webbing solution).
- Six spray guns (2 for vinylite plastic, 2 for webbing, and 2 for adhesive material).
- Twelve 50-foot lengths of ½-inch fluid hose (pressure pot to spray gun).
- Twelve 50-foot lengths of 3/16-inch air hose (pressure pot to spray gun).
- Twelve 25-foot lengths of 3/16-inch air hose (compressor to pressure pot).
- One air regulator.
- One air motor (for use on agitator).
- One compressor (approximately 100 cubic feet per minute).

**Cost of Equipment**

With prices prevailing at the time of the experimental work, it was found that the approximate total cost of the spray equipment required for this operation would be $1,430. A compressor of the type used was priced at $2,500. The combined cost of these items represents a sizable investment, but it must be recognized that this equipment will last almost indefinitely and that with minor repairs and the replacement of some hose, a life of 20 years could be expected. Prorating the cost over this period would bring this item into proper perspective. This scale of depreciation is based on the assumption that the outfit will be used for not more than 6 months in any one year.

**Requirements for Small Operation**

In the event that the user of plastic has only a few storage sections to seal or if unlimited time is available in which sealing may be accomplished for a larger operation, a smaller unit (figure 8) than the one previously described may be considered. This smaller unit, operated by one man, would need a small-type com-
Figure 8.—Plastic spray equipment with small-type compressor used in experimental work for one-man operation.

pressor rated at a minimum of 30 cubic feet per minute at approximately 90 pounds pressure.

It is to be recognized that in a sealing operation the compressor runs for approximately 8 hours each day during the entire period of application. Small compressors are, as a rule, not constructed for continuous use; therefore if the smaller unit is used, it must be of the heavy-duty type. The smaller compressor shown in figure 8 was used in experimental work in Norfolk, Va., and was found to be inadequate. The length of hose required further reduced the efficiency of this unit and, accordingly, it is recommended that a heavier type of compressor than the one shown in the illustration be used.

Because of the viscous nature of sprayable plastic, it requires an industrial type of spray gun having a delivery rate of about 22 cubic feet per minute. It is believed that a compressor rated at 100 pounds and delivering approximately 60 cubic feet per minute would be desirable. The cost of this equipment, based on prices prevailing at the time of the experimental work, was approximately $1,400.

On a smaller operation of this kind, three spray guns are required and one-half of the number of the other items shown in the list on page 13.
Additional Equipment

In addition to the equipment listed for both the larger and smaller operations, spare parts consisting principally of hose connections, needles and tips for spray guns, and a diaphragm for the air regulator should be available. As explained later under the heading Safety, it will be noted that exhaust fans will be needed where interior work is done with a minimum of air space and ventilation. These fans can be of a small portable type having blades not less than 16 inches and they should be arranged so as to disturb any accumulation of saturated air.

Most tobacco-storage warehouses are supplied with some type of fire-prevention equipment. When plastic is applied, it is desirable that an extinguisher of a type suitable for use with this material be available. When plastic is stored in quantity and leakage might occur, or when filling or mixing operations are performed, it is desirable to have available either a 20-pound Ansul dry-powder type or a 20-pound CO₂ hand extinguisher. This type of extinguisher should also be placed near actual operations so that it will be handy in the event of accidental spilling of the material or breakage of the hose.

LABOR

Experience Not Required

The application of plastic coating is somewhat different from that of paint and other sprayable materials. Experience in spray painting or lacquer work is probably a handicap to anyone engaged in plastic spraying because of the wide differences in processes. Plastic does not require the blending or uniform application expected in other fields. Streaks or laps do not appear in this material and it can be applied very easily, the only necessary consideration being to build up the proper thickness and continuity of film.

In conducting the experimental work on plastic sealing, the Department received the cooperation of the Flue-Cured Tobacco Cooperative Stabilization Corp. Sealing was performed by the employees of this organization, none of whom had previous experience in this type of work. In figure 9 these men are shown performing rather difficult operations on the exterior of a storage warehouse. The movable platform on which they are working was prepared by them and designed for this work. It can be seen that adaptability and physical activity are the qualifications that are required of such employees.

Training

The employees of the Stabilization Corporation received a course of intensive instruction for 1 week under an experienced operator who trained them in the use of the equipment and the preparation and application of the material. During this course of training, problems which arose with respect to applying plastic compounds were worked out and the most effective means developed. After the completion of their training, these men studied the various new problems which confronted them and developed short cuts in their procedure.

In its training program, the Navy found that almost any applicant with normal mechanical aptitude could operate this type of spray unit and satisfactorily apply plastic materials. The Navy training period was slightly longer than that of the Stabilization Corporation employee, and the instruction covered very thoroughly the repairing and maintenance of the equipment.

While a degree of mechanical ability is obviously desirable, it is believed that practically any active man with normal intelligence can be trained in a short period to apply plastic coating efficiently.
APPLICATION

The use of plastic compounds for sealing tobacco warehouses is obviously in the earliest stage of its development. In this section the discussion or instruction is based on the experience obtained by the Department in the limited work completed in this field up to this time. It is anticipated that with wider application of plastic a much higher degree of efficiency will be developed.

Economies in Application

In view of the cost of the material it is important to stress economical application in the use of plastic. As later indicated, material costs under this method
are relatively higher than the costs of paper and mineral asphalt similarly used. The application of a thinner coating and the limiting of the coating to only a few large areas tend to effect economies as compared with estimates established for Navy application and for specialized packaging. However, economical operation should be stressed.

In any application, therefore, it is not advisable to extend the coverage of plastic beyond that point where it furnishes adequate sealing and is supported by a sufficiently wide adhesive margin. Where the material is applied to the edge of a fire door, for example, an effort should be made to seal only the crack between the door and the surrounding door jamb. In some instances, it is desirable and economical to extend the material beyond this area in order to cover hinges and fastenings or where bolt holes require sealing. Figure 10 gives an example of this type of application.

The sealing of fire doors presents a safety problem. Adequate access to the building that is being sealed must be maintained in accordance with regulations of the local fire department. It is recognized that in many instances the doors that are sealed are already blocked by the stored hogsheads. In such cases, no complication will exist.
Fire doors should be closed when sealed. If the door is not in operating condition the space should not be sealed, but the door should be repaired and closed prior to the sealing operation. In sealing over the tracks of fire doors, paper or other material should be placed over the track so that sealing materials can be rapidly removed in order to place the door in operating condition. Binding agent should never be applied directly on the track or roller of a movable fire door.

A second point to be stressed in application is the thickness of the material. It has been found that one pass of the spray gun will apply less than 0.005 inch of solution. A pass in this instance shall be construed as the slow movement of the gun from left to right and back to its starting position. Two passes of the gun will, therefore, give a coating of between 0.005 and 0.010 of an inch—a thickness entirely adequate in most instances for sealing purposes. It is evident

Figure 11.—Application of plastic sealing to interior of a warehouse.

that this application will considerably reduce over-all costs as compared with those established by the Navy in the application of a heavier coating.

Problems in Application

Fumes Inflammable

Wherever possible, plastic sealing should be applied from the outside of the building in order to avoid any fire hazard. It is recognized, as stated under the heading Safety, that the fumes of the solvents used are highly inflammable. Where inside application is desirable, concentration of fumes should be avoided by the use of exhaust fans. Where there are high ceilings or where adequate
ventilation exists, inside work is generally safe if reasonable precautions are taken (fig. 11).

**Effect of Temperature on Application**

An important consideration in this type of work is the atmospheric condition and temperature. Manufacturers of plastics state that the range of temperature for the application of these materials extends from 40° to 120° F. Because of the viscous nature of the material and the fact that the major part of the work is performed in the open air, the practical range is probably from 50° to 100° F. Beyond these extremes, working conditions would be very difficult.

In addition to the discomfort caused by working under exposed conditions or in unheated buildings, there is the further problem at low temperatures of viscosity of the plastic solution. Greater air pressure is required, and care must be exercised in order to avoid excessive application. When temperatures rise above 90° F., solvents evaporate rapidly; and in order to obtain a wet application, continuous adjustment of the spray-gun nozzle is necessary.

As previously stated, it is unlikely that a situation will be found where retarder is required. In isolated cases, however, where the temperatures exceed 100° F., such as on roofs or on walls exposed to direct sunlight, the addition of methyl isobutyl ketone, methyl hexyl ketone, toluene, or similar solutions may be necessary. If a retarder is used, care must be exercised in adding it to the solution, as excessive quantities would affect the application and permit the coating to festoon or run before drying. As the solution will be thinner and will dry more slowly with than without retarder, it may be necessary to make an additional pass of the spray gun in order to build up the required thickness.

**Weather—A Problem**

Plastic is difficult to apply in exposed locations during windy weather. Under abnormal conditions, if protection cannot be furnished in the form of a removable screen, it may be necessary to discontinue operations. In view of the fact that webbing consists of spraying fairly light threadlike strands into the air, it is necessary to provide protection from the wind. Large plywood sheets, hinged together to form an easily portable screen, have been used effectively as a wind-breaker. Considerable time will be saved if such steps are taken to afford adequate protection. If this type of work cannot be protected, it must be delayed until more favorable weather conditions prevail. Plastic coating is easier to apply than webbing and only where extremely high winds occur will any difficulty be found in applying plastic material.

During rainy periods it is extremely difficult to apply plastic unless the work can be performed under sheds or on the inside of buildings. Plastic will not adhere to wet surfaces; therefore areas to be sealed must be allowed to dry thoroughly before work is continued.

**Oil—Grease—Dirt**

The only other condition under which plastic cannot be applied is on oily surfaces. If oil or grease has penetrated into building materials, other methods of sealing must be adopted. Where the grease or oil is on the surface and can be removed with kerosene, Stoddard solvent, or other similar materials, satisfactory application is possible.

It is to be noted at this point that binding agent will adhere readily to all types of dry building materials. In warehouses where deposits of dust and scrap exist, the force of the air pressure from the spray gun tends to clean the surface, and the sealing, in all instances, is effective even under extremely dirty conditions.
Figure 12.—Removing strippable plastic from sealed fire door.

**Strippable or Permanent**

Plastic coating, when sprayed without an adhesive base, is strippable and does not adhere permanently to the surface on which it is applied. This is demonstrated in figure 12, showing the removal of the coating from a sealed door.

When sprayed into cracks and small holes, plastic will remain almost indefinitely and, except for shrinkage, will maintain its sealing qualities. Webbing compound will not adhere to surfaces permanently, and unless bound with adhesive, or covered with a plastic finishing coat, will not remain in position for any ex-
tended period of time. It should, therefore, be covered with the finishing coat as soon as possible after application.

Although plastic is generally strippable and easily removable, it becomes a more or less permanent coating when properly applied with binding agent forming a base, and will withstand a considerable amount of rough treatment.

Plastic material shrinks as it dries and tends to shrink further with aging. The amount of binding agent used should be in relation to the size of the opening to be covered and in no instance should it be applied in a band less than 2 inches wide around the perimeter of the area to be sealed. This method of application will prevent shrinkage from pulling the plastic away from the surface and thereby breaking the seal. Where sealing is required in a corner where two surfaces adjoin, such as is found under the eaves of the building, it is essential that a strip of binding agent be applied directly in the apex of the angle, as well as on the two margins, in order to keep the shrinkage from drawing the material across the corner.

**Use of Webbing**

Webbing compound is needed on any crack in excess of \( \frac{1}{4} \) inch; its application is demonstrated in figure 13. On an opening or a void in excess of 18 inches, it is necessary to break the opening into smaller sections by the use of strips of tape. Webbing will bridge a space 18 to 24 inches wide, but beyond that point application without support is not practical. As an illustration, a window 36 inches wide by 72 inches high would require one center strip from top to bottom with three cross strips evenly spaced.
Webbing agent sprayed from a standard spray gun produces long cobweb-like filaments that bridge over the gaps or voids to be sealed. In the event that taping has been used to reduce the space, these filaments do not pass through the grid or space but will attach themselves on each side of the gap. This crisscross spraying should be continued until a translucent film having the appearance of a fairly thick cobweb is built up. It need not be a solid sheet but only strong enough to withstand spraying of successive coats of sealing compound without rupturing. It will tend to sag when first applied but as it dries it will shrink and form a tight background. Under normal temperatures webbing will be sufficiently dry within 10 or 15 minutes and ready for the final application.

**Coloring for Inside Work**

When spraying the interior of a building where visibility is poor, coloring agents may be added to the plastic in order to bring out distinctly the area sprayed.

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*Figure 14.*—Small cracks in concrete wall sealed with plastic.

Yellow, red, and blue dyes were used by the Navy but have not been found practical for permanent application. They can be used, however, as the material fades with aging and the resulting color will not be objectionable.

**Preparation of Material**

In figure 3, page 5, plastic compound is shown in the pressure pot ready for application. When webbing agent is added or when pigment is required, it is necessary to agitate the solution until it is evenly mixed. Agitation is also required in cold weather when webbing solution sometimes separates after stand-
ing or when the temperature causes the solution to become too thick to be properly sprayed. Pressure pots should be equipped with an agitator operated by an air motor (fig. 6), which, in addition to performing the work, will accelerate the operation.

How To Apply Plastic

In the application of plastic solution the background to be sprayed must be considered. Air pressure tends to blow the plastic through small openings and it is desirable to make the first pass with the spray gun relatively light in order to form a foundation. It has been found that in spraying against webbing, the guns should be held at a sufficient distance (see fig. 17), approximately 12 to 18 inches initially, and moved closer on finishing passes, so that the background is not torn or displaced by the pressure. In spraying large solid surfaces the spray gun should be held from 6 to 8 inches from the surface to be sprayed, whereas on cracks or crevices, such as those shown in figure 14, it should be held very close to the surface, thereby eliminating unnecessary coverage.

The distance at which the gun is held from the object being sprayed affects the wetness or dryness of the application. The greater the distance the drier the resulting coat. A relatively wet application is desirable and should be maintained except where runs are apparent in the application. Wherever these develop either the gun should be held farther away or an adjustment in the spray nozzle should be made.

In figures 15 through 18, steps in the sealing of an opening are shown. Figure 15 shows that the binding agent has been applied directly to the tile wall. The second step shows webbing being applied; the third, the spraying of the finishing coat. In figure 18, the damaged wall is seen to be adequately sealed.

Backgrounds of Cheesecloth, Paper, and Wire

In covering large openings, where an excessive amount of webbing solution would be required, cheesecloth or similar material may be used as a background. The basic solution (without webbing) is applied directly on this foundation, and satisfactory results are obtained. In some instances where too much draft or air pressure exists, cheesecloth has a tendency to sag, and this type of application is not satisfactory.

When many large doors and windows are to be sealed, paper can be applied over the openings and the seams and edges sealed with plastic at a much lower cost than if the solution were applied over large areas. Sisalkraft paper of a heavy grade is desirable. This type of sealing should be used only in protected locations, as the paper seal will not stand exposure to the weather. The use of plastic is recommended when there are relatively few openings of this nature and the material is available, as the cost is not prohibitive, considering the saving in labor.

Plastic coating should not be sprayed directly against a rigid, porous background, such as wire screen. The air pressure tends to blow the material through the background, leaving minute holes which affect the final result.

Temporary Sealing of Screened Openings

In sealing screened doors and screened ventilators it has been found that sisal-kraft paper may be used advantageously. The first step is to apply a margin of binding agent around the frame of the door. Paper adheres to this margin and as a final step the seams and edges are sealed with plastic coating. This sealing gives a gastight result and it is readily removable when fumigation work has been completed. Figure 19 shows an example of this type of application.
Figure 15.—First step in sealing an injury to hollow-tile wall. Binding agent has been applied.

Figure 16.—Second step. Application of webbing compound.
Figure 17.—Third step. Application of plastic coating. Note distance of spray gun from webbed background.

Figure 18.—Injury in hollow-tile wall completely sealed with vinylite plastic.
Doors

The sealing of a roll-down steel fire door presents a serious problem when work is to be accomplished with the use of mineral asphalt and paper. When plastic is used, however, the operation is greatly simplified. In figure 13 on page 21 webbing is being applied to a door of this type. It is to be noted that the wide cracks around the perimeter of the door are being webbed, following the application of binding agent. In figure 20, a section of the completely sealed door is shown. Sealing with plastic does not affect the operation of the door in the event that it must be opened and in most instances, after reclosing, it is only necessary to repair the injury around the perimeter.

On wooden doors where a considerable number of cracks are to be sealed it may be found more expedient to seal the entire surface with plastic. In this case, binding agent would be used only on the edge, with a strip or two applied on the surface of the door to keep the material from loosening or flapping.

Eaves, Flashings, and Skylights

Eave areas of buildings can be readily and economically sealed with plastic at a considerable saving in both labor and material as compared with methods
previously employed. Where shed roofs adjoin the wall of a building, as illustrated in figure 21, plastic is easily applied and it makes a very satisfactory seal.

Plastic materials may be used in sealing flashings, skylights, and ventilators in warehouse roofs. It is more economical and practical to seal these openings from the inside where this is possible. Work on the roofs of the buildings is complicated by the amount of hose required, the distance from the compressor, and the corresponding loss of nozzle pressure at the spray gun. Where this work can be done, plastic will form an adequate seal and resist weathering and the direct rays of the sun. Under Equipment are listed items required for the operation of a spray unit. It is to be noted that a recommendation is made for the use of 100 feet of both air and fluid hose. It can be seen that working at this or greater distances from the compressor will seriously affect the free air delivery. Charts indicate that at 80 pounds pot pressure an approximate 25-percent loss would result at the nozzle. It also is important not to exceed this range of operation unless serious consideration is given to the loss of pressure brought about by the additional hose required.

An outside wall constructed of hollow tile is shown in figure 22 with cracks and imperfections sealed with plastic material. This sealing, which would be extremely difficult under any other method, makes the wall entirely gastight. It is obvious that the labor required to seal such a wall with plastic roofing cement

![Figure 20.—Close-up of roll-down steel door sealed with vinylite plastic coating. Note application of plastic to surface of door.](PMA 17503)
or calking compound would be a sizable item. Plastic in an operation of this kind can be easily and rapidly applied and the cost of labor, as compared with that for other sealing methods, correspondingly reduced.

**Removal of Plastic**

Vinylite plastic is a strippable compound and can be readily removed from any surface where binding agent has not been applied. In removing it where adhesive has been applied, the use of a solvent may be necessary; or, if the surface is smooth, it can be readily removed by scraping.

![Figure 21](10097)

*Figure 21.—Eave area sealed with plastic, showing sprinkler pipe and fire-door track sealed to concrete wall. Note: Plastic should not be applied directly to track.*

The material is not highly injurious to the hands. Gloves should be worn, however, while spraying, particularly by persons having hairy hands. If gloves are not available, an oily lotion should be applied to the hands to prevent sticking of the plastic. Plastic can be removed from the hands or clothing and tools after it has dried or at the end of the day.

Plastic will not harden or set when kept in airtight containers. It can be carried over in the pressure pots from day to day. Guns, however, must be cleaned with
thinner at the end of each day's operation. This operation should be performed in the open air whenever possible, but, in any case, where adequate ventilation exists. Hose should be blown out, as it is extremely difficult to clean after the material has hardened. When a sealing program has been completed, all equipment, including hose, should be carefully cleaned and blown out with compressed air. This operation is shown in figure 23.

**Maintenance**

Plastic sealing is an innovation. Until it becomes well known, the public will continue to be attracted and fascinated by it. It has been observed that laborers and visitors around warehouses that have been sealed continue for some time after its application to pinch and punch holes in the sealing material. Instances have occurred where samples have been removed with the use of a pocketknife or other sharp instrument. This human curiosity has a tendency to decrease as familiarity with the material increases, and after a period of several months it is reduced to a minimum. In the meantime, however, a considerable amount of patching and replacement is necessary with plastic sealing in order to maintain an effective seal.

Actual maintenance requirements, due to aging, checking, and normal injury, are relatively small and the belief is that plastic sealing will probably need less care than paper sealing. In connection with the Department's work at Charleston, S. C., it was observed that one solid fire door had been moved approximately 3 inches without injury to the seal. This indicated that plastic retains its elas-

*Figure 22.—Hollow-tile fire wall sealed with plastic. Note the number of cracks and imperfections which have been sealed.*
ticy and tensile strength sufficiently to wear well under adverse conditions. Patching can be done easily, and additional coats adhere to the original application and are not unsightly.

COSTS AND COMPARISONS

Labor Saving

In approaching the subject of costs and of the savings to be effected by the use of plastic, as compared with other materials, it is to be recognized that to a large extent the reduction in cost is attributable to the difference between the amount of time (man-hours) required for the application of mineral asphalt and paper and for the application of plastic sealing compound. The limited scope of the operations studied would seem to make a comparison difficult; however, the variation between the time involved in the two types of operations is so extreme that one conclusion is possible. The application of plastic sealing, material and labor both being considered, results in a definite saving as compared with other methods.

Paper and Mineral Asphalt

In sealing a group of storages at Wilmington, N. C., with paper and mineral asphalt, a total of approximately 366 man-hours was required to seal one floor of a particular section. This amount of labor held very consistently throughout the four two-story sections which were sealed. Fumigations subsequently made at this warehouse indicate that an extremely satisfactory job had been done. Paper

Figure 23.—Cleaning plastic spray equipment in the open air.
was applied on wooden frames and all joints were carefully sealed with mineral asphalt. In these units 3,584 square feet of paper was required for the walls in addition to that used for the sealing of windows, ventilators, and doors. If plastic had been used in this operation complete wall surfaces would not have been covered but only cracks and other openings would have been sealed. The size of each of the eight units was 128 by 100 by 14 feet. Materials used accounted for only $67.06 out of a total of $327.70. Labor at 70 cents per hour with supervisory labor at $1.07 an hour made up the difference of $260.64.

As an additional example of paper and mineral asphalt sealing, the following figures are quoted on a section of the new concrete storages at Newport News, Va. In this operation a total of $15.38 was expended for sealing, out of which materials amounted to $6.28, with 13 hours of labor accounting for $9.10. These warehouses represent a perfect example of tobacco-storage facilities from a fumigation standpoint and only a limited amount of work was necessary to seal them for fumigation.

Plastic Sealing

At Norfolk, Va., a single section, 160 by 140 by 17½ feet, was completely sealed with plastic. This operation was performed at a total cost of $235.85. Labor was included at the rate of $1 per hour for 54 hours. Materials used—plastic, gasoline and oil for the compressor, and sisalkraft paper and mineral asphalt (used in locations which were inaccessible for the use of plastic because of the arrangements of the stored tobacco)—totaled $181.85. The sealing of the Norfolk warehouse included four 12-foot by 14-foot doors, twenty-two 3-foot by 8-foot windows, 260 feet of shed flashing, 120 feet of cracks where sheds adjoin the building, and approximately 100 small holes and cracks in the concrete walls of the warehouse. The sealing of this section, it is believed, is comparable with the work performed at Wilmington. The use of plastic resulted in a saving of over $90 as compared with the cost for the established method. In arriving at the amount saved, it should be noted that plastic materials were included at top retail prices and that labor was included at a higher rate than at Wilmington. It can be seen, therefore, that the figures quoted are conservative and that the actual saving was probably greater than that shown.

The plastic sealing of a warehouse section at North Charleston, S. C., required labor amounting to 6 hours and 10 minutes at $1 an hour. Inside measurements of this section were 160 by 100 by 19 feet. Plastic sealing was applied to the end walls, the two 12-foot by 14-foot doors, and also two small 3-foot by 8-foot doors. Many small holes and cracks in the hollow tile walls were sealed. Materials in this operation, including gas and oil for the compressor, amounted to $72.83.

In this instance roof flashings, due to their inaccessibility, were sealed with calking compound, asbestos roofing cement, and roofing felt. It is estimated that approximately 20 man-hours was required for this work in order to seal effectively 320 feet of flashing. The cost of this operation per section amounted to approximately $61 for labor and materials and must be added to the over-all cost for one section. Plastic sealing was not considered practical, as it would have been necessary to use more than 300 feet of hose and the loss of nozzle pressure would have seriously affected the efficiency of the operation. Had it been possible to seal this unit prior to the storage of tobacco, plastic could have been applied from inside the building. The time of application would probably have been reduced but in any event would not have exceeded that required for sealing this flashing area by other methods.

In quoting the costs of the various plastic operations listed, the price of materials was based on the amount used for the individual section. By purchasing plastic materials in quantity a substantial reduction in price could be obtained.
Construction of Warehouses

In the foregoing comparisons consideration must be given to the type of building to be sealed. In the first instance at Wilmington, the warehouse is an old-type, brick-wall, heavy mill-construction building with two floors divided into four sections each.

The storage units at Newport News are modern reinforced-concrete and steel-type buildings. The doors, windows, and ventilators are so constructed that very little sealing is necessary to place them in fumigable condition. It is believed that, in this instance, even with the limited amount of work necessary, plastic could have been applied in a shorter time.

At Norfolk, Va., the warehouses have brick fire walls and are built of reinforced concrete, with some stucco included. In the construction of roofs and sheds, wood and composition roofing material are used. These warehouses are not in good condition from a construction standpoint because of wartime operation.

Warehouses at North Charleston, S. C., are largely constructed of hollow tile, with wood and composition roofing and sheds. Less sealing was required on these buildings and the Navy equipment, used for sealing work, was of the more efficient type. It is to be recognized, in this instance, that the situation is not comparable with any of the other examples; however, the extremely limited amount of labor required illustrates the efficiency of plastic application.

Cost of Plastic Materials

Established costs, based on square-footage application of plastic coating per gallon, are not applicable to an analysis of this kind. Very little sealing in a tobacco warehouse can be figured on a square-footage basis.

At the time experimental work was performed by the Department, the cost of plastic material was approximately $3 per gallon in 50-gallon drums, f. o. b. factory, with a slight quantity discount allowed. Webbing agent was quoted at approximately $3.75 per gallon in 50-gallon drums, with sealing compound at approximately $7.25 on the same basis. Pigment, used in much smaller quantities, would not affect materially the over-all cost of this material when added to the bulk price. These prices were used in calculating the cost of the various plastic-sealing operations mentioned in this publication. They are based on minimum quantities of material, and it is recognized that quantity purchasing will effect further reduction in the cost of plastic sealing as compared with that of other methods. It is also believed that with the more extensive use of plastic for sealing, a further reduction can be effected in the cost of these compounds.

SAFETY

Limited Fire Hazard

Vinylite plastic, when dry, is not a fire hazard. It will burn when in contact with flame but does not carry it readily. The solvents used, however, are highly inflammable, methyl ethyl ketone having a flash point of 19° F. or −7° C., and acetone a flash point of −4° F. or −20° C. Acetone, despite its lower flash point, is being used more extensively as a solvent at this time. It is a less expensive ingredient and is equally as satisfactory. As these solvents are highly volatile and dissipate rapidly, there is danger at any time when a concentration of fumes occurs during actual application.

When adequate precautions are taken it is not likely that a serious fire hazard will develop in tobacco warehouses by the use of plastic materials. However, it
would seem desirable to consider this question in each instance for the particular warehouse being sealed. Investigations made by the Department indicate that in instances where plastic was sprayed in booths and in confined quarters, there was little or no danger if exhaust fans were properly operated.

Plastic materials, owing to the inflammable and explosive nature of the solvents, require special equipment in case of fire. Water buckets, sand, and extinguishers of the type usually found in tobacco-storage warehouses are not adequate for use in fighting fires developed from plastic spraying. A special type of extinguisher is recommended by the Department. The 20-pound Ansul dry-powder type or the 20-pound CO₂ hand fire extinguisher should be adequate. It is essential that this equipment be located where it will be available during all phases of the sealing operation.

When plastic compound or any of its component parts have been spilled, or when seepage occurs from leaking drums, any accumulation must be allowed to dry thoroughly before closing the doors of the room, or building, where such a condition exists. As has been pointed out, there is no fire hazard in this material after it has thoroughly dried, and dried residue may be disposed of in ordinary trash containers. Semidried or wet materials should not be placed in closed drums or trash containers but should be allowed to dry thoroughly before they are disposed of.

**Proper Ventilation**

In tobacco warehouses where there is generally considerable airspace and where adequate ventilation is available, there is little or no hazard in the use of this material. In order to avoid any concentration of fumes, it is essential that exhaust fans be kept in operation where plastic is being applied inside any building. Forced ventilation will largely eliminate the fire and explosion hazards connected with the application of this material and, if other safety measures are followed, the danger will be reduced to a minimum.

In the introduction of this publication it is stated that the fumes of the solvents are toxic where a concentration exists. It is unlikely, except where operations are performed in closed quarters, that this toxic condition will be hazardous. Should it be found necessary to have operators work for long periods in a very limited space, all safety measures should be taken and masks for the operators should be supplied.

**Regulations of the Navy**

No smoking should be the rule on the job whether inside or outside, and smoking should not be allowed at any time where substantial quantities of any material are open to the air, especially when spray guns or other equipment are being cleaned. The following statement is an excerpt from Navy Safety Regulations, issued October 17, 1946:

1. **SMOKING**

When spray packaging is being done in the open air there shall be no smoking nor lighting of matches within 20 feet of spraying or mixing operations.

   *Positively no smoking shall be permitted in enclosed spaces during such operations.*

2. **SPARK-MAKING APPARATUS**

   There shall be no spark-making apparatus permitted within 20 feet of spraying or mixing operations.

   This includes electrical and acetylene welding, and all types of electrically operated equipment such as motors, generators, control relays, etc. All electrical circuits shall be dead within the spray packaging area and there shall be no welding permitted in any part of the ship directly above the restricted zone.
3. NONSPARKING SHOES
All members of the spray packaging team or other personnel engaged in the packaging operation within the hazardous area shall wear rubber or canvas shoes in order to avoid the hazard of sparks from shoe nails.

4. SPRAY PACKAGING IN CONFINED QUARTERS
Confined quarters shall be thoroughly ventilated during spraying operations so that the concentration of solvent vapors never becomes great enough to produce a health or explosion hazard. All mixing operations shall be accomplished in open air.

5. GROUNDING OF SPRAY GUNS
The guns used in spray packaging shall be grounded to the steel deck or other permanent steel part of the ship's structure at all times during the spray packaging operation. This may be accomplished by the use of a stranded copper wire conductor wound around the spray hose from the gun to the pressure feed tank. One end of the conductor shall be connected to the spray gun and the other end shall be grounded to the pressure feed tank. The pressure feed tank shall remain in contact with any metal structure of the ship at all times during the spraying operation. The spray gun shall be used with bare hands, thereby grounding the body of the operator during the packaging procedure.

6. PRECAUTIONS AGAINST NONGROUNDED METAL PARTS ON SPRAY PACKAGES OR EQUIPMENT BEING PACKAGED

Particular precautions shall be observed to prevent the directing of the sprayed plastics or ventilating air stream against nongrounded metal objects. Parts such as steel contour rings mounted on wood decks, metal structures built into the plastic wall of the package, or any other isolated metal part of the object being packaged should be grounded prior to any packaging.

These regulations, insofar as they apply to steel decks and problems which would be met by the Navy, are not applicable for use in the tobacco industry. However, certain points should be stressed in addition to those previously mentioned in this publication. Paragraph 2 of the Navy regulations applies with respect to electric circuits in tobacco warehouses. Grounded conduit could cause an explosion when spraying is in progress; thus it is a requirement that electricity be cut off wherever this condition exists.

Paragraph 4 is particularly pertinent, and it should be stressed that all mixing operations shall be accomplished in open air. In tobacco-warehouse work it is not considered necessary to stress the use of rubber-soled shoes or the grounding of spray guns or other equipment.