

AN EVALUATION OF THE SERVICEABILITY  
OF CALCIUM CHLORIDE BAGS

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Research Laboratory Division  
Office of Testing and Research  
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Michigan State Highway Department  
John C. Mackie, Commissioner  
Lansing, March 1959

## SYNOPSIS

This report describes the testing of calcium chloride bags to determine their adequacy in protecting their contents during shipping, handling, and storage. Bags furnished by three calcium chloride producers were subjected to various accelerated exposure tests with the following results:

1. During brief periods of storage and under normal handling procedures, all bags were satisfactory.

2. Under severe exposure where bags might come in contact with free moisture or high relative humidity, the bags furnished by Solvay and Columbia were superior to those furnished by Dow-Wyandotte.

3. Several structural weaknesses were noted in the Dow bag which impair its serviceability. The manufacturer should be able to correct these defects easily and inexpensively.

4. The tests used in this study correctly duplicated conditions reported from the field, but at a more accelerated rate.

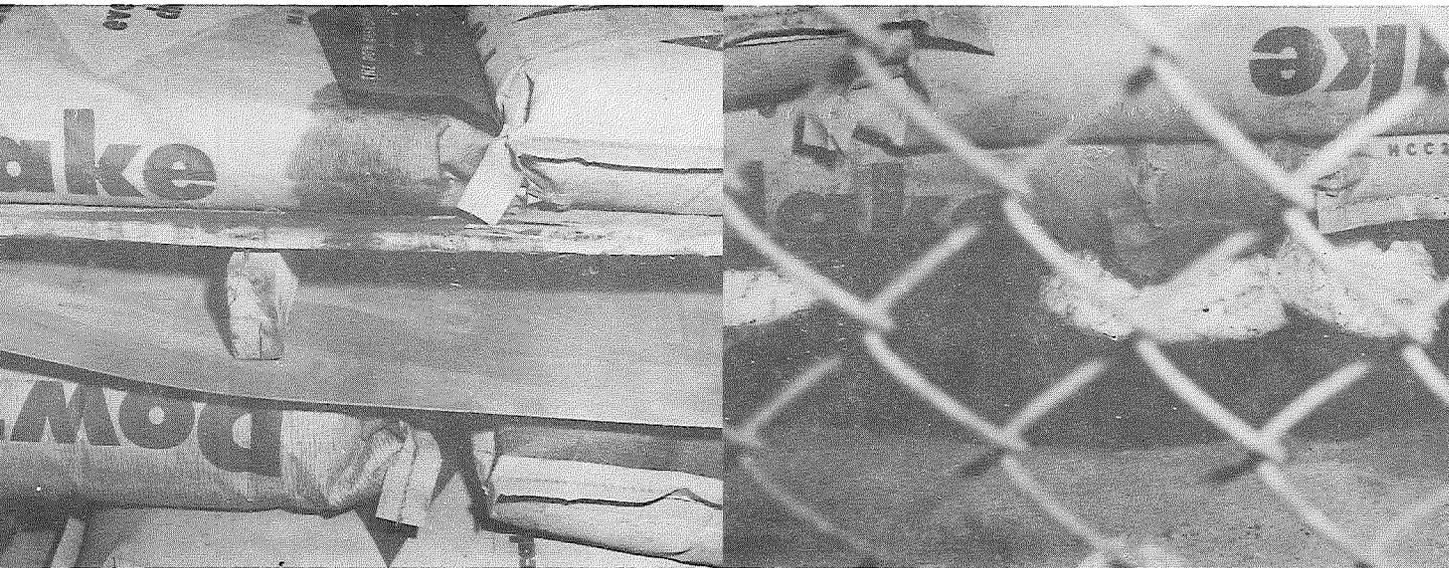
## AN EVALUATION OF THE SERVICEABILITY OF CALCIUM CHLORIDE BAGS

Calcium chloride is a very hygroscopic material which readily absorbs moisture from the air or from other available sources, and which, if sufficient moisture is present, will dissolve in the moisture it attracts (deliquescence). If, as is usually the case for bagged material, insufficient moisture is present to allow complete dissolving, the moistened portion of the material cakes and forms hard lumps. In some cases, entire bags become too hard for use in normal spreading operations. For this reason, specifications covering the purchase of calcium chloride require that it be furnished in moisture-proof containers, and that the material may be rejected when found to have become caked or sticky in the container, before opening.

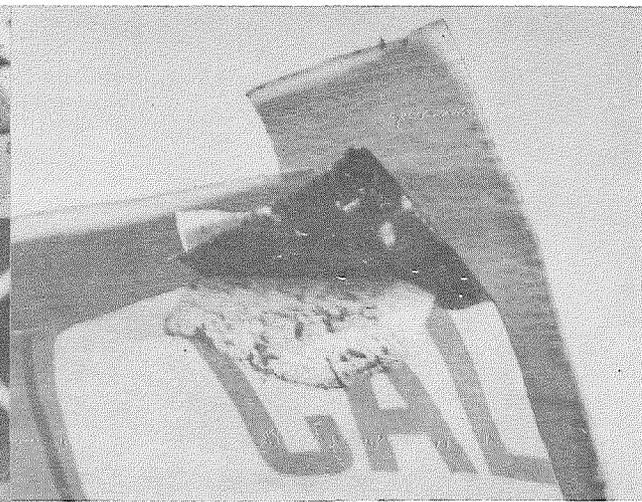
During recent months, the Office of Maintenance of the Michigan State Highway Department has become increasingly concerned about an abnormally large number of calcium chloride bags, all furnished by the Wyandotte Chemical Company, which have not properly protected their contents during storage. This has resulted in considerable inconvenience, as well as a loss of calcium chloride due to hardening and spillage from wet bags. Figure 1 clearly illustrates a typical example of calcium chloride deterioration during storage. This particular material had been stored for about a month under the Michigan State University stadium during December and January, and had not been exposed directly to the elements.

Such conditions are particularly undesirable during the winter maintenance season, when the presence of defective material could be a serious obstacle to proper ice control procedures. The willingness of producers to replace unusable material is but poor compensation for loss of time, increased handling problems, and possible blame for highway accidents.

Consequently, at the request of the Office of Maintenance and with the authorization of R. L. Greenman, Assistant Testing and Research Engineer, a project was undertaken by the Research Laboratory Division, to evaluate calcium chloride bags as furnished by different producers.

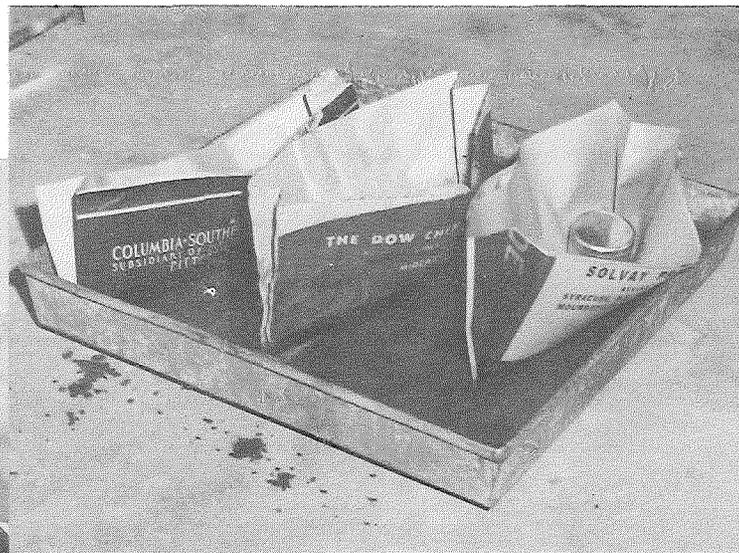
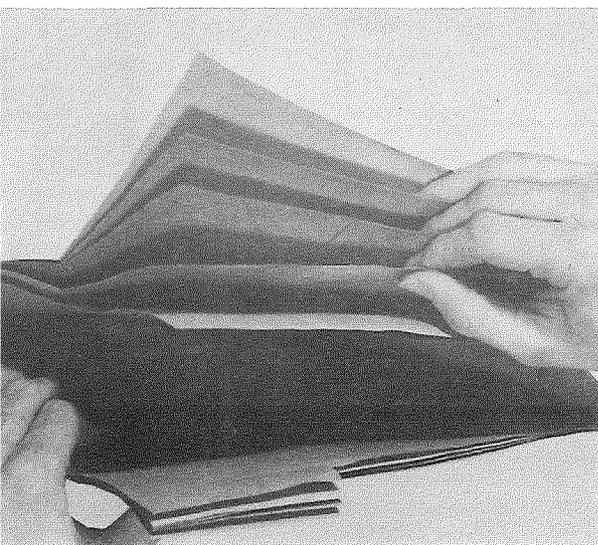


▲ Figure 1. Typical deterioration of calcium chloride bags during storage.

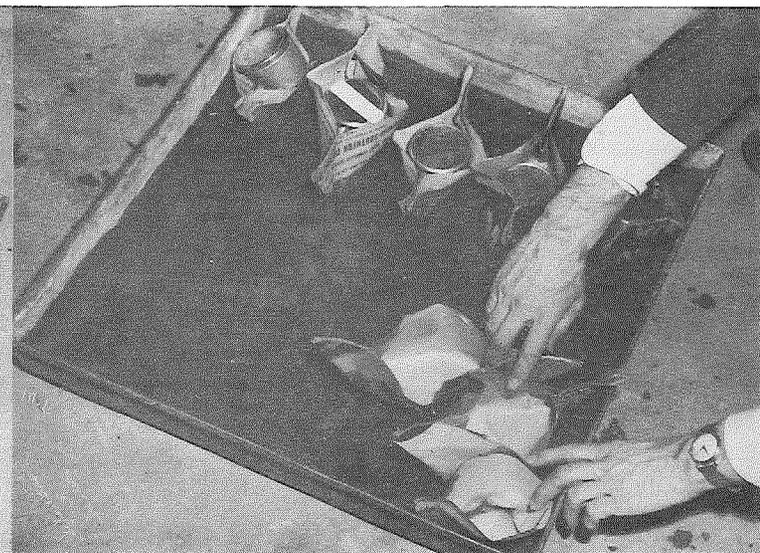


▲ Figure 2. Section of Dow-Wyandotte bag showing asphalt layer between Kraft paper.

Figure 3. Section of Solvay bag showing fine-ply construction.



A. Bottom Sections.



B. Seams, Joints and Gusset Edges.

▲ Figure 4. Method used to check various bag sections for moisture penetration.

## CALCIUM CHLORIDE BAGS TESTED

There are three major producers of calcium chloride: Dow Chemical Company; Solvay Process Division of Allied Chemical and Dye Corporation; and Columbia-Southern Chemical Corporation, a subsidiary of Pittsburgh Plate Glass Company. The calcium chloride furnished by Wyandotte Chemical Company is produced, bagged, and shipped directly by the Dow Chemical Company.<sup>1</sup> The form of bag used by Dow and Wyandotte is identical and will be referred to in this report as the Dow-Wyandotte bag. The bags used by Solvay and Columbia are similar to each other but entirely different from the one made by Dow.

Because all of the storage problems reported concerned the Dow-Wyandotte bag, a trip was made to inspect the procedures used in its construction and testing. For this reason, a more lengthy description of such operations is given for the Dow-Wyandotte bag than for those made by Solvay or Columbia.

### Dow-Wyandotte Bag

The Dow-Wyandotte bag, made entirely in Dow's Bag Plant, is constructed of heavy machined creped sheets of Kraft paper, laminated with asphalt, and reinforced with a glass yarn diagonally criss-crossed on a 9/16-in. spacing. A section of this construction is shown in Figure 2. The paper is of such water resistance as obtained by normal rosin sizing and is treated to prevent oils in the asphalt from staining either the paper or the contents. Gusset type construction at the sides of the bag provides rigidity and allows the bag to be held in place more easily during filling. Apparently this advantage is considered more important than possible weakening of the asphalt and the bag structure along the folded seams.

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<sup>1</sup>Dow also furnishes high-test calcium chloride (Peladow) to Solvay, but that material is packaged in Solvay bags.

The bag is made from flat stock, folded into a tubular form, trimmed to desired length, shaped, and sealed at the bottom by sewing through glued tape with the stitching left exposed. After filling, the top is sealed in a similar manner.

Considerable effort is made by Dow to produce an outstanding bag both from a strength and a moisture resistance standpoint. All material used meets rigid specifications and the finished product is subjected to numerous acceptance tests. The most impressive of these is the "drop test" in which the bag and contents are dropped a distance of 4 ft onto a solid surface. Dow bags, filled with 100 lb of flake calcium chloride, must withstand 40 such drops on their flat areas and 3 drops on each gusset edge. The bags are much weaker per unit area along the gusset edge than along the flat portion of the front or back. The pellet form of calcium chloride (Peladow) requires a stronger bag than does the more interlocking flake form.

#### Solvay Bag

A section of the Solvay bag is shown in Figure 3. This bag is of relatively simple construction consisting of five heavy paper bags nested one within another. The fourth layer from the outside is lined on the inner side with a water repellent polyethylene coating which provides the bag's basic moisture resistance. The outer layers provide strength and resistance to puncturing, while the inner ply gives additional strength and protects the waterproofed layer from possible abrasion due to direct contact with the calcium chloride. The end closures are made with double seal strips of asphalt treated paper. The first strip is stitched to the bag; the second, a wider strip, is glued to the bag over the first strip. This gives increased strength at the base and prevents moisture entry through the stitched holes.

Solvay's bag is made by Multiwall Bag Division of Owens-Illinois Glass Company.

#### Columbia Bag

Columbia's bag is similar to Solvay's except that it is of four ply construction rather than five and the end sections are sealed differently. The polyethylene waterproofed layer is placed second from the inside, the same as in the Solvay bag, with but two outside protective layers.

The ends are closed by stitching directly through the bag, and then applying an asphalt-treated strip to protect the exposed stitching and provide a moisture barrier along the joint.

The Columbia bag is furnished by Bagpak Division of International Paper Company.

## TESTING PROCEDURES

Because the main trouble reported concerned the inability of some bags to protect calcium chloride from moisture, all testing procedures were designed to simulate moisture conditions that might be encountered under adverse field storage and handling conditions. No quantitative strength tests were made although the general effects of moisture on this property was noted during the tests.

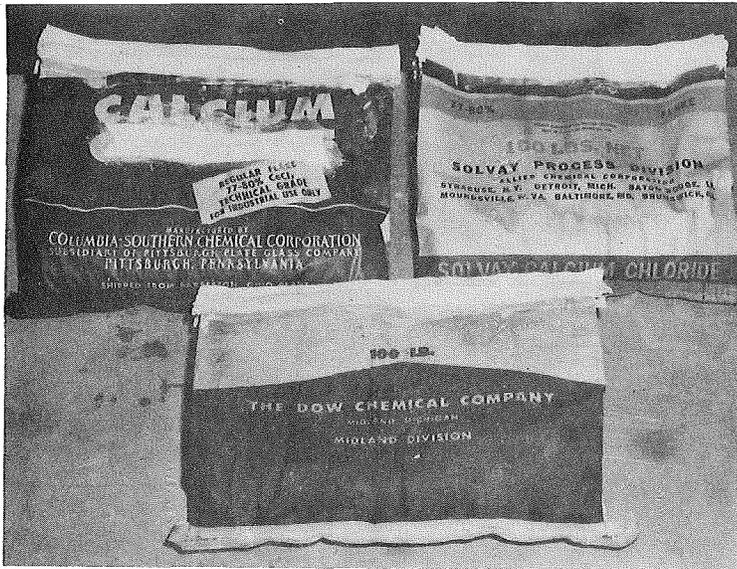
### Immersion

This form of test was used to determine, rapidly, any defects in bag construction that might allow water entrance through either the paper itself, the seams, folded gusset areas, or sewed joints. Figure 4 shows the method used in this test to check water resistance of different sections of each bag.

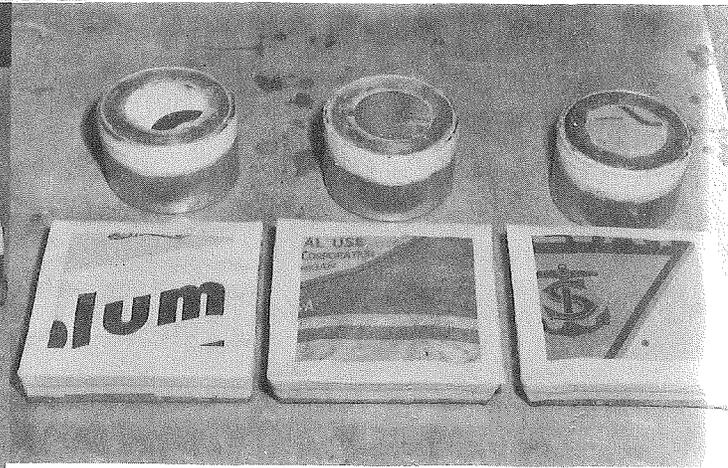
### Moisture Absorption

Moisture absorption tests were made by placing enclosed samples of calcium chloride, protected by the bag or a bag section, in an atmosphere of 100 percent relative humidity and in an outdoor atmosphere of varying humidity. In these tests a weighed amount of calcium chloride was placed in a container and periodic changes in weight due to moisture absorption were recorded. After 30 days of exposure the container and contents were examined, and weighed together and individually.

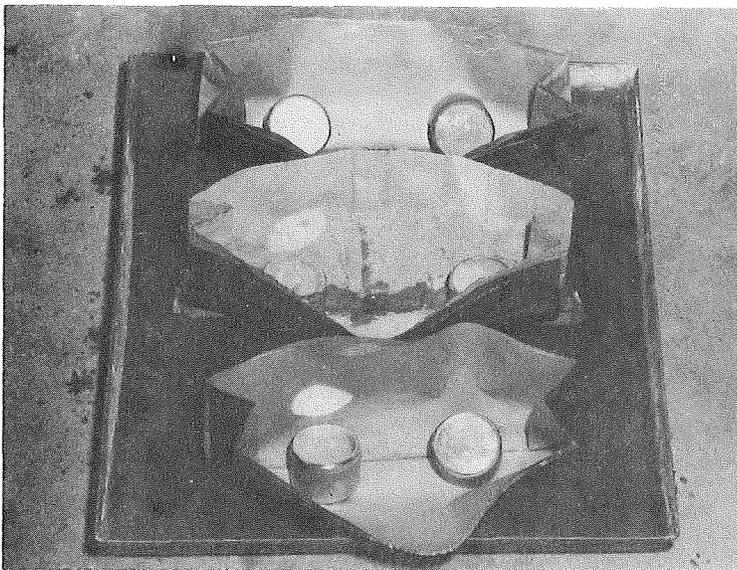
Figure 5 shows bottom sections of each bag type filled with 3,500 grams of regular calcium chloride flakes, before being placed in an atmosphere of 100 percent relative humidity. All artificial openings were securely taped and sealed with paraffin. The samples were placed in a concrete curing moist room, each resting on open supports to prevent puddling of water around the bag bottoms.



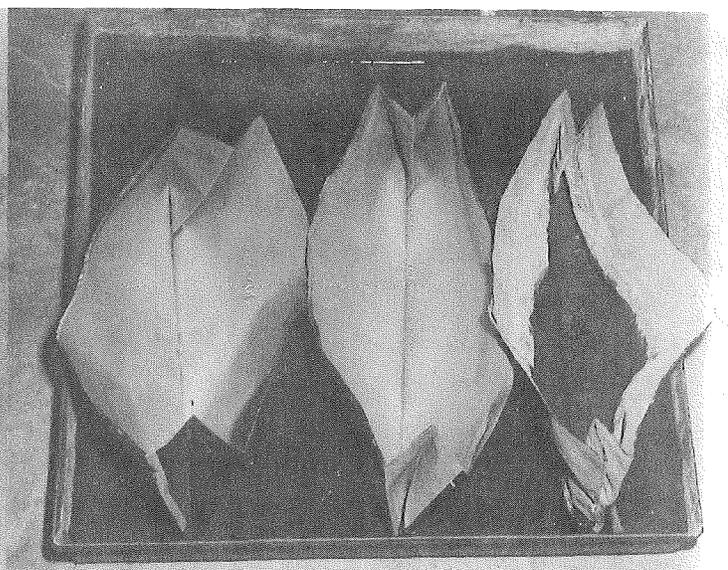
▲ Figure 5. Bagged calcium chloride prepared for exposure to 100 percent relative humidity.



▲ Figure 6. Containers of calcium chloride covered with flat bag sections, prepared for exposure tests.



A. 5 Minute Immersion



B. 30-day Immersion

▲ Figure 7. Effect of immersion on bottom sections of bags.

Figure 8. Appearance of bags before opening after 30-day exposure in humidity room.

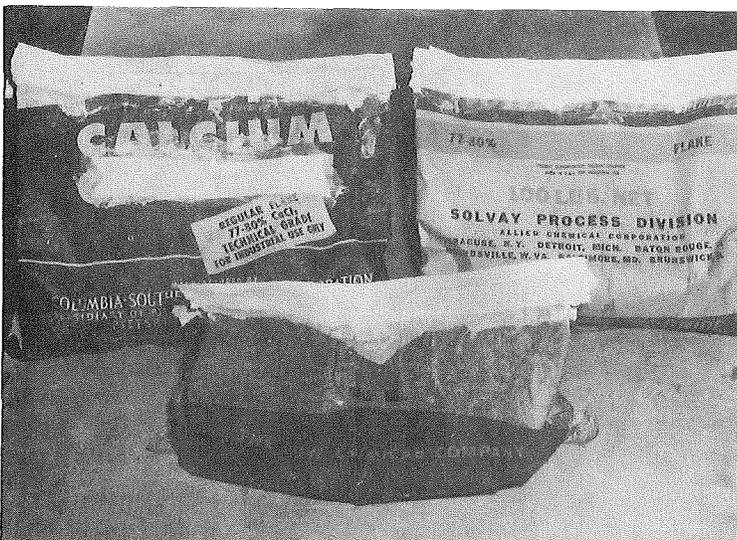


Figure 9. Appearance of calcium chloride after 30-day bag storage in humidity room.

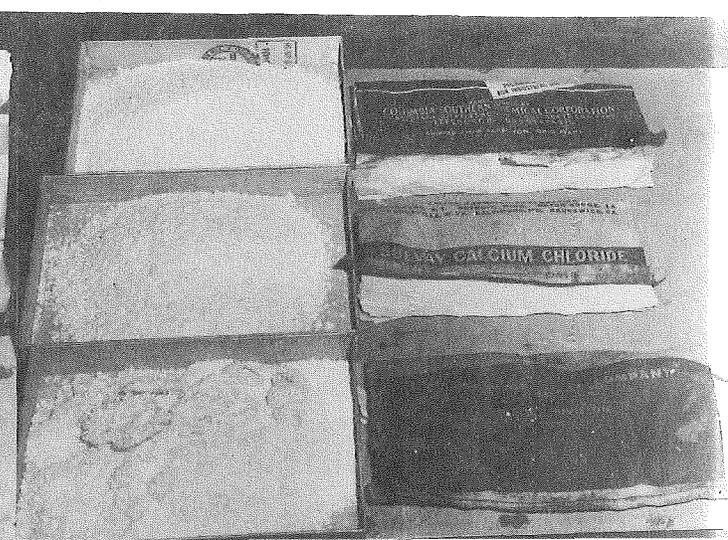


Figure 6 shows other forms of samples used. Each circular can was partially filled with calcium chloride and the top covered with a flat bag section containing no joints, bent sections, or seams. The sample was so prepared that any moisture increase to the calcium chloride would have to come through the bag section. The calcium chloride was not in contact with the bag section during this test. These samples were placed in the 100 percent relative humidity room.

The square containers shown in Figure 6 were filled to the top with calcium chloride and covered with flat bag sections. These sections were securely taped to the container and the edges sealed with paraffin so that, as in the case of the circular samples, any moisture penetration would have to be through the bag section cover. These samples were placed out of doors protected from direct exposure to the elements. The bag covers were in contact with the calcium chloride.

In all tests the samples were surface dried at room temperature prior to each weighing. New bags were used throughout this study and all calcium chloride used to test the containers was of the regular 77-80 percent flake form.

## TEST RESULTS

The tests used in this study were accelerated, and as such were admittedly severe in some cases. For example, calcium chloride bags are not expected to resist immersion in water, nor to encounter such humidity and moisture conditions as exist in a concrete-curing room. However, during handling operations or prolonged storage, such conditions could well exist, at least for short periods of time. Furthermore, the tests definitely provide an index of the relative merit of each bag and indicate a lower limit of acceptability. A bag successfully withstanding the more severe tests should resist normal exposure with no trouble.

Figure 7 shows the effect of immersion on the bottom sections of the bags. Immediately upon contact with water, the Dow-Wyandotte section began leaking and filled with water within a few minutes. Figure 7-A shows this by a picture taken within 5 minutes after initial contact of the section with water. The Dow-Wyandotte bag section is in the middle. Figure 7-B shows the same models after 30 days of continuous immersion. The Dow-Wyandotte sample had been removed from the test

after three days because it not only filled with water but became saturated by capillary action to such an extent that it no longer maintained structural strength. The dried sample (right) was placed back in the water an hour before taking this picture. The Columbia and Solvay bags remained dry inside during the entire test and only a slight capillary rise was noted in the paper of these bags. The outer layers became slightly damp, but beyond the moisture barrier the insides were completely unaffected by exposure.

The models made from various sections of each bag responded as follows during the 30-day immersion period:

Section	Dow-Wyandotte	Solvay	Columbia
full bottom	filled rapidly	dry	dry
back seam	wet one day	dry	dry
bend at gusset	wet one day	dry	dry
flat paper	dry	dry	dry

Figure 8 shows the appearance of the half-bag sections containing calcium chloride after 30 days in the moist room. The Dow-Wyandotte bag was soggy and had little structural strength, while the other bags were in good shape. The calcium chloride in the Dow-Wyandotte bag was quite moist and had begun to lump badly, particularly around the bag bottom. The entire inside bag surface was wet. The Solvay and Columbia protected samples were relatively dry and entirely free-flowing.

The appearance of the calcium chloride samples after removal from the bags is illustrated in Figure 9. The graph of Figure 10 shows the moisture gains of the bags and contents during storage in the moist room. The gross weight of the bag and contents increased approximately 5 percent (based on original weight) for the Solvay and Columbia bags. These two containers were approximately the same in moisture content throughout the test, there being less than 1 percent difference. The Dow-Wyandotte bag and contents increased 13.5 percent in weight. Some of this increase was due to the absorbent quality of the bag. The calcium chloride itself showed the following moisture pickup when stored in the different bags: Solvay - 3.3 percent; Columbia - 3.0 percent; Dow-Wyandotte - 9.5 percent.

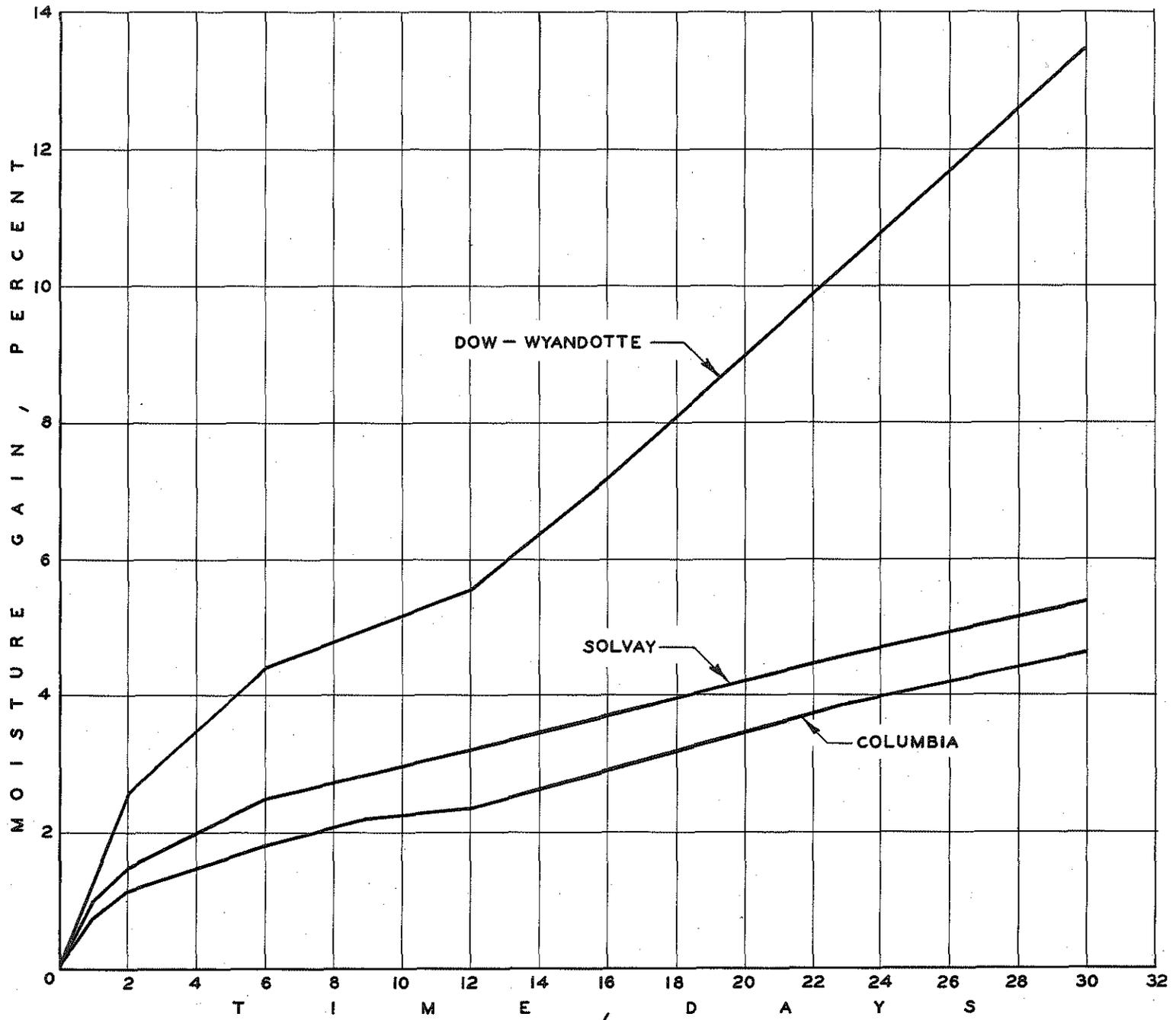


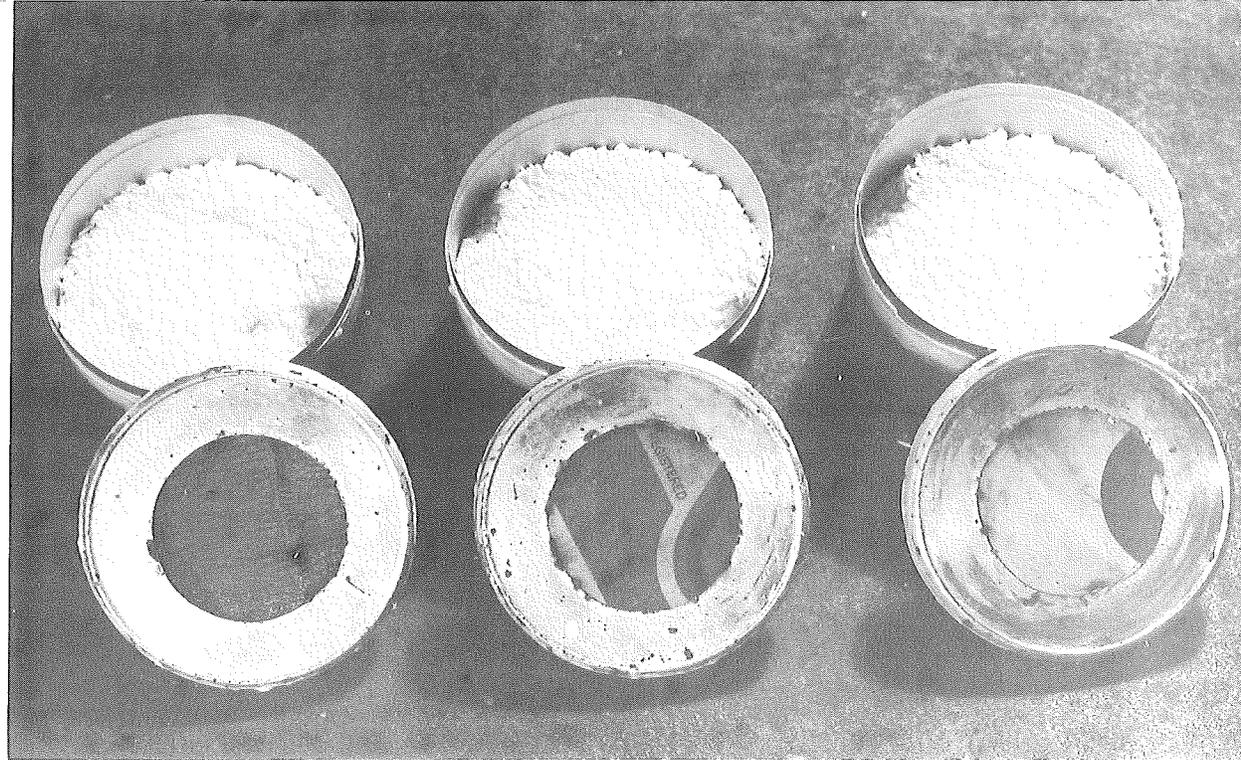
Fig 10. Moisture Gains of Bags and Contents During Storage in Humidity Room.

In this test the Solvay and Columbia bags were slightly damp through the outer layers of paper. Beyond the moisture barrier, however, the paper was dry. There were light spots of moisture at the bottoms of these bags but this moisture had not migrated enough to affect the calcium chloride.

Figure 11 shows the appearance of the calcium chloride in the circular cans, protected by a layer of the flat front surface of each bag, after 30 days of exposure in the humidity room. Generally, all cans contained material that was free-flowing after the test. Some slight lumping began in the can protected by the Dow-Wyandotte section but this was not too serious. There were only small moisture increases in the containers and contents during this test. Most of the increase in weight of the Dow-Wyandotte containers was due to the high moisture pickup of the paper. The percent moisture gained by the calcium chloride, based on the original weight used, was: Dow-Wyandotte - 1.2 percent, Solvay - 0.6 percent; and Columbia - 1.0 percent. These differences are not too significant. When analyzed with other data, however, they continue the trend showing poorer resistance of the Dow-Wyandotte bag to moisture penetration.

The outdoor weathering test of calcium chloride samples covered with bag sections showed no significant change in moisture absorption for the different bag covers. This test more nearly approaches normal field conditions and indicates that where deterioration does occur during field storage that it is caused by migration of moisture to a poor joint, seam, or bent section rather than by direct penetration of the bag material itself. Figure 12 shows the condition of each pan of calcium chloride after 30 days of outdoor exposure. The section of Dow-Wyandotte bag was wetter than the others but the periodic moisture pickup for the pans and contents for all samples was practically identical.

A particularly noticeable defect in the Dow-Wyandotte bag, found during these tests, was the absorptive property of the paper used. It not only allowed local moisture conditions to spread rapidly to other (possibly less moisture resistant) portions of the bag, but in doing so greatly reduced the structural strength of the bag. In addition, the seams became loose and paper could easily be stripped from the protective asphalt center section (Figure 13). The rapidity of this absorption, compared with that of the other bags tested is shown in Figure 14. In this test, strips of each bag were placed in water and the capillary absorption noted. Practically no capillary rise is noticeable in the Columbia and Solvay bag



Dow-Wyandotte

Solvay

Columbia

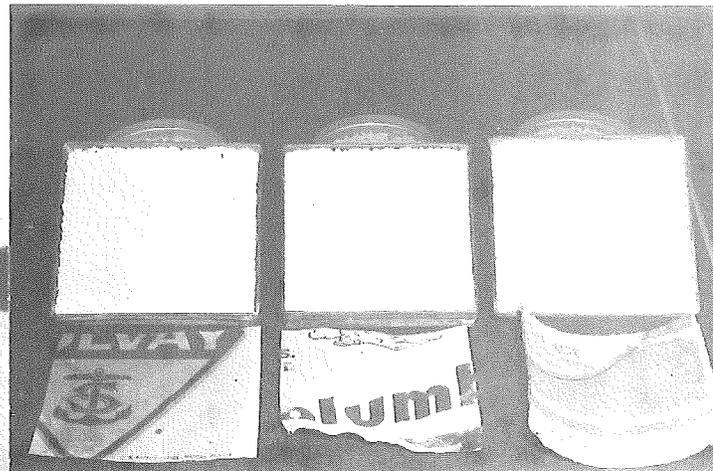
▲ Figure 11. Appearance of calcium chloride after 30-day exposure in humidity room: circular containers covered by flat bag sections.

Figure 12. Appearance of calcium chloride after 30-day outdoor exposure: Square pans covered by flat bag section.



▲ Figure 13. Effect of saturation on adhesion of outer paper to the asphalt center (Dow-Wyandotte bag).

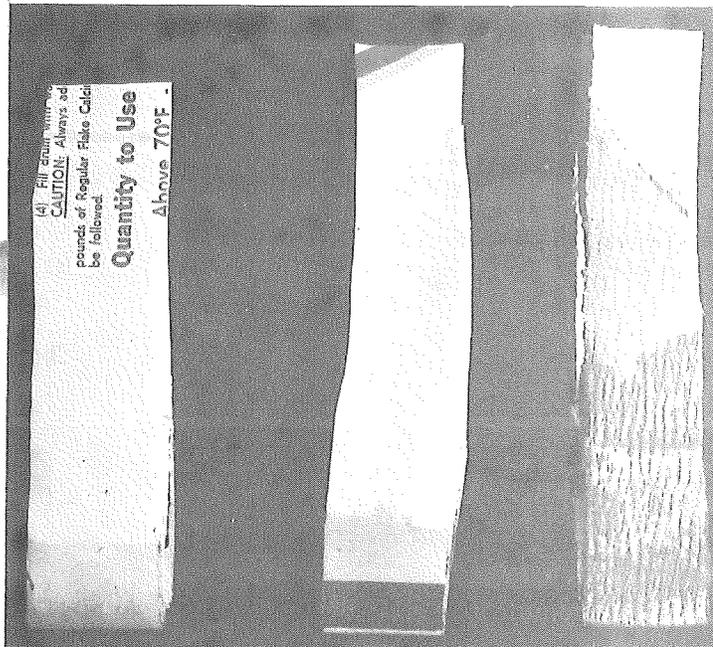
Figure 14. Capillary moisture absorption of test strips from different bags.



Solvay

Columbia

Dow-Wyandotte



strips, but the Dow-Wyandotte bag shows a considerable rise. The high rate of absorption by the Dow-Wyandotte bag might be due to the treatment used to blot the excess asphalt. It is a serious defect and one that accentuates the damage caused by any contact of the bag with moisture.

## CONCLUSIONS

Accelerated exposure tests used in this study support the following conclusions concerning the suitability of different types of bags for storing calcium chloride:

1. Solvay and Columbia bags successfully protected their contents during all of the exposure tests, and performed about equally in this respect.

2. Dow-Wyandotte bags were not successful in protecting their contents except in the mildest tests used.

3. The principal defects of the Dow-Wyandotte bag were: (a) porous openings along the end closures, particularly at the bottom corners; (b) highly absorptive paper allowing moisture to spread over a wide area, resulting in lessened bag strength and increased opportunity for moisture entry; (c) poor moisture resistance along seams and gusset folds.

4. The defects of the Dow-Wyandotte bag, should be easy for the manufacturer to correct.

5. The tests used in this study, although of an accelerated nature, are realistic and simulate conditions which could be encountered during storage and handling of calcium chloride bags. The test results show why the bags act as they do in service.