STORAGE AND HANDLING PROPERTIES OF A SYNTHETICALLY GRANULATED SALT

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John C. Mackie, Commissioner
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STORAGE AND HANDLING PROPERTIES OF A SYNTHETICALLY GRANULATED SALT

This report describes the testing of a synthetically granulated form of sodium chloride, designated commercially as "Cubidow," to determine if its handling and storage properties are such that it could be substituted for rock salt, as normally used for winter highway maintenance.

Covered and uncovered stockpiles of rock salt and Cubidow were subjected to outdoor weathering for nine months, during which they were observed and tested periodically for handling and durability characteristics.

It was found that Cubidow did not weather as well as rock salt. After about a month or more of exposure, depending on weather conditions, Cubidow became quite soft and readily broke into its original small particles. After mild exposure or when stored in protected areas, Cubidow could be handled in the same manner as rock salt and should perform as well for winter ice control operation.

The objective of this study is to evaluate storage and handling properties of a synthetic rock salt when used under conditions which might be encountered during normal highway winter maintenance operations. This material, produced by the Dow Chemical Company, is marketed under the trade name "Cubidow."

From the standpoint of gradation and chemical content Cubidow meets MSHD specifications for sodium chloride (rock salt). However, the Office of Maintenance questioned the durability and handling characteristics of this material when stored and applied during ice control operations. At the request of R. L. Greenman, Assistant Testing and Research Engineer, in his memorandum to E. A. Finney dated October 2, 1959, the Research Laboratory Division initiated Project 59 G-98 to evaluate the questionable properties of Cubidow.

As a preliminary to this work an inspection was made of several stockpiles of Cubidow being tested by the Dow Chemical Company at Midland.

The only outdoor stockpiles available had been in place less than a month at the time of the inspection. During this period, the Cubidow, protected by a polyethylene cover, had developed no visible signs of deterioration. Another stockpile, stored uncovered for about a year in an enclosed warehouse, was in excellent condition.

Because rock salt has been widely used for winter maintenance purposes and its properties in this respect are well known, it was decided to compare the properties of Cubidow with those of rock salt as part of this testing program. The work began in late September 1959. A memorandum report, dated October 29, 1959, described the results obtained from approximately one month of testing and indicated that longer term observations would be required to fully evaluate the relative properties of the two materials.

TEST MATERIALS

The two forms of sodium chloride used during this program were furnished as being representative of the normal productions of their respective manufacturers. In this report the synthetic form of salt will be referred to by its trade name, "Cubidow," and the normally used salt by the designation "rock salt." All materials used in these tests were furnished in bags.

Cubidow

Cubidow is produced by evaporating salt brine, compressing the residue into hard sheets, and crushing the hardened material to meet a desired gradation. Fig. 1 shows Cubidow in sheet form before crushing, and as crushed to meet MSHD specifications and used for this study. In crushed form it can be furnished in bulk or in bags.

Two samples of Cubidow were tested. The original was of a pink color and was used for the bulk of the testing. A white material, said to be an improvement over the pink, was furnished several months after testing began. This was also included in the program but on a more limited scale.

Rock Salt

The rock salt used in this project for comparison with Cubidow was furnished by the International Salt Company. Two grades of rock salt are

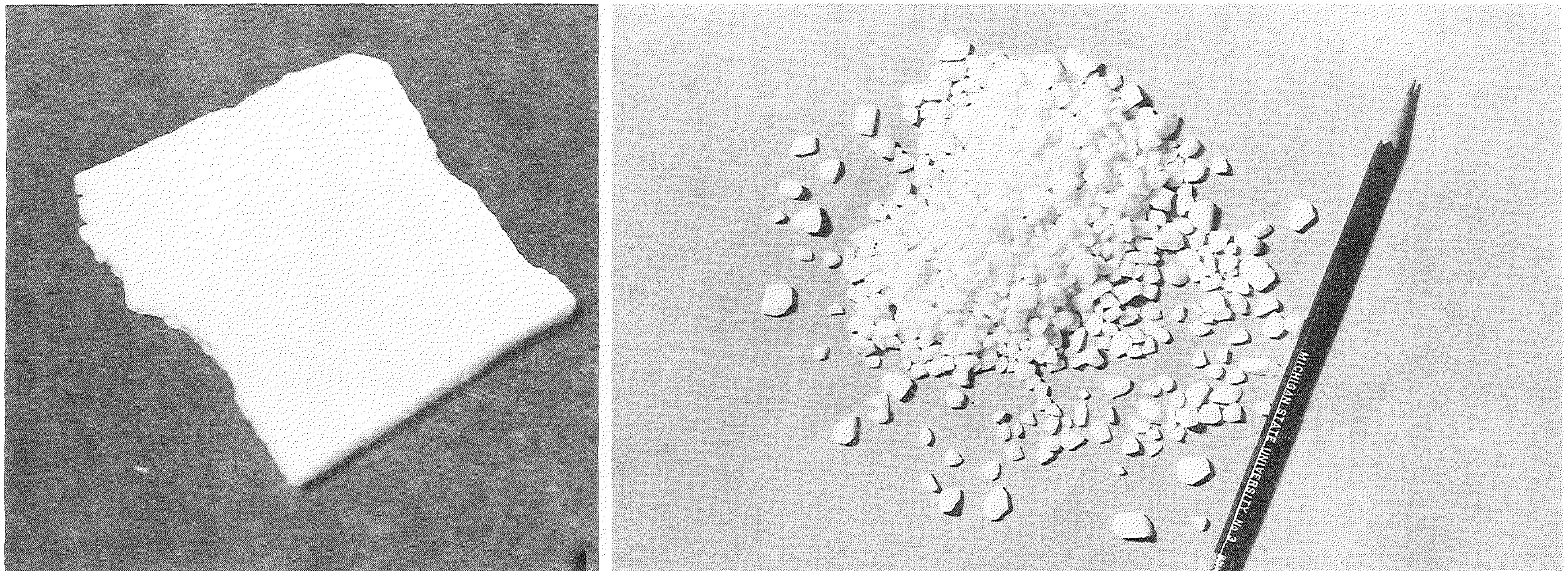


Figure 1. Cubidow in sheet form before crushing (top left), and as crushed for use in tests (top right).

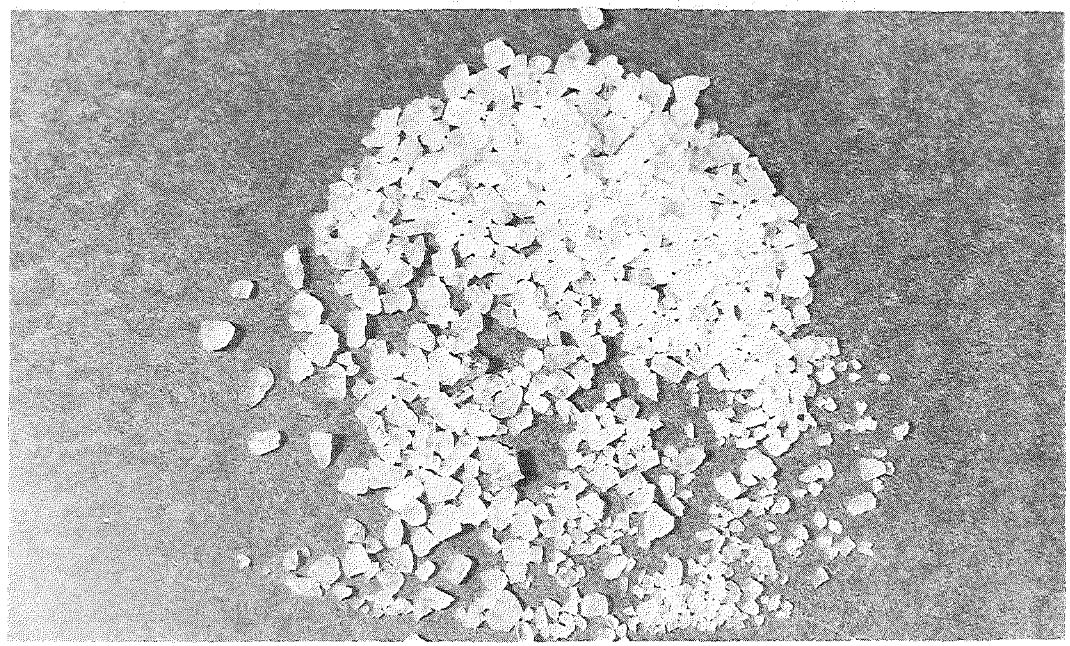


Figure 2. Rock salt as used in tests (right).

normally furnished for ice control purposes, CC grade and Number 1. For the initial testing in this program, a mixture of equal parts of these two grades was used (Fig. 2). The finer CC grade was used in later testing for comparison with the white Cubidow.

TESTING PROCEDURES

The storage and durability properties of Cubidow and rock salt were compared under identical outdoor weathering and laboratory testing procedures. Covered and uncovered stockpiles of each material were placed in an outdoor test area, observed periodically, and tested in the laboratory for abrasion resistance.

The first stockpiles were made using 500-lb samples of rock salt and Cubidow. One stockpile of each material was covered with polyethylene, and another was left exposed to the weather. All stockpiles were placed on polyethylene bases, arranged to avoid puddling of water around the stockpile bottom, as much as possible. Fig. 3 shows the general arrangement of the stockpiles at the start of testing.

Durability of representative samples from the stockpiles was tested at time intervals of approximately one, four, and nine months. The white Cubidow and finer rock salt were placed in covered stockpiles several months after the original materials and consequently were subjected to less weathering. Moisture contents of the stockpiles were obtained periodically by drying representative samples to constant weight at 220 F.

Samples were taken from the interiors of the stockpiles and reduced for laboratory use by quartering. The laboratory testing consisted primarily of sieve analysis of samples, before and after subjection to the abrasive action of a laboratory ball mill rotating at a speed of 108 rpm. Gradation changes were measured by the 3/8-in., No. 4, No. 10, and No. 40 sieves. Fig. 4 shows an interior view of the ball mill loaded with the material to be tested. Fifty metal balls, approximately 1/2-in. in diameter, were used to furnish the abrasive action. The total weight of the metal charge was 590 g. Tests at 2-, 5-, 10-, 15-, and 20-min intervals of rotation showed the breakdown of samples to be a direct function of the time of abrasion. The 20-min interval was arbitrarily selected for comparative purposes during this study.

The ball mill test as used here is not a standard but does give a quantitative comparison of durability of the different materials, under controlled

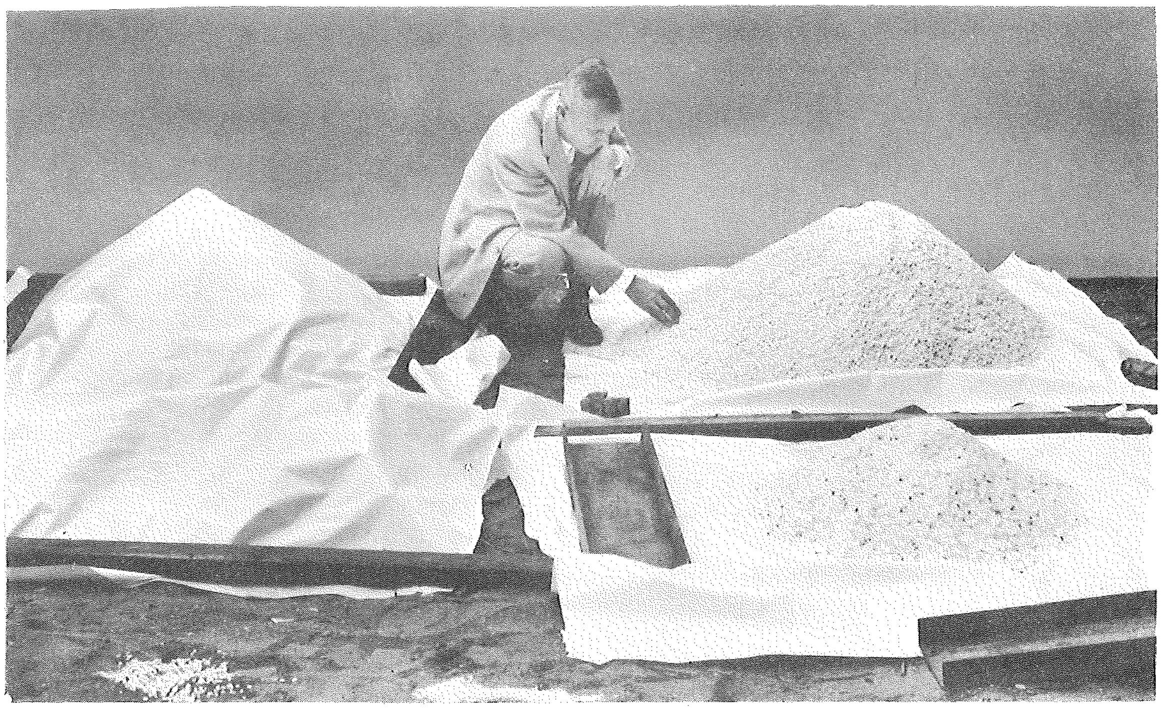


Figure 3. General arrangement of stockpiles at start of test.

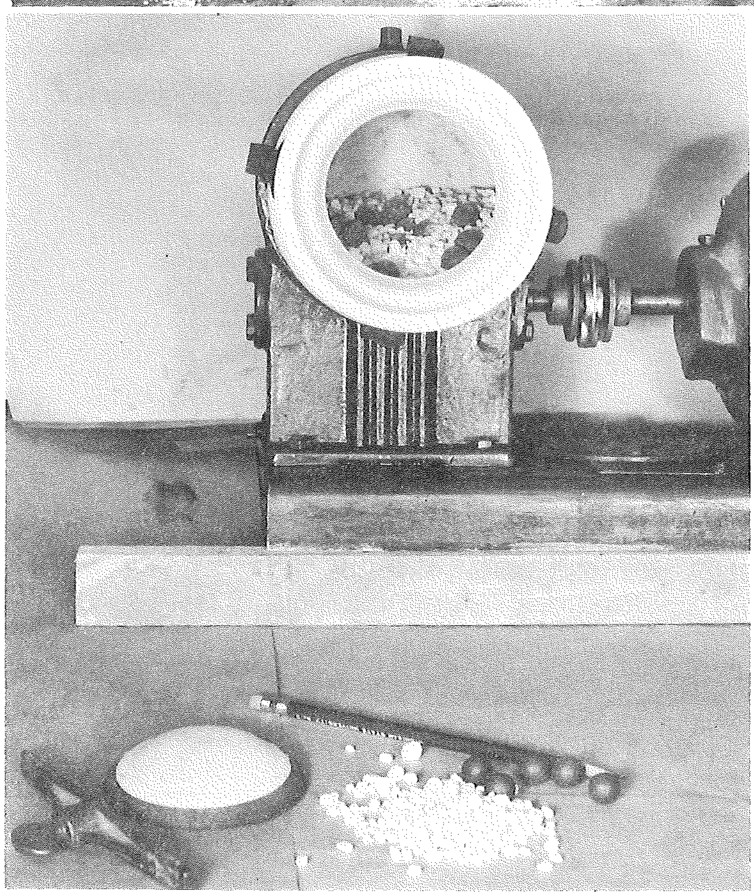


Figure 4. Ball mill used to test durability of rock salt and Cubidow.

conditions of test. The difference in sieve sizes of the material before and after test was a measure of the degradation of the particles, and consequently, a measure of the durability to be expected of the material under normal handling and storage conditions.

Other laboratory tests consisted of checking moisture absorption of the different salts during storage at various humidity and temperature conditions, rate of dissolving in water, and ice-melting properties.

TEST RESULTS

The effects of weathering on covered and uncovered stockpiles are shown pictorially in Figs. 5 through 7, and graphically by Figs. 8 through 10. In these figures, the First Samples are the original pink Cubidow and the rock salt mixture shown in Figs. 1 and 2. The Second Samples are the white Cubidow and the finer grade of rock salt, stored only from February 1 to July 1, 1960.

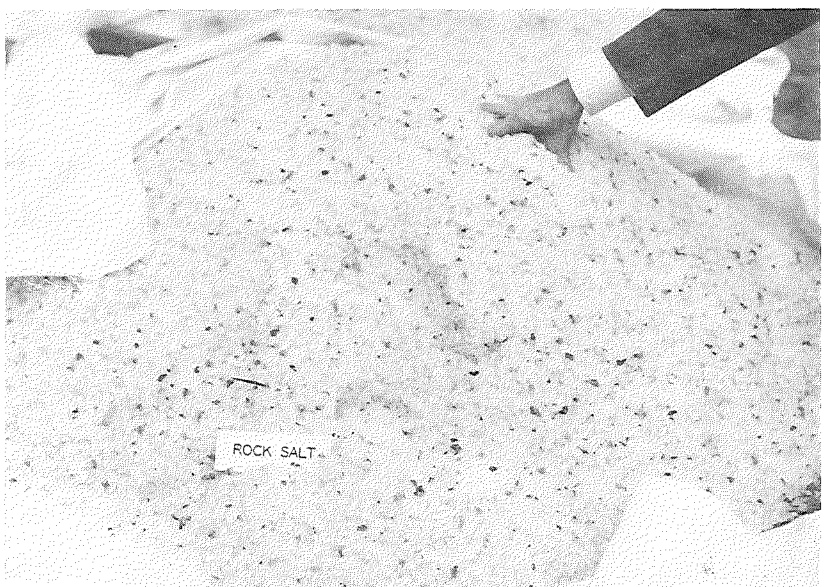
After approximately one month of storage (during October 1959), the original stockpiles appeared as shown in Fig. 5. The covered stockpiles of each material were free-flowing, crust-free, and generally in excellent condition. A crust had formed on the uncovered stockpiles hard enough to resist moderate finger pressure. These crusts, however, could be broken down readily by light hand pressure. Temperatures were mild during the first month of test, varying from a high of 70 to a low of 24 F. Approximately 5 in. of rain fell over one 10-day period during this month.

After the first months of exposure, however, the stockpiles became progressively worse, particularly those that were uncovered. The deterioration of Cubidow was much more rapid than that of rock salt. This can be seen in the degradation curves (Figs. 8 and 9).

After nine months of exposure, at the end of the test, the First Samples appeared as shown in Fig. 6. These photographs are also typical of the way the stockpiles looked during these last six months of exposure. In spite of the heavy crusting--visible in the photographs--the hardened lumps could be broken down by foot pressure into their original crushed particle size (Fig. 6). The rock salt crust was harder than that of the Cubidow, but it could be broken into much firmer and larger individual particles. Although retaining individual particle shape, the Cubidow had deteriorated so badly that it could be reduced to its pre-compaction size

Covered Cubidow

Uncovered Cubidow

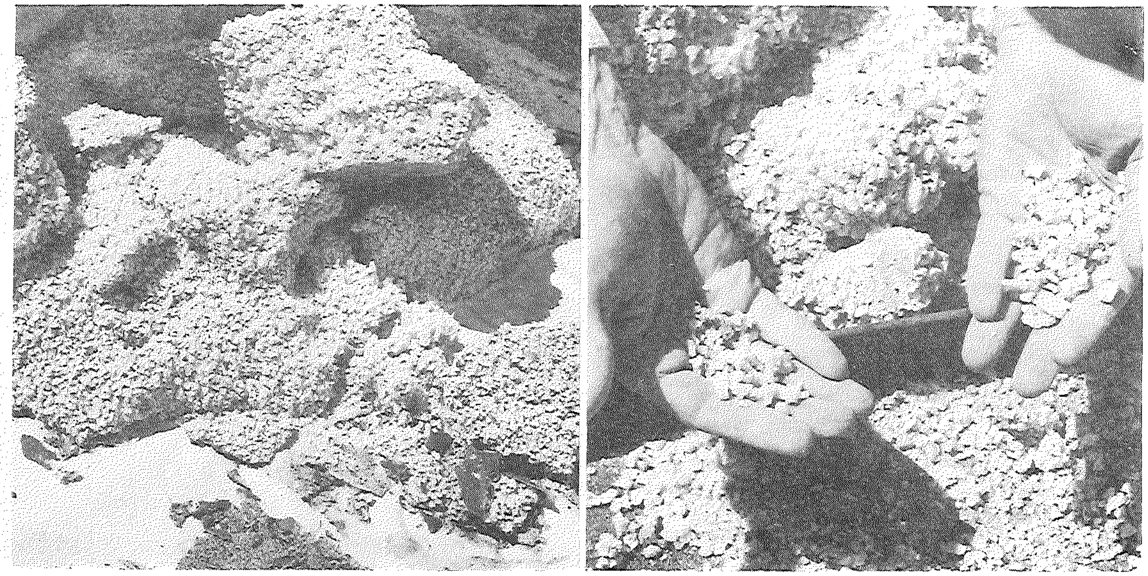


Covered Rock Salt

Uncovered Rock Salt

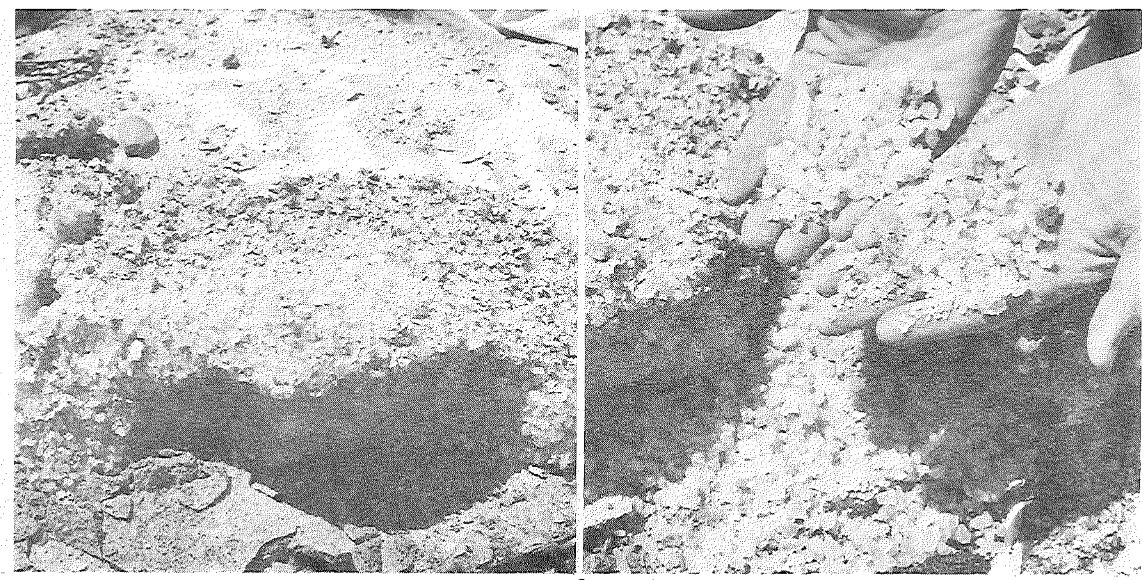
Figure 5. Condition of stockpiles after one month of exposure (First Sample).

Covered Cubidow



Uncovered Cubidow

Covered Rock Salt



Uncovered Rock Salt

Figure 6. Condition of stockpiles after nine months of exposure (First Sample). Note how hardened portions could be completely broken up by hand pressure.

by mere finger pressure (Fig. 7). Almost 90 percent of the uncovered Cubidow First Sample passed the No. 40 sieve at the conclusion of the ball mill test (after nine months of exposure). The softening of First Sample Cubidow was significantly noticeable after about two months of storage, but the Second Sample began softening within less than a month of exposure. The Second Sample was supposed to be the more durable of the two, and its earlier softening could have been due largely to the more severe weather in the first month of exposure (February 1960). Other than in rate of softening, the First and Second Samples weathered and handled similarly.

Figure 7. Breakup of Cubidow to precompacted condition (covered First Sample after 9 months of exposure).

Fig. 10 shows moisture fluctuations within the stockpiles during exposure. These data show that Cubidow absorbs moisture more readily than does rock salt. This appeared to be the direct cause of the softening and lack of stability of Cubidow. The increase in moisture of rock salt appeared to be a surface effect only, whereas Cubidow absorbed moisture into the particles, resulting in a soft material. The covered stockpile of Cubidow retained its moisture to a greater extent than the uncovered stockpile, which dried out during favorable weather conditions. Air drying did not decrease the breakup rate of Cubidow in the ball mill. If dried in an oven at 220 F, however, Cubidow regained much of its original resistance to abrasion (Fig. 9). Abrasion resistance of rock salt was relatively unaffected by oven drying.

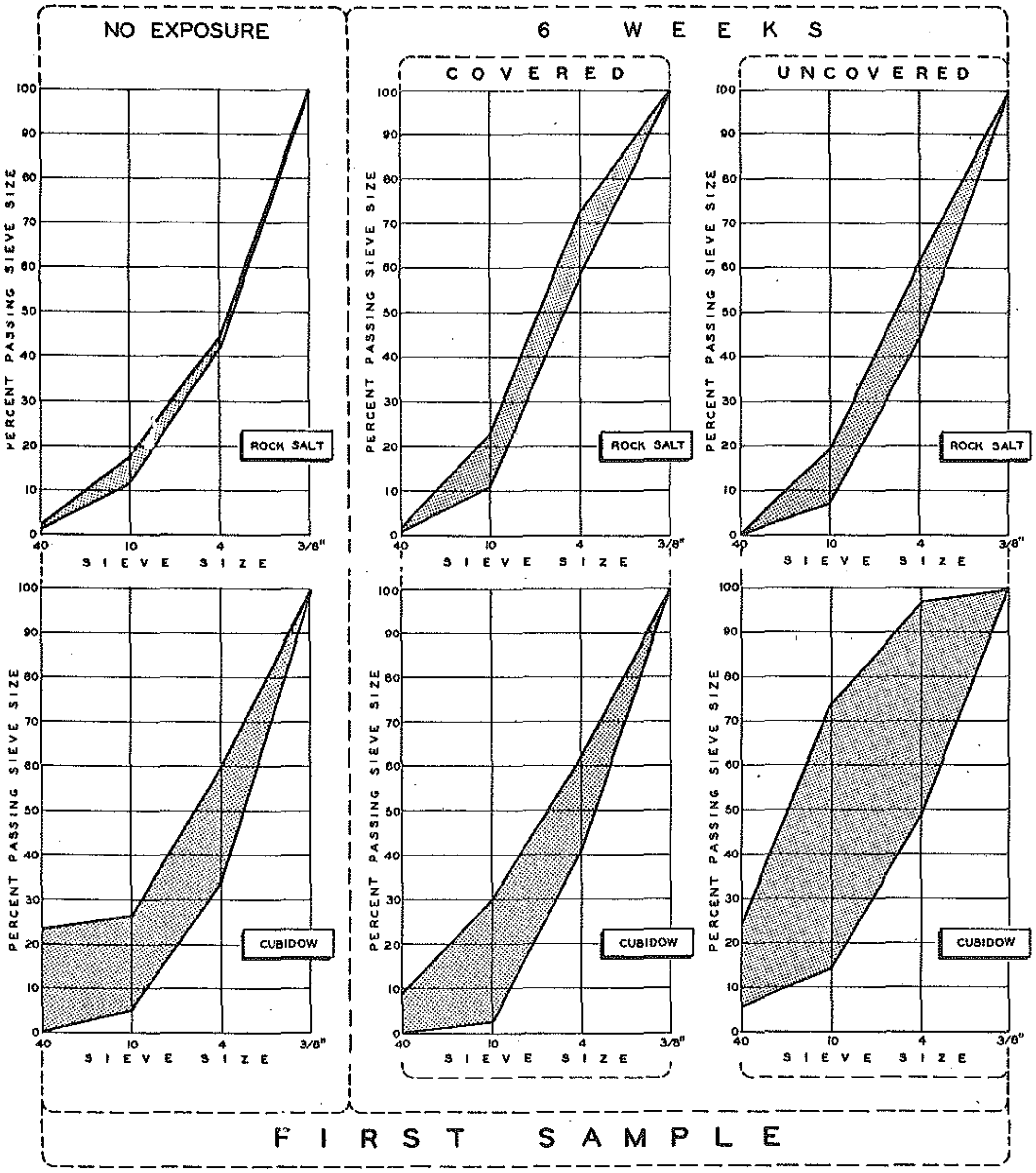


Figure 8. Sample degradation after various periods of exposure, before and after ball mill abrasion test (First Sample).

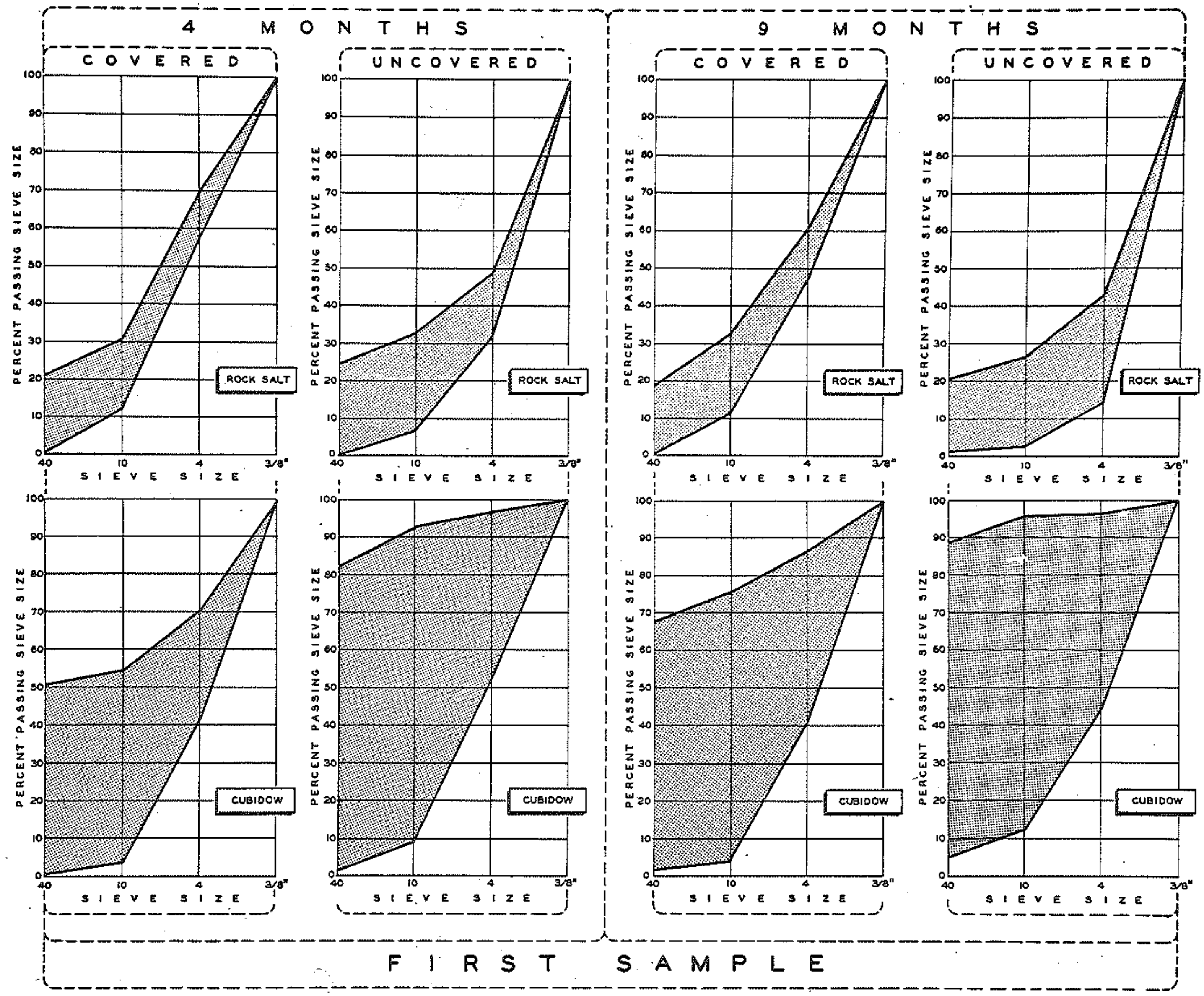


Figure 8 (con't). Sample degradation after various periods of exposure, before and after ball mill abrasion test (First Sample).

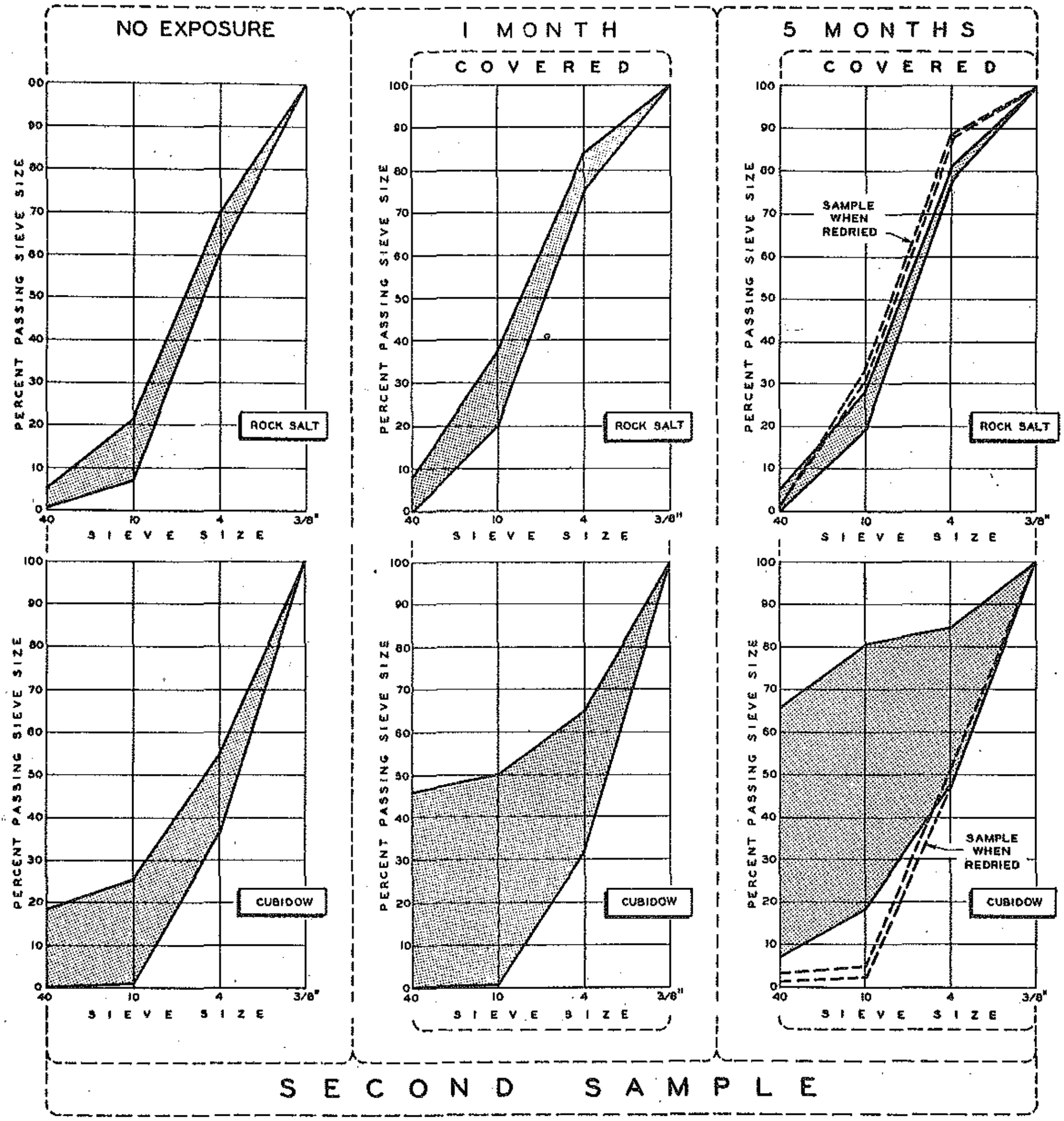


Figure 9. Sample degradation after various periods of exposure, before and after ball mill abrasion test (Second Sample).

Weather conditions just prior to sampling and testing undoubtedly affected the test results to a certain degree. Also, the relatively small size of the test stockpiles would emphasize the detrimental effects of weathering. Regardless of these factors, however, the trend of the results is quite clear and follows the same pattern in all tests.

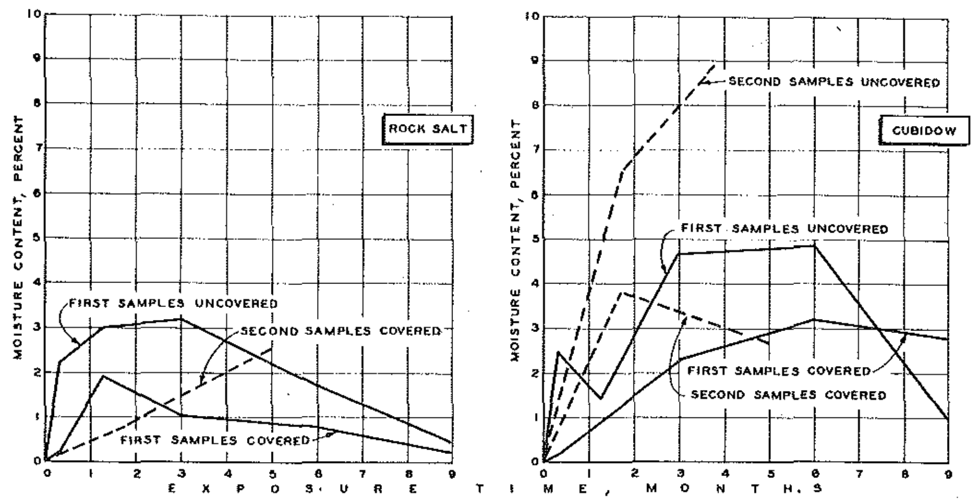


Figure 10. Moisture content of stockpiles during exposure.

Uncovered samples of both salts were partially dissolved by rain and moisture trapped around the base of the stockpiles. This condition does not always show up in the gradation curves because weathering also tended to bond the salt particles together, and such bonding did not break down entirely during sieving and handling.

Laboratory tests, using small samples, showed that both rock salt and Cubidow stored very well under indoor conditions. Samples remained firm and free flowing after 12 cycles of freezing and thawing (0 to 80 F) and after several weeks in air of 100-percent humidity. In the humidity test, rock salt picked up 0.5 percent moisture; Cubidow 1 percent. Both salts dissolved in water at the same rate. No visible impurities remained in Cubidow after dissolving, but there were some in the rock salt.

Ice melting properties of Cubidow and rock salt were tested at temperatures ranging from minus 7 to plus 40 F. Both salts melted ice at about the same rate. The depth of penetration into the ice was a function of the particle size.

CONCLUSIONS

On the basis of outdoor storage studies and special laboratory testing, the following conclusions have been reached concerning the storage and handling properties of the synthetically granulated sodium chloride, Cubidow:

1. Although meeting gradation and chemical content specifications for rock salt, Cubidow is not an equivalent material.

2. Upon prolonged exposure to weather Cubidow became quite soft, tending to return to its pre-compacted condition. Normal rock salts, formed under natural processes over a long period of time, did not do this.

3. Cubidow absorbed more moisture during storage than did rock salt. With rock salt, moisture absorption appeared to be primarily a surface effect, whereas with Cubidow the moisture was absorbed throughout the entire particle, resulting in loss of strength.

4. For short term uncovered storage conditions, not exceeding a month during bad weather, Cubidow retained its free flowing and durable properties and handled equally as well as rock salt. Its deterioration was a function of storage time and weather.

5. Covered Cubidow weathered better than the uncovered. This also was true for rock salt. Both materials formed a crust at the surface which could be readily broken down by extra effort during handling.

6. Moist Cubidow regained some of its strength if allowed to dry. In this respect, covered stockpiles were at a disadvantage if they once became wet, because the covering prevented evaporation of the moisture.

7. Cubidow in its soft condition could cause serious handling problems, especially when applied by mechanical spreaders.

8. Cubidow melts ice as well as does rock salt.

9. If stored in covered bins or sheds Cubidow seems to retain its characteristics well over long periods of time.

10. Neither Cubidow nor rock salt should be stored for long periods exposed to the weather. Rain dissolves the salt and causes undesirable crusting at the surface.