# Investigations of the Sieve Analysis Method

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## Introduction

Grain size distribution is of paramount importance in the premix field. It is one of the many factors affecting the quality of granulated sugar. Variations in analytical results between laboratories are frequently greater than tolerances required. This investigation was undertaken to determine the sources of error in the sieve test method and to specify conditions required for accurate analyses.

Investigations of the sieve test for granulated sugars by the USNC of ICUMSA were reported at the Phoenix, Arizona meeting January 21-22, 1966(6)[3]. A survey showed individual variations in the equipment and procedures for shaking the sieves, in the sieves used, in the lengths of time the sieves are shaken, and in other factors. The Ro-Tap shaker is used by most, and two companies (4) have found an advantage in decreasing the speed of the shaker from 154 to about 115 taps per minute. Shaking times range from 2 to 10 minutes, with an average of about 6 minutes. Sample weights sieved vary from 50 to 200 grams, with the majority using 100 gram samples.

Carpenter and Deitz (1) have thoroughly investigated the factors affecting the sieving of bone char. Their findings were studied to determine if the results reported for bone char were directly applicable to granulated sugar.

## Experimental

Tests were limited to one grade of granulated sugar using a Tyler Ro-Tap shaker with Tyler 8″ diameter sieves. The particle size distribution of the sugar approached a normal distribution with a mean size of about 280 microns and a standard deviation of about 80 microns.

The Ro-Tap shaker was operated at 154 taps per minute unless otherwise specified. All comparisons of variables were made with a common set of sieves in the $4\sqrt{2}$ series. Values reported are in U. S. Standard Sieve Series mesh numbers. Sieves were selected for openings close to nominal values by calibration with glass spheres (2, 3).

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[3] Numbers in parentheses refer to literature cited.

Sugar to be sieved was stored under dry air at 80°F and the sieves purged with dry nitrogen while testing.

Samples were riffled to the size used on the sieves.

## Results and Discussion

All samples for testing were obtained by riffling or remixing individual sieve fractions from previous separations. Good sample reproducibility was obtained by riffling. Hand-quartered samples were not as reproducible. Sampling with a P-K laboratory blender and a homemade mixer gave fair reproducibility, but results were not representative of the entire batch..

The operating instructions for the Ro-Tap Testing Sieve Shaker, provided by the Tyler Company, state that "it is important that the nest of sieves be loose enough (in the shaker) so they will rotate freely in the Item No. 22 Supporting Plate when the Ro-Tap is in operation." The importance of this instruction is sometimes overlooked in routine sieve testing. The sieving of near-fit particles of sugar on the No. 70 sieve with the sieve free to rotate was compared to the results obtained with the sieve rigidly in the shaker. Those particles which pass the next larger sieve and are retained on the next smaller sieve in the $4\sqrt{2}$ series are considered near fit. More particles passed through the sieve when it was free to rotate. With about 50 grams retained on the sieve, the difference was 15 grams.

To determine if the findings of Carpenter and Deitz on the sieving of bone char were applicable to sieving of granulated sugar, selected tests on important variables were repeated with granulated sugar. The results obtained with each variable tested are discussed separately.

***Sieving time***

The rate of passage of particles through a sieve decreases exponentially with sieving time. If the sieving rate decreases very slowly, the openings are not uniform, and the sieve should be discarded. Carpenter and Deitz carried out sieving until the rate was low enough that additional sieving would have made a relatively small change in the results. The sieving time was not extended to reach an extremely low rate because of possible attrition. They recommended a terminal sieving rate of 0.1 gram per minute.

Sieving rate curves for sugar were similar to those reported for bone char. Typical curves are shown in Figure 1. A sieving rate of 0.1 gram per minute was a satisfactory end point for sieving sugar. The time required to reach this sieving rate depended upon the amount of material retained on the sieve and the grain size distribution.

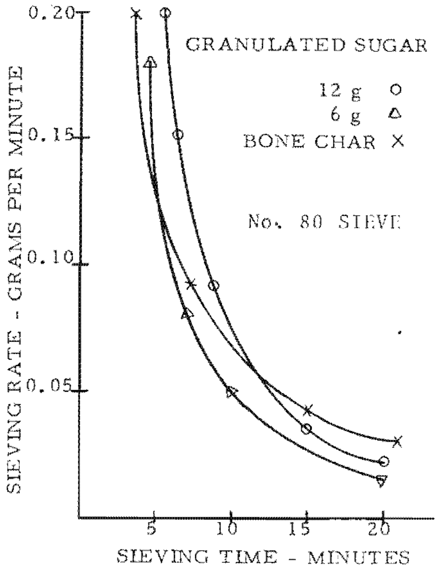


**Figure 1.—Typical sieving rate curves for granulated sugar and bone char.**

***Effect of the amount of near-fit particles on a sieve***

Carpenter and Deitz found that, for sieves No. 35 and finer, sieving time depended upon the amount of near-fit particles retained on the sieve and the size of the sieve openings. For sieves coarser than No. 35, sieving time depended only upon the weight of near-fit particles retained on the sieve. Their correlations for the sieving time required to reach a sieving rate of 0.1 gram per minute were:

For sieves No. 35 and finer

$$T = 1 + 0.0137 \frac{W}{D}$$

For sieves No. 35 and coarser

$$T = 2 + 0.23\ W$$

Where T = sieving time in minutes; W = weight of near-fit particles retained in grams; and D = size of sieve openings in cm.

Tests were made to determine the sieving time required to reach a sieving rate of 0.1 gram per minute with various weights of near-fit particles of sugar on the No. 60, 70, and 80 sieves. These results are compared with the correlation for bone char on sieves No. 35 and finer in Figure 2. The correlation for sugar is similar to that for bone char but with

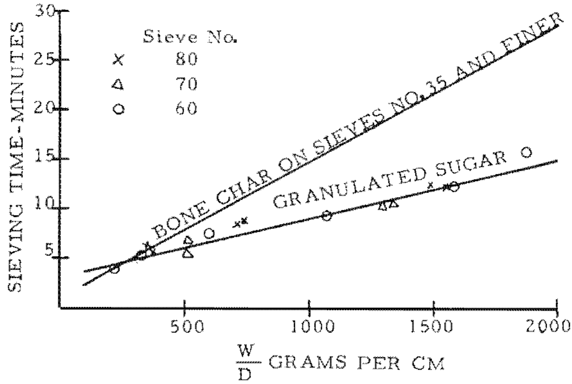


**Figure 2.—Comparison of sieving times required for bone char and granulated sugar.**

$T = 3 + .0060 \frac{W}{D}$. The constants are related to the apparent density of the material sieved.

The percent of near-fit particles of sugar retained on the sieves are shown in Figure 3 for the No. 60 sieve and in Figure 4 for the No. 80 sieve. The size distribution of the weights tested were the same; however, as the amount sieved increased, the percentage retained increased. The curves show that 50 grams of near fits were excessive for the sieves used.

The results of these tests with sugar indicated that additional sieve openings were blocked by wedged particles as the amount of near fits sieved was increased. This condition is normally described as sieve blinding. When 50 grams of near fits are applied to a sieve, blinding may become appreciable; therefore, the sample size should be limited if the amount of near fits to a particular sieve is excessive. Sampling and weighing errors must be considered when reducing the sample size to obtain the limit. The results of sieve analyses of 50 gram portions of sugar, obtained using a sample riffle, were reproducible.

Carpenter and Deitz mentioned that excessive sample weights can cause sieve blinding, but blinding was not reported with as much as 60 grams for bone char on the No. 50 sieve and 40 grams on the No. 80 sieve.

The hold-up of smaller near-fit particles of sugar on a blinded sieve was nearly eliminated by brushing the back side of the sieve to dislodge wedged particles and then continuing the sieving. With about 50 grams retained on the No. 50 or No. 70

sieves an additional 10 to 15 grams were passed using this procedure.

In tests with as much as 60 grams of near-fit particles of sugar retained on the No. 70 sieve, fine particles were not held up on the blinded sieve.

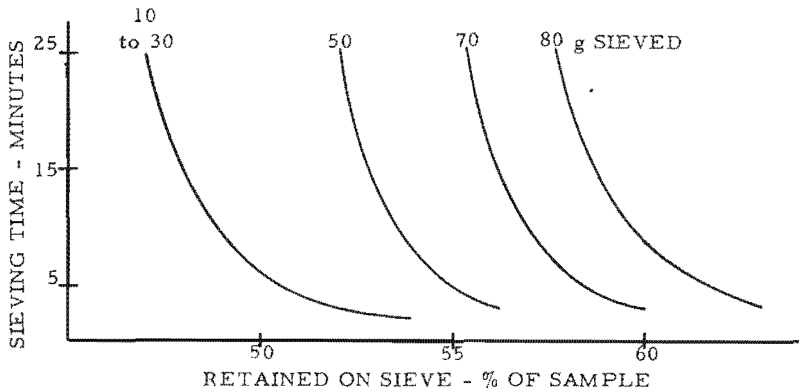


**Figure 3.—Effect of amount of near fits on the No. 60 sieve.**

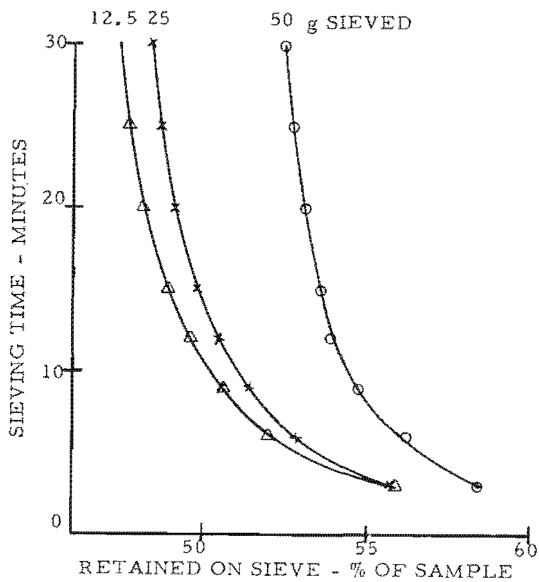


**Figure 4.—Effect of amount of near fits on the No. 80 sieve.**

### *Effect of oversized and undersized particles on the passage of near-fit particles through a sieve*

Carpenter and Deitz established that the sieving of near-fit particles is not affected by excessive amounts of smaller particles in the sample or the presence of excessive amounts of large particles on the sieve.

Similar results obtained by other investigations are cited in a comprehensive review (5) of work on the sieve analysis.

Sugar samples were first sieved in a $4\sqrt{2}$ series of sieves to obtain the desired particle size fractions. The near-fit particles were made up of nearly equal amounts of particles passing through the sieve to be tested and particles retained on that sieve.

Tests were made with 20 grams of near fits and 75 grams of oversize and undersize particles to the No. 70 sieve. The excessive amounts of oversize and undersize particles had little effect on the amount of near fits retained on the sieve as shown in Table 1. With larger amounts of near-fit particles of sugar, the sieve openings becomes blocked by wedged particles.

Table 1.—Effect of oversize and undersize particles—No. 70 sieve.

| Near fit<br>Oversize<br>Undersize | 20 g<br>0<br>0 | 20 g<br>75<br>0 | 20 g<br>75<br>75 |
|---|---|---|---|
| **Min** | | | |
| 2 | 11.5 | 11.7 | 12.0 |
| 4 | 11.0 | 11.2 | 11.5 |
| 6 | 10.7 | 11.0 | 11.3 |
| 9 | 10.5 | 10.9 | 11.1 |
| 15 | 10.2 | 10.7 | 11.0 |
| 20 | 10.1 | 10.6 | 10.9 |
| 25 | 10.0 | 10.5 | 10.8 |

The presence of oversized particles on a sieve could increase the wedging of near fits into the openings. Therefore, the load of each sieve should be kept to a minimum, by using a $4\sqrt{2}$ series of sieves.

Figure 5 illustrates the effect of clamping the sieves rigidly in the shaker. For accurate analyses the sieves must be free to rotate as specified by the Tyler Company.

### *The effects of mechanical variables*

a. Ro-Tap Knocker Cushion

No significant difference in results was found using rubber or cork knocker cushions.

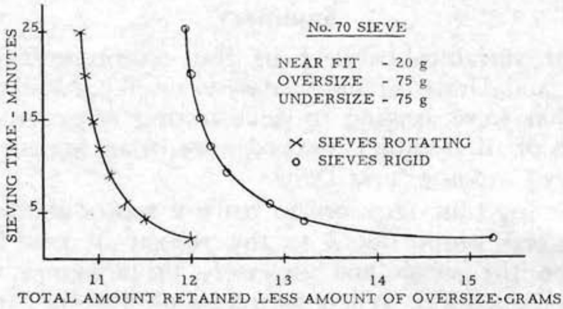


**Figure 5.—Effect of free vs. rigid sieve stack.**

b. Position of Sieve in the Stack

The passage of particles through a particular sieve was not affected by its position in the stack.

c. Speed of Ro-Tap Shaker

The Ro-Tap normally operates at a speed of about 154 taps per minute. Carpenter and Deitz found an optimum of about 115 taps per minute for bone char, glass beads, sand, granular bismuth, rounded floridin, and iron filings. Two sugar manufacturers (4) have reported improvement in reproducibility of sugar sieve analyses with speeds reduced to about 115 taps per minute.

Sieving of near-fit particles of sugar was compared at 154 and 115 taps per minute. The slower speed allowed more particles to pass the sieve as shown in Figure 6. The accuracy of the sieve analysis was improved by decreasing the speed of the shaker.

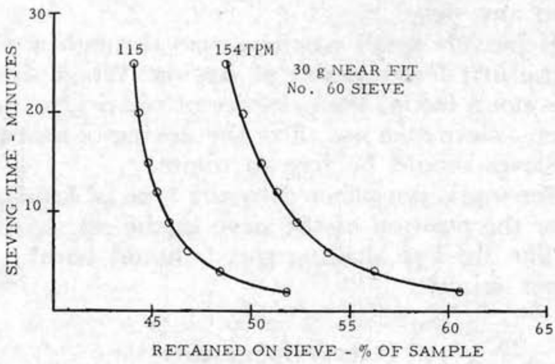


**Figure 6.—Effect of Ro-Tap speed.**

## Summary

Selected variables covered in the comprehensive work of Carpenter and Deitz on sieve analysis with particular reference to bone char were applied to sieve testing of granulated sugar. The effects of all variables checked were in agreement with those reported by Carpenter and Deitz.

The sieving time required to reach a reproducible end point in sieving was proportional to the weight of near-fit particles retained on the sieves and inversely proportional to the size of the sieve openings. When 50 grams of near-fit particles were sieved, the sieves became blinded, and the results inaccurate. Excessive amounts of relatively small particles did not affect the sieving of near-fit particles; they passed through during the first few minutes of sieving. Relatively large particles also had no effect when the sieves were not blinded by near-fit particles.

More particles passed through the sieves when the Ro-Tap speed was reduced from the normal 154 taps per minute to a speed of 115 taps per minute. Sieving was not affected by the type of Ro-Tap knocker cushion used or the position of the sieve in the set.

Clamping the sieves rigidly in the shaker, instead of allowing them to rotate as specified by the Tyler Company, reduced the number of particles passing through the sieves.

## Conclusions

1. All sieves should be calibrated and tested for uniformity of openings.
2. A $4\sqrt{2}$ series of sieves should be used to minimize sieve blinding. The sample size should be adjusted so that less than 50 grams of near-fit particles are applied to any sieve.
3. Relatively small particles pass through a sieve during the first few minutes of sieving. When sieve blinding is not a factor, the presence of relatively large particles on a sieve does not affect the sieving of near-fit particles.
4. Sieves should be free to rotate.
5. Sieving is not affected by the type of knocker cushion, or the position of the sieve in the set.
6. The Ro-Tap shaking speed should be about 115 taps per minute.

## Acknowledgments

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