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REPORT

234-5 BUILDING BN LINE EQUIPMENT TESTS

TASK III MIXER

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DECLASSIFIEDIntroduction

Several operations that are important to the process as carried out in Task III (Reduction) are performed by the mixer. In order to specify the process certain tests were made to study these operations and are discussed in this report. They include:

Test 1. Mixing Time

Test 2. Mixer Discharge Rate

Test 3. Mixer Holdup

Test 4. Mixer Capacity

The object of Test 1 was to determine the minimum time required to give adequate mixing and produce a homogeneous charge. The object of Test 2 was to determine the time required to discharge various fractions as well as the total charge from the mixer. This information must be known in order to prepare various charges. The object of Test 3 was to determine the amount of hold-up of material in the mixer and evaluate the importance of this problem. The object of Test 4 was to determine the maximum size charge that can be processed in Task III, studying various powder densities.

Conclusions

Test 1. Mixing Time

1. The charge will be mixed after six (6) minutes of mixing. (See Figure 1.)
2. Additional mixing does not affect homogeneity.

Test 2. Mixer Discharge Rate

1. The mixer will discharge essentially 100 per cent of the contents in 20 seconds. The mixer should be kept dumping for two minutes to be completely discharged.
2. One-half of a normal charge will be discharged in 4 seconds. If other fractions of the powder are to be dumped, the dumping times required can be obtained from Figure 2.

Test 3. Mixer Holdup

1. Holdup in the mixer will be less than one gram.
2. Once the initial loss to the system is established, the variation between the powder dumped from Task II and the powder dumped from the mixer will probably be 0.1 to 0.3 grams.

Test 4. Mixer Capacity

1. The volume of powder that the mixer can handle is dependent upon the bulk density of the powder. The maximum charge should be limited as shown in Figure 3.
2. If the mixer is overloaded, calcium will pass through the mixer selectively.
3. If the powder contains lumpy material, the volume that the mixer can accommodate without the lumps passing through is reduced considerably.

Recommendations

1. It is recommended that a ten (10) minute mixing time be established as a minimum. This allows some factor of safety.
2. It is recommended that the mixer design be reviewed to determine its adequacy each time a change in process is anticipated.
3. It is recommended that if sulfur is used, it be mixed with the calcium prior to admission to the mixer through the chemical addition chute to prevent sulfur holdup.
4. It is recommended that the mixer be dumped a minimum of two (2) minutes to assure complete discharge. To dump fractional portions of a charge, use the chart. (See Figure 2)
5. It is recommended that powder containing lumps not be dumped into the mixer.

Procedure

Test 1. Mixing Time

The setup for this test consisted of the mixer and motor which were removed from Task III and reassembled separately so that the mixer charge could be sampled. The mixer was wired into the Task controls and operated in the normal fashion.

One hundred and fifty (150) grams of calcium, 14.3 grams of sulfur, and 400 grams (300 cc) of cerous fluoride were added to the mixer and the mixer started. Thief samples from the load and discharge ends of the mixer were taken at two minute intervals for 20 minutes and were analyzed for cerium.

Figure 1 shows the results of these analyses with the per cent cerium plotted vs. mixing time for both the load and discharge ends. The third curve represents the theoretical per cent cerium in a homogeneous mix. This curve dropped off from 50.4 per cent to 48 per cent because some lumps of cerous fluoride were discharged during the first part of the test. (See Test 4 Discussion)

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In this test, thorough mixing is demonstrated when the load and discharge curves approach the theoretical value and occurred after six minutes. Since additional mixing does not affect the homogeneity, a mixing time somewhat longer than the minimum is desirable to be assured of proper mixing.

The two major reasons for the fluctuation in results were the accuracy of the analytical method (± 3 per cent) and the method of sampling. However, it was felt that these methods were adequate for a test of this type.

Test 2. Mixer Discharge Rate

The setup for this test was the same as used in Test 1. A 505 gram charge, consisting of 355 grams cerrous fluoride, 135 grams calcium and 15 grams sulfur, was discharged for consecutively shorter times from 150 seconds down to one second and the weight and per cent dumped recorded. Results are plotted in Figure 2. The mixer was completely discharged after each test (See Test 3) so that the powder in the mixer could not have worked further through the mixer than it will in normal operation.

The volume discharge from the mixer is rapid and is almost a straight-line function with time since it is a constant speed screw feed. For a standard 320 to 350 gram (metal) charge the per cent of the charge dumped is given on Figure 2. For other charges, the volume dumped vs. dumping time should be used following the rate defined by the slope of the line between 5 and 90 per cent (14.5 cc/sec).

Test 3. Mixer Holdup

This test was run in conjunction with Test 2. Following each of the dumping tests, the mixer was dumped for a total of two minutes (Test 2 dump time plus Test 3 dump time). The total powder discharged was then weighed to determine the holdup in the system.

The maximum mixer holdup on the ten (10) runs made was 0.3 grams and is not considered significant. However during the course of the test work it was noted that if the sulfur was added individually, it had a marked tendency to hold up in the equipment. By combining the calcium and the sulfur before making the addition, the sulfur would adhere to the calcium grains and eliminate the problem. This procedure was adopted and followed in all test work.

Table I lists the results of the mixer holdup test.

TABLE I

	1 Wt. Added	2 Wt. in System	3 Wt. Dumped	4 Total Holdup ⁺	5 Holdup on Run ^{**}
1.	505.0	505.0	504.9	0.1	0.1
2.	504.9	505.0	505.0	0.0	-0.1*
3.	505.0	505.0	504.9	0.1	0.1
4.	504.9	505.0	504.9	0.1	0.0
5.	504.9	505.0	504.7	0.3	0.2
6.	504.7	505.0	505.0	0.0	-0.3*
7.	505.0	505.0	505.0	0.0	0.0
8.	505.0	505.0	504.9	0.1	0.1
9.	504.9	505.0	504.9	0.1	0.0
10.	504.9	505.0	504.8	0.2	0.1

* minus indicates pickup

+ Col. 2 - Col. 3

** Col. 1 - Col. 3

Test 4. Mixer Capacity

The mixer is designed so that the discharge end is always open and the mixing is dependent upon the direction of rotation of the mixer; when the mixer is rotated in one direction it retains and mixes the charge, when it is rotated in the opposite direction it dumps the charge. Obviously with this type of mixer there is a limit to its capacity as the material will pass through the open end. The limit was determined for various bulk densities as it was not known what the bulk density would be for the process material.

The three bulk densities tested and the stand-in materials used were:

ρ -1.0, Na_2CO_3 ; ρ -1.35, CaF_2 ; and ρ -1.9, MgO . The powders were added in 100 cc increments together with the weights of calcium and sulfur that would normally be added to the equivalent weight of PuF_4 powder. The makeup of an individual increment for each material is given in Table II.

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TABLE II

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	$\rho = 1.0$ (Na_2CO_3)	$\rho = 1.35$ (CaF_3)	$\rho = 1.9$ (MgO)
Powder	100 cc Na_2CO_3	100 cc CaF_3	100 cc MgO
Ca	37.5 g	50 g	70 g
S	4 g	5 g	7 g
Equivalent PuF_4	100 g	133 g	190 g
Equivalent Pu	75 g	102 g	145 g

The mixer was operated in its normal operating position in the Task III equipment. The mixer valve was open and a lucite can placed beneath the discharge spout to catch the material that passed through the mixer. The lucite can permitted easy visual observation during the test.

The test was performed by adding 100 cc increments of the powder being tested together with the necessary calcium and sulfur to the rotating mixer. When the capacity was exceeded, material spilled over into the lucite can.

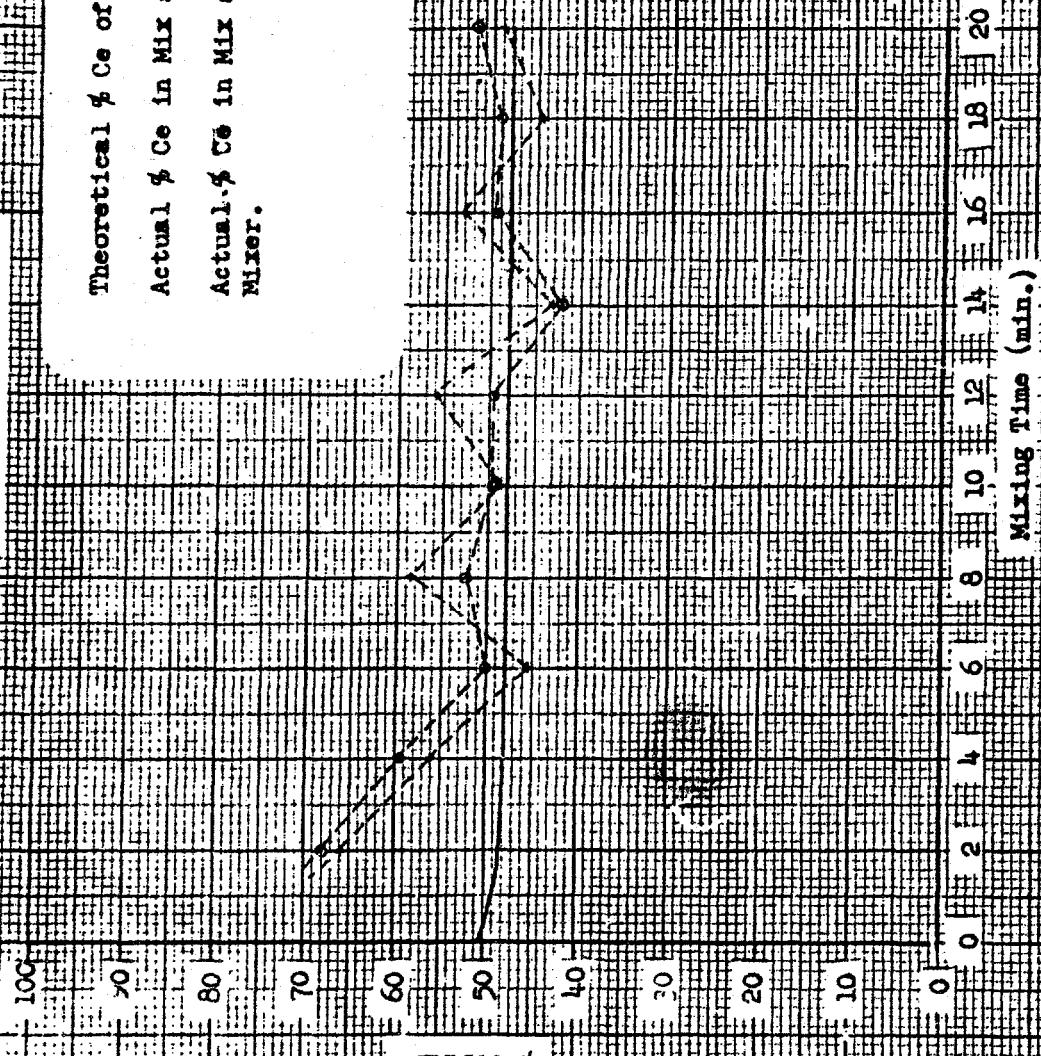
After the fifth increment of 1.0 density powder was added, 97 grams of calcium was selectively discharged from the mixer. This constituted two-thirds ($2/3$) of the increment which left one-third in the mixer. From this the capacity of the mixer is calculated to be $4 \times 75 + 1/3 \times 75 = 325$ g Pu.

Following the addition of the third increment of 1.35 density powder, 65 grams of CaF_3 in the form of lumps was discharged which would indicate either that the capacity was 260 g Pu or that the larger pieces are discharged prematurely. The test was repeated with powder that was ground to remove the chunks. Sixty-seven grams of calcium passed out of the mixer after the fifth addition had been made. The mixer capacity is $4 \times 102 + 65 = 473$ g Pu. Thus the material charged to the mixer must not contain any lumps ($+ 1/8"$) or the capacity will be seriously reduced.

The capacity of the mixer with 1.9 density powder was determined to be 680 g Pu. Figure 3 is a plot of the amount of plutonium that can be processed for various powder densities. Capacities of both the S-1 crucible and the A-331 crucible are also plotted based upon previous experience in the RG Line equipment. From this it can be seen that if the S-1 crucible is used it is the limiting factor for all powders having a density of 1.3 g/cc or more. Below this value the mixer will be the limiting item. Likewise, if the A-331 crucible is used the mixer capacity is the limiting factor up to a density of 1.97 g/cc.

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Figure 1
Task III Mixing Time

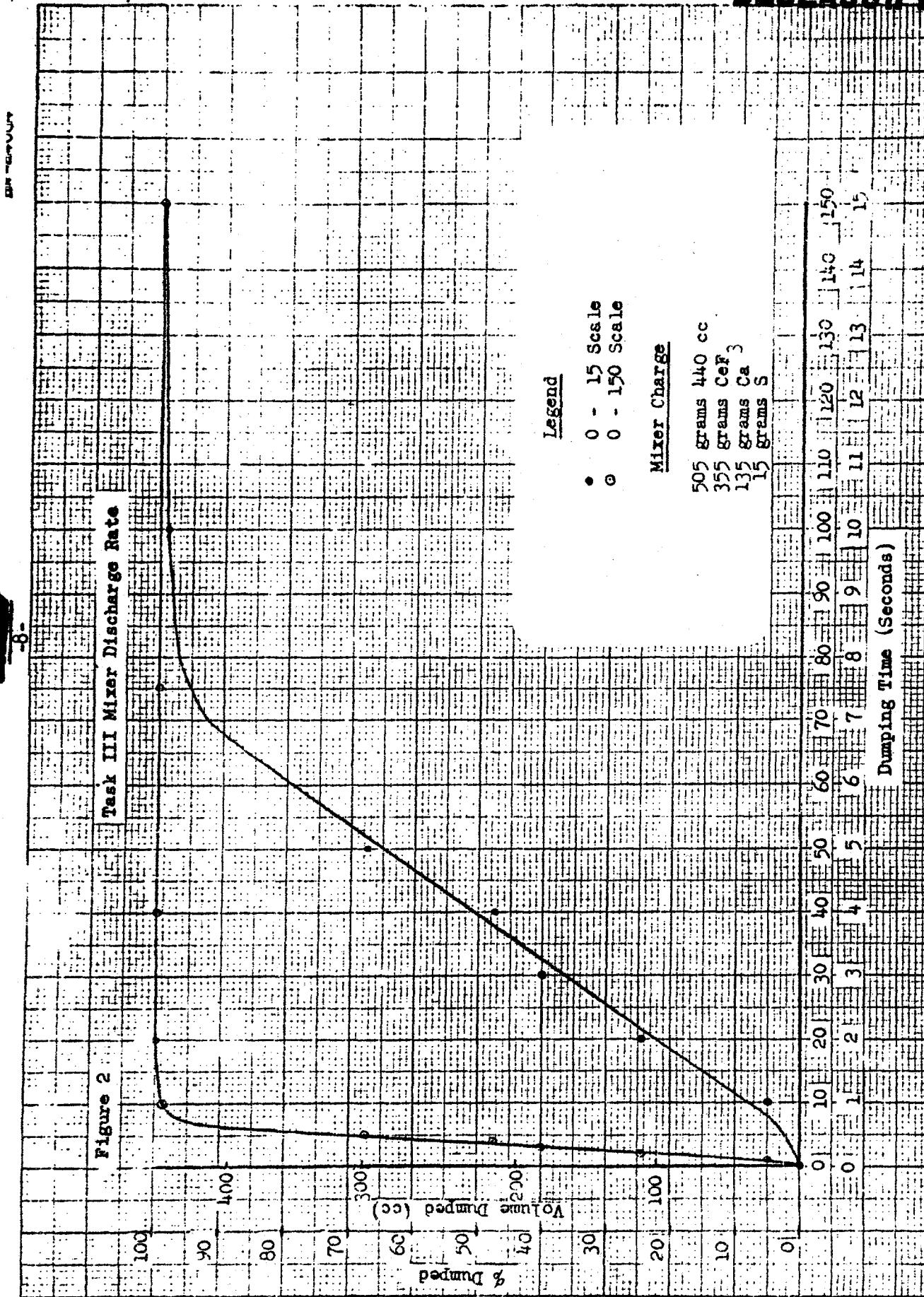


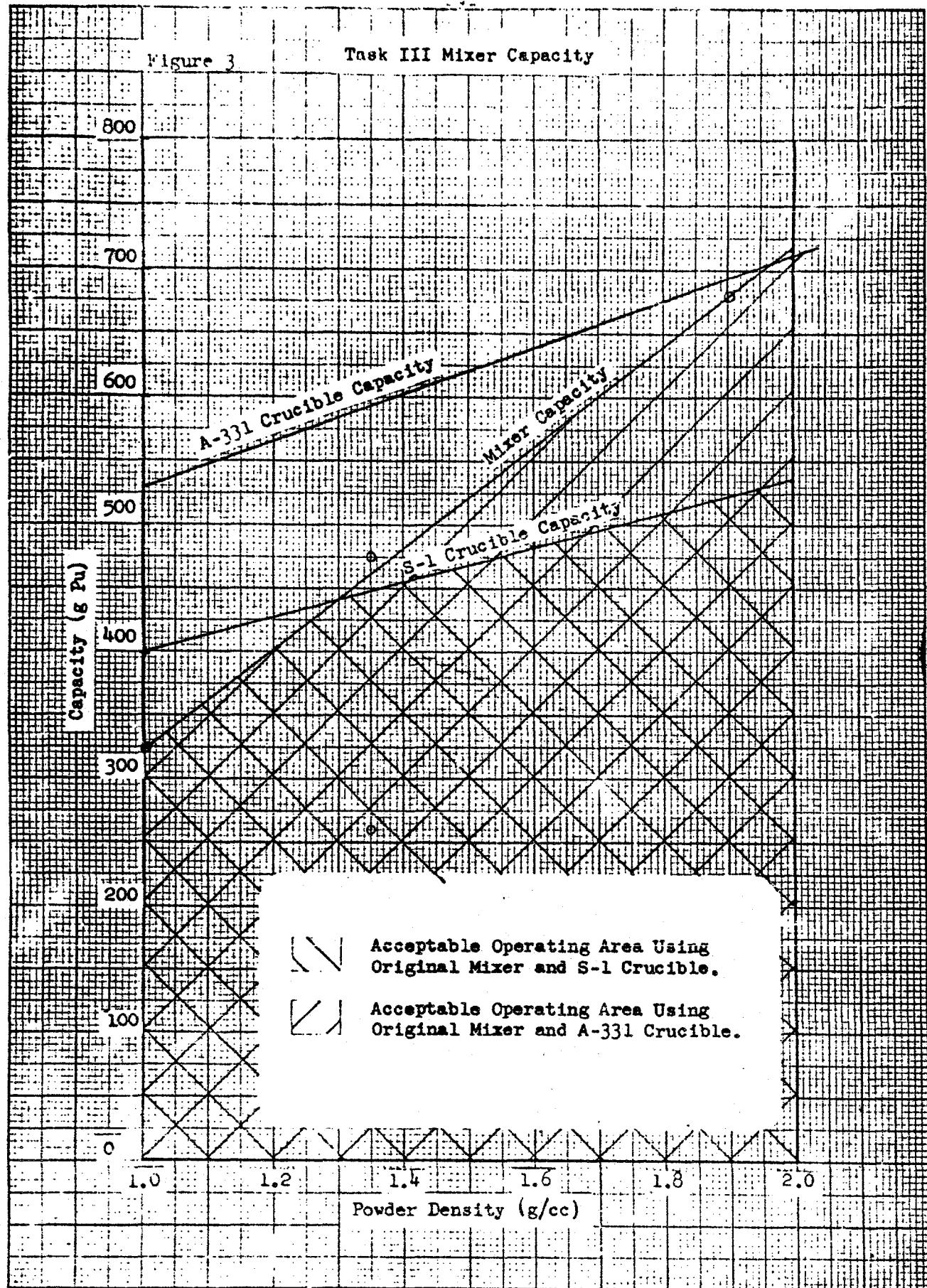
Theoretical % Ce of Homogeneous Mix.

Actual % Ce in Mix at Load End of Mixer.
Actual % Ce in Mix at Discharge End of
Mixer.

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