A COMPARISON OF THE PARTICLE SIZE DISTRIBUTION OF A KAOLIN PROCESSED ON A BRADLEY MILL VERSUS THE SAME KAOLIN PROCESSED ON A RAYMOND MILL

by

James T. Tanner, Jr.
Senior Mineral Processing Engineer

ABSTRACT

The particle size distribution of kaolin processed on a 69-inch Bradley mill was found to be finer than the particle size distribution of the same kaolin processed on a 66-inch Raymond mill. The reason for this phenomena is not clear. The shearing action in the Bradley mill must be greater than in the Raymond mill.

The particle size determinations comparisons were made using two deflocculants, i.e., 0.1% hexametaphosphate, and 0.05% sodium polyacrylate 211. The hexametaphosphate was found to be the better deflocculant for this particular clay.

Different ultrasonic treatments were used in dispersing the kaolin. There was very little difference between the results of an 8-minute and 12-minute treatment in most cases.

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Sample No. 5702 Book: Miscellaneous

BACKGROUND

Gene Moore, Plant Superintendent, and Gene Herman, President and Sales Manager of Wilkinson Kaolin, mentioned the fact that numerous particle size analyses had revealed a difference in the particle size distribution of kaolin processed in a Raymond mill versus the same kaolin processed in a Bradley mill. The Minerals Research Laboratory decided to investigate to prove or disprove this observation. Furthermore, the MRL decided that the investigation should include the use of two different but widely used deflocculants (hexametaphosphate and sodium polyacrylate 211) in order to: 1) test the dispersing characteristics of the two and 2) ensure bias due to the characteristics of the deflocculant was not introduced. Different ultrasonic treatments were also investigated to determine the optimum treatment necessary to achieve the ultimate size distribution.

PROCEDURE

Sample Preparation

Approximately 2.5 grams of kaolin was weighed out on digital balances. This sample was then placed in a 40 ml. Pyrex glass beaker, which was filled with either a 0.1% solution (by weight) of hexametaphosphate or a 0.05% solution of sodium polyacrylate. Deionized water was used as the liquid, and one drop of photoflow was added as a surface tension reducing agent. The beaker and its contents were then placed in a Branson ultrasonic bath where it remained for the time period shown (Figures 1-21). After ultrasonic treatment, the slurry was stirred for 4 minutes with a magnetic stir bar, and was then pumped into the sample cell of the Micromeritics 5000E Sedigraph that had previously been zeroed with deionized water containing one drop of photoflow. Following these procedures, the particle size distribution was measured.

Specific Gravity Determination

The true specific gravity of the kaolin must be determined in order to determine particle size. This value was determined with a Beckman Model 930 air comparison pycnometer. The pycnometer measures the volume of the sample by comparing the difference in air displacement caused by the presence of the sample against the known volume of the sample container. The measurement is made directly in cubic centimeters. The sample was weighed on a Mettler AC 100 digital balance and the specific gravity was calculated as follows:

$$\text{S. G.} = \frac{\text{W (grams)}}{\text{Volume (cc's)}}$$

Particle Size Analysis

The particle size distributions were determined with a Micromeritics 5000E Sedigraph (see Figures 1-21). This instrument

measures the sedimentation rates of particles dispersed in a liquid and automatically interprets this data in accordance with Stokes' Law to yield a cumulative mass percent distribution in terms of equivalent spherical diameters.

The instrument determines, by means of a finely collimated beam of X-Rays, the concentration of particles remaining at decreasing sedimentation depths as a function of time. The logarithm of the difference between initial (time = 0) and instantaneous (time = t) transmitted X-Ray intensity is electronically generated, scaled, and presented linearly as "cumulative mass percent finer" on the Y axis of an X-Y recorder. To minimize the time required for analysis, the position of the sedimentation cell is continuously changed so that the effective sedimentation depth is inversely related to elapsed time. This cell measurement is independently coordinated with the X-axis of the X-Y recorder to indicate the equivalent spherical diameter corresponding to the elapsed time and instantaneous sedimentation depth.

DISCUSSION OF RESULTS

As stated in the Background section of this report, the objectives were to: 1) determine the optimum ultrasonic treatment for clay produced by the Bradley mill and Raymond mill (the clay feed stock to both mills was identical), 2) to compare the particle size distributions determined by using both hexametaphosphate (Calgon) and polyacrylate 211 at different ultrasonic treatments, and 3) compare the optimum particle size distribution obtained for the Bradley mill and Raymond mill products.

As can be seen from Figure 13, the optimum particle size distribution of kaolin produced from the Bradley mill using 0.1 percent hexametaphosphate was found to be obtained with an 8 minute ultrasonic treatment. The twelve minute treatment produced a

distribution identical to the 8 minute treatment, except at the 0.25 micron level. At that level, the percentage of particles for the 12 minute treatment were slightly less than obtained for the 8 minute treatment. This is not thought to be significant since the accuracy at these very fine sizes diminishes. The addition of 0.1% hexametaphosphate had been found to be optimum for Wilkinson clay in previous experiments. Actually, Micromeritics, Inc. recommends 0.05% for kaolin; however, MRL found that this dosage was not sufficient to disperse this particular kaolin.

Figure 14 indicates that a 12 minute ultrasonic treatment with 0.05% polyacrylate was slightly better than either a 4 minute or 8 minute treatment for clay produced in the Bradley mill. The results of this test, when compared with those of Test 13, indicated that the hexametaphosphate was the better deflocculant of the two. This can be seen by the differences in fineness for particle sizes of one micron and smaller. This observation proved to be true in all future tests, as can be seen from the particle size distribution curves.

A twelve minute ultrasonic treatment gave the best results for the Raymond mill clay product dispersed with hexametaphosphate. (Figure 15) At first, this seemed to be inconsistent with the observation of the particle size distribution obtained with the 8 minute ultrasonic treatment of the Bradley mill product using 0.1% hexametaphosphate as a dispersant. However, when one reviews all of the particle size distribution curves, it can be readily seen that the Bradley mill product is slightly "finer" in every case and therefore appears to be better delaminated than the Raymond mill product. This makes it easier to disperse because of the larger exposed surface area.

The twelve minute ultrasonic treatment on the Raymond mill product shown in Figure 15, where 0.1% hexametaphosphate was used, is finer than the same treatment shown in Figure 16, where 0.05% polyacrylate was used. This is also shown in Figures 9 and 12. Once again, this indicates that the hexametaphosphate was a better

dispersant than polyacrylate. At this point, one might ask why 0.1% polyacrylate (or even more) was not used to increase deflocculation. This was because it was found early in the investigation that higher dosages than 0.05% resulted in an even coarser particle size distribution. (See Figures 19, 20, and 21.) This is evidence of a reversal in behavior of the polyacrylate dispersant when a higher dosage was used, which was caused by the "bridging" effect associated with this dispersant.

Figures 17 and 18 show another comparison of the twelve minute ultrasonic treatment time of both the Bradley and Raymond mill products which had been dispersed with 0.05% polyacrylate 211 and 0.1% hexametaphosphate. (See Figures 9 and 12) In both cases, the Raymond mill product had a coarser particle size distribution, as was shown by earlier experiments.

In summary, the Bradley mill produces a finer particle size kaolin than does the Raymond mill. The reason for this is unknown at this point. Perhaps the Bradley mill shears the hexagonal clay plates apart more efficiently than does the Raymond mill. Possibly other factors entered into the picture at the time the samples were taken, such as mill loading or the relative velocities of the respective air separators of the two mills.

CONCLUSIONS

1. The particle size distributions of clay processed on the Bradley mill were finer than the same clay processed on the Raymond mill regardless of the treatment used.

2. The particle size distributions of clay deflocculated with hexametaphosphate were always finer than the particle size distributions of the same clay deflocculated with polyacrylate 211, regardless of the mill used.

3. Larger additions of sodium polyacrylate 211 results in coarser particle size distributions, indicating that either a reversal in charge on the particle is taking place or a bridging effect is occurring.

4. An ultrasonic bath treatment of 8 minutes was sufficient for the Bradley mill product dispersed with 0.1% hexametaphosphate while 12 minutes was needed for the same product dispersed with 0.05% polyacrylate. This is in contrast to the 4 minute time used by most kaolin producers.

5. A 12 minute ultrasonic bath treatment was required to fully disperse the Raymond mill product using 0.1% hexametaphosphate as the dispersant. There was very little difference in the particle size distribution between the 12 minute and 8 minute ultrasonic treatment for the Raymond mill product dispersed with 0.05% polyacrylate 211.

FIG. 13. PSD FROM BRADLEY MILL COMPARISON OF ULTRASONIC TREATMENT TIME (DISPERSANT: 0.1% HEXAMETAPHOSPHATE)

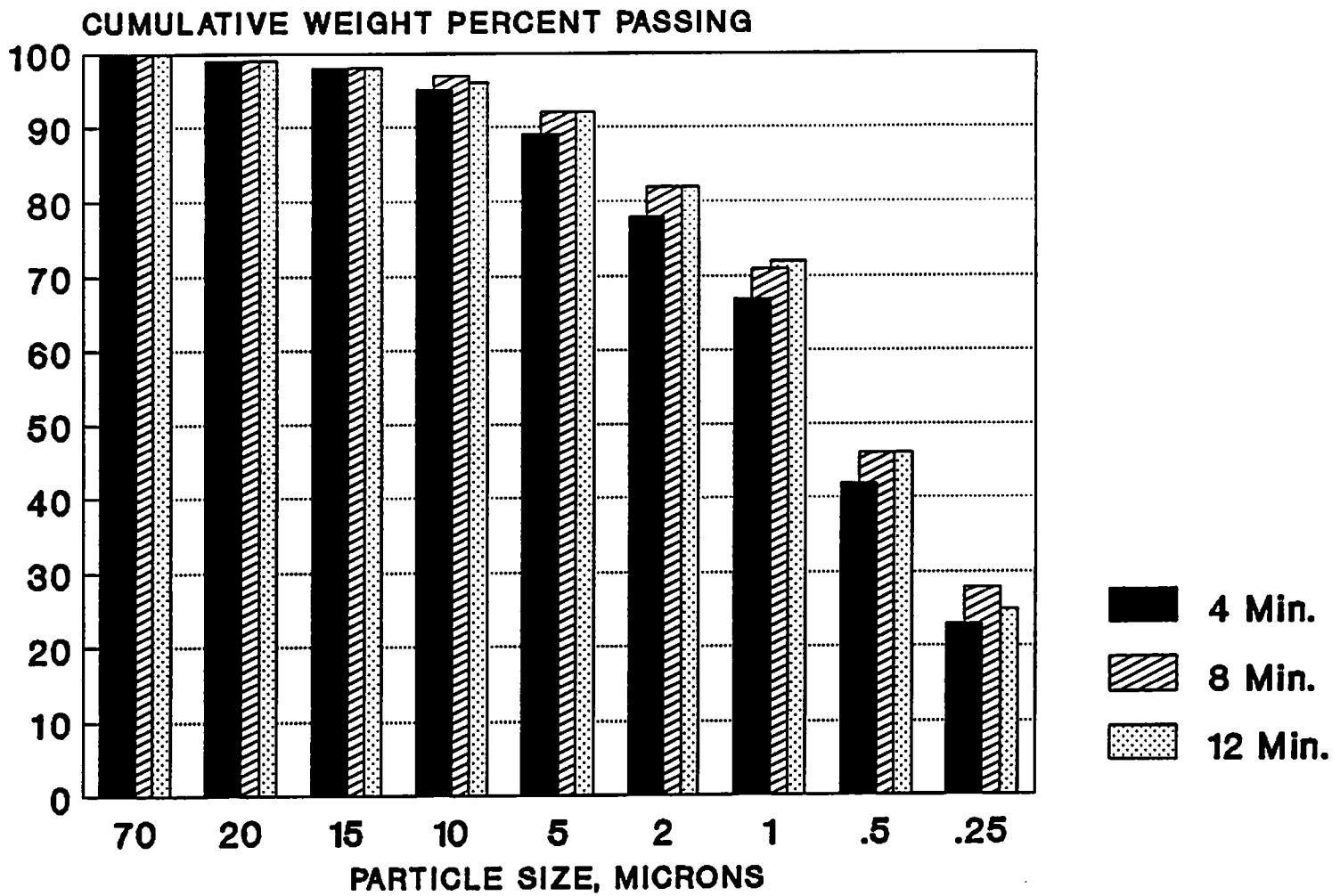


FIG. 15. PSD FROM RAYMOND MILL COMPARISON OF ULTRASONIC TREATMENT TIME (DISPERSANT: 0.1% HEXAMETAPHOSPHATE)

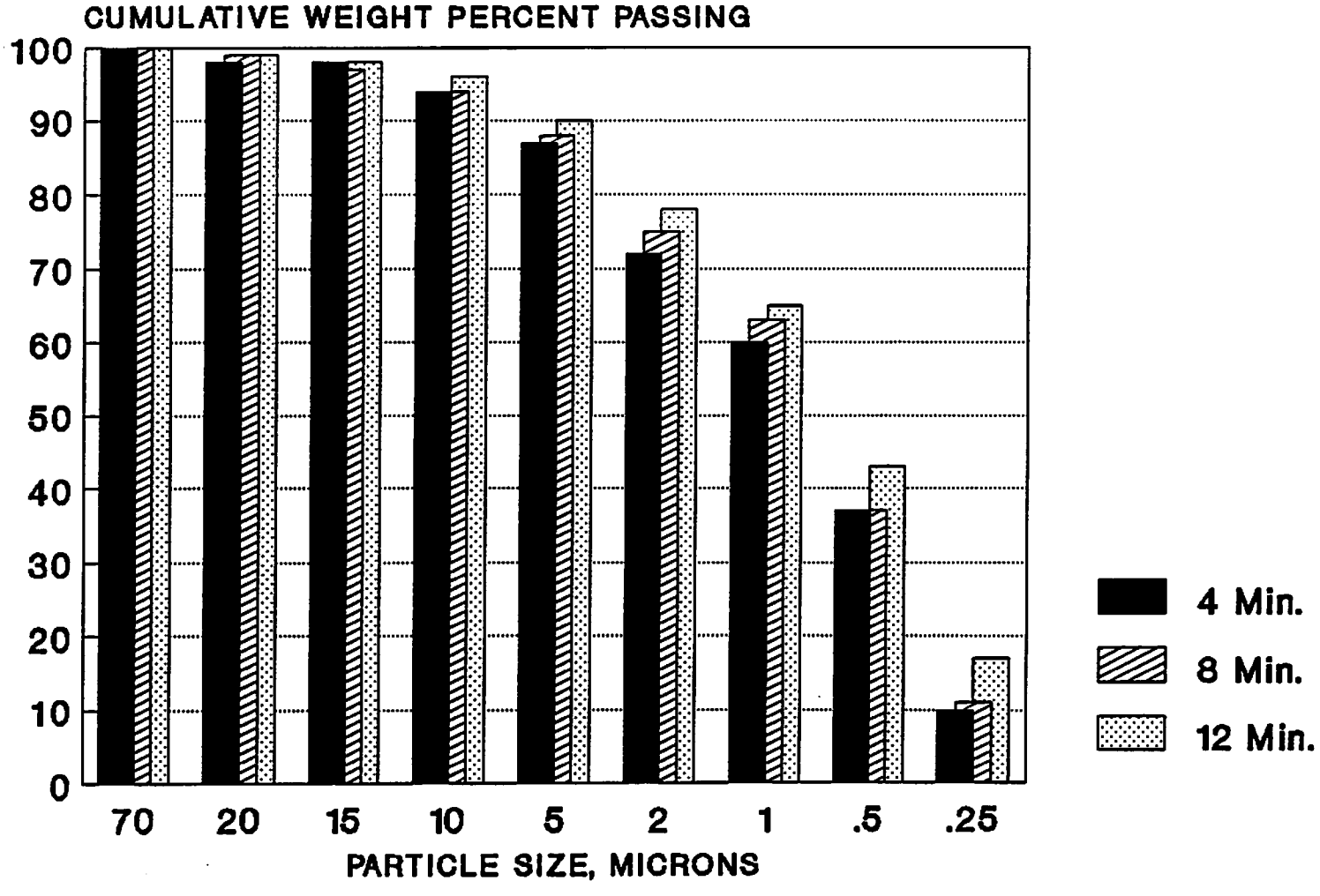


FIG. 16. PSD FROM RAYMOND MILL COMPARISON OF ULTRASONIC TREATMENT TIME

(DISPERSANT: 0.05% POLYACRYLATE 211)

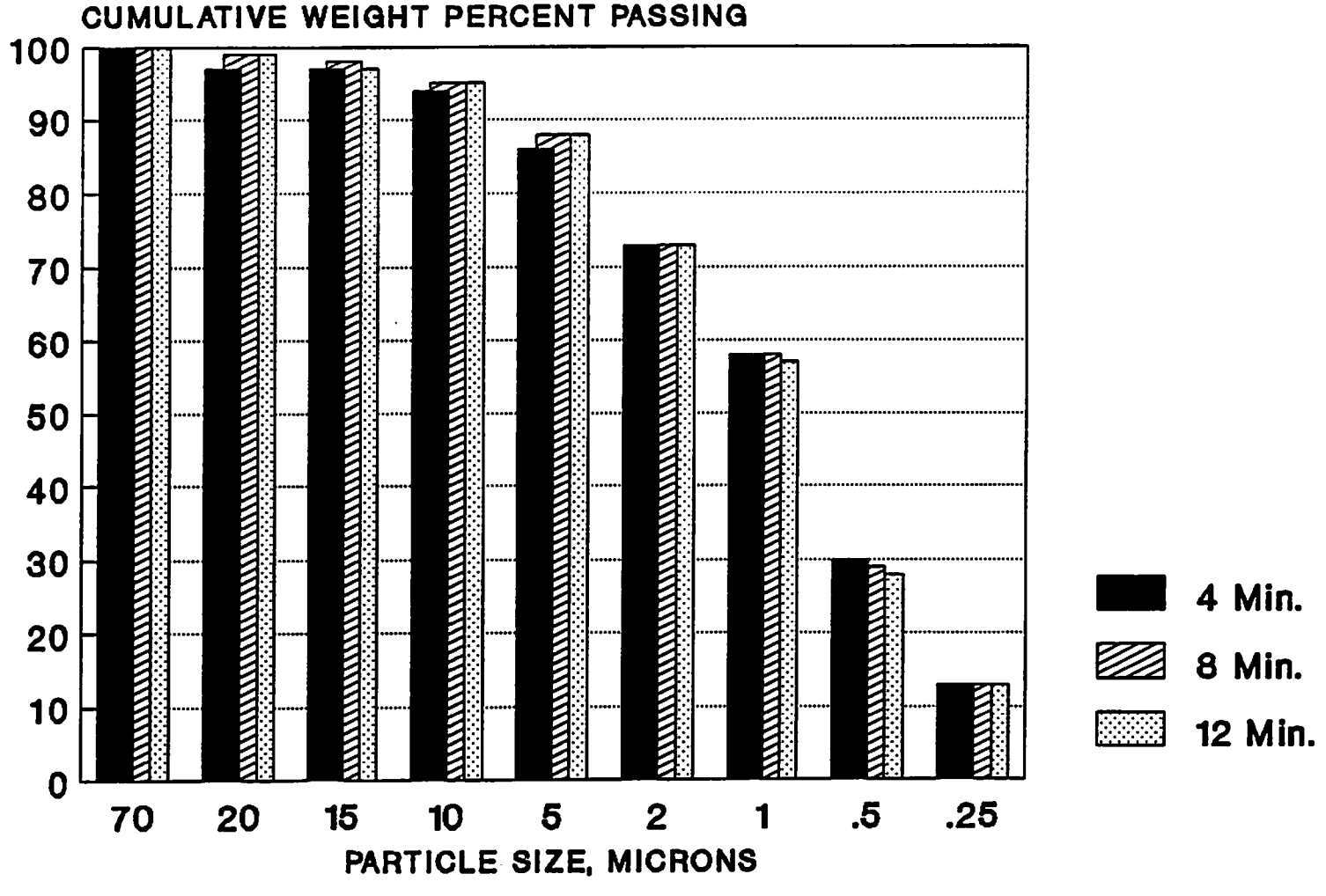


FIG. 14. PSD FROM BRADLEY MILL COMPARISON OF ULTRASONIC TREATMENT TIME

(DISPERSANT: 0.05% POLYACRYLATE 211)

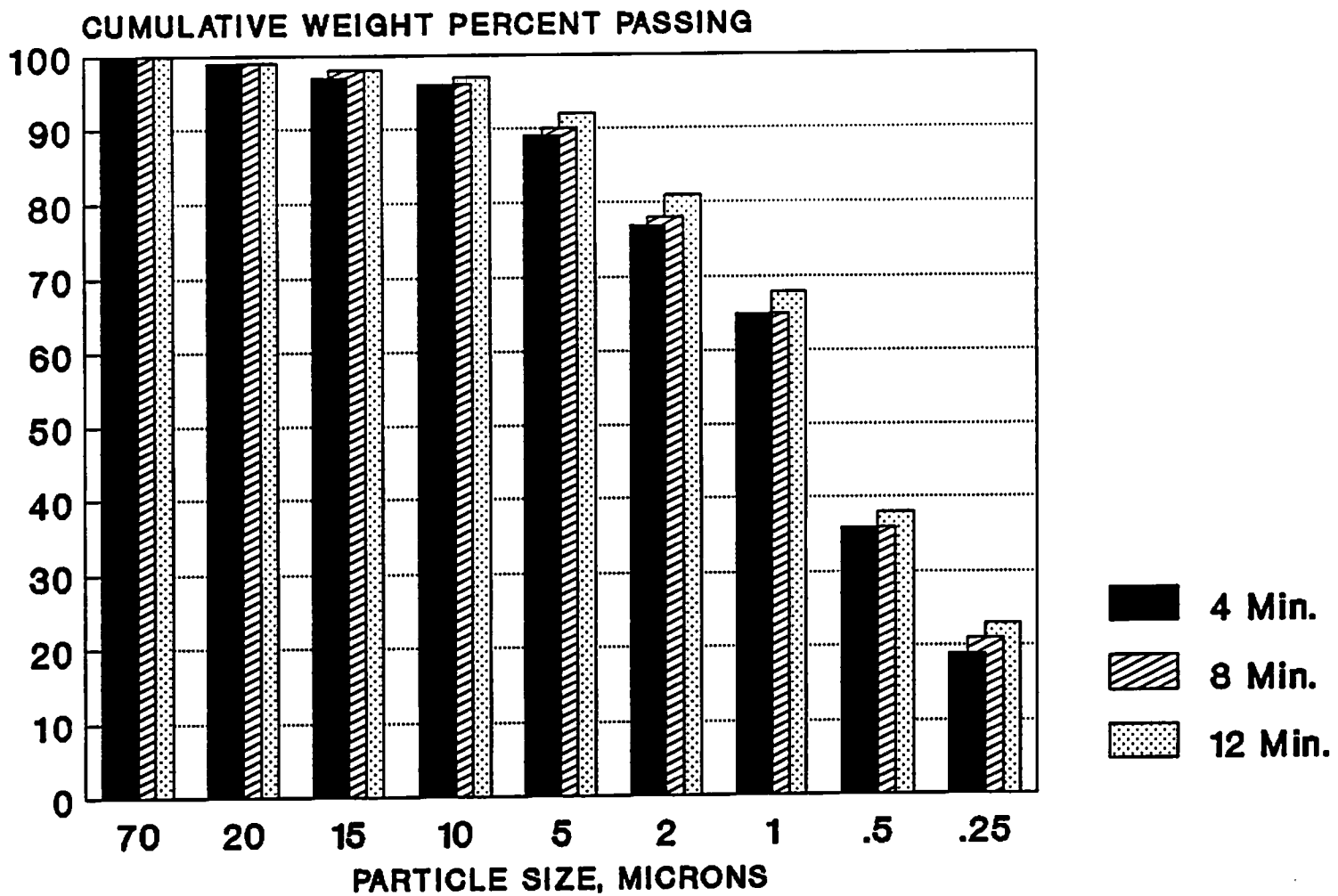
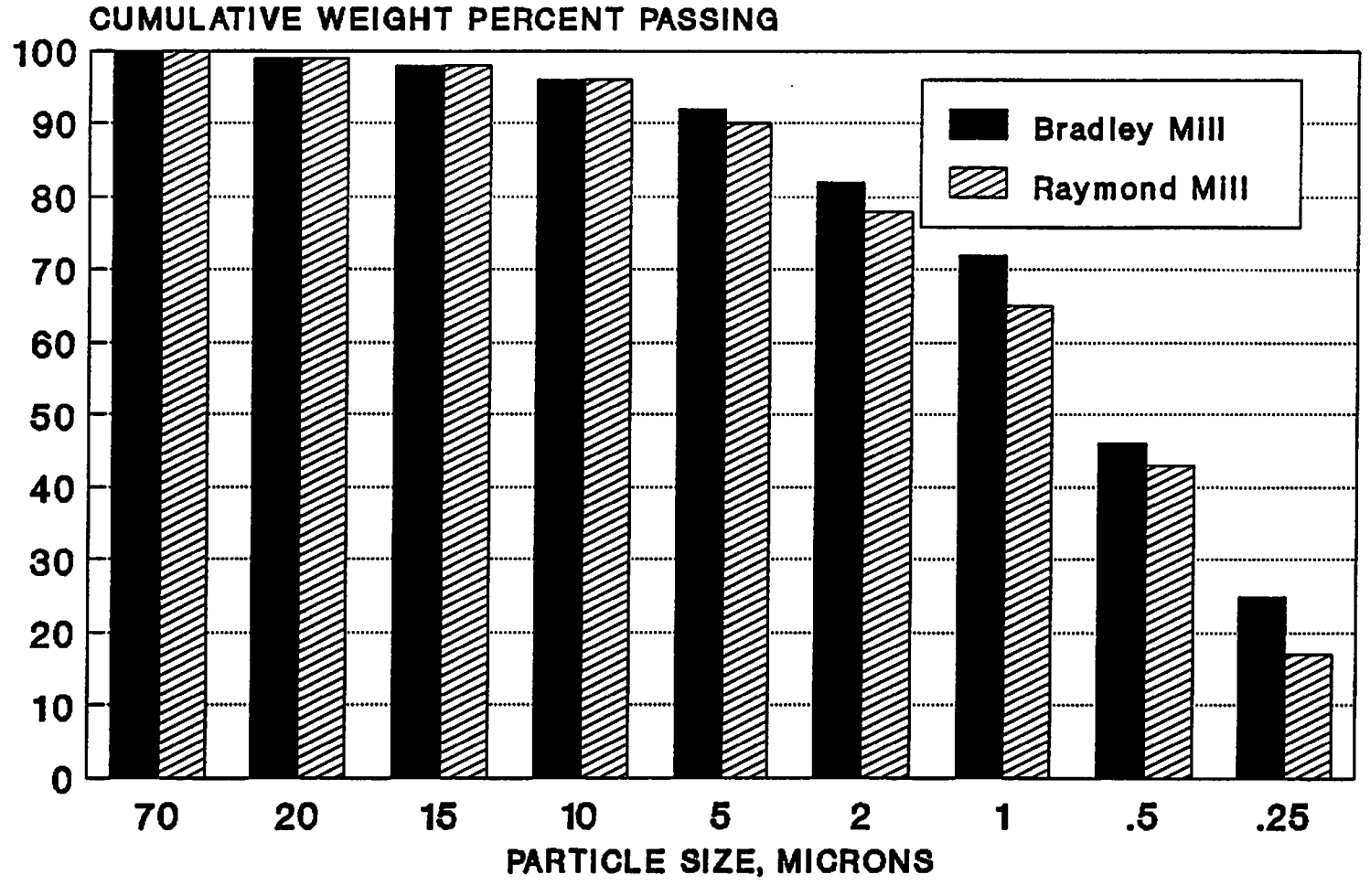
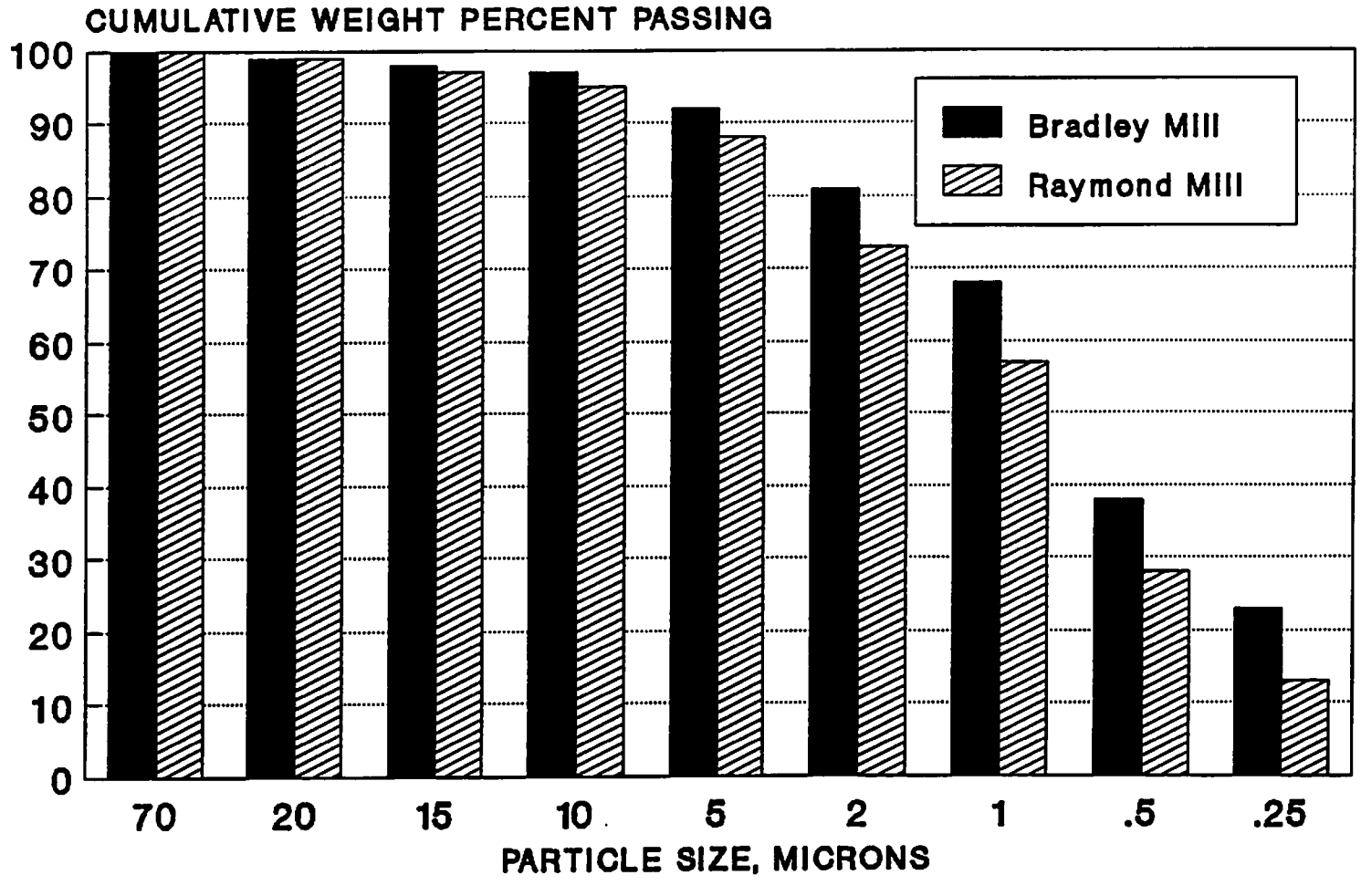


FIG. 18. PARTICLE SIZE DISTRIBUTION RAYMOND MILL VERSUS BRADLEY MILL
(DISPERSANT: 0.1% HEXAMETAPHOSPHATE)



Stirring time was 12 minutes ultrasonic.

FIG. 17. PARTICLE SIZE DISTRIBUTION RAYMOND MILL VERSUS BRADLEY MILL
(DISPERSANT: 0.05% POLYACRLYATE 211)



Stirring time was 12 minutes ultrasonic.

FIG. 13. PSD FROM BRADLEY MILL
COMPARISON OF ULTRASONIC TREATMENT TIME
(DISPERSANT: 0.1% HEXAMETAPHOSPHATE)

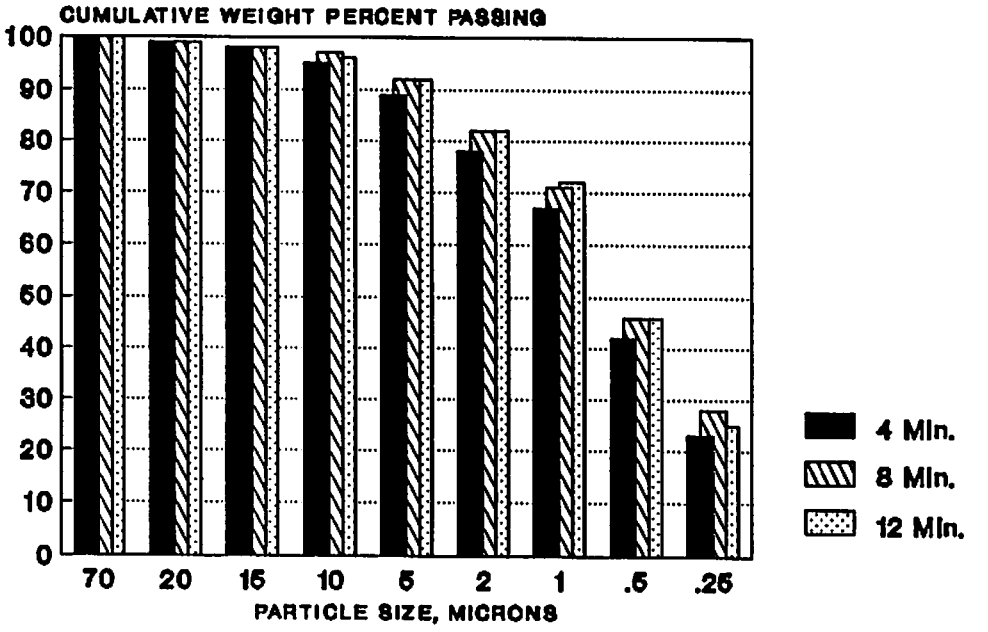


FIG. 14. PSD FROM BRADLEY MILL
COMPARISON OF ULTRASONIC TREATMENT TIME
(DISPERSANT: 0.05% POLYACRYLATE 211)

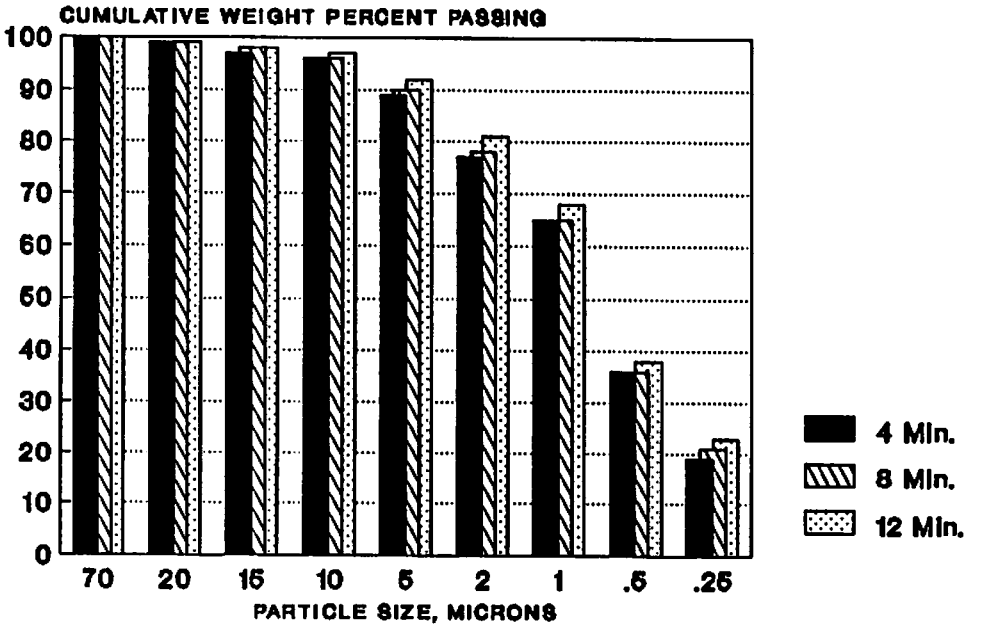


FIG. 15. PSD FROM RAYMOND MILL
COMPARISON OF ULTRASONIC TREATMENT TIME
(DISPERSANT: 0.1% HEXAMETAPHOSPHATE)

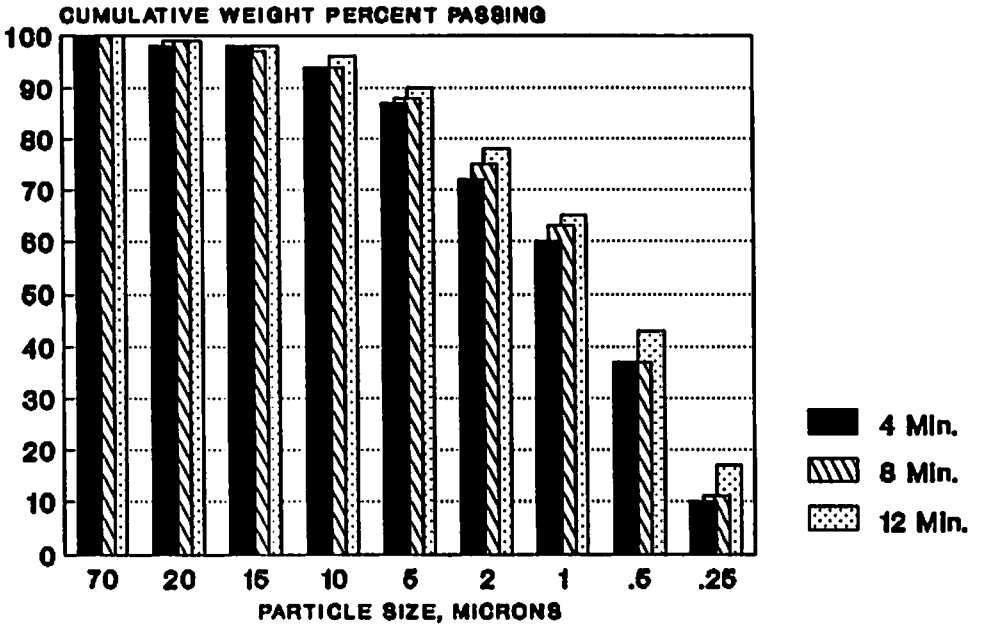


FIG. 16. PSD FROM RAYMOND MILL
COMPARISON OF ULTRASONIC TREATMENT TIME
(DISPERSANT: 0.05% POLYACRYLATE 211)

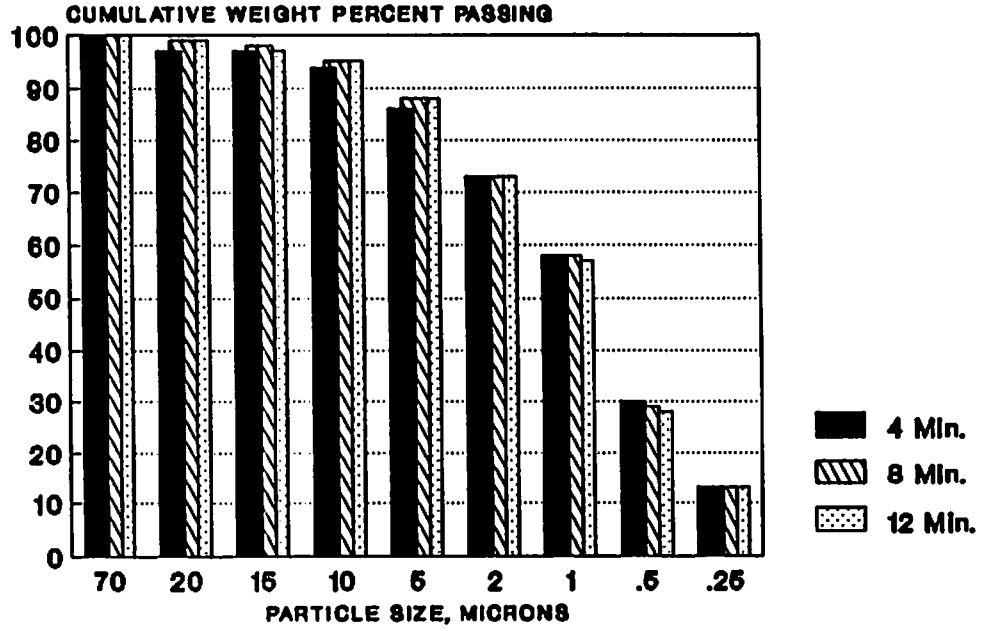
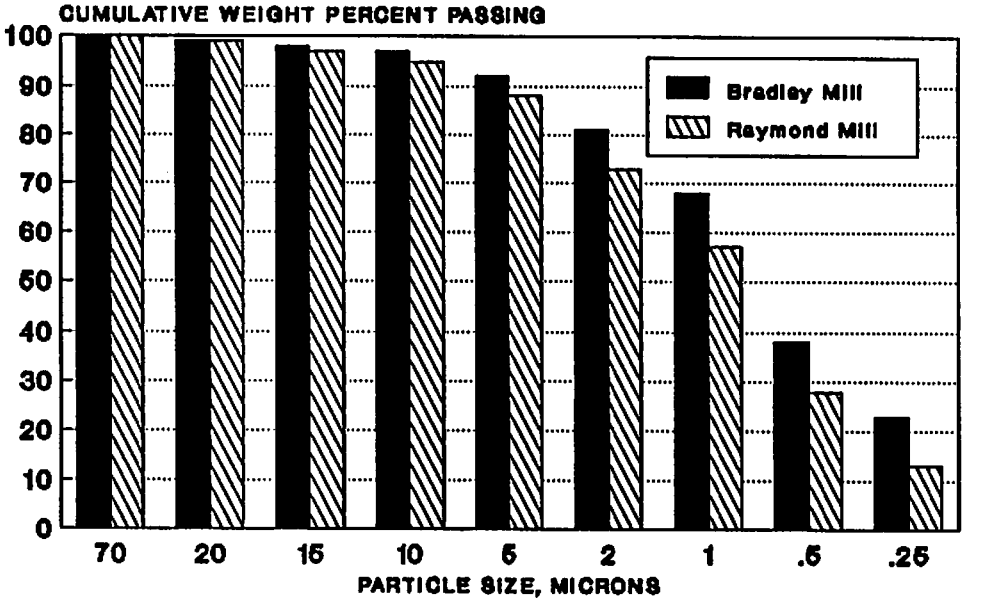
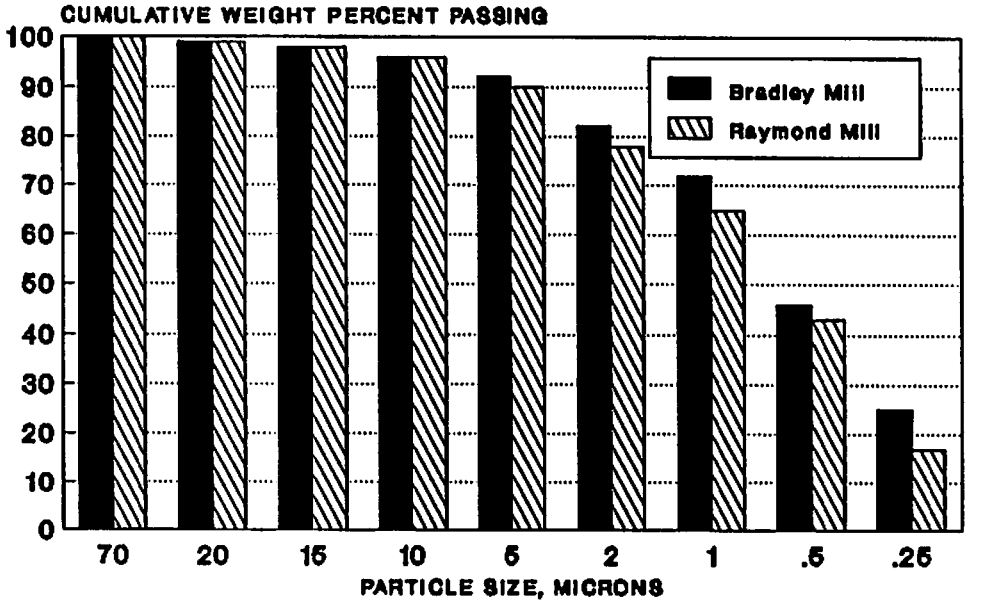


FIG. 17. PARTICLE SIZE DISTRIBUTION RAYMOND MILL VERSUS BRADLEY MILL (DISPERSANT: 0.05% POLYACRLYATE 211)



Stirring time was 12 minutes ultrasonic.

FIG. 18. PARTICLE SIZE DISTRIBUTION RAYMOND MILL VERSUS BRADLEY MILL (DISPERSANT: 0.1% HEXAMETAPHOSPHATE)



Stirring time was 12 minutes ultrasonic.

Figure 1

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION Bradley Mill Kaolin

DATE 2/14/91

Density 2.62 g/cc LIQUID 0.1 Hexametaphosphate Density 0.9941 g/cc Viscosity 0.7225 cp

BY JTT

Preparation 4 min. Ultrasonic - 4 min. stir

TEMPERATURE 35 °C

RATE 934 START DIA. 70 um

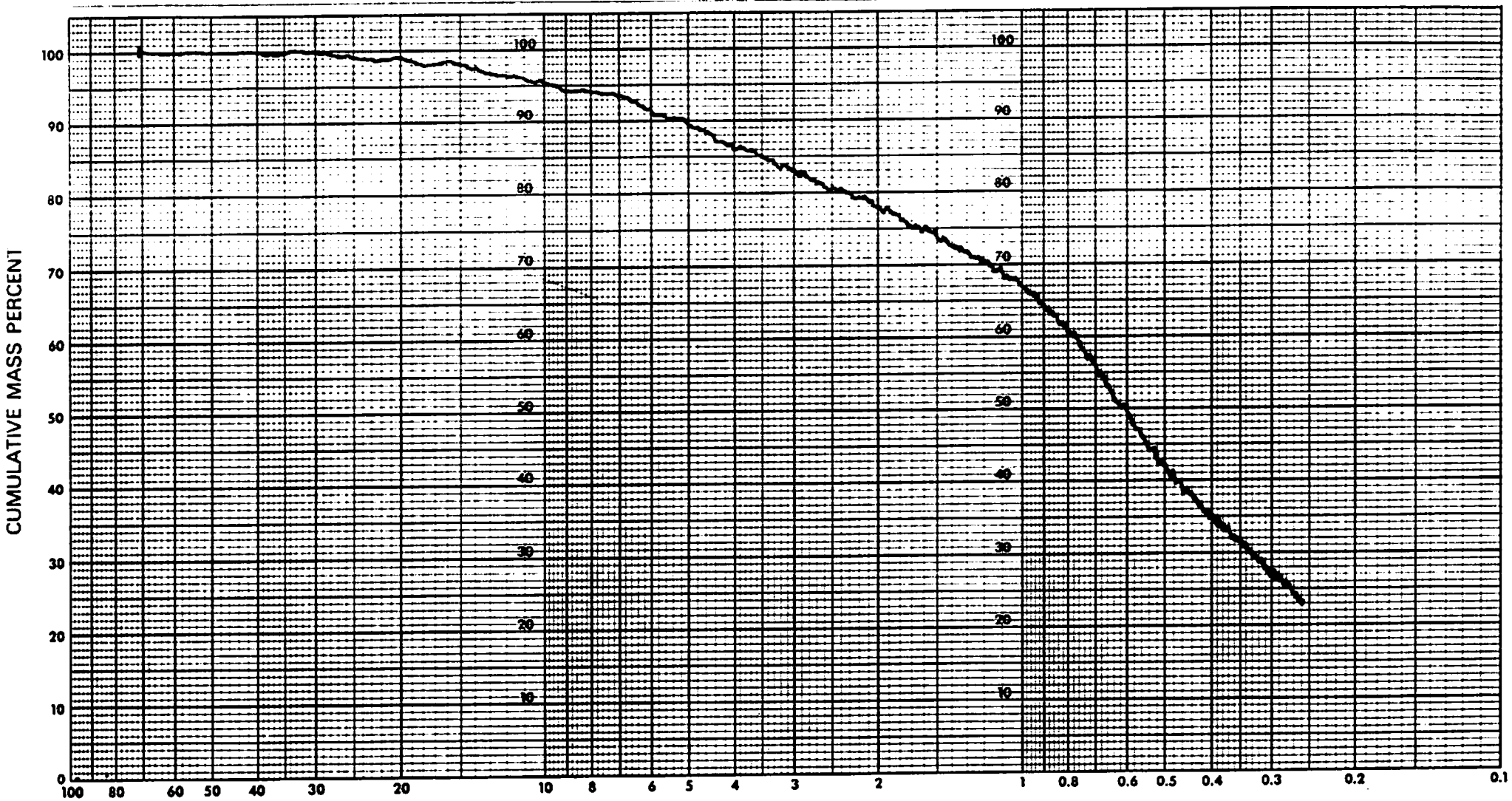


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Figure 2

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION Bradley Mill Kaolin

DATE 2/15/91

Density 2.62 g/cc LIQUID 0.1% Hexametaphosphate Density 0.9947 g/cc Viscosity 0.7523 cp

BY JTT

Preparation 8 min. Ultrasonic bath, 4 min. stir

TEMPERATURE 33 °C

RATE 897 START DIA. 70 µm

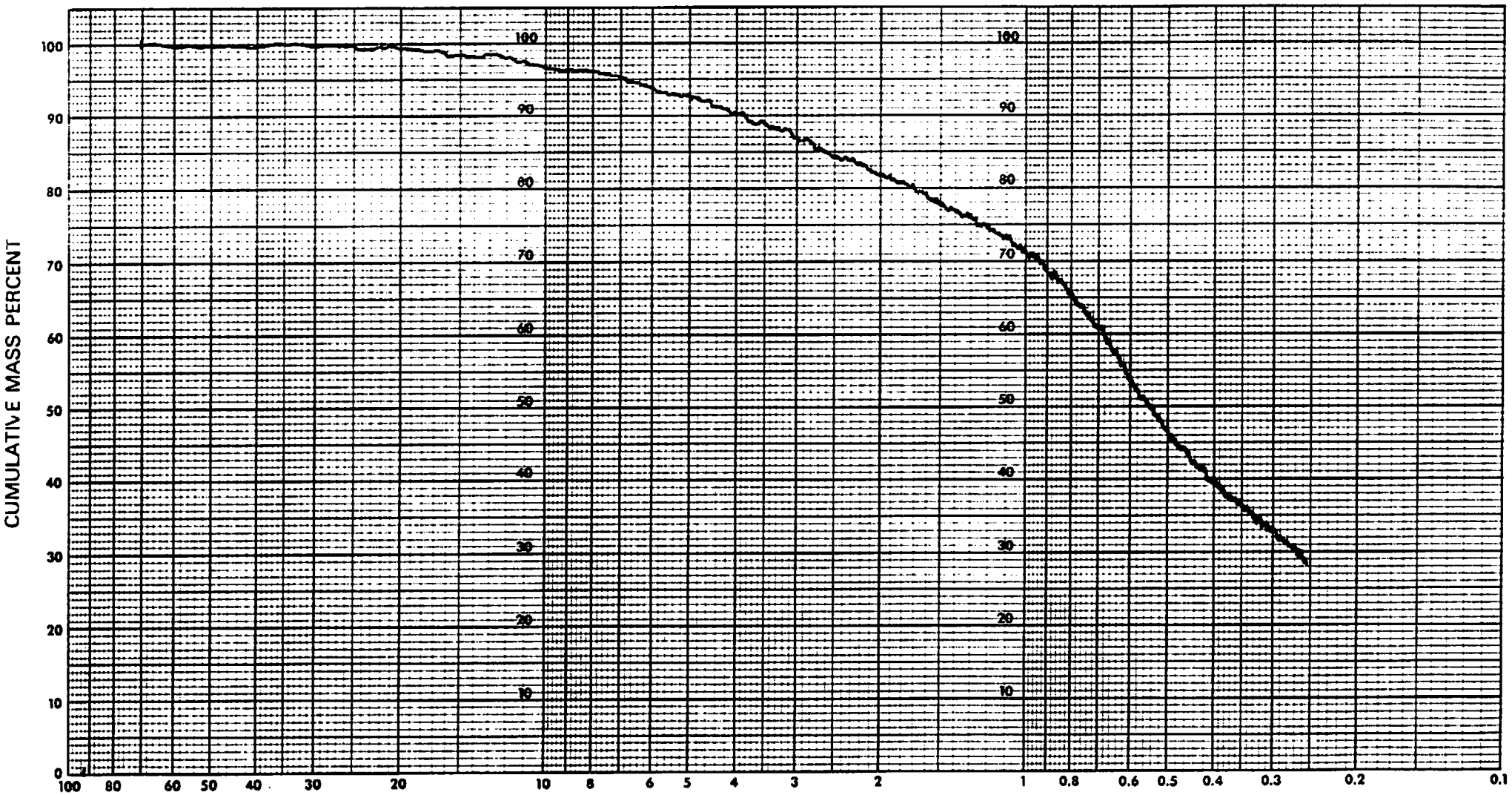

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Figure 3

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION Bradley Mill Kaolin

DATE 2/4/91

Density 2.62 g/cc LIQUID 0.1% Hexametaphosphate Density 0.9941 g/cc Viscosity 0.7225 cp

BY JTT

Preparation 12 min Ultrasonic Bath, 4 min. stir

TEMPERATURE 35 °C

RATE 934 START DIA. 70 µm

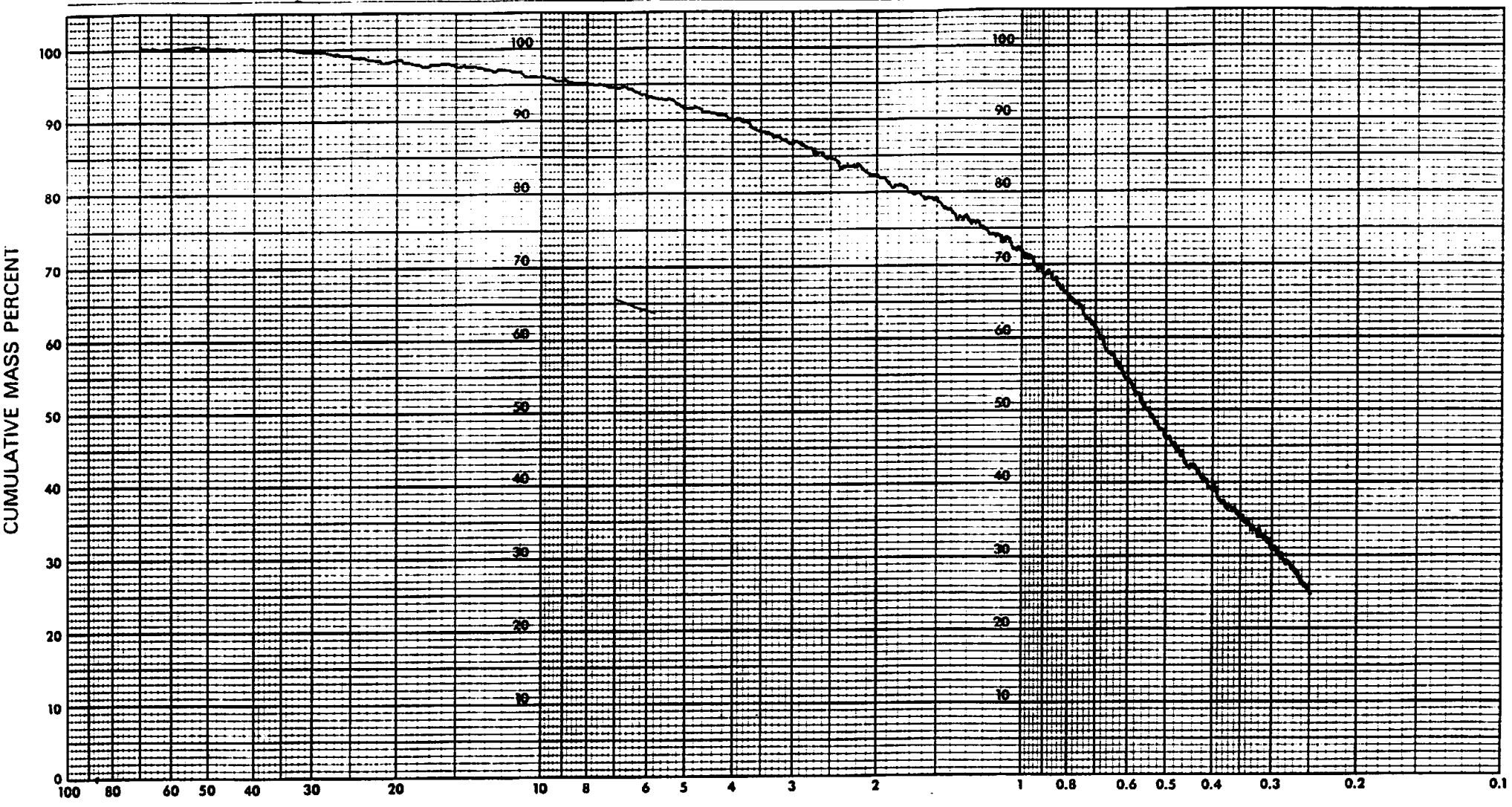

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Figure 4

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION Bradley Mill Kaolin

DATE 2/7/91

Density 2.62 g/cc LIQUID 0.05% Poly A Density 0.9941 g/cc Viscosity 0.7225 cp

BY JTT

Preparation 4 min. Ultrasonic Bath, 4 min. stir

TEMPERATURE 33 °C

Poly A = Polyacrylate 211

RATE 934 START DIA. 70 µm

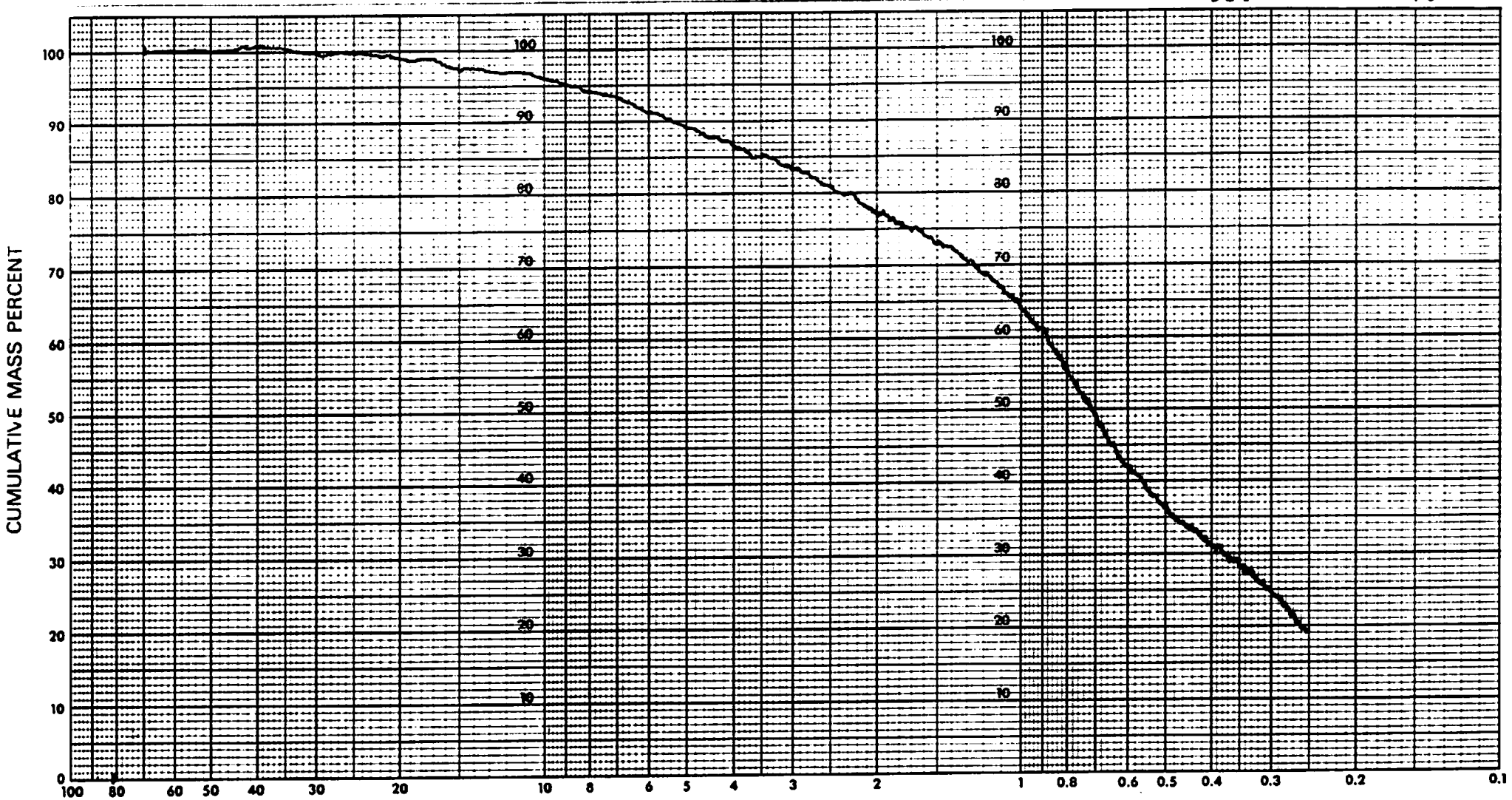

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Figure 5

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION Bradley Mill Kaolin

DATE 2/7/91

Density 2.62 g/cc LIQUID 0.05% Poly A Density 0.9941 g/cc Viscosity 0.7225 cp

BY JTT

Preparation 8 min. Ultrasonic - 4 min. stir

TEMPERATURE 35 °C

Poly A = Polyacrylate 211

RATE 934 START DIA. 70 µm

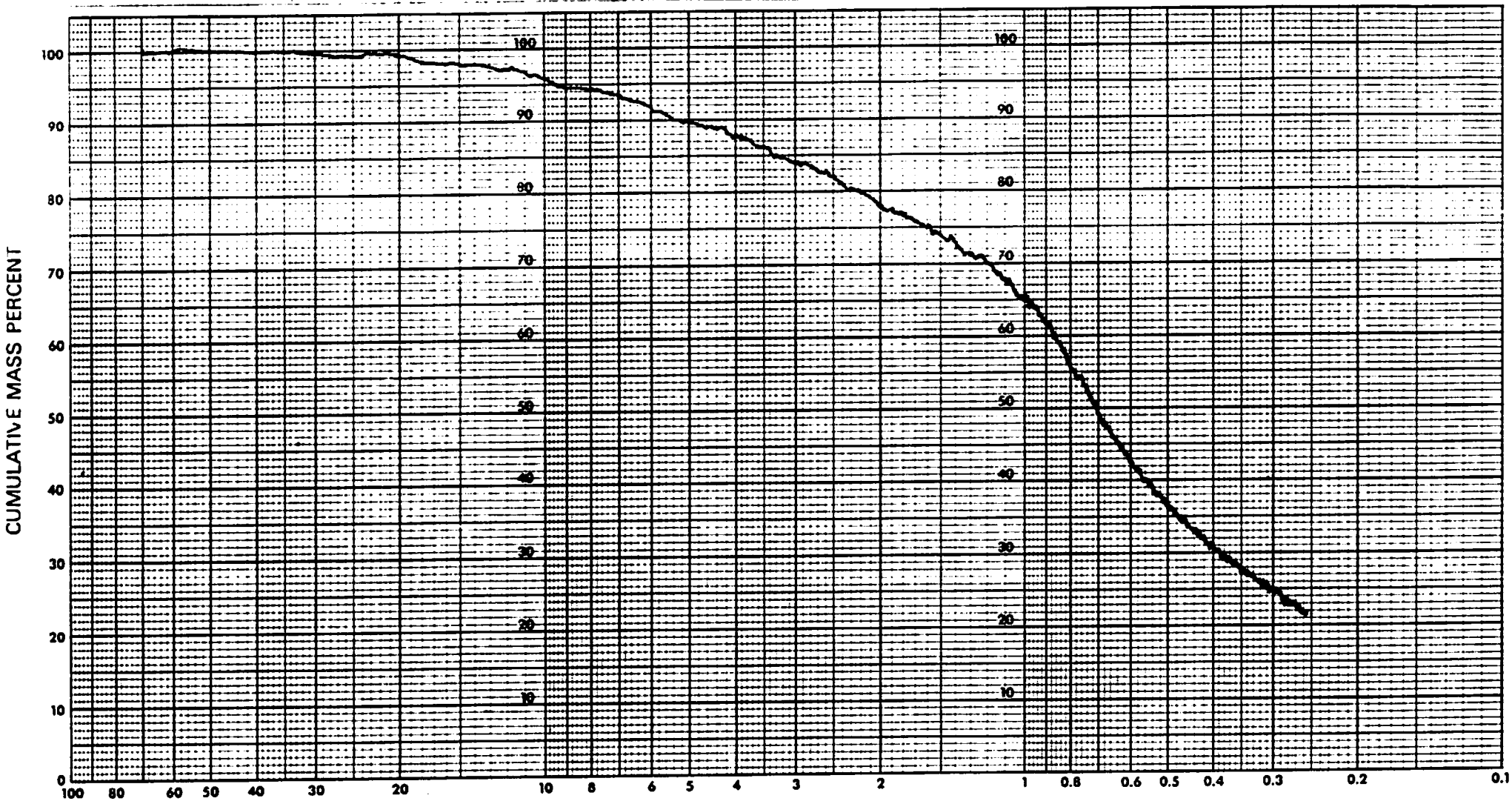

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Figure 6

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION Bradley Mill Kaolin

DATE 7/7/91

Density 2.62 g/cc LIQUID 0.05% Poly A Density 0.9941 g/cc Viscosity 0.7225 cp

BY JTT

Preparation 12 min. Ultrasonic, 4 min. stir

TEMPERATURE 35 °C

Poly A = Polyacrylate 211

RATE 934 START DIA. 70 µm

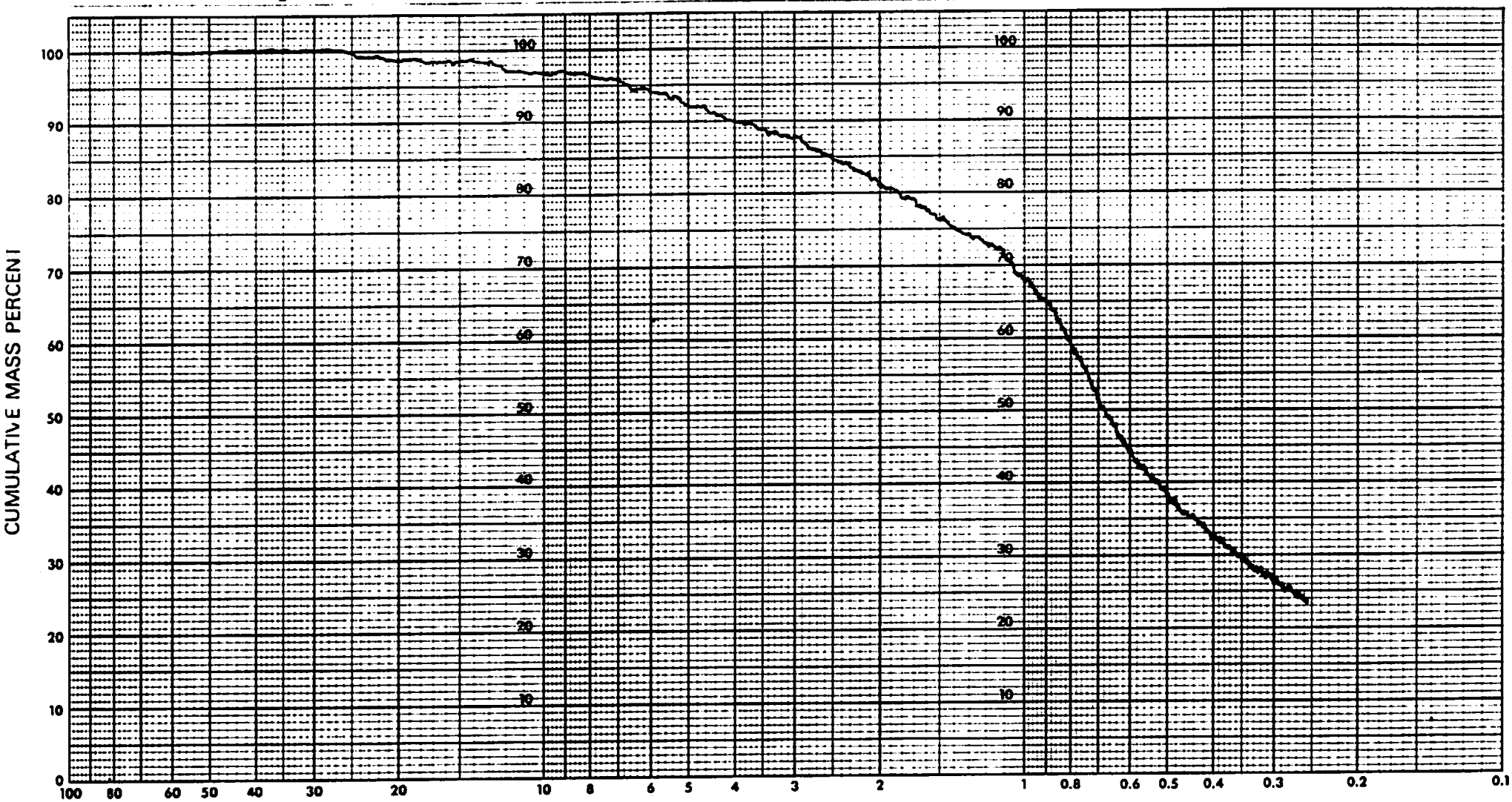

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Figure 7

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION Raymond Mill Kaolin

DATE 2/4/91

Density 2.62 g/cc LIQUID 0.1 Hexametaphosphate Density 0.9937 g/cc Viscosity 0.7085 cp

BY JTT

Preparation 4 min. ultrasonic 4 min. stir

TEMPERATURE 36 °C

RATE 953 START DIA. 70 µm

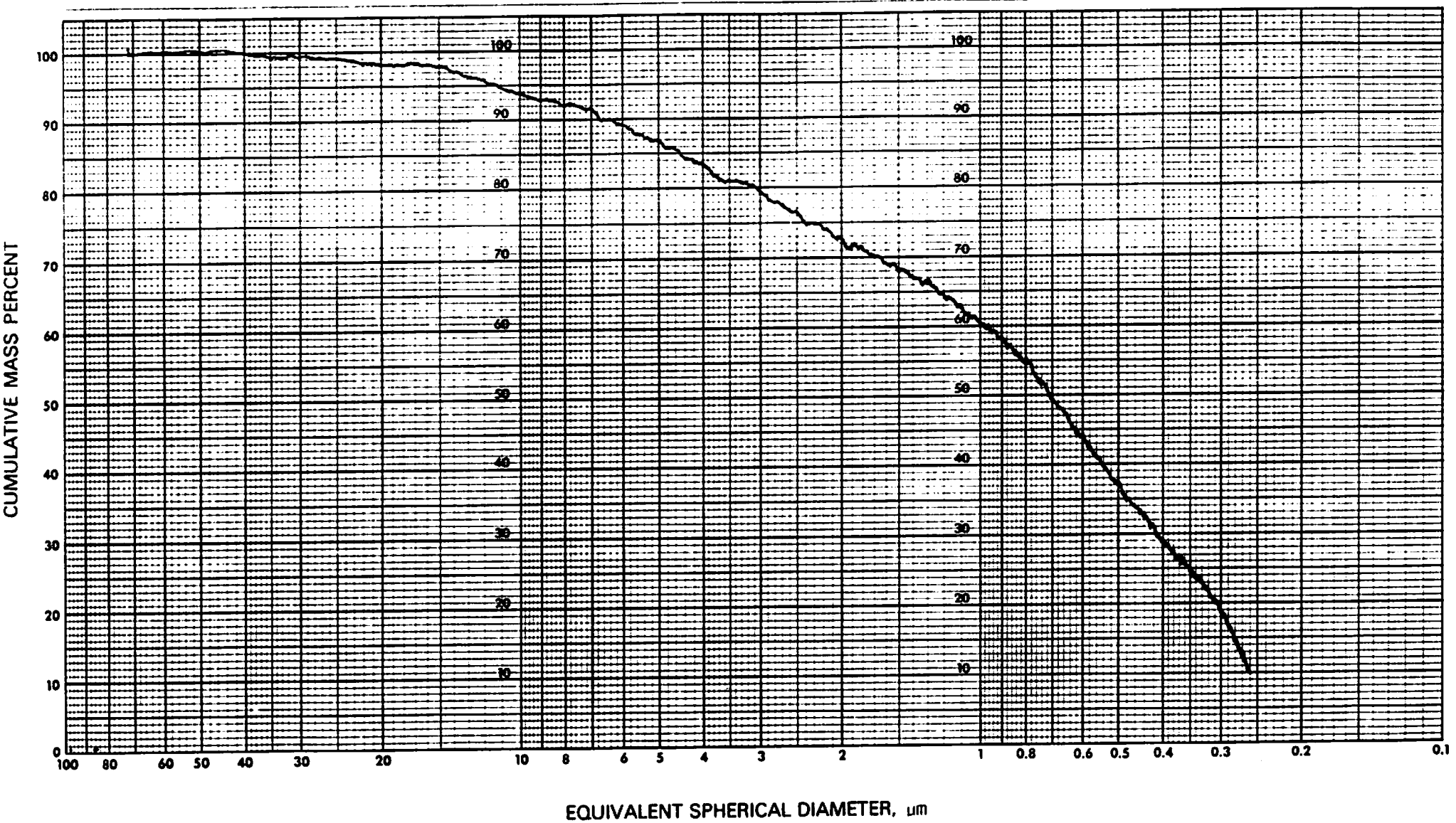

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Figure 8

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION Raymond Mill Kaolin

DATE 2/14/91

Density 2.62 g/cc LIQUID 0.1 Hexametaphosphate Density 0.9937 g/cc Viscosity 0.7085 cp

BY JTT

Preparation 8 min. ultrasonic bath - 4 min. stir

TEMPERATURE 35 °C

RATE 934 START DIA. ___ µm

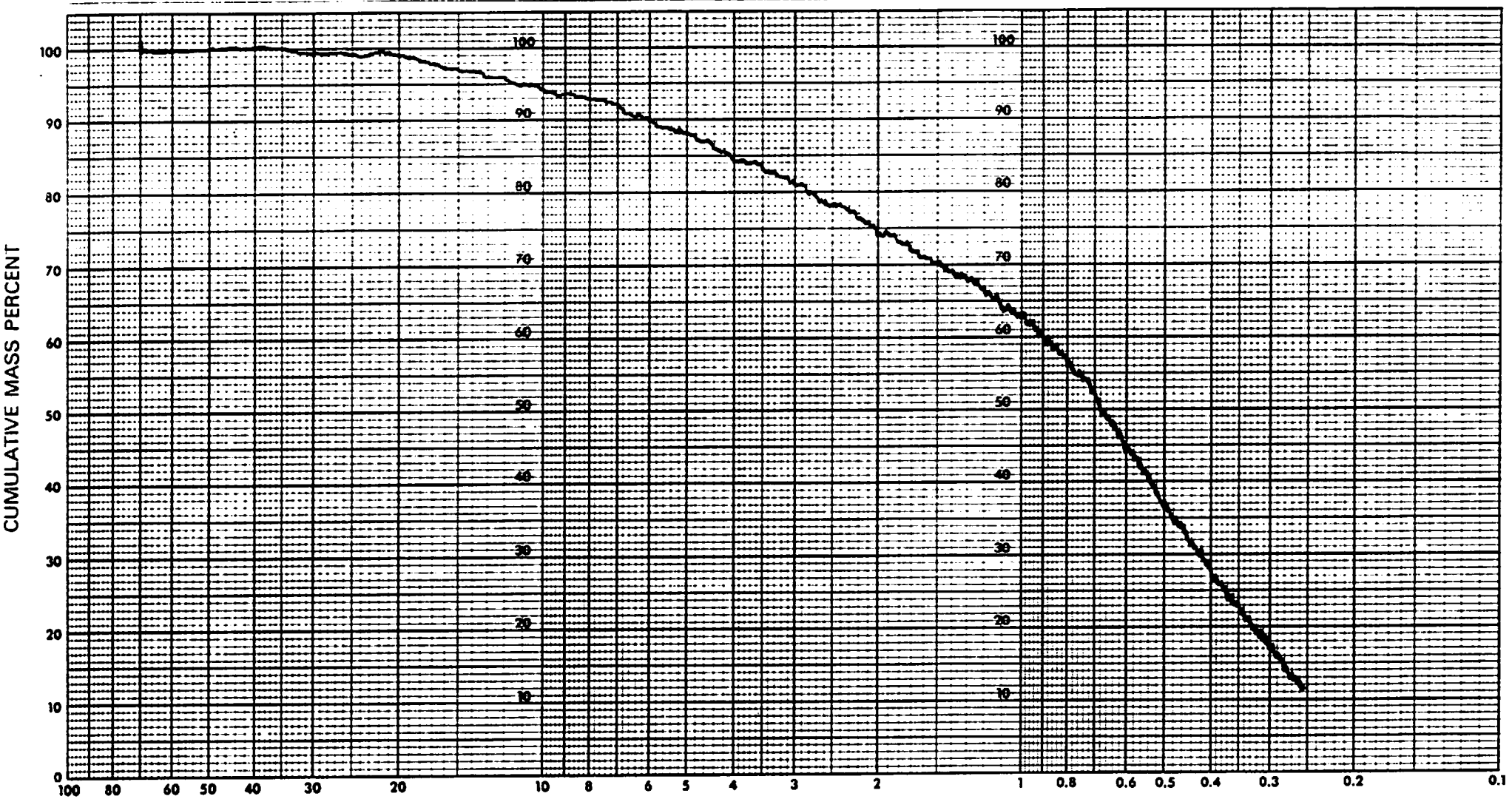

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Figure 9

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION Raymond Mill Kaolin

DATE 2/4/91

Density 2.62 g/cc LIQUID 0.1 Hexametaphosphate Density 0.9941g/cc Viscosity 0.7225p

BY JTT

Preparation 12 min. Ultrasonic bath, 4 min. stir

TEMPERATURE 35 °C

RATE 934 START DIA. 70 um

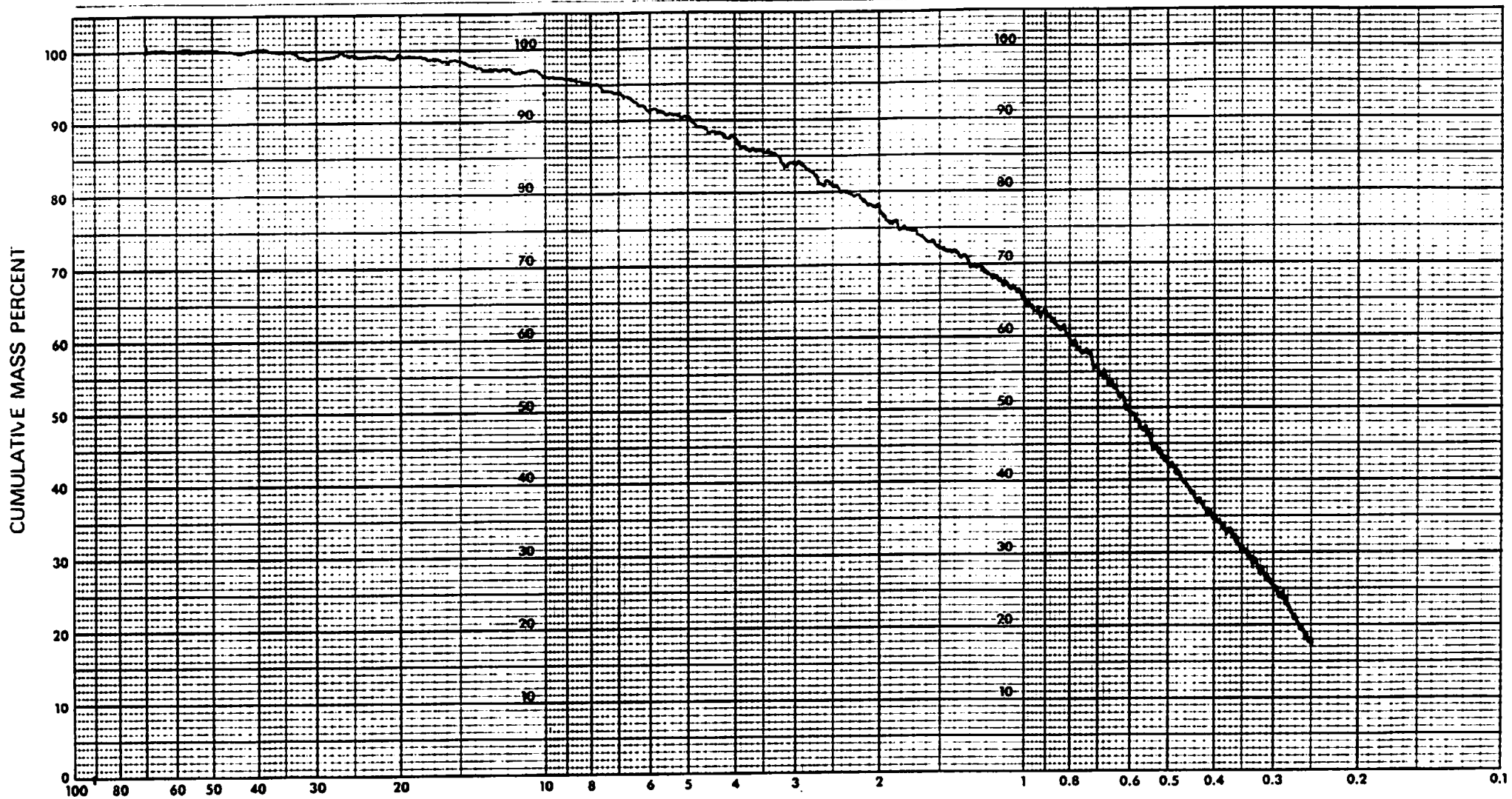

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Figure 10

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION: Raymond Mill Kaolin

DATE: 2/14/91

Density 2.62 g/cc LIQUID 0.05% Poly A Density 0.9941 g/cc Viscosity 0.7225 cp

BY: JTT

Preparation: Ultrasonic 4 min. Stir 4 min. deflocculated with 0.15% Polyacrylate 211

TEMPERATURE 35 °C

RATE 934 START DIA. 70 µm

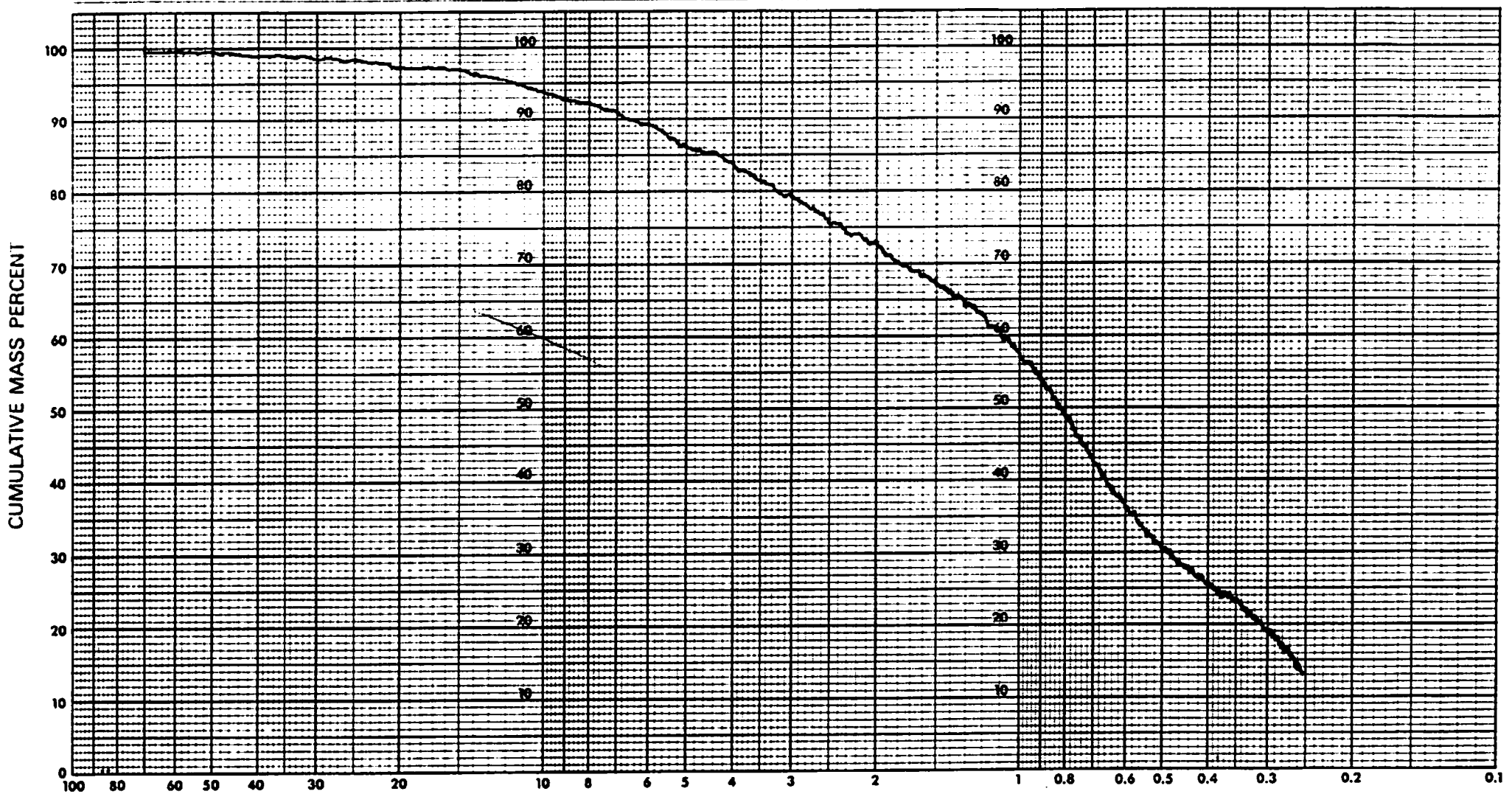

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Figure 11

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION Raymond Mill Kaolin

DATE 2/7/91

Density 2.62 g/cc LIQUID 0.05% Poly A Density 0.9941 g/cc Viscosity 0.7225 cp

BY JTT

Preparation 8 min. Ultrasonic 4 min. stir
deflocculated with 0.05% Polyacrylate 211

TEMPERATURE 35 °C

RATE 934 START DIA. 70 µm

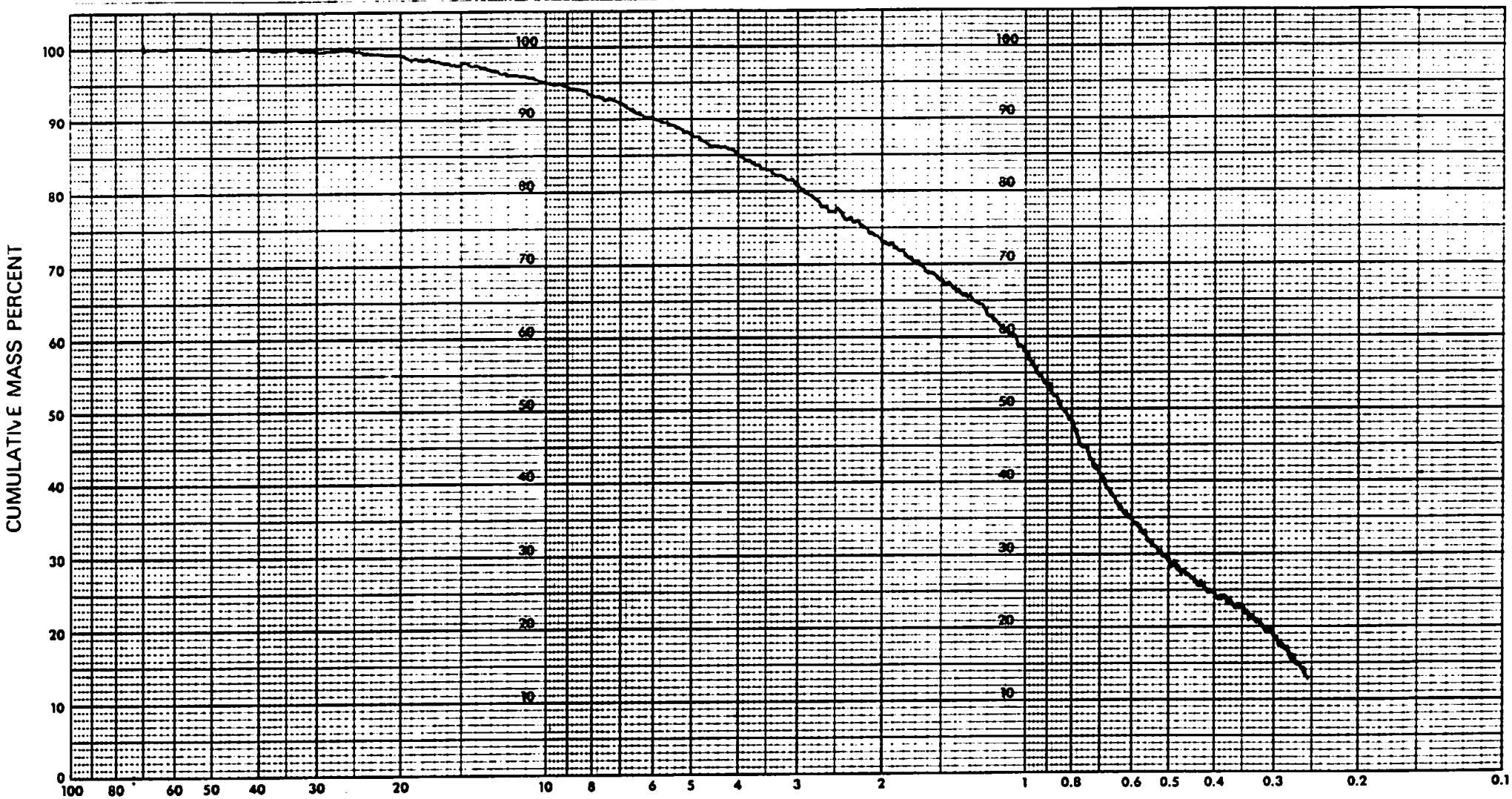

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Figure 12

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION Raymond Mill Kaolin

DATE 2/7/91

Density 2.62 g/cc LIQUID 0.05 Poly A Density 0.9941 g/cc Viscosity 0.7225 cp

BY JTT

Preparation Ultrasonic 12 min., stir 4 min.
deflocculated with 0.05% Polyacrylate 211

TEMPERATURE 35 °C

RATE 934 START DIA. ___ µm

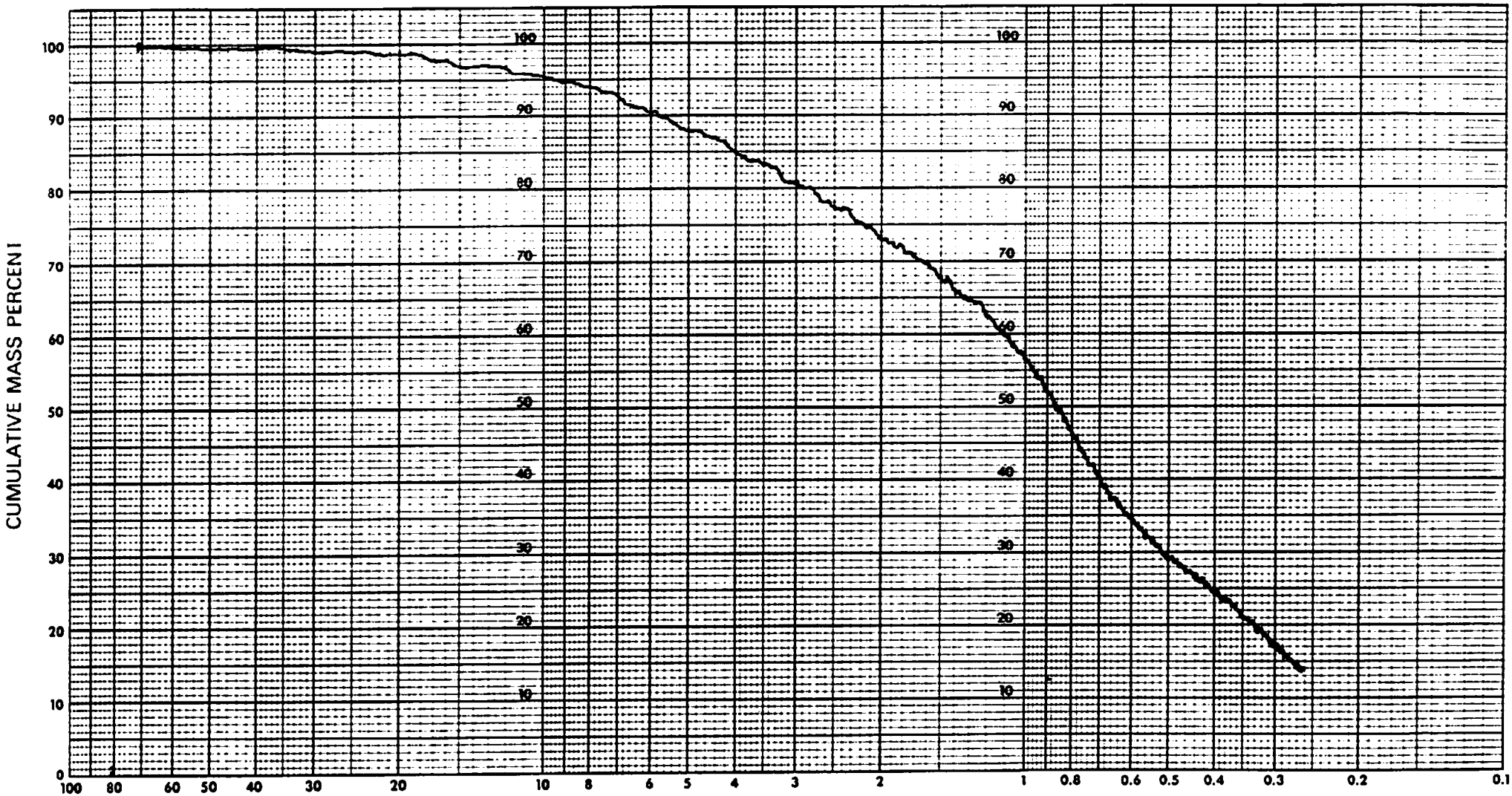

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Figure 19

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION Raymond Mill Kaolin

DATE 2/4/91

Density 2.62 g/cc LIQUID 0.1% Poly A Density 0.9941 g/cc Viscosity 0.7085 cp

BY JTT

Preparation Ultrasonic 8 min., stir 4 min.
deflocculated with Polyacrylate 211

TEMPERATURE 36 °C

RATE 953 START DIA. 70 µm

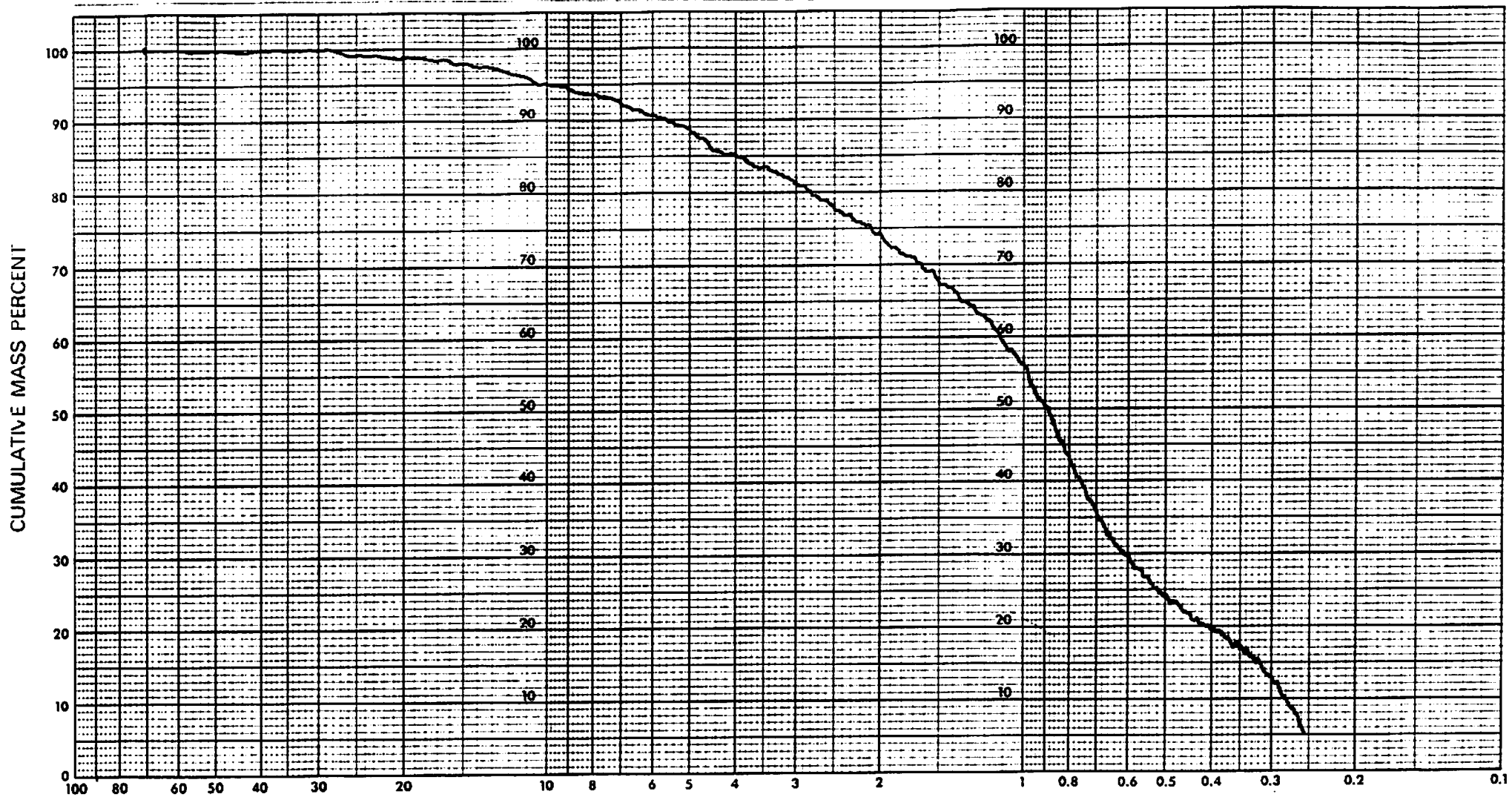

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Figure 20

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION Raymond Mill Kaolin

DATE 2/4/91

Density 2.62 g/cc LIQUID 0.15 Poly A Density 0.9941 g/cc Viscosity 0.7225 cp

BY JTT

Preparation Ultrasonic 4 min., stir 4 min.
deflocculated with Polyacrylate 211

TEMPERATURE 35 °C

RATE 934 START DIA. 70 µm

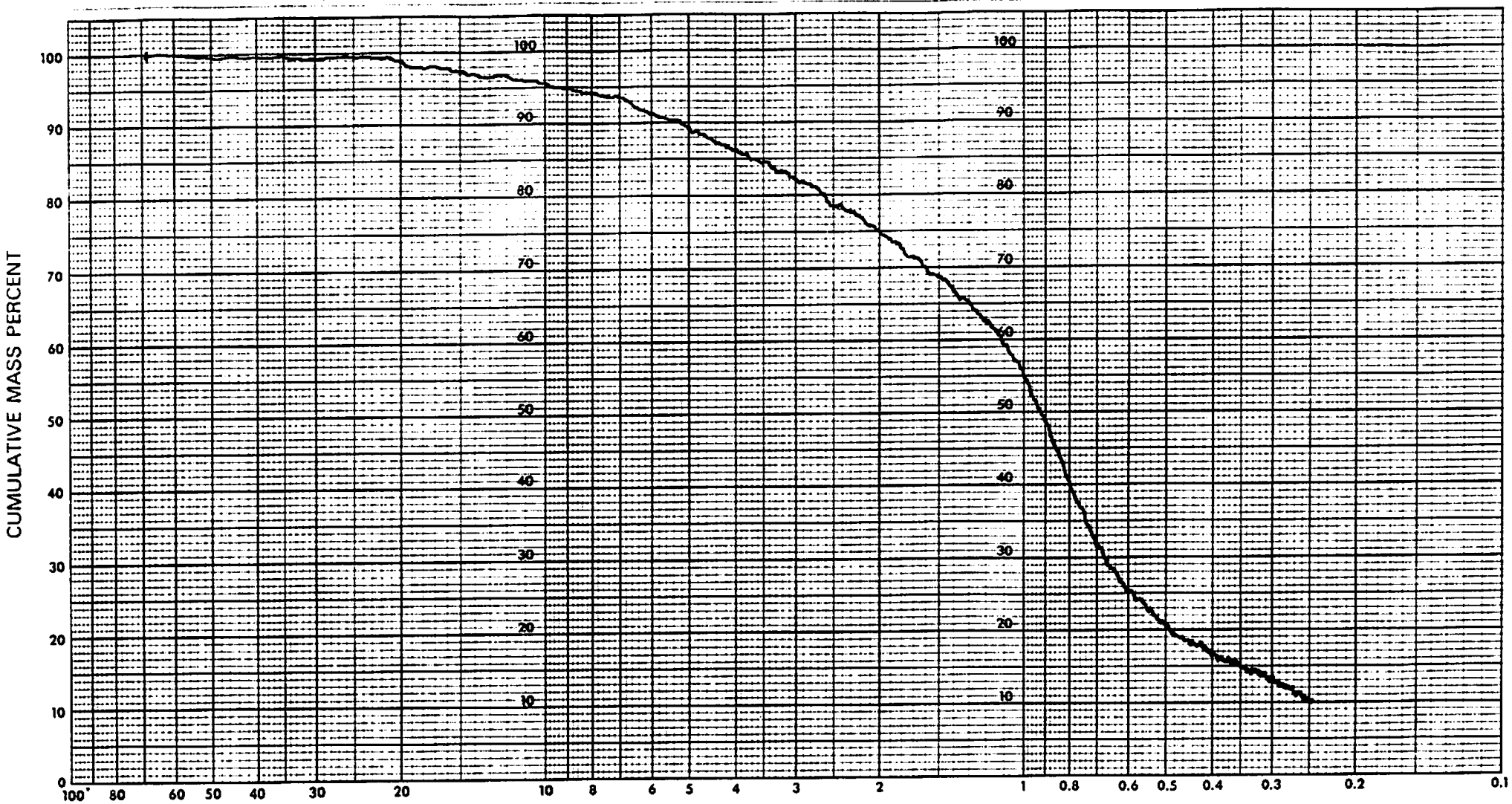

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Figure 21

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION Raymond Mill Kaolin

DATE 2/4/91

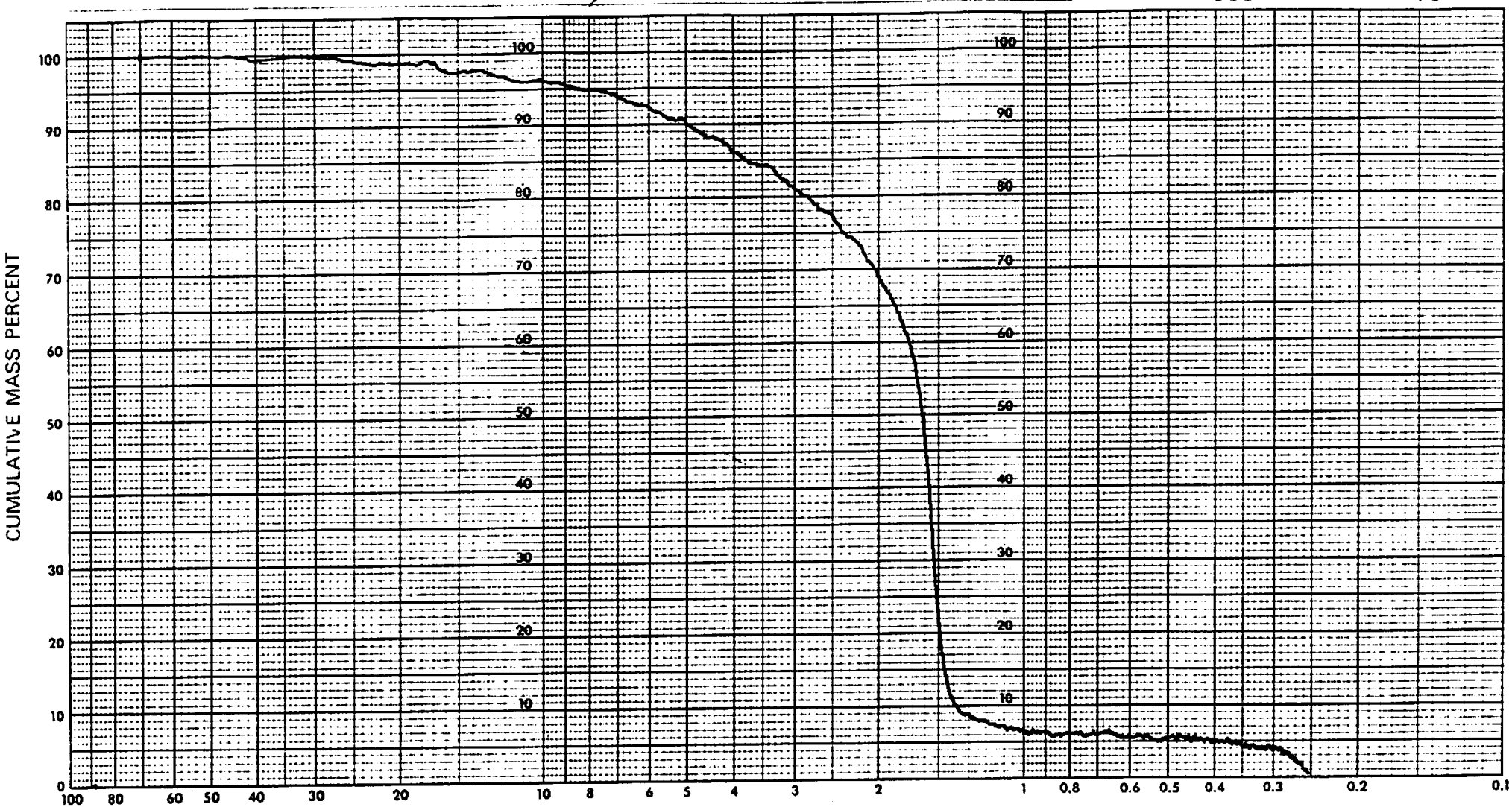
Density 2.62 g/cc LIQUID 1% Poly A Density 0.9937 g/cc Viscosity 0.7085 cp

BY JTT

Preparation Ultrasonic Bath 4 min., stir 4 min.
deflocculated with Polyacrylate 211

TEMPERATURE 36 °C

RATE 953 START DIA. 70 µm



micromeritics instrument corporation

Form 500/42701