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ADTC-TR-75-83

FINAL REPORT

LAYOUT AND CALIBRATION OF THE RAIN SIMULATION FACILITY AT THE HOLLOMAN TEST TRACK

PREPARED BY

TEST TRACK DIVISION
6585TH TEST GROUP
HOLLOMAN AIR FORCE BASE, NEW MEXICO

15 NOVEMBER 1975

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ARMAMENT DEVELOPMENT AND TEST CENTER
AIR FORCE SYSTEMS COMMAND - UNITED STATES AIR FORCE
EGLIN AIR FORCE BASE, FLORIDA

THIS TECHNICAL REPORT HAS BEEN REVIEWED AND IS APPROVED.

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Chief, Test Track Division

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REPORT DOCUMENTATION PAGE

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(14)

1. REPORT NUMBER: ADTC-TR-75-83
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER: (9)
4. TITLE (and Subtitle): LAYOUT AND CALIBRATION OF THE RAIN SIMULATION FACILITY AT THE HOLLOMAN TEST TRACK. (6)
5. TYPE OF REPORT & PERIOD COVERED: Final rept.
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): Friedrich P. Ehni (10)
8. CONTRACT OR GRANT NUMBER(s):
9. PERFORMING ORGANIZATION NAME AND ADDRESS: 6585th Test Group (AFSC), Test Track Division (TK), Holloman AFB, New Mexico 88330
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: JON: 9950S007
11. CONTROLLING OFFICE NAME AND ADDRESS: 6585th Test Group (AFSC), Holloman AFB, New Mexico 88330
12. REPORT DATE: 15 November 1975 (11)
13. NUMBER OF PAGES: 74
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Same as 11 (12) 81 p.
15. SECURITY CLASS. (of this report): Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE: N/A
16. DISTRIBUTION STATEMENT (of this Report): Approved for public release; distribution unlimited.
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report): Same as 16
18. SUPPLEMENTARY NOTES:
19. KEY WORDS (Continue on reverse side if necessary and identify by block number): This
20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

The Holloman AFB, New Mexico Test Track Rain Simulation Facility, extends over one rail of the 50,000 ft track in sections of 400 ft length up to a total length of 18,000 ft. An overview of the physical layout, control set-up, test set-up and test instrumentation is given. Performance data expressed in terms of drop number distribution over eight drop size classes from 0.5 to 4 mm, equivalent rain rate, liquid water content, and median mass diameter are presented; and, the constants of a least square exponential approximation to drop size distribution are included for nine rows of sample volume locations. cont on p1473 B

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Also included are graphs for the estimation of the number and size of drops encountered by a test specimen moving through the rain field.

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1473B

FOREWORD

A new rain simulation facility was installed at the Test Track at Holloman AFB, New Mexico in 1973 and a comprehensive test effort was performed subsequently to establish and chart its characteristics. A total of approximately 15,000 measurements were taken and evaluated in the course of this effort.

This report was prepared by Mr. Friedrich P. Ehni.

Capt Donald E. Schenk was Test Manager of the project and designed the test set up.

Mr. Robert T. Stouffer was in charge of the data processing. He performed, with the help of temporary employees, the extremely tedious work of transferring the test information from paper printout to punched cards and applying the necessary quality checks. He also rewrote and expanded existing computer programs for use on the local computer (PDP 11), developed new programs, all those for statistical evaluation, and wrote two in-house papers which formed the basis of this report.

ABSTRACT

The Holloman AFB, New Mexico Test Track Rain Simulation Facility, extends over one rail of the 50,000 ft track in sections of 400 ft length up to a total length of 18,000 ft. An overview of the physical layout, control set-up, test set-up and test instrumentation is given. Performance data expressed in terms of drop number distribution over eight drop size classes from 0.5 to 4 mm, equivalent rain rate, liquid water content, and median mass diameter are presented; and, the constants of a least square exponential approximation to drop size distribution are included for nine rows of sample volume locations. Also included are graphs for the estimation of the number and size of drops encountered by a test specimen moving through the rain field.

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LIST OF SYMBOLS

A	Sample area
D_i	Median droplet diameter of size class i
D_R	Reference diameter of the exponential approximation of droplet distribution
F_D	Density factor of natural rain according to Marshall and Palmer
H	Sample depth (hood opening of droplet counter)
L	Rainfield length
LWC	Liquid water content normalized to 1 cubic meter of air
M_i	Mass of droplets of size class i
$M_{i\%}$	Mass of droplets of size class i in % of total droplet mass
MMD	Median mass diameter
m	Number of measurements
N_i	Number of droplets in size class i, normalized to 1 cubic meter of air
N_0	Hypothetical number of droplets of zero diameter of the exponential approximation of droplet distribution
n_i	Number of droplets counted at one sample location after application of edge correction
R	Natural rain rate
S	Sample length
t	Exposure time set on droplet counter
V_i	Terminal velocity of droplets of size class i
V_s	Total volume sampled at one location
ΔD	Deviation from median droplet diameter within size class i

μ_i — Mean number of droplets in size class i normalized to 1 cubic meter of air

σ_i — Standard deviation of number of droplets in size class i normalized to 1 cubic meter of air

1. INTRODUCTION

The purpose of this report is to furnish information on the setup and performance of the Holloman Test Track's Artificial Rainfield. The rainfield provides a simulated rain environment over the west rail of the 50,000 ft long test track. It is set up to routinely cover a length up to 6,000 ft in 400-ft increments but can be extended up to 18,000 ft. The rainfield consists of removable 400-ft sections with water control, manifolds, risers, and spray heads.

The performance of the rainfield depends on controlled conditions such as, for instance, length, water pressure, and sprinkler type, and on uncontrollable conditions, primarily wind, which have a significant effect on the simulated rain. In order to measure rainfield performance undisturbed by wind, a 20-ft model section which simulated one representative 8-ft modular length of the actual rainfield was set up in a sheltered environment off the track. To obtain performance data which could be compared with those of natural rain, the water drop size distribution was measured. Other parameters such as liquid water content, equivalent rain rate and statistical characteristics were derived from these measurements.

2. MECHANICAL LAYOUT OF THE RAINFIELD

The layout of the artificial rainfield is essentially based on a study performed by Inca Engineering Corporation under Air Force Contract F29600-70-0020 with its final report "Four Hundred Foot Prototype Rainfield for the AFSWC Rain Simulation Facility." However, for reasons of cost vs performance, only two mainfolds with different height risers and nozzle types were installed instead of the four recommended in the study. A detailed description of the rainfield layout is presented in Appendix A.

3. LAYOUT OF TEST

In the past, testing of artificial rainfield performance was conducted on 400-ft sections at selected locations of the track. However, various difficulties inherent in track testing limited the amount of collected data and their validity. Some of these difficulties were:

a. Test planning had to fit into sled run schedules, test periods were time limited, and in case of too high winds, tests had to be postponed and rescheduled.

b. Tests were more time consuming since the rain drop counter with instrument trailer had to be lifted to and removed from the rails for each test.

c. More people were involved during tests than in the testing of the model section since the central control station had to be manned for water control.

d. Wind was present during most tests. This caused a wider spread of test data and obscured the analysis of data for variability of performance with respect to sample locations relative to sprinklers and rail and for different type nozzles.

Although performance testing of the artificial rainfield at "live" sections at the track may yield more realistic results, the considerations above led to the decision that for establishing base line data, the tests had to be performed in a laboratory type of environment. Therefore, a 20-ft long section of the artificial rainfield was installed in a wind protected area off the track. Since the spray patterns of adjacent sprinklers are overlapping, an 8-ft portion centered in the 20-ft rainfield section was used for all tests. Test samples were taken from locations of a 3-dimensional array along and above the simulated rail over one complete cycle of the spray configuration. Compared to earlier tests at the track, the measurements and test procedures were much simplified as ambient conditions were under control, communication problems were reduced since all metering and controls were at one location, and test scheduling was independent of use of the track for sled runs. This test setup made it possible to collect considerably more data yielding much closer estimates of rainfield performance than would have been feasible from tests at the Track. Details of the test layouts are presented in Appendix B.

4. TEST PROCEDURE

For the physical layout of the test field see Appendix B. The basic test instrument used for data collection was the droplet counter designed and constructed for the Track by the Illinois Institute of Technology Research Institute (IITRI) (Reference 2). The droplet counter projects the shadow-image of a defined volume of the rainfield on the screen of a TV image tube. The image is scanned similar to a TV process. The video output consists of two voltage levels, one representing intercept with the shadow of a droplet, the other one representing no presence of a droplet. The time duration for each droplet intercept is measured, its location on the screen stored, and each event of the longest intercept associated with each droplet location transferred to one of eight counters according to its duration/droplet size. The instrument is set to process 7.5 frames per second. For these specific tests the eight drop size categories were set from 0.5 to 4 mm $\pm$ 0.25 mm each. The data output of the droplet counter is a digital printout of the number of droplets in the eight drop size categories. (An automatic punched card output will be available for future measurements.) The volume sampled with every frame was set to an area of 2.875 in x 3.281 in and a depth of 4.0 in amounting to 37.73 cubic in or 618.3 cubic centimeters. With the instrument set to count over a period of 10 seconds (75 frames) for one printout, a volume of .04637 cubic meters or 1.638 cubic feet per sample was tested. At each sample location (Appendix 5, Figure B2 and B3) a total of 50 ten-second samples were taken representing a total sampled volume of 2.319 cubic meters or 81.9 cubic feet.

5. DATA EVALUATION METHODS

The evaluation of the test data had to meet the following objectives:

a. Arrive at a set of baseline data which characterize the artificial rainfield performance in terms of droplet distribution within the space traveled by test specimens.

b. Derive data which are required to compare rainfield performance with natural rain.

c. Provide a set of data which allow an estimation of the droplet population intercepted by a test specimen of given size and position relative to the rail, traveling through a defined length of rainfield. Several computer programs were applied to process the test data. Selection of characteristic terms, the equations and computer programs followed in part the recommendations of a study made for the Air Force by Mueller and Sims (Reference 3). The equations incorporated in the evaluation programs are presented below.

5.1 The Edge Correction.

The droplet counter introduces certain errors in the droplet count distribution which are relatively small and cannot be corrected by deterministic methods. Some of these errors are:

a. Droplets being shadowed partially or completely by other droplets being located along the same line of sight.

b. Droplets being located so close to other droplets along scan lines that the logic system does not differentiate between them and thus, for instance, counts two close droplets as one (larger) droplet.

c. Droplets intersected by the edges of the viewing window. If these droplets appear with less than one-half within the window, they are registered in a smaller drop size category.

The probability for errors of type a. and b. can be kept very small as long as the droplet density is reasonably limited by setting the depth of the sample (hood opening of the counter) volume not too large. Errors of type c. are corrected statistically by an algorithm suggested by IITRI (Reference 2) referred to as edge correction. The algorithm is given in Appendix C. The edge correction was applied to all droplet counter data before further processing.

5.2 Liquid Water Content (LWC).

The liquid water content is the sum of the water content (in grams) of all droplets, normalized to a volume of air of one cubic meter. The droplets are assumed to be of spherical shape. With specific weight of one for water and an equal distribution of droplet diameters within each droplet size class $D \pm \Delta D$ the mean water content

$$M_i = N_i \frac{\pi}{12} \left[(D_i + \Delta D)^3 + (D_i - \Delta D)^3\right]$$

where

$$N_i = n_i / V_s$$

is the normalized droplet count for 1 m^3 and n_i is the edge corrected number of droplets of class i counted in the total sampled volume V_s of the droplet counter.

$$V_s = AHt\ 7.5$$

where

A - window area of droplet counter sample volume

B - hood opening (depth) of droplet counter sample volume

t - total sample time

The number 7.5 is the rate of exposures per second of the droplet counter

The liquid water content is

$$LWC = \sum^{i} M_i$$

The mass in % of the liquid water content $M_{i\%}$, and the accumulated mass in % of the liquid water content $M_{j\%}$, are derived from M_i and LWC:

$$M_{i\%} = 100 M_i / LWC$$

$$M_{j\%} = \sum_{i=1}^{j} M_{i\%}$$

5.3 Median Mass Diameter (MMD).

The median mass diameter is frequently used as a characteristic of rain/sprays. It is the droplet diameter which divides the total liquid water content into two equal parts.

$$MMD = D_j + 2\Delta D \frac{50 - M_{j\%}}{M_{(j\% + 1)} - M_{j\%}}$$

The index j denotes the largest class diameter D with an accumulated mass of less than 50% of the total mass.

5.4 Average and Standard Deviation.

Important statistical characteristics of the artificial rainfield are the mean normalized droplet count μ_i over m identical measurements

$$\mu_i = \frac{1}{m} \sum_{i=1}^{m} N_i$$

and the standard deviation σ_i in each size class

$$\sigma_i = \sqrt{\frac{1}{m} \sum_{i=1}^{m} (N_i - \mu_i)^2}$$

5.5 Relation of Droplet Distribution to Natural Rain Rate.

In order to establish a relation of the droplet distribution measured by the droplet counter to natural rain, the rain rate is computed which would result from the same droplet distribution if obtained from natural rain. To obtain this equivalent rain rate the water content of each droplet size class is multiplied by the terminal velocity of droplets of that class.

Gunn and Kinzer (Reference 4) give empirical data on the terminal velocity of raindrops approximated by a power series (Clark and Moyers) as

$$V_i = C_0 + C_1 D_i + C_2 D_i^2 + C_3 D_i^3 + C_4 D_i^4$$

(V_i in m/sec and D_i in mm)

with $C_0 = -\ .27128$

$C_1 = +5.22306$

$C_2 = -1.10757$

$C_3 = +\ .11115$

$C_4 = -\ .0046884$

Multiplying the terminal velocities V_i by the respective mean water content M_i and summing the products over all droplet size classes yields the equivalent rain rate ER:

$$ER = .036 \sum^{i} M_i V_i \quad \text{in mm/hr}$$

The equivalent rain rate is not identical with the rain rate computed from the water level collected by a rain gage in the artificial rainfield. This is so because most droplets in the artificial rainfield do not reach terminal velocity within the short distance between nozzle and rail.

5.6 Exponential Approximation to Droplet Size Distribution.

Marshall and Palmer (1948) (Reference 5) and other researchers (Reference 6 and 7) have approximated the droplet size distribution of natural rain of various densities by an exponential expression of the general form

$$N_i = N_0 \exp\left(-D_i / D_r\right)$$

This expression yields a straight line on semi-log paper with the linear abscissa representing the droplet size class i and the logarithmic ordinate representing the corresponding number of droplets per volume of air in the size class N_i. This line intercepts the ordinate at N_0 - the hypothetical count for zero diameter droplets - and has a negative slope defined by the reference diameter D_R.

Marshall and Palmer define D_R in terms of natural rain R:

$$D_R = 0.244\ R^{.21} \qquad (R \text{ in mm/hr and } D_R \text{ in mm})$$

and

$$N_0 = 8000(2\Delta D) \qquad (\Delta D \text{ in mm and } N_0 \text{ in } m^{-3}\ mm^{-1})$$

The droplet distribution of the artificial rainfield follows very closely an exponential expression of the above form. Therefore, the droplet averages of each of nine sample rows were used to compute the two characterisitic parameters N_0 and D_r by the least squares method for the straight line approximation in semi-log presentation. The two parameters N_0 and D_R allow to relate the rainfield performance to natural rain. If the approximation of natural rain by Marshall and Palmer is chosen, the two characteristic coefficients of the computed exponential approximation are interepreted as

$$R = (D_R / 0.244)^{-0.21}$$

and

$$F_D = N_0 / 8000\ (2\Delta D)$$

where F_D is a density factor by which the "natural rain" is multiplied to fit the measured data of the artificial rainfield.

5.7 Estimated Number of Droplets Encountered by a Target.

Based on the row average and standard deviation, it can be estimated how many droplets of each size range a target can expect to encounter traveling through a given length of rainfield. The average number of droplets for each size range μ_{iL} is proportional to the rainfield length L,

$$\mu_{iL} = \frac{L}{S}\ \mu_{is}$$

where the subscript s stands for the sample length S, i.e., s = 4 inch x 75 exposures = 25 ft.

The standard deviation σ is proportional to the square root of the rainfield length L:

$$\sigma_{iL} = \sqrt{L/S}\ \sigma_{is}$$

In Figures 28-35 plots are presented for the values of $\mu, \mu \pm \sigma$, and $\mu \pm 2\sigma$. If we assume a normal distribution of droplet number occurrences the 1σ and 2σ lines represent the limits of the 68% and 95% confidence intervals respectively. These plots present the values which a test specimen of 6 inches diameter can expect to encounter while traversing a specified distance. Therefore the sample data μ_i are first multiplied by the ratio of the specimen area (28.27 sq in) to the sample area (9.43 sq in) which is approximately 3. The sample data σ_i are multiplied by the square root of this ratio.

6. PRESENTATION AND DISCUSSION OF TEST DATA.

For test sample locations, see Figures B2 and B3.

The artificial rainfield data are all normalized to one cubic meter of air. This normalization, however, does not imply that the droplet distribution would be homogeneous within one cubic meter anywhere in the rainfield. The user of the data has to consider that the presented droplet densities, etc., apply only to the space near the sample rows they refer to. For larger areas interpolation of applicable sample row data is suggested. A 6-inch diameter target for instance, with its center 5 inches above the rail, would have to travel 54.8 m or approximately 180 ft to intercept with one m^3 of rainfield of density indicated for sample row 10 to 26.

For the interpretation of graphs, it must be noted that zero droplet densities are located at the bottom line of the graph (since the log presentation gives no provision to show true zero).

6.1 Overview of Data.

Figures 4 through 14 show the sample location averages of droplet densities in the eight size classes for one sample row per graph. They give an insight into the variation of densities within the row caused by the varying distance from the nozzles and by differences in nozzle performance and alignment.

Figures 15 through 25 show the average number of droplets per cubic meter versus droplet size class over each of the nine sample rows. They also show the straight line least squares approximation (dashed line) to the droplet density distribution. The two characteristic constants of the linear approximations, N_0 and D_R are presented in the summary view of Figure 27. Figure 15 through 25 also show the lines of $\mu + 1\sigma$ and $\mu - 1\sigma$ where σ is the standard deviation of the sample averages of the nine sample locations of each row. These lines are an indicator for the variation of droplet densities within each sample row. Figure 26 shows how the sample rows are located compared to the target areas of five typical monorail sleds.

Figure 27 gives a summary of rainfield data associated with the nine row locations.

6.2 Density of Sample Locations for Test.

In order to determine if it was sufficient to set the sample spaces 12 inches apart, or if a closer spacing was required for the analysis, the center row directly above the rail (locations 10-26) was sampled with 6-inch sample-to-sample spacing. Comparison of row averages for 6-inch spaced sample volumes (all locations) and for 12-inch spaced sample volumes (even numbered locations only) show (see Figures 2 and 3) that a 12-inch spacing is sufficient for obtaining good data, as the row averages as well as the standard deviations are almost identical.

6.3 Optimum Nozzle Pressure.

Comparing the rainfield performance by the three different pressure settings, two characteristics were considered:

a. How well does the drop size distribution compare with model rain?

b. How homogeneous is the spray pattern a test specimen will encounter.

Consideration of a: Figures 5 through 7 and 16 through 18 show that with increasing pressure, the spray consists of more small droplets and less large droplets. This trend makes a low pressure spray more desirable for testing in a rainfield which requires simulation of heavy rains which according to References 3, 6, and 7 contain higher densities of large droplets.

Consideration of b: Figures 5, 6, and 7 show that for the specific set of nozzles selected the most homogeneous distribution along the track is obtained at a pressure of 5 psi.

For a rainfield output simulating heavy rain and a homogeneous spray pattern, a nozzle pressure of 5 psi appears most desirable.

6.4 Catalog of Data.

Tables 1 through 9 represent a catalog of data for all nine rows of sample locations. The first nine data columns of each table present the processed data for each sample location, normalized to one cubic meter. ER is the equivalent rain rate (para 5.5) in mm/hr, LWC the liquid water content (para 5.2) in grams/cubic meter, MMD the median mass diameter in mm (para 5.3) and N (drop size class) is the number of droplets per cubic meter in the eight drop size classes from 0.5 to 4.0 mm, each class with a range of $\pm$ 0.25 mm.

The tenth data column lists the row averages of all other data columns.

The data show, as should be expected, that with increasing height over the rail, i.e., for sample volumes closer to the nozzles, the spray pattern becomes less homogeneous. Also, there are areas of high incidence of large droplets on some sample locations closer to the nozzles. These large droplets appear to break up into smaller ones, as they fall.

6.5 Estimation of Droplets Encountered During a Sled Run.

Figures 28 through 35 present graphs of the expected number of droplets of the eight drop size classes versus the distance, a sled with a 6-inch diameter target area (see, also, Figure 26) may encounter going through the rainfield. Also plotted on these graphs are the sigma and 2-sigma deviation (68% and 95% confidence limits) from the expected number of droplets. These graphs are based on the data collected from sample volumes 10 through 26 at 5 psi nozzle pressure.

A word of caution is indicated in the use of these graphs for the estimation of droplet numbers of the 3.5 and 4 mm size classes. As seen from Tables 1 through 9, Figures 4 through 14, and especially from Table 10, there was a high incidence of zero counts in these size classes. With the number of samples taken, the droplet count frequency distribution was far from a normal distribution.

7. CONCLUSION

All the data presented were collected under zero wind conditions. Presently, sled testing through the rainfield is performed only at calm wind conditions with wind components across the track not exceeding 3 knots and wind components in track direction not exceeding 5 knots. These limits are based on overall observations of spray-pattern deviations. It appears highly desirable to extend the presently available data into a known wind environment. This could be done by the use of the described test set up in an open area under various wind conditions. A conversion of the droplet counter to automatic punched card output, which is in progress, will greatly accelerate the data processing. In addition to testing, a computer simulation of droplet trajectories under the presence of wind may provide the base for an assessment of rainfield performance deterioration due to wind.

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7. Extremes of Hydrometers at Altitude for MIL-STD-2108 Supplement-Drop Size Distributions

Average drop counts and derived data for sample locations 1 through 9.
ER = Equivalent Rain in mm/hr; LWC = Liquid Water Content in grams/cubic meter;
MMD = Median Mass Diameter in mm; N( ) = Number of drops in size class (mm) per cubic meter.

LOC	1	2	3	4	5	6	7	8	9	ROW AVG
ER	53.2	101.0	66.8	61.8	46.4	56.3	45.5	79.8	39.6	61.2
LWC	2.37	4.48	3.23	2.73	2.11	2.66	2.37	3.68	1.83	2.83
MMD	1.63	1.59	1.29	1.67	1.53	1.40	1.04	1.46	1.49	1.46
N(0.5)	1,620.0	3,080.0	4,550.0	2,580.0	1,700.0	2,900.0	4,420.0	3,140.0	1,660.0	2,850.0
N(1.0)	557.0	1,290.0	1,180.0	747.0	569.0	940.0	1,040.0	1,130.0	492.0	883.0
N(1.5)	274.0	490.0	327.0	246.0	249.0	273.0	225.0	446.0	221.0	306.0
N(2.0)	118.0	184.0	114.0	92.6	102.0	113.0	71.6	161.0	92.2	116.0
N(2.5)	56.9	79.0	40.4	44.8	35.8	44.2	28.4	64.8	33.6	47.5
N(3.0)	12.4	37.1	12.6	23.3	14.5	12.8	8.24	20.1	8.8	16.7
N(3.5)	5.57	10.1	8.03	12.5	4.74	5.57	4.18	7.89	1.89	6.72
N(4.0)	.47	4.4	4.31	2.82	.48	1.41	.47	1.41	1.44	1.91

Table 1

Locations 10-26

LOC	10	12	14	16	18	20	22	24	26	ROW AVG
ER	43.1	67.4	38.7	88.5	101	50.2	21.2	87.2	61.6	62.1
LWC	1.92	4.43	1.98	3.99	4.57	2.47	1.21	4.01	2.70	3.03
MMD	1.62	1.45	1.09	1.56	1.56	1.21	0.82	1.43	1.66	1.38
N(0.5)	1,120.0	3,640.0	3,820.0	2,990.0	3,020.0	3,640.0	3,250.0	3,060.0	1,330.0	2,874.0
N(1.0)	498.0	1,530.0	783.0	1,300.0	1,420.0	994.0	575.0	1,400.0	714.0	1,020.0
N(1.5)	217.0	485.0	181.0	397.0	490.0	249.0	100.0	474.0	294.0	321.0
N(2.0)	104.0	150.0	58.7	160.0	222.0	73.8	28.5	158.0	139.0	122.0
N(2.5)	36.9	56.9	27.5	74.2	85.5	32.7	11.3	65.6	47.6	48.7
N(3.0)	13.3	25.9	7.79	28.3	26.0	13.5	1.38	23.7	24.7	18.3
N(3.5)	3.23	16.2	1.86	8.79	12.1	6.62	0.46	8.33	5.55	7.02
N(4.0)	0.94	6.57	1.88	4.23	1.88	0.48	0.94	3.29	1.41	2.40

Table 2

Locations 27-35

LOC	27	28	29	30	31	32	33	34	35	ROW AVG
ER	29.3	100.0	31.9	98.3	91.8	36.1	27.2	90.3	20.0	58.3
LWC	1.37	4.48	1.77	4.48	4.17	1.94	1.54	4.08	0.99	2.76
MMD	1.42	1.58	0.88	1.51	1.54	0.97	0.82	1.50	1.26	1.28
N(0.5)	1,100.0	3,150.0	4,460.0	3,450.0	2,700.0	4,030.0	4,040.0	2,420.0	1,100.0	2,940.0
N(1.0)	473.0	1,390.0	801.0	1,340.0	1,250.0	879.0	759.0	1,230.0	390.0	946.0
N(1.5)	166.0	452.0	154.0	518.0	486.0	205.0	141.0	525.0	126.0	308.0
N(2.0)	59.1	200.0	50.0	216.0	198.0	60.7	25.0	181.0	41.5	115.0
N(2.5)	27.5	82.8	14.4	69.2	83.7	16.7	9.94	71.5	14.0	43.3
N(3.0)	7.34	25.6	5.05	29.6	27.9	5.48	4.57	26.0	4.58	15.1
N(3.5)	0.93	8.32	0.93	11.1	6.95	1.86	1.86	7.40	0.46	4.42
N(4.0)	0.47	7.51	0.94	1.41	0.47	0.47	0.94	2.82	0	1.67

Table 3

Locations 36-44

LOC	36	37	38	39	40	41	42	43	44	ROW AVG
ER	10.0	108.0	98.3	52.6	27.2	69.9	97.4	70.7	9.6	60.4
LWC	0.55	4.64	4.53	2.56	1.39	3.23	4.71	3.17	0.52	2.81
MMD	0.98	1.74	1.44	1.28	1.18	1.48	1.28	1.59	1.02	1.33
N(0.5)	1,250.0	2,590.0	4,340.0	2,770.0	2,050.0	3,240.0	5,990.0	2,290.0	1,140.0	2,851.0
N(1.0)	222.0	1,010.0	1,560.0	979.0	550.0	1,010.0	1,810.0	831.0	199.0	908.0
N(1.5)	64.4	492.0	478.0	326.0	170.0	337.0	509.0	353.0	55.5	309.0
N(2.0)	15.6	218.0	176.0	105.0	60.7	132.0	155.0	164.0	22.8	117.0
N(2.5)	5.89	99.4	62.4	37.9	15.8	61.3	62.4	58.0	4.53	45.3
N(3.0)	1.84	31.4	24.6	8.69	3.67	16.4	25.6	21.9	1.38	15.1
N(3.5)	0	15.2	12.9	3.24	1.39	9.75	7.40	6.50	0	6.26
N(4.0)	0	5.17	6.1	0.94	0	0.94	5.17	1.41	0	2.19

Table 4

Locations 45-53

LOC	45	46	47	48	49	50	51	52	53	ROW AVG
ER	11.2	134.0	33.0	56.6	50.4	53.0	[illegible]4.2	81.6	15.8	52.2
LWC	0.565	5.76	1.72	2.75	2.37	2.52	1.88	3.66	0.77	2.44
MMD	1.17	1.74	0.99	1.29	1.41	1.36	0.92	1.55	1.28	1.30
N(0.5)	647.0	2,440.0	3,250.0	3,170.0	1,900.0	2,540.0	4,170.0	1,990.0	762.0	2,319.0
N(1.0)	257.0	1,390.0	790.0	1,060.0	812.0	901.0	892.0	1,070.0	295.0	830.0
N(1.5)	73.2	630.0	147.0	316.0	293.0	300.0	192.0	452.0	107.0	279.0
N(2.0)	21.0	252.0	53.6	114.0	118.0	103.0	51.3	179.0	36.2	103.0
N(2.5)	8.15	120.0	16.1	36.5	39.2	40.1	12.2	70.7	11.3	39.4
N(3.0)	1.38	46.0	7.95	9.61	10.1	12.3	6.87	19.2	2.29	12.9
N(3.5)	0.46	18.1	2.37	4.64	2.79	4.18	2.32	7.41	0.46	4.75
N(4.0)	0	6.1	0.96	1.88	0.94	0.94	0	2.35	0	1.46

Table 5

Locations 54-62

LOC	54	55	56	57	58	59	60	61	62	ROW AVG
ER	8.63	112.0	37.8	64.8	50.1	56.3	40.9	56.6	9.39	48.5
LWC	0.47	4.8	1.85	3.05	2.38	2.65	2.11	2.56	0.537	2.27
MMD	0.99	1.71	1.22	1.39	1.37	1.36	1.07	1.53	0.88	1.28
N(0.5)	614.0	1,880.0	2,440.0	2,700.0	1,780.0	2,450.0	3,400.0	1,540.0	1,010.0	1,980.0
N(1.0)	270.0	1,160.0	792.0	1,090.0	862.0	960.0	976.0	763.0	326.0	800.0
N(1.5)	63.5	536.0	184.0	360.0	315.0	326.0	240.0	308.0	70.3	267.0
N(2.0)	17.9	239.0	62.8	146.0	112.0	101.0	61.9	139.0	12.5	99.1
N(2.5)	1.81	88.4	22.1	40.9	42.0	38.2	21.6	45.1	1.36	33.5
N(3.0)	0.92	40.6	10.1	14.7	7.78	14.6	6.85	13.7	0.46	12.2
N(3.5)	0	14.8	3.25	5.10	3.25	5.57	3.25	1.85	0.46	4.17
N(4.0)	0	3.76	1.41	1.88	0	1.41	0.94	2.82	0	1.36

Table 6

Locations 63-71

LOC	63	64	65	66	67	68	69	70	71	ROW AVG
ER	7.61	22.5	231.0	76.8	28.6	94.1	170.0	10.4	3.23	71.58
LWC	0.43	1.08	9.91	3.68	1.42	4.28	7.45	0.57	0.17	3.22
MMD	0.87	1.34	1.74	1.33	1.17	1.51	1.64	1.00	1.01	1.29
N(0.5)	1,060.0	1,250.0	4,660.0	3,660.0	2,020.0	3,440.0	4,110.0	1,150.0	257.0	2,400.0
N(1.0)	206.0	365.0	2,470.0	1,380.0	611.0	1,410.0	1,970.0	246.0	90.0	972.0
N(1.5)	55.7	129.0	1,020.0	442.0	145.0	442.0	836.0	67.4	22.5	351.0
N(2.0)	8.05	41.4	442.0	148.0	43.2	185.0	338.0	21.9	4.92	137.0
N(2.5)	2.27	17.1	185.0	58.6	16.2	63.3	139.0	5.43	2.72	54.4
N(3.0)	0.92	6.87	80.4	16.5	7.33	35.2	45.9	0.92	0	21.6
N(3.5)	0.46	0.93	34.1	4.18	1.39	7.41	19.8	0	0	7.59
N(4.0)	0	0.47	13.6	2.35	1.88	4.23	11.3	0	0	3.76

Table 7

Locations 72-80

LOC	72	73	74	75	76	77	78	79	80	ROW AVG
ER	5.77	77.4	89.8	76.8	31.1	67.8	144.0	7.27	3.87	56.0
LWC	0.32	3.28	4.13	3.47	1.49	3.04	6.39	0.38	0.21	2.52
MMD	0.95	1.8	1.45	1.54	1.32	1.58	1.60	1.04	0.98	1.36
N(0.5)	498.0	1,220.0	3,730.0	2,020.0	1,280.0	1,820.0	3,910.0	483.0	311.0	1,700.0
N(1.0)	186.0	682.0	1,450.0	1,090.0	557.0	873.0	1,850.0	205.0	117.0	779.0
N(1.5)	45.5	340.0	432.0	405.0	202.0	343.0	705.0	47.7	30.0	283.0
N(2.0)	7.60	162.0	165.0	170.0	61.9	161.0	268.0	13.0	7.17	113.0
N(2.5)	3.17	76.5	53.4	63.9	21.7	58.1	110.0	2.72	0.90	43.4
N(3.0)	0	27.8	26.0	21.0	5.95	18.3	44.6	1.84	0.46	16.2
N(3.5)	0	7.86	8.34	7.43	2.32	6.49	19.9	0	0	5.82
N(4.0)	0	3.76	7.04	0.94	0.47	0.94	7.04	0	0	2.24

Table 8

Locations 81-89

LOC	81	82	83	84	85	86	87	88	89	ROW AVG
ER	7.16	50.4	93.3	97.2	41.9	60.7	133.0	5.64	7.36	55.2
LWC	0.39	2.24	4.28	4.38	2.02	2.75	5.93	0.33	0.41	2.53
MMD	0.97	1.61	1.44	1.55	1.32	1.51	1.57	0.86	0.94	1.31
N(0.5)	590.0	1,150.0	3,630.0	2,510.0	1,690.0	1,770.0	3,400.0	631.0	704.0	1,786.0
N(1.0)	219.0	604.0	1,490.0	1,300.0	802.0	831.0	1,760.0	205.0	223.0	826.0
N(1.5)	52.1	264.0	469.0	527.0	259.0	336.0	694.0	38.5	57.7	300.0
N(2.0)	10.3	109.0	150.0	215.0	90.0	127.0	264.0	8.5	11.0	109.0
N(2.5)	4.08	49.6	67.4	86.0	29.3	48.2	87.8	1.81	2.31	41.8
N(3.0)	0.46	11.4	25.5	24.7	9.64	17.4	43.3	0	0	14.7
N(3.5)	0	6.5	13.7	8.34	1.39	4.17	17.1	0	0.47	5.74
N(4.0)	0	0.47	3.83	1.88	0.47	2.35	6.10	0	0	1.68

Table 9

3.5 mm

	9 Locations				17 Locations			
Number of Drops/10-Sec	0	1	2	3	0	1	2	3
Frequency	336	94	15	4	647	164	29	8
Relative Frequency	74.8	20.9	3.3	0.9	76.3	19.3	3.4	0.9
Number of Samples:	449				848			

4.0 mm

	9 Locations				17 Locations			
Number of Drops/10-Sec	0	1	2	3	0	1	2	3
Frequency	406	40	3	0	767	76	5	0
Relative Frequency	90.4	8.9	0.7	0	90.4	9.0	0.6	0
Number of Samples:	449				848			

Frequency of Occurrence of
3.5 and 4.0 mm Drops in Locations 10-26

Table 10

Figure 1
SECTION OF RAINFIELD (looking North)
Note feed line (left horizontal pipe), the two manifolds with the two different height risers and the pump house at the right.

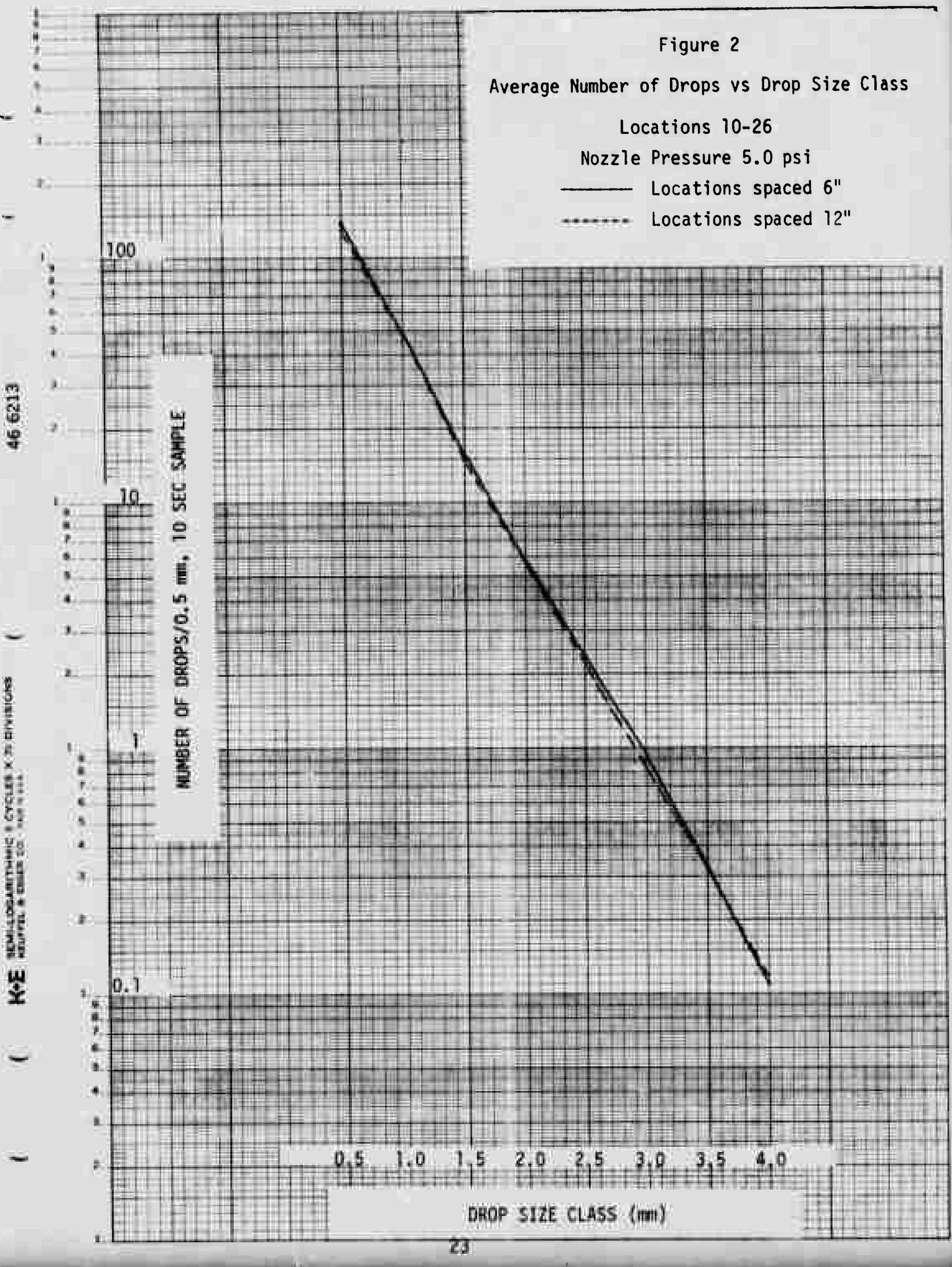


Figure 2

Average Number of Drops vs Drop Size Class

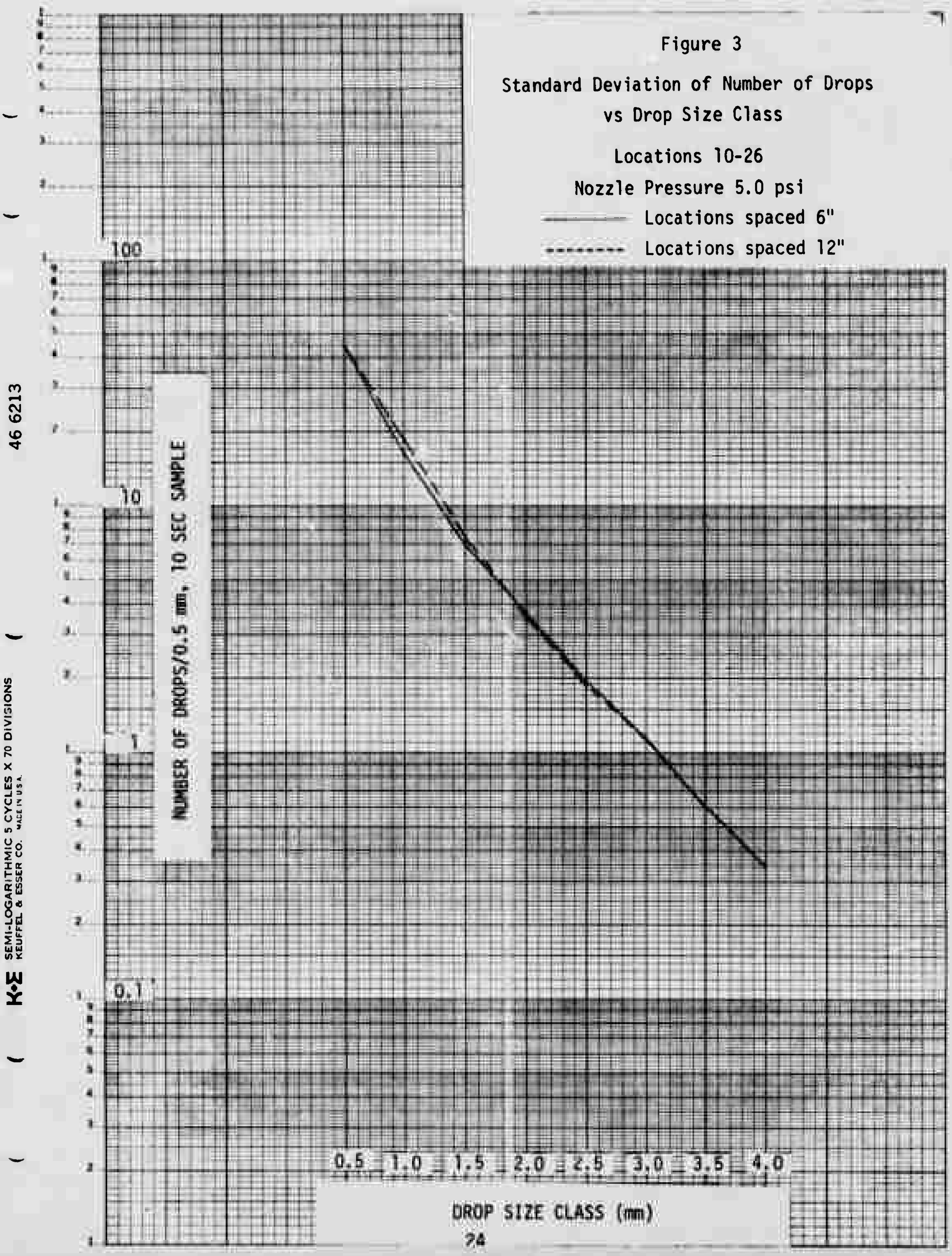


Figure 3
Standard Deviation of Number of Drops
vs Drop Size Class
Locations 10-26
Nozzle Pressure 5.0 psi
Locations spaced 6"
Locations spaced 12"
100
10
1
0.1
NUMBER OF DROPS/0.5 mm, 10 SEC SAMPLE
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
DROP SIZE CLASS (mm)
46 6213
K•E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

Figure 4

Average Drop Density vs Sample Location 1-9
for Drop Size Classes 0.5 to 4mm
Nozzle Pressure 5 psi

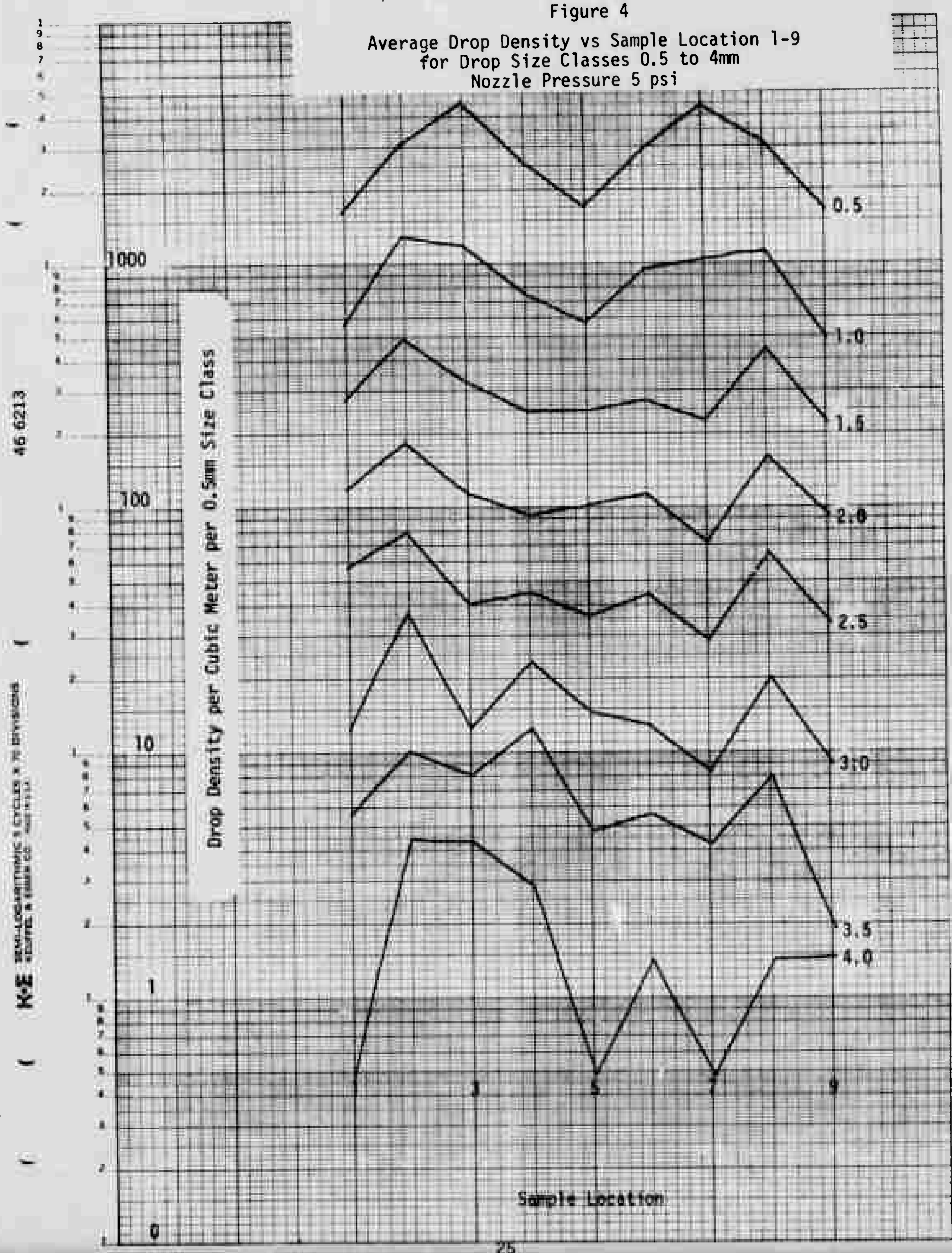


Figure 5

Average Drop Density vs Sample Location 10-26
for Drop Size Classes 0.5 to 4mm
Nozzle Pressure 3.5 psi

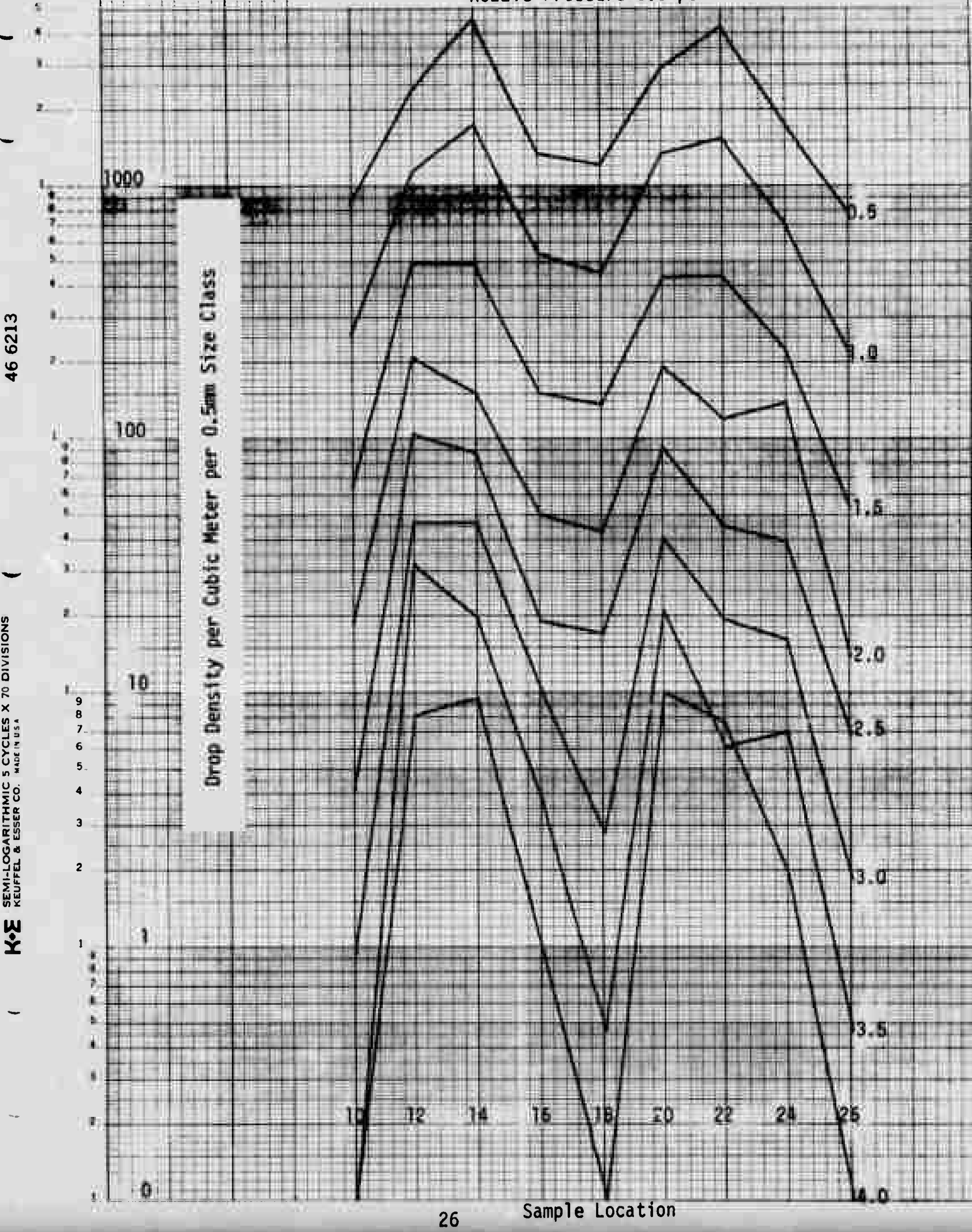


Figure 6

Average Drop Density vs Sample Location 10-26
for Drop Size Classes 0.5 to 4mm
Nozzle Pressure 5 psi

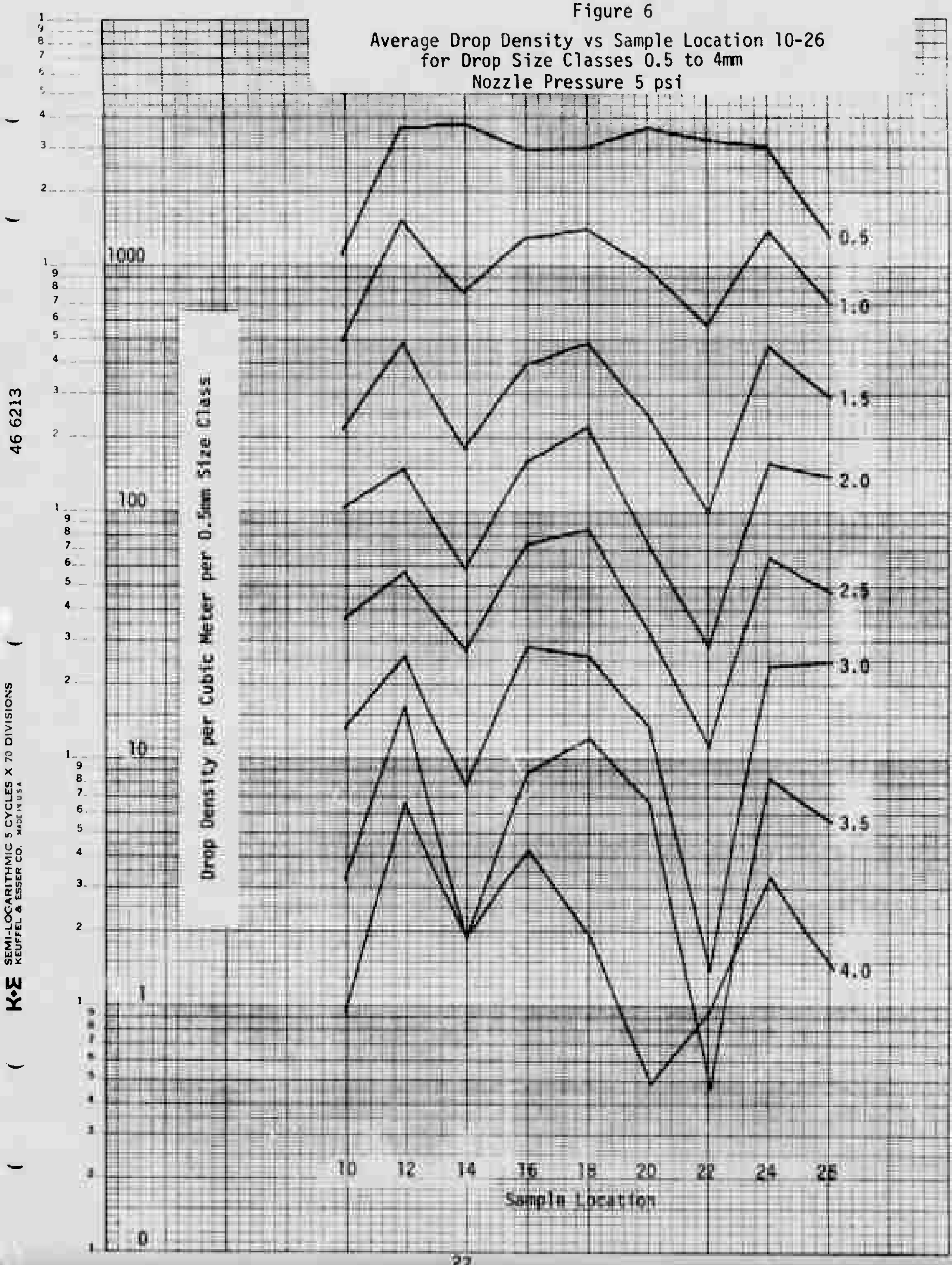


Figure 7

Average Drop Density vs Sample Location 10-26
for Drop Size Classes 0.5 to 4mm
Nozzle Pressure 6.5 psi

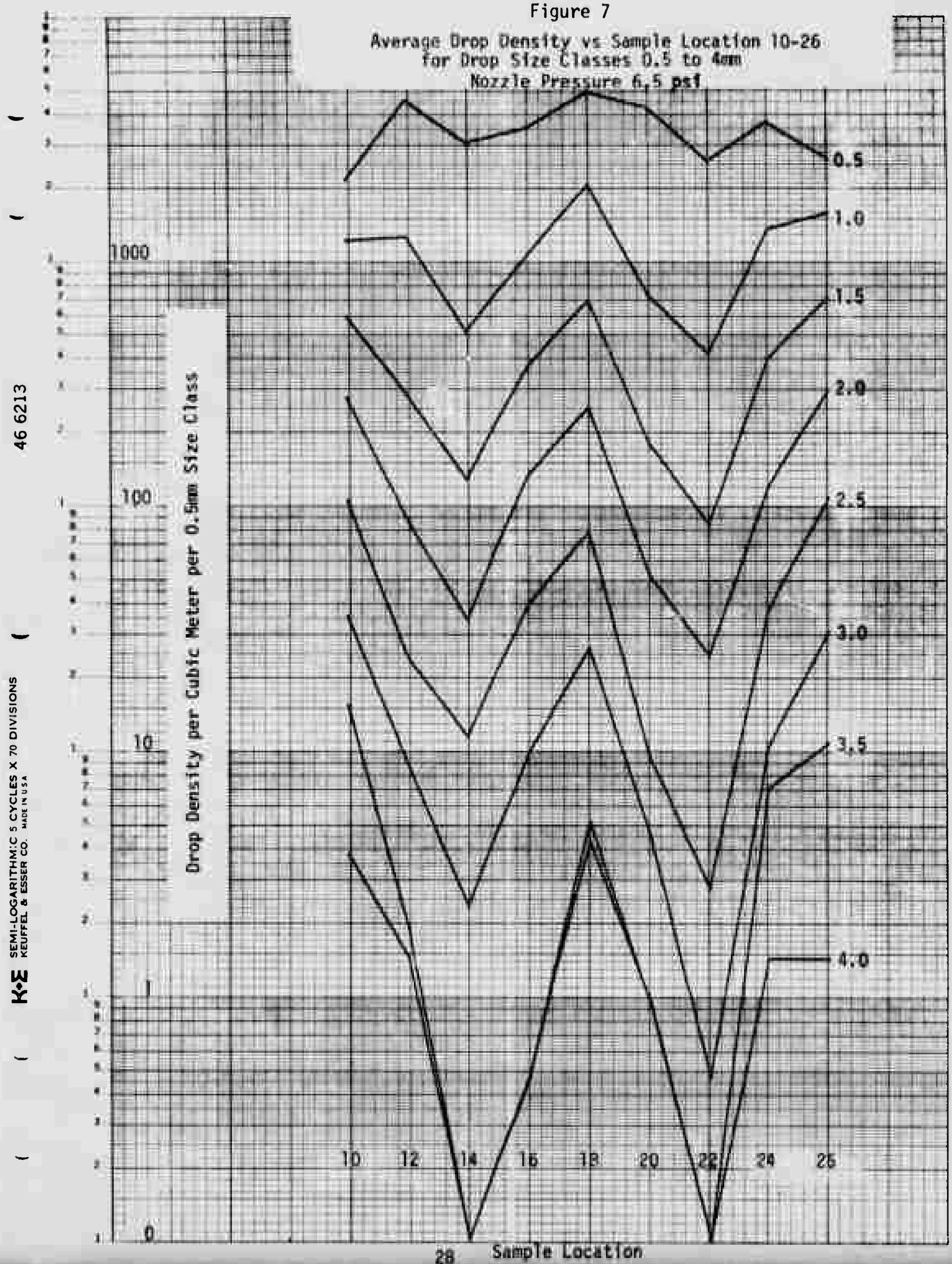
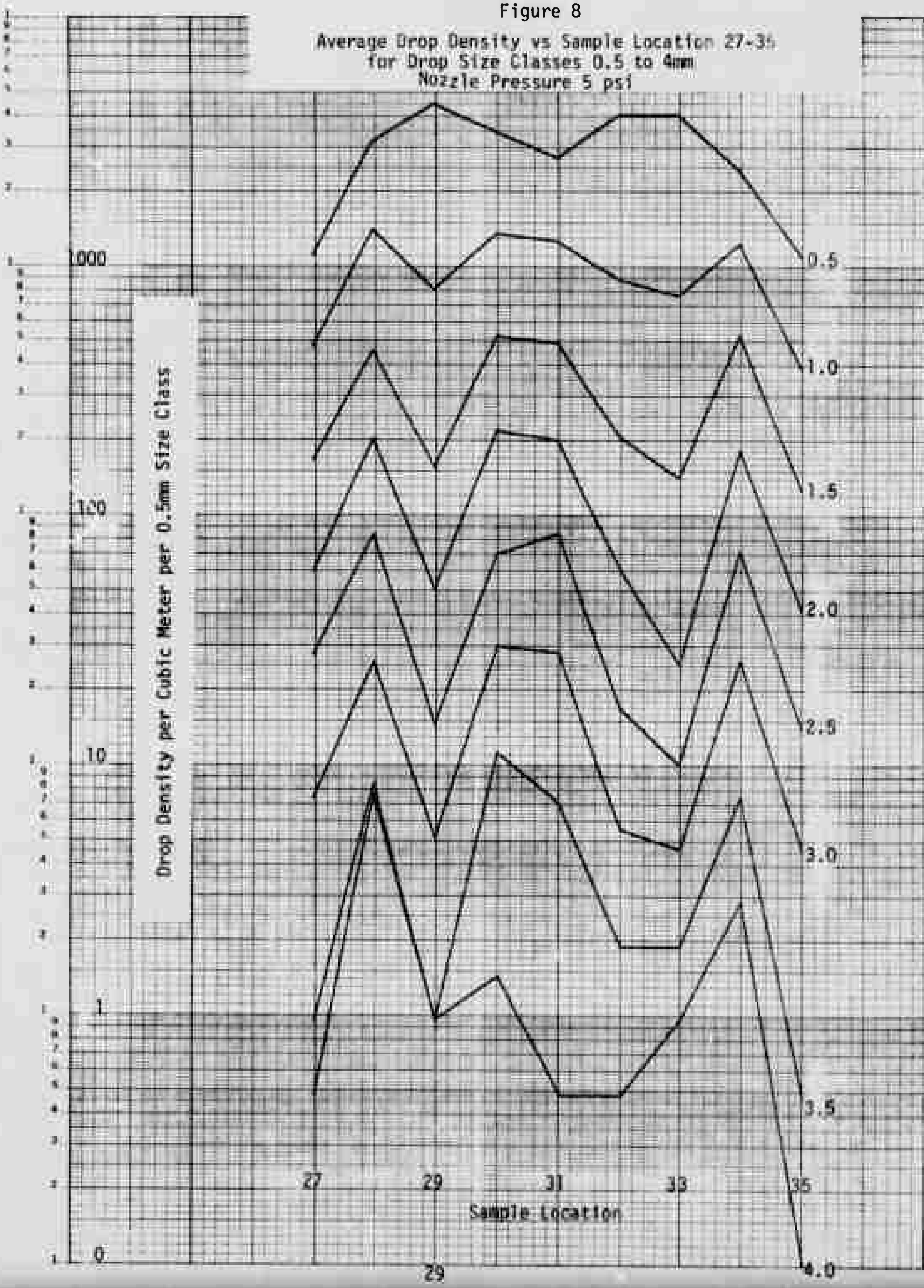


Figure 8



K•E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS KEUFFEL & ESSER CO. MADE IN U.S.A. 46 6213

Figure 9

Average Drop Density vs Sample Location 36-44
for Drop Size Classes 0.5 to 4mm
Nozzle Pressure 5 psi

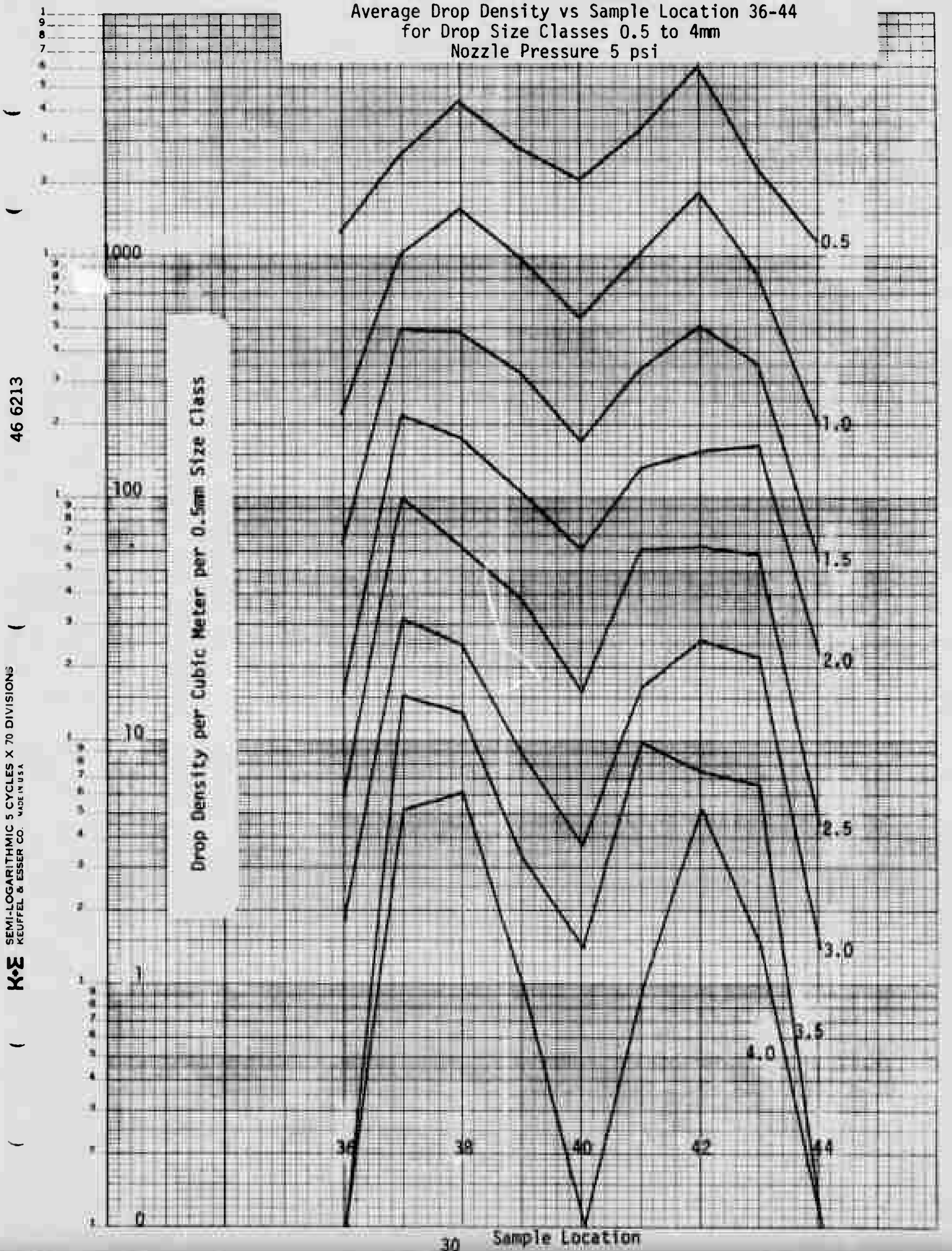


Figure 10

Average Drop Density vs Sample Location 45-53 for Drop Size Classes 0.5 to 4mm

Nozzle Pressure 5 psi

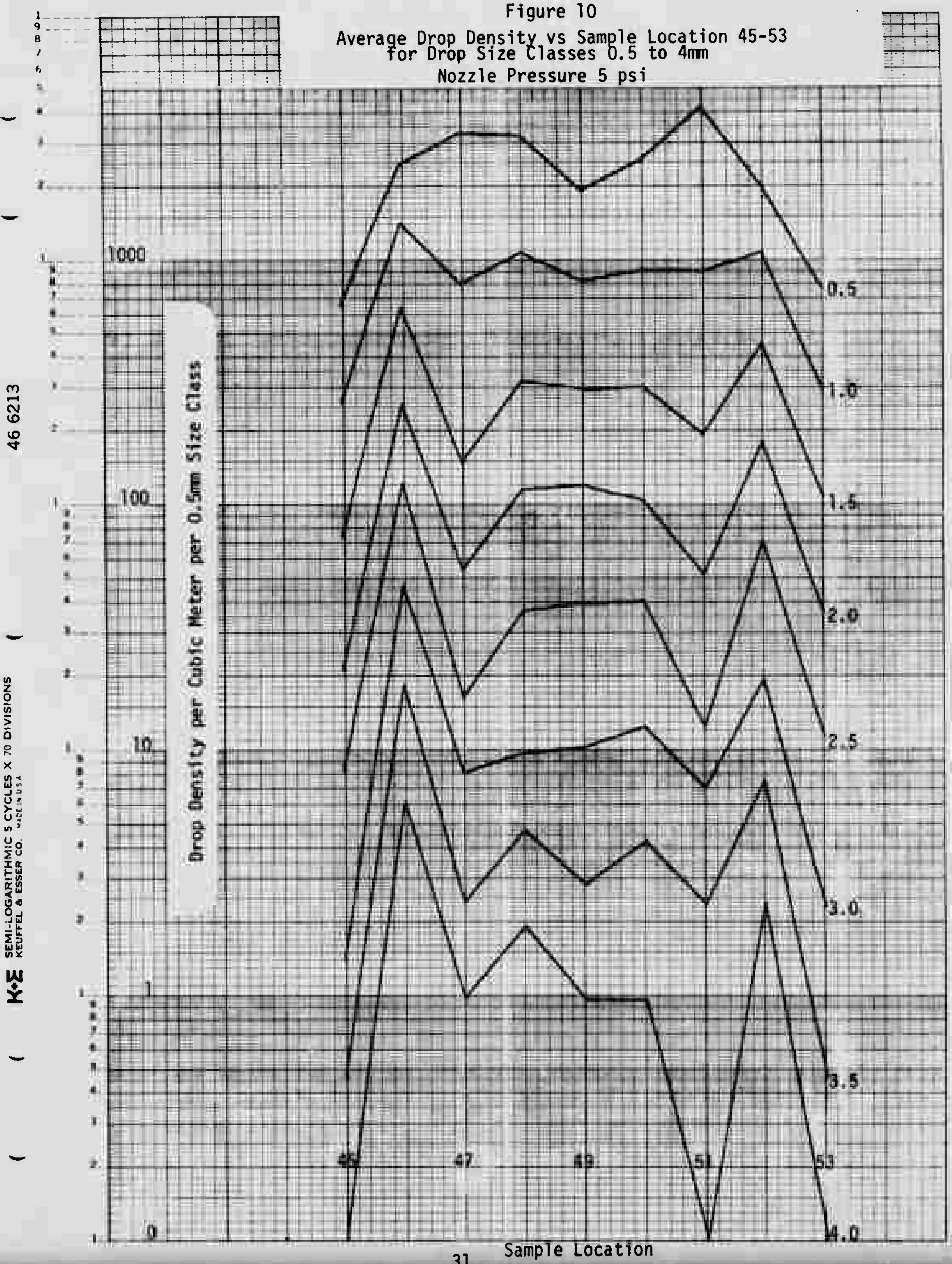
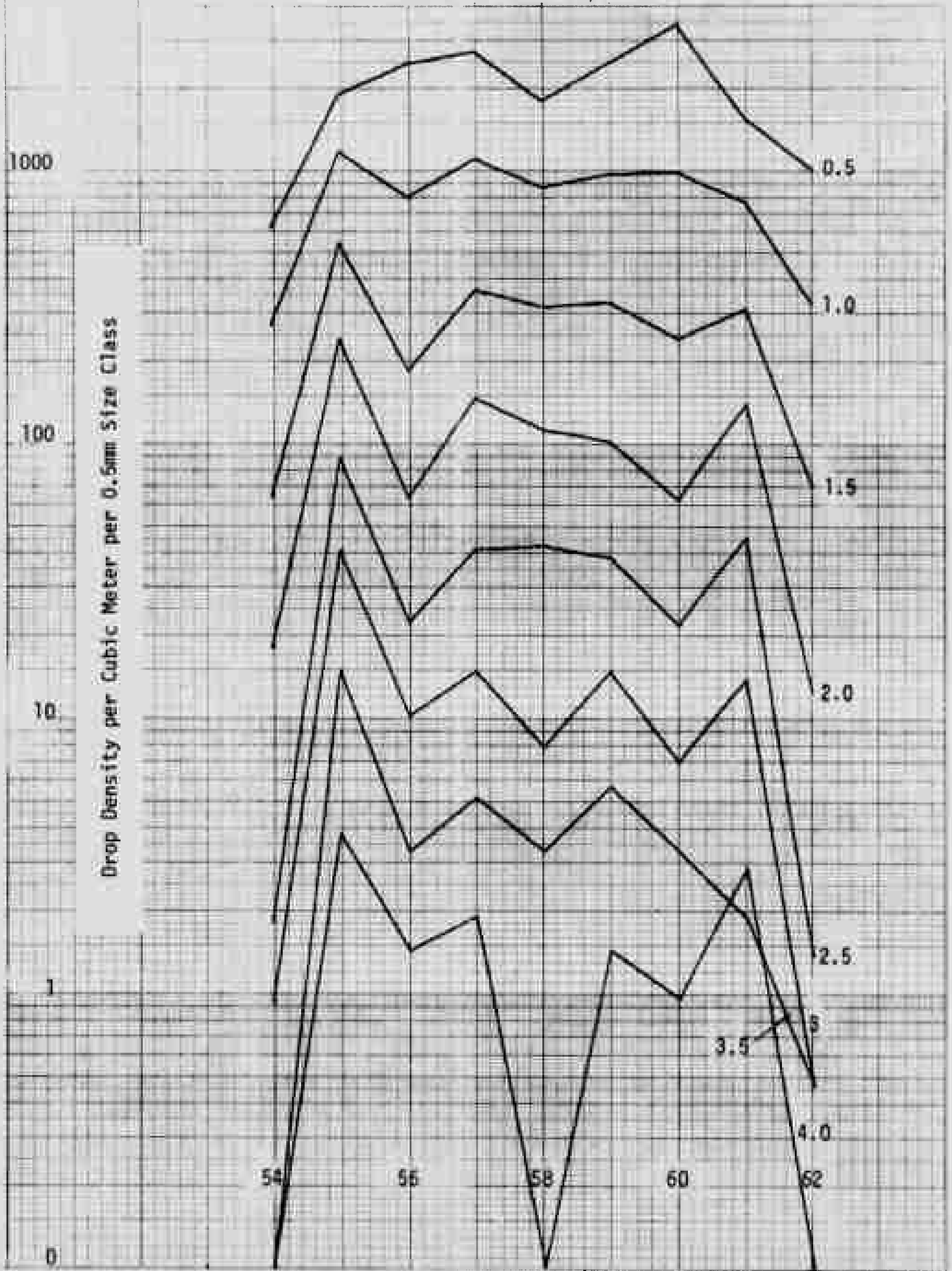


Figure 11

Average Drop Density vs Sample Location 54-62
for Drop Size Classes 0.5 to 4mm
Nozzle Pressure 5 psi



Sample Location

Figure 12

Average Drop Density vs Sample Location 63-71
for Drop Size Classes 0.5 to 4mm
Nozzle Pressure 5 psi

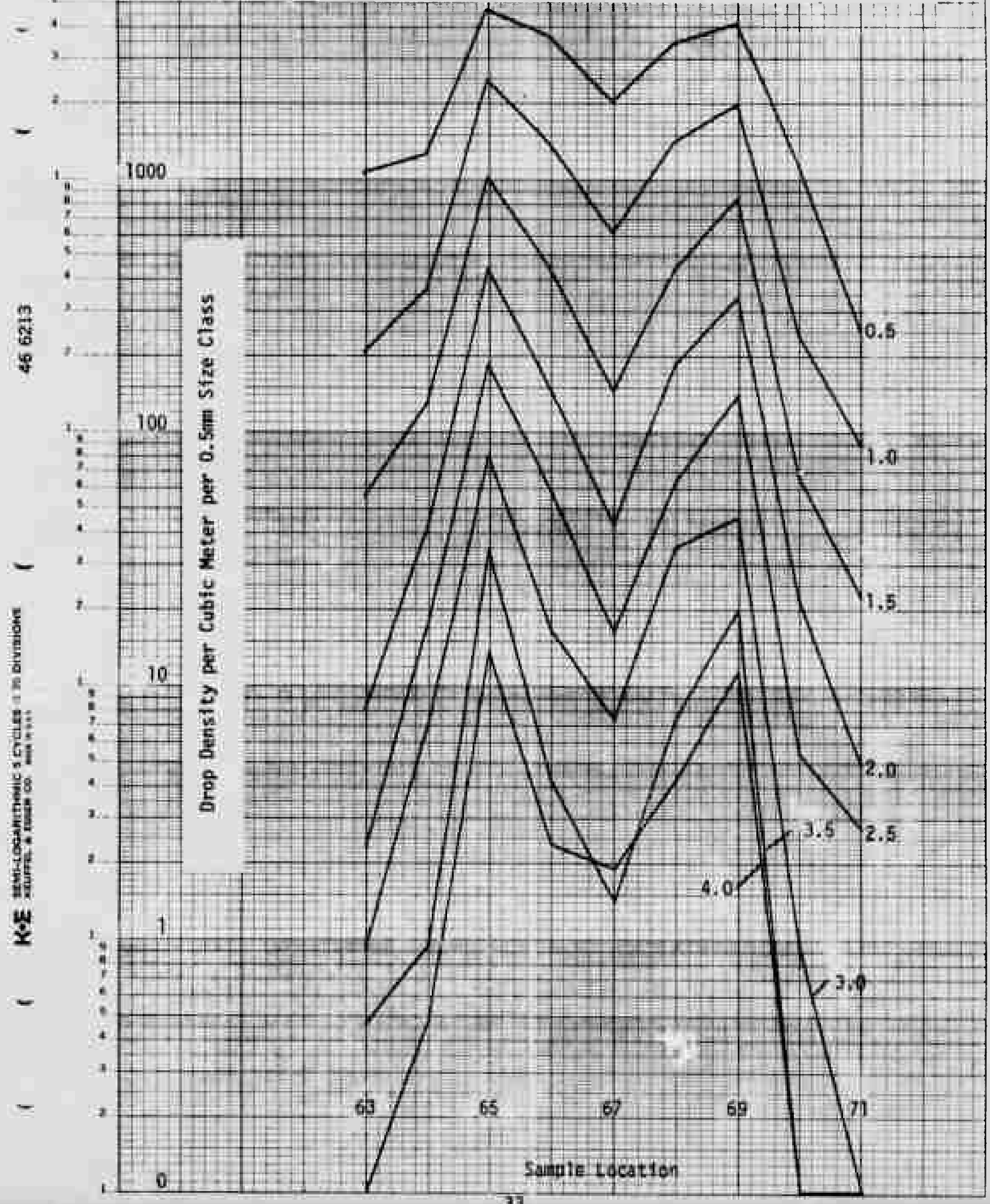


Figure 13

Average Drop Density vs Sample Location 72-80
for Drop Size Classes 0.5 to 4mm
Nozzle Pressure 5 psi

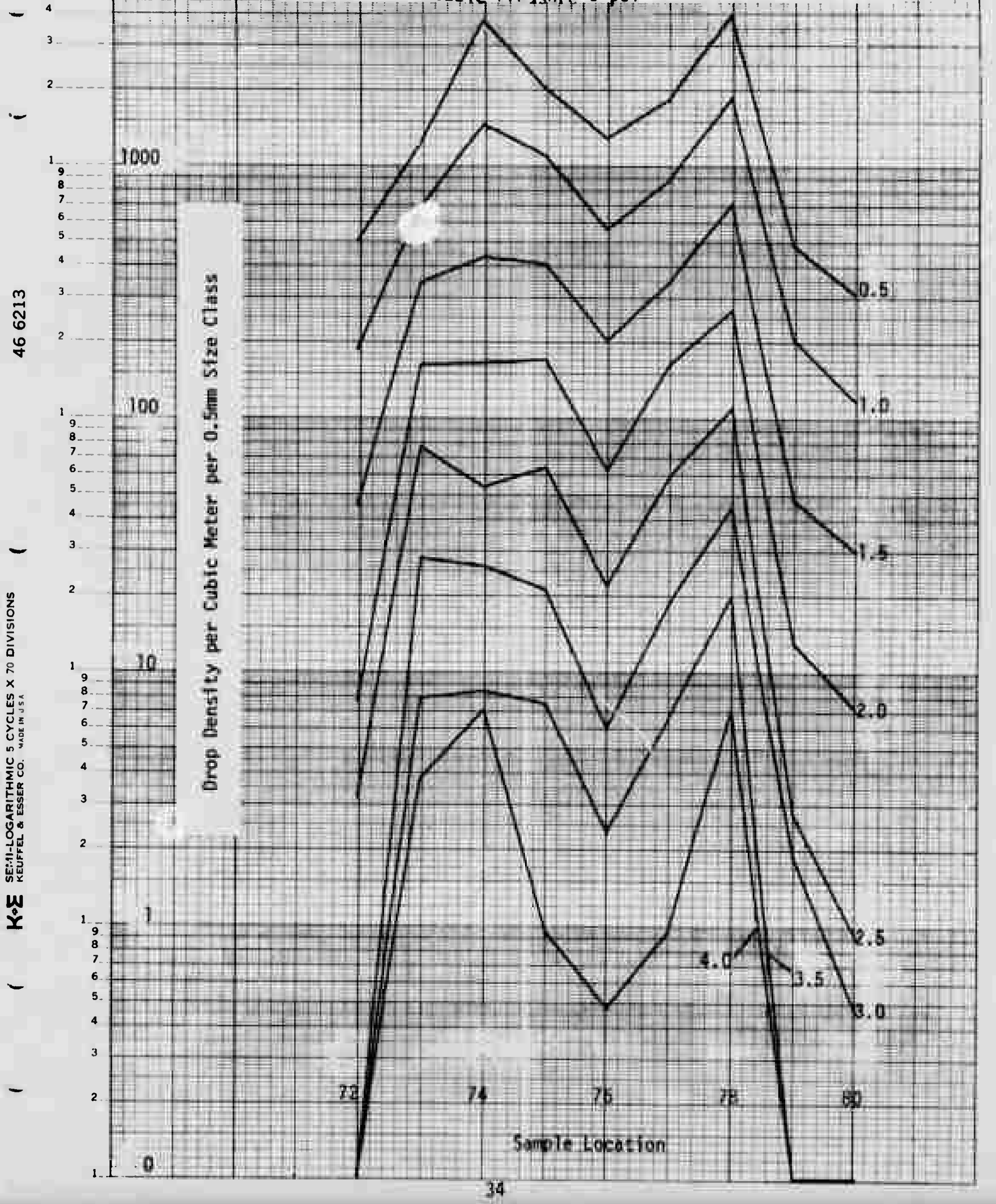


Figure 14

Average Drop Density vs Sample Location 81-89
for Drop Size Classes 0.5 to 4mm
Nozzle Pressure 5 psi

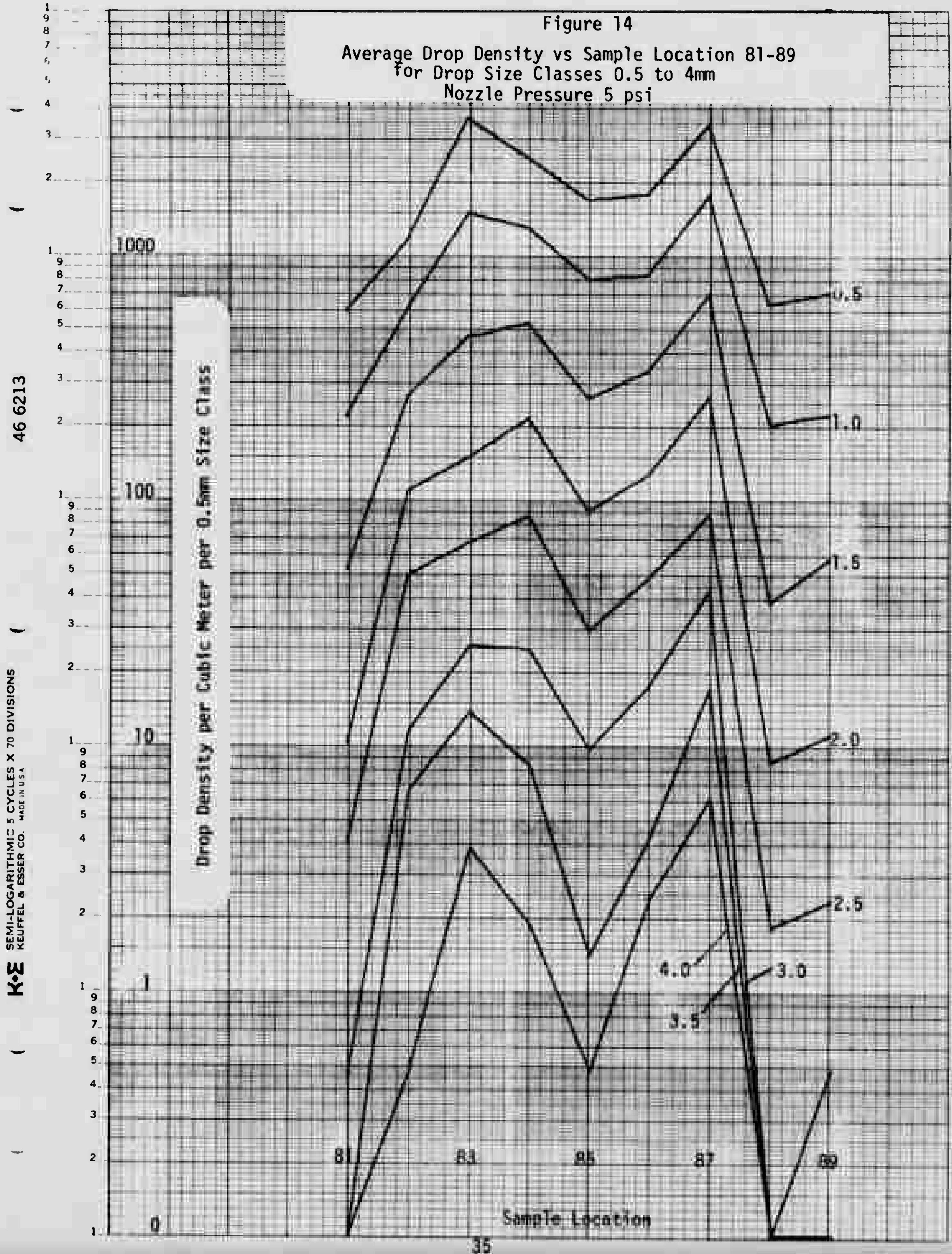
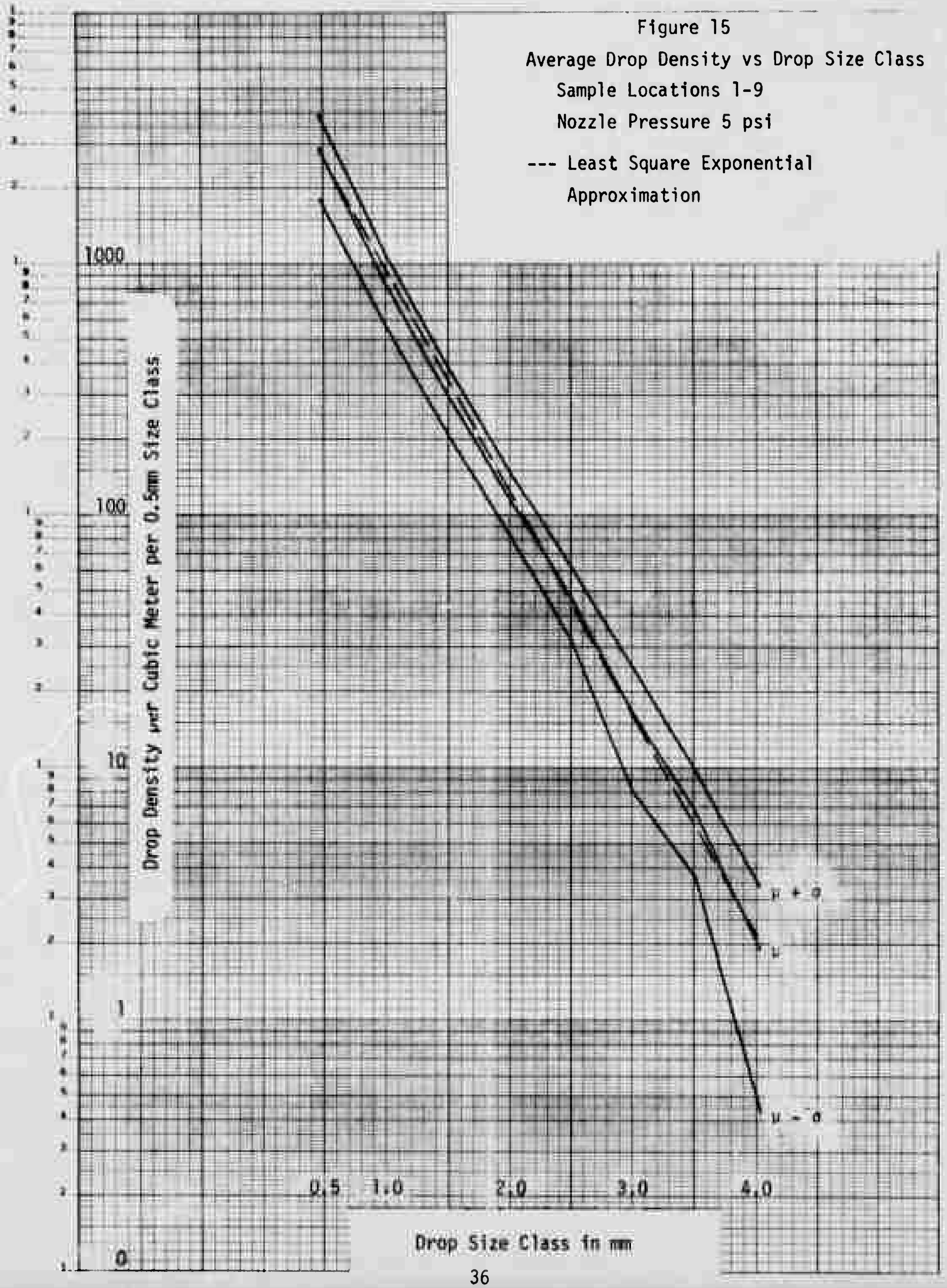


Figure 15

Average Drop Density vs Drop Size Class
Sample Locations 1-9
Nozzle Pressure 5 psi

--- Least Square Exponential Approximation



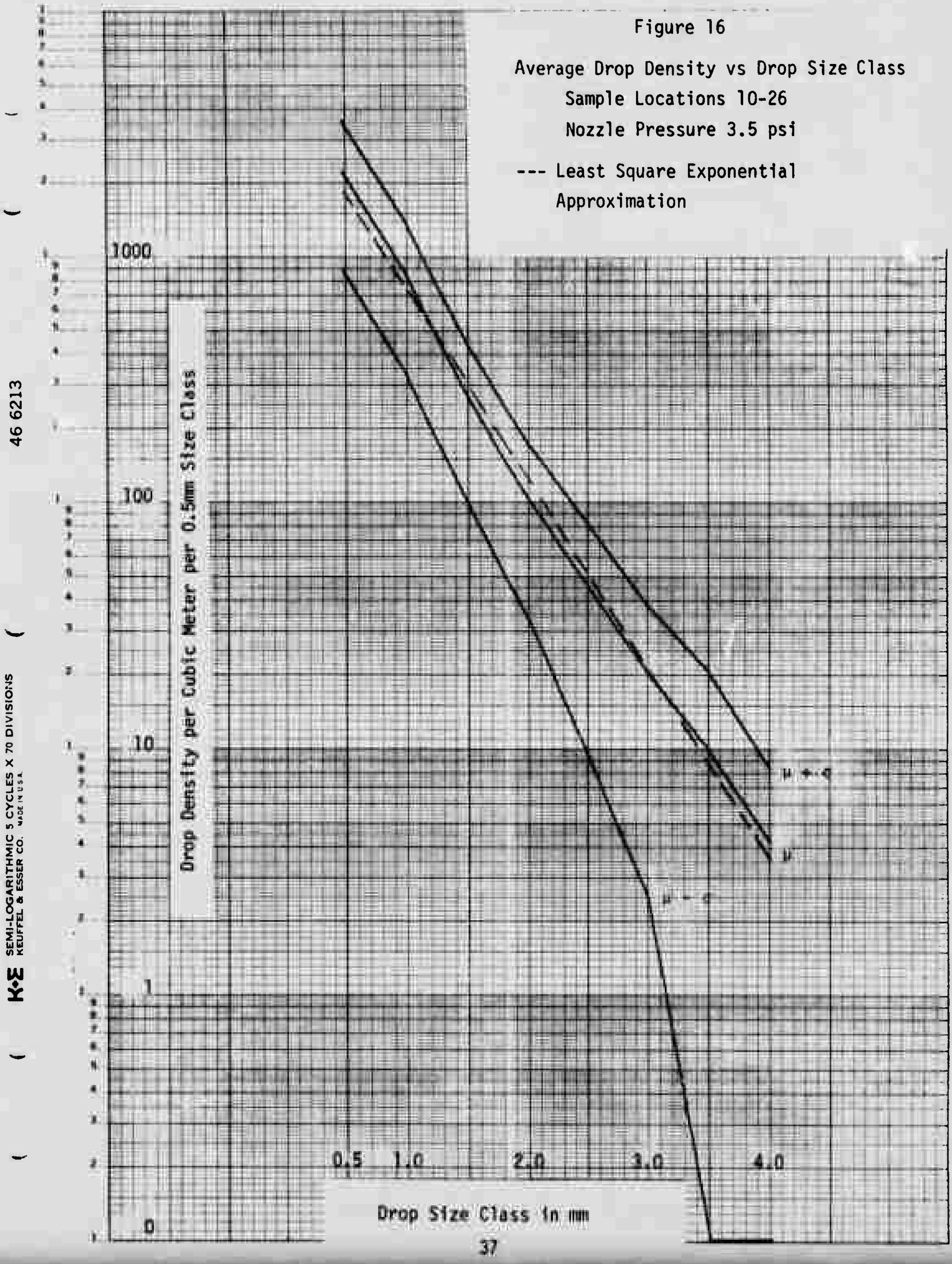


Figure 16
Average Drop Density vs Drop Size Class
Sample Locations 10-26
Nozzle Pressure 3.5 psi
--- Least Square Exponential Approximation
1000
100
10
1
0
Drop Density per Cubic Meter per 0.5mm Size Class
0.5
1.0
2.0
3.0
4.0
Drop Size Class in mm
μ + σ
μ
μ − σ
46 6213
K·E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

Figure 17

Average Drop Density vs Drop Size Class

Sample Locations 10-26

Nozzle Pressure 5 psi

--- Least Square Exponential Approximation

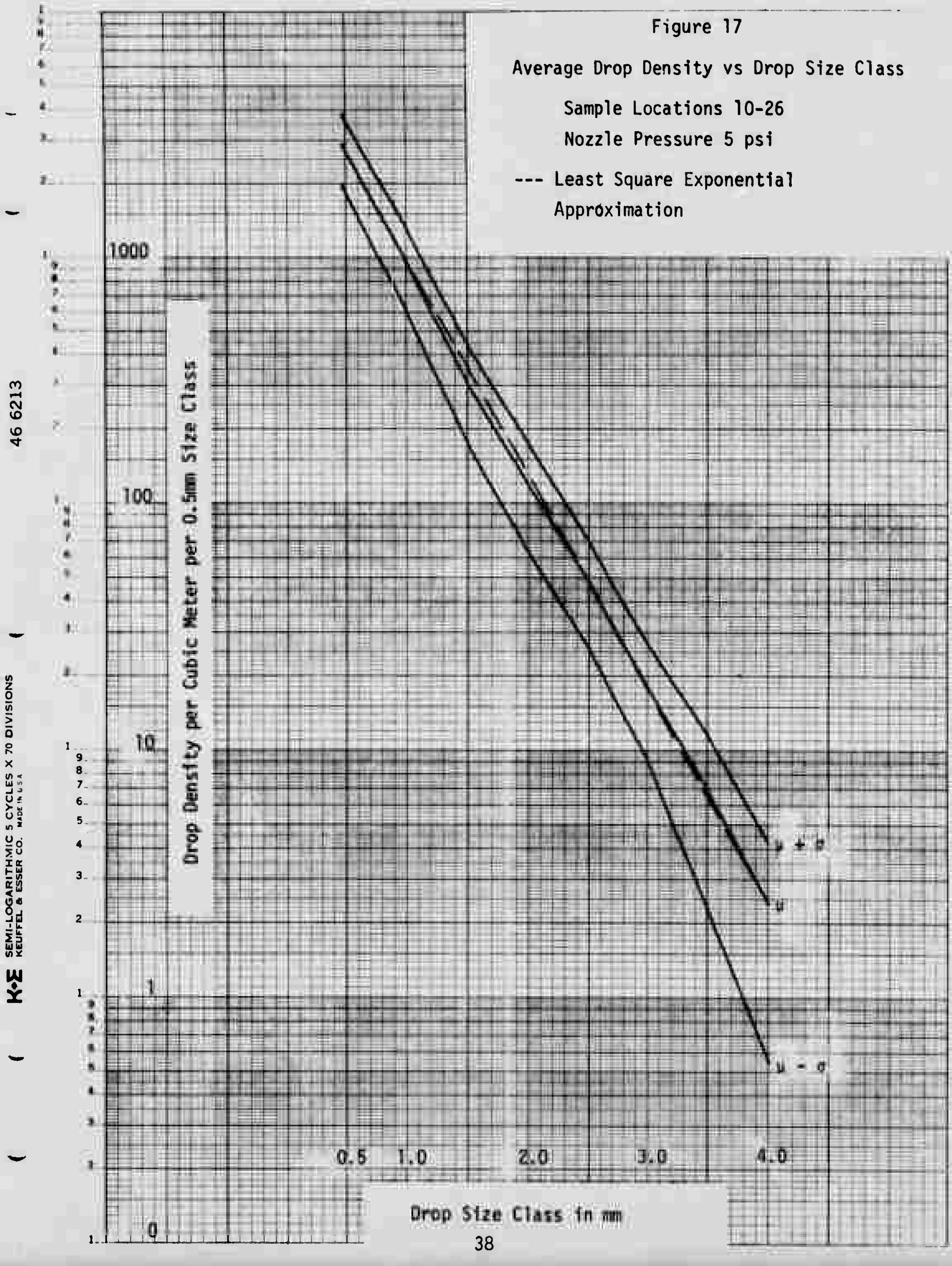


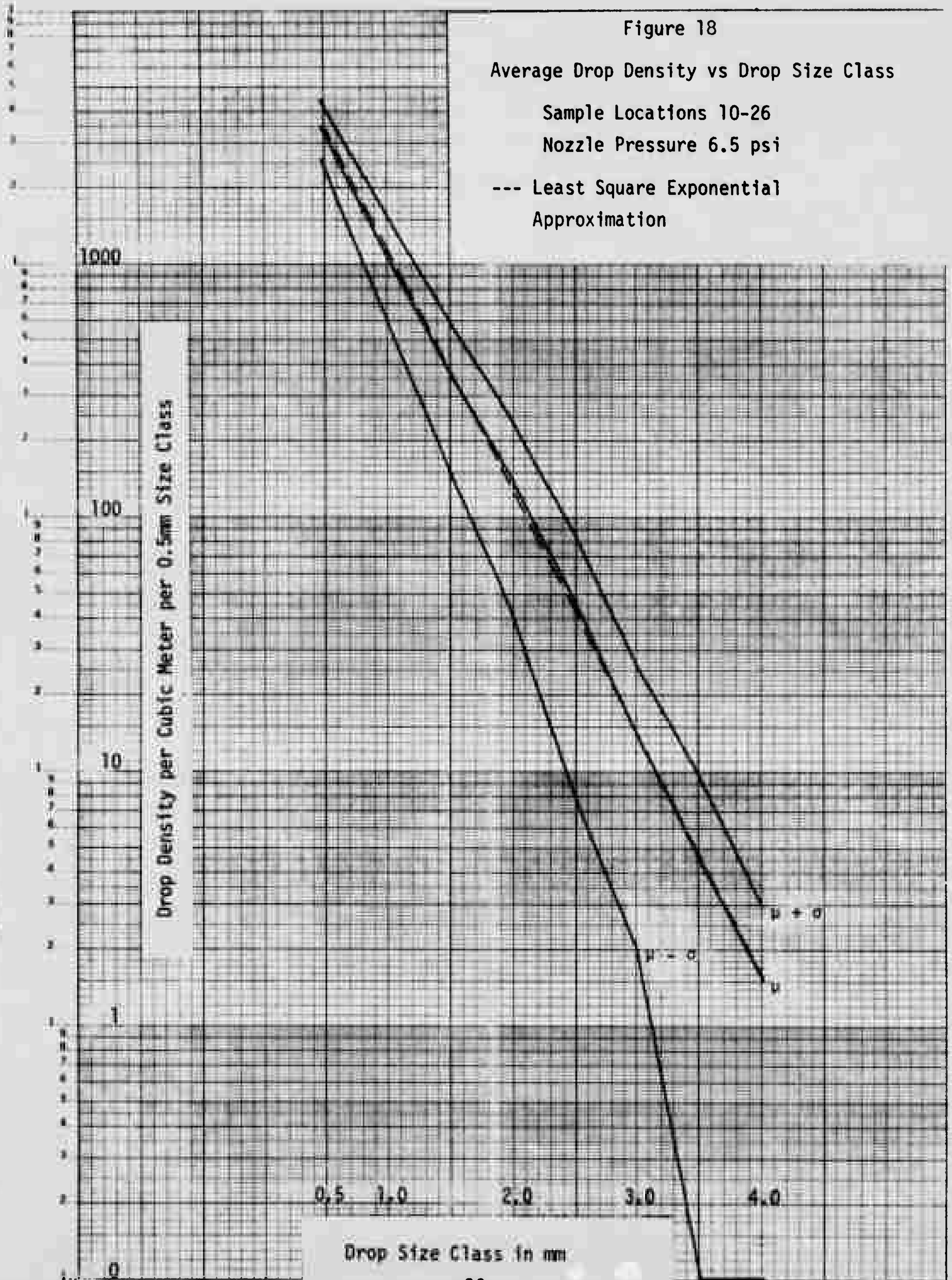
Figure 18

Average Drop Density vs Drop Size Class

Sample Locations 10-26

Nozzle Pressure 6.5 psi

--- Least Square Exponential Approximation



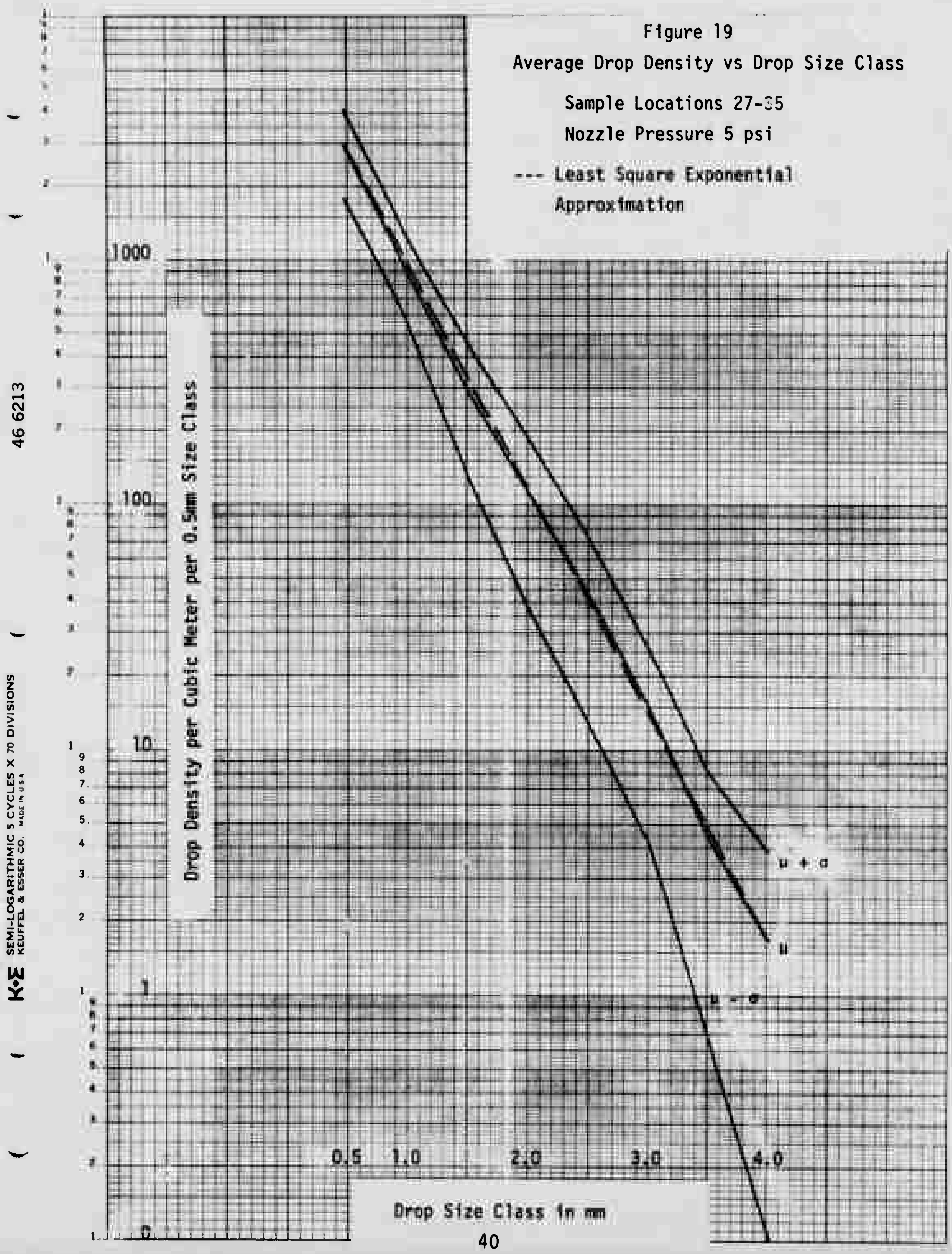


Figure 19

Average Drop Density vs Drop Size Class

Sample Locations 27-35

Nozzle Pressure 5 psi

--- Least Square Exponential Approximation

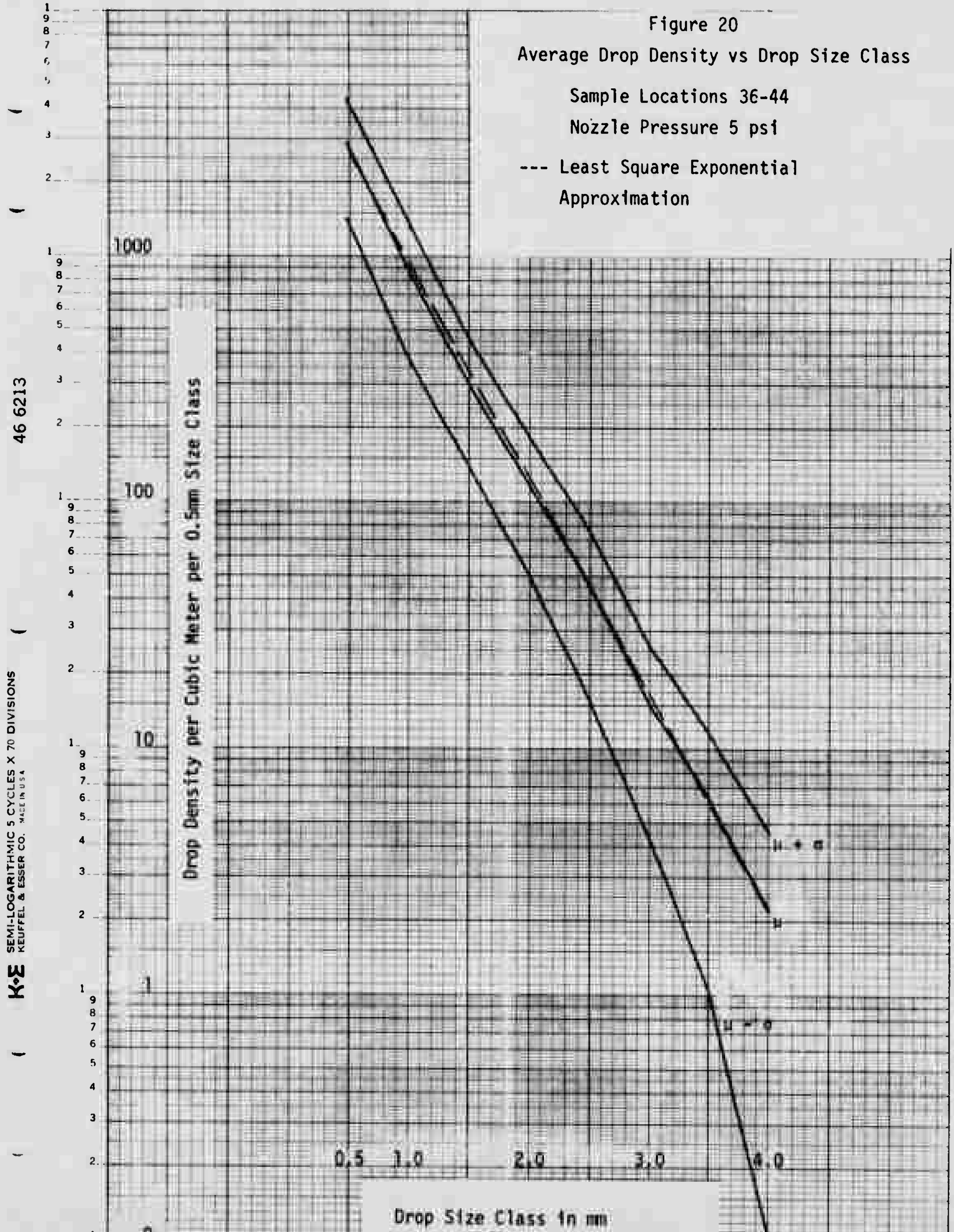


Figure 20
Average Drop Density vs Drop Size Class
Sample Locations 36-44
Nozzle Pressure 5 psi

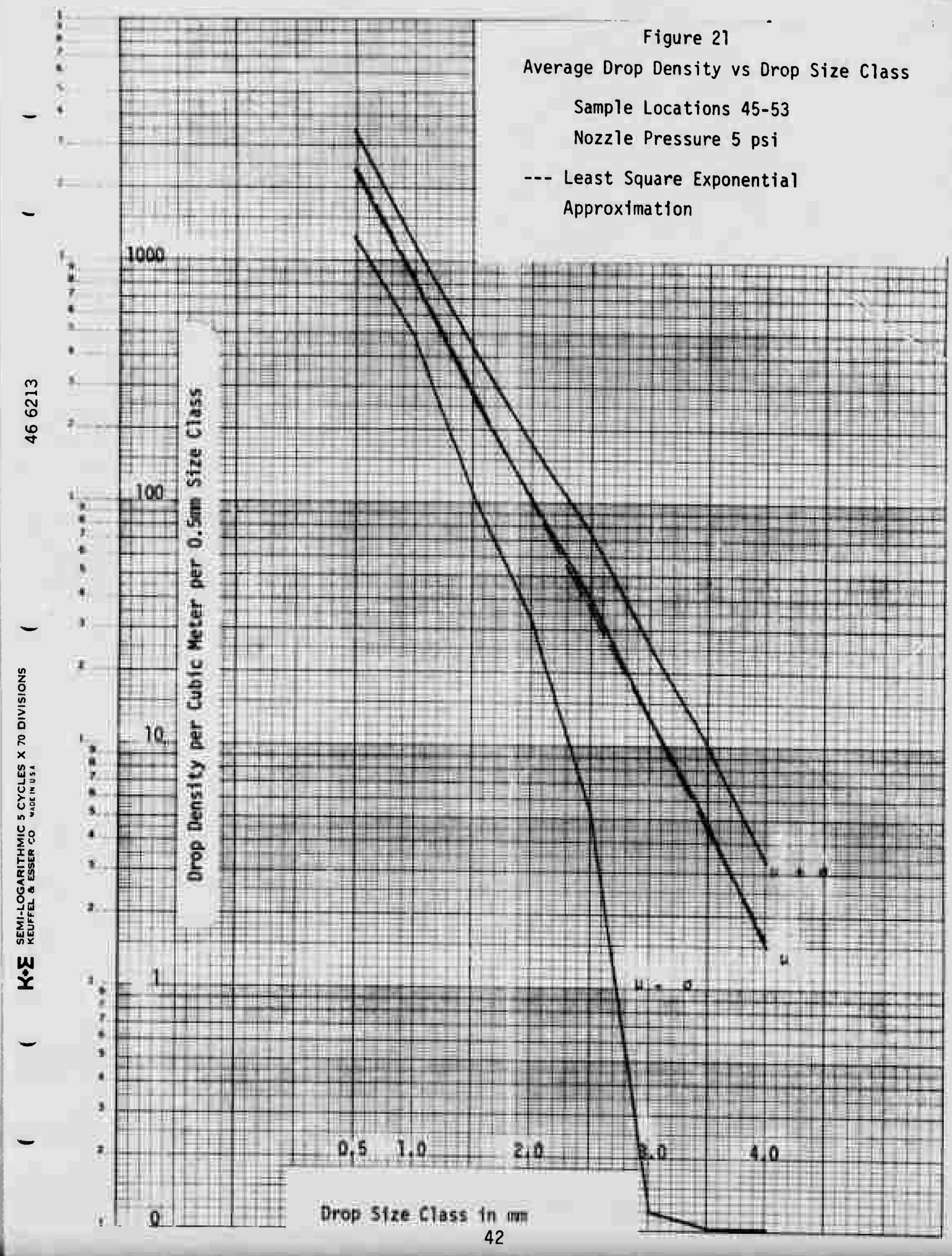


Figure 21
Average Drop Density vs Drop Size Class
Sample Locations 45-53
Nozzle Pressure 5 psi
--- Least Square Exponential
Approximation
Drop Density per Cubic Meter per 0.5mm Size Class
1000
100
10
1
0
0.5
1.0
2.0
3.0
4.0
Drop Size Class in mm
46 6213
K·E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN USA

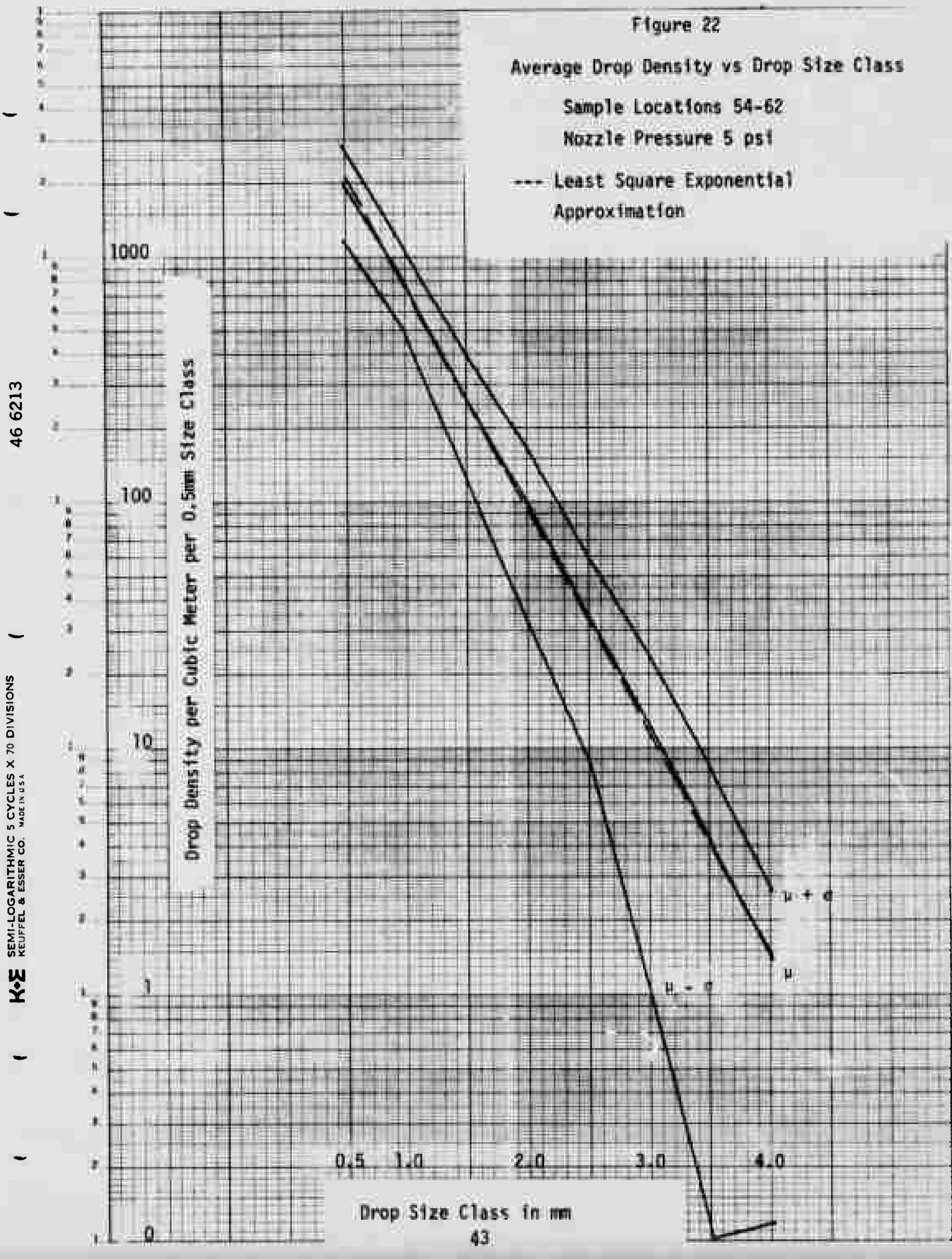


Figure 22
Average Drop Density vs Drop Size Class
Sample Locations 54-62
Nozzle Pressure 5 psi
--- Least Square Exponential Approximation
1000
100
10
1
0
Drop Density per Cubic Meter per 0.5mm Size Class
0.5
1.0
2.0
3.0
4.0
Drop Size Class in mm
μ + σ
μ
μ - σ
46 6213
K·E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

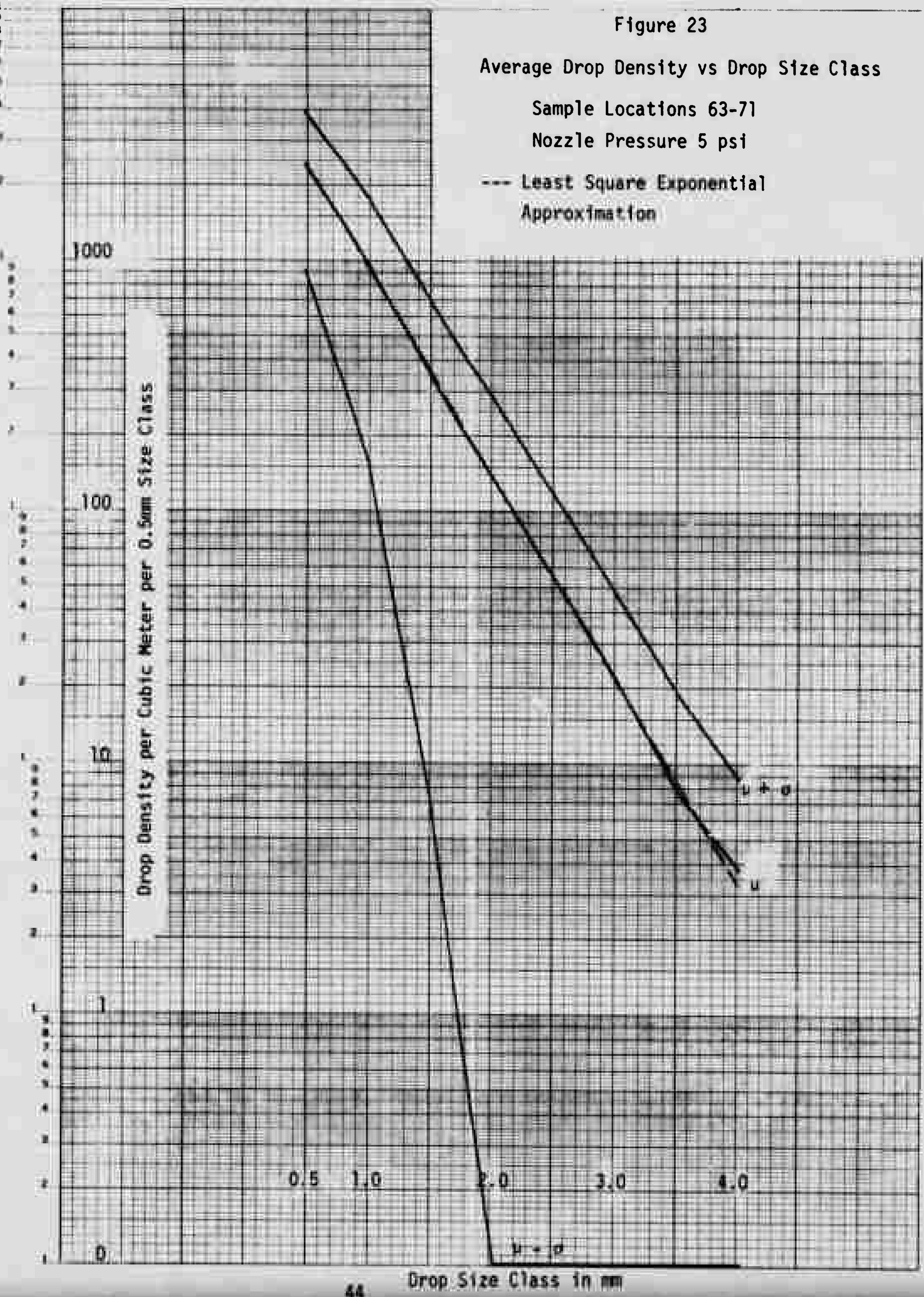


Figure 23
Average Drop Density vs Drop Size Class
Sample Locations 63-71
Nozzle Pressure 5 psi
--- Least Square Exponential Approximation
1000
100
10
1
0
Drop Density per Cubic Meter per 0.5mm Size Class
0.5
1.0
2.0
3.0
4.0
μ + σ
μ
Drop Size Class in mm

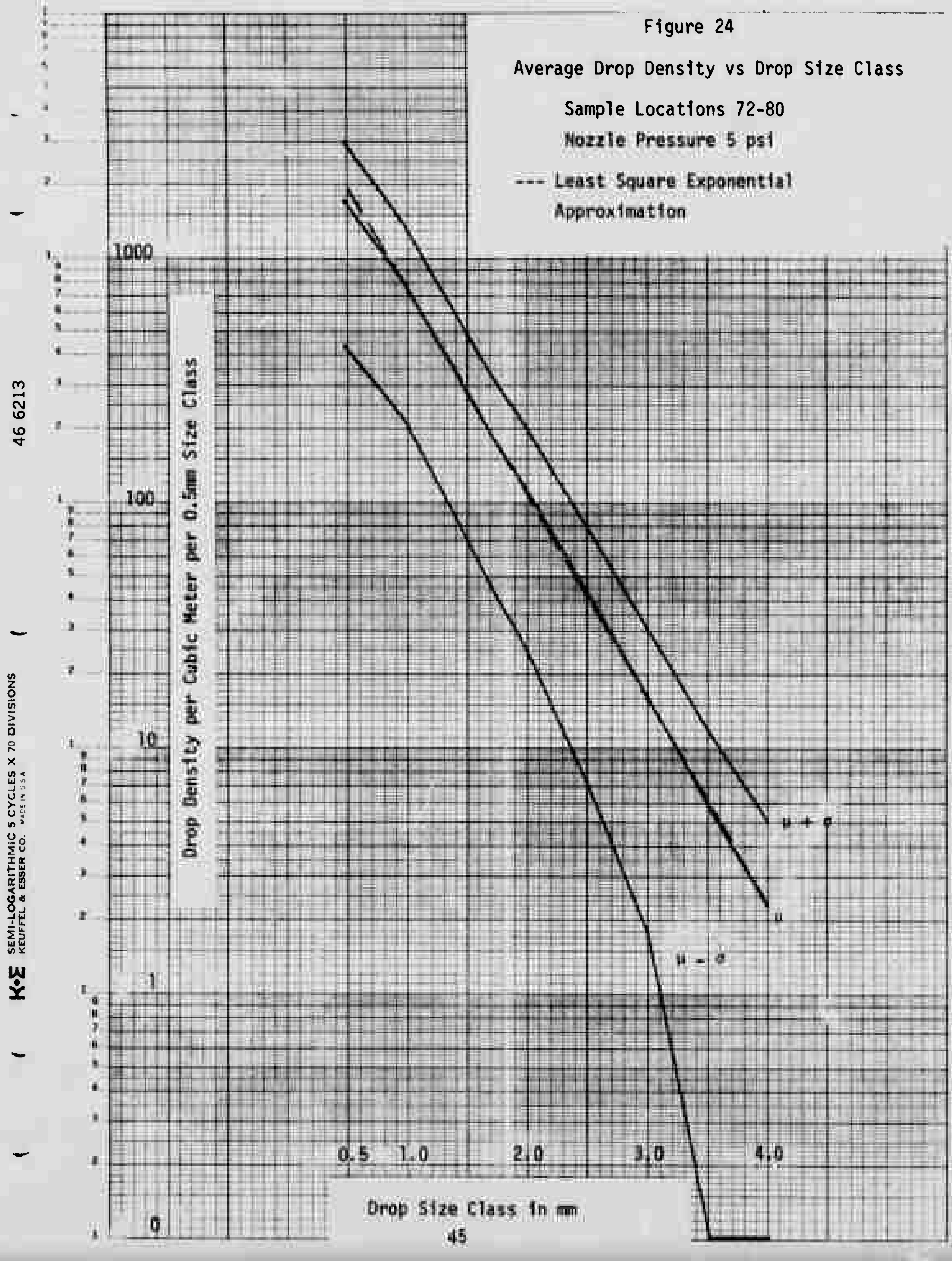
Figure 24

Average Drop Density vs Drop Size Class

Sample Locations 72-80

Nozzle Pressure 5 psi

--- Least Square Exponential Approximation



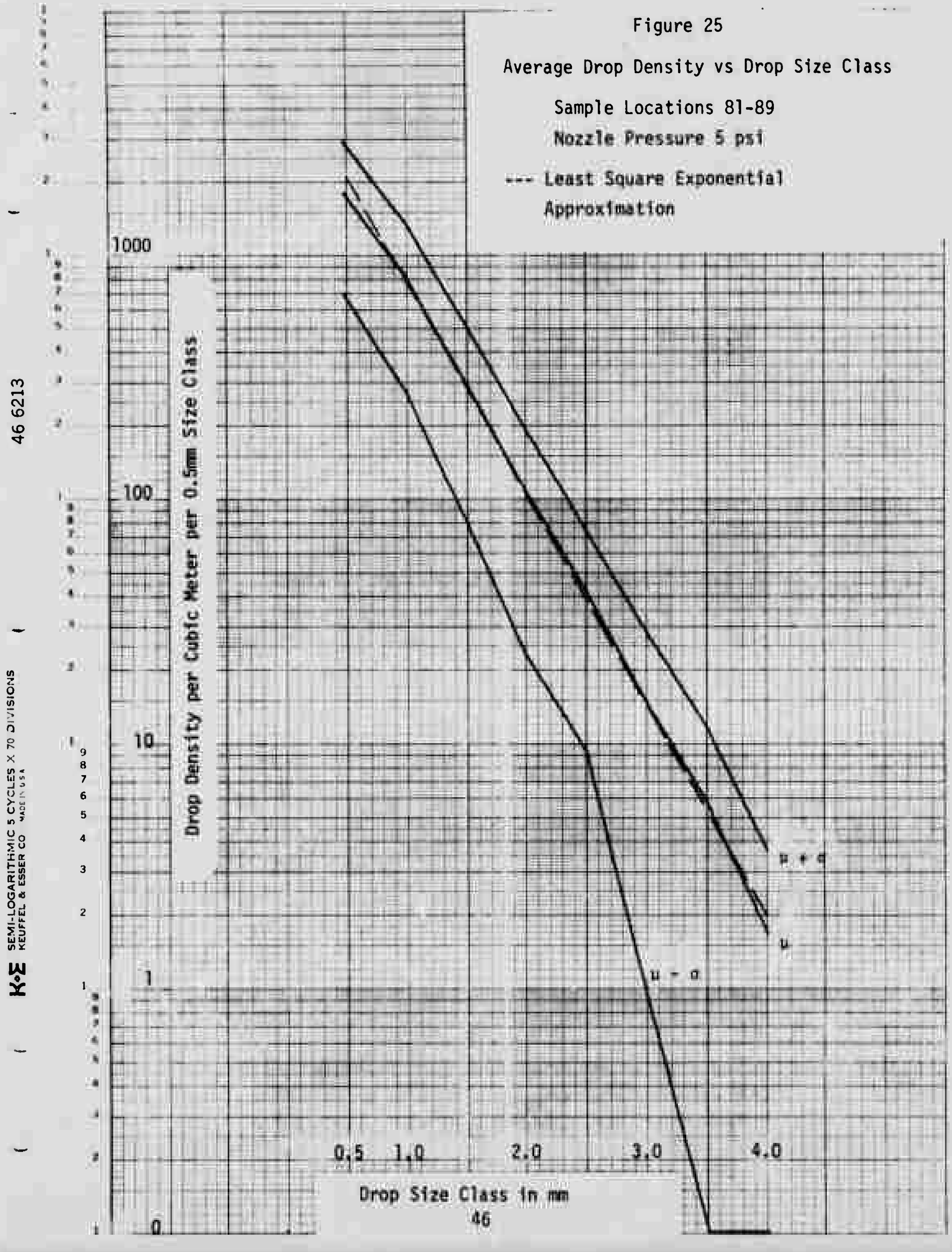


Figure 25

Average Drop Density vs Drop Size Class

Sample Locations 81-89

Nozzle Pressure 5 psi

--- Least Square Exponential Approximation

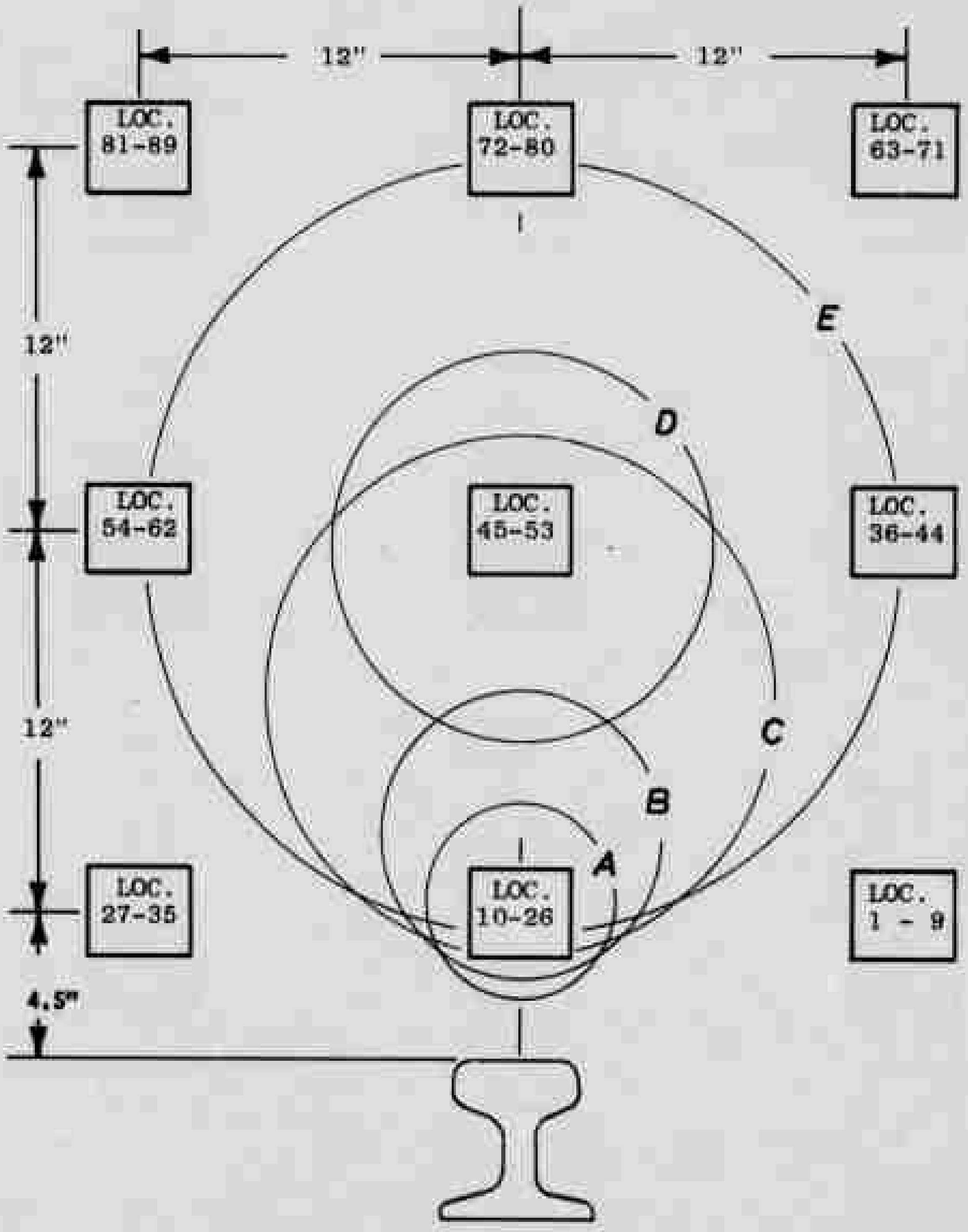


FIGURE 26

TARGET AREAS OF TYPICAL SLEDS

Relative to the Nine Rows of Sample Locations

A: 6" MONORAIL

B: 9" MONORAIL

C: 16" MONORAIL

D: 12" GOOSENECK

E: 24" GOOSENECK

	LOC. 81-89	LOC. 72-80	LOC. 63-71
N_O	5660	4957	6017
D_R	.502	.522	.533
ER	55.2	56.0	71.58
LWC	2.53	2.52	3.22
MMD	1.31	1.36	1.29

	LOC. 54-62	LOC. 45-53	LOC. 36-44
N_O	6119	6670	7040
D_R	.479	.479	.493
ER	48.5	52.2	60.4
LWC	2.27	2.44	2.81
MMD	1.28	1.30	1.33

	LOC. 27-35	LOC. 10-26	LOC. 1-9
N_O	8100	7230	7100
D_R	.47	.50	.493
ER	58.3	62.1	61.2
LWC	2.76	3.03	2.83
MMD	1.28	1.38	1.46

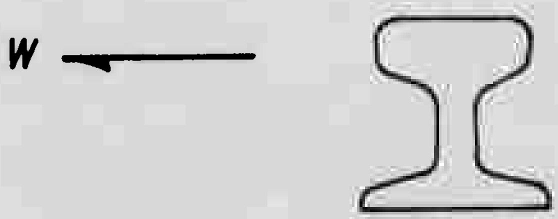


FIGURE 27

Average Sample Row Data at the 9 Test Rows

N_O = Zero Droplet Count of Exponential Distribution Approximation
D_R = Reference Diameter of Exponential Distribution Approximation
ER = Equivalent Rain Rate
LWC = Liquid Water Content
MMD = Median Mass Diameter

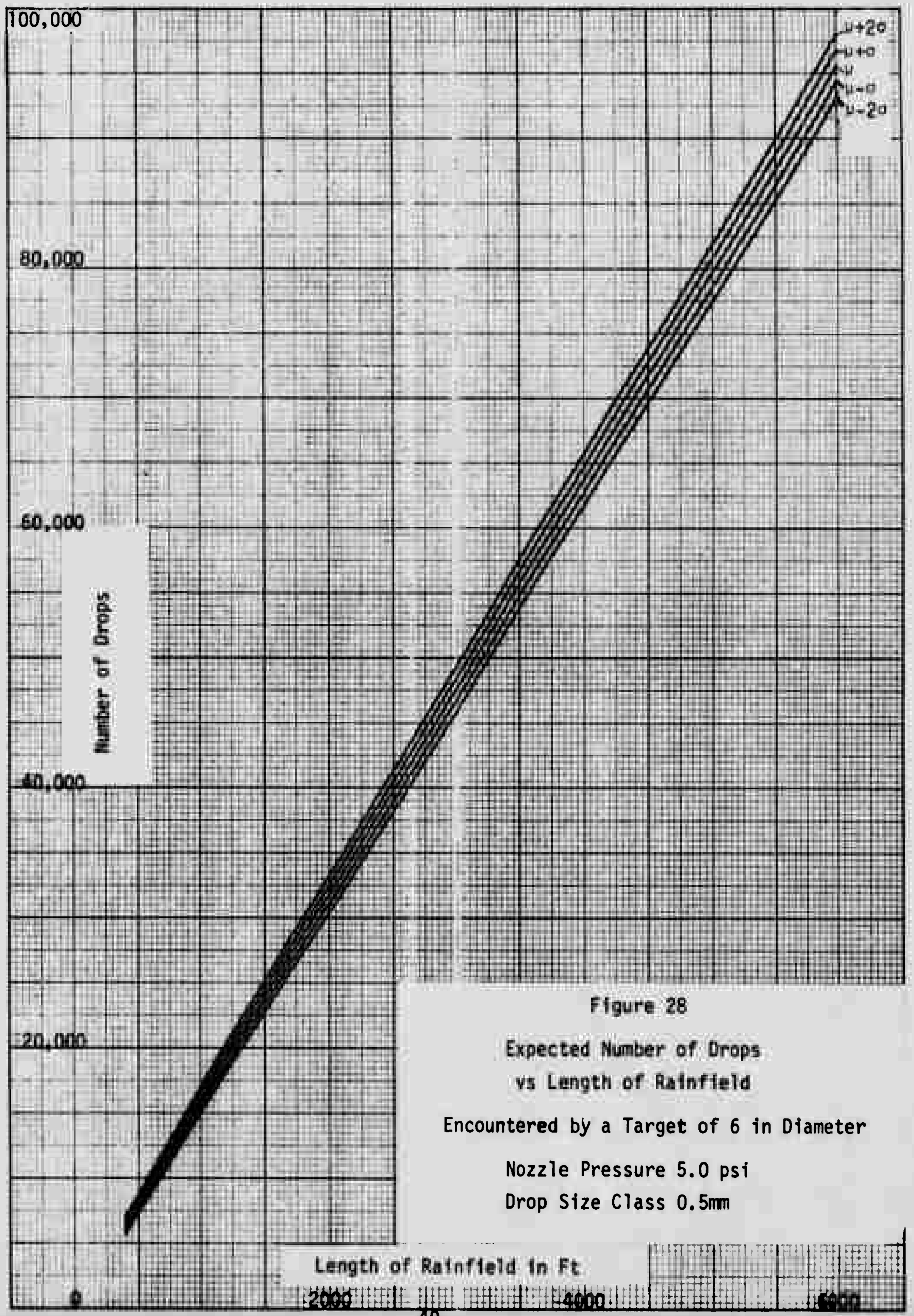


Figure 28

Expected Number of Drops
vs Length of Rainfield

Encountered by a Target of 6 in Diameter

Nozzle Pressure 5.0 psi
Drop Size Class 0.5mm

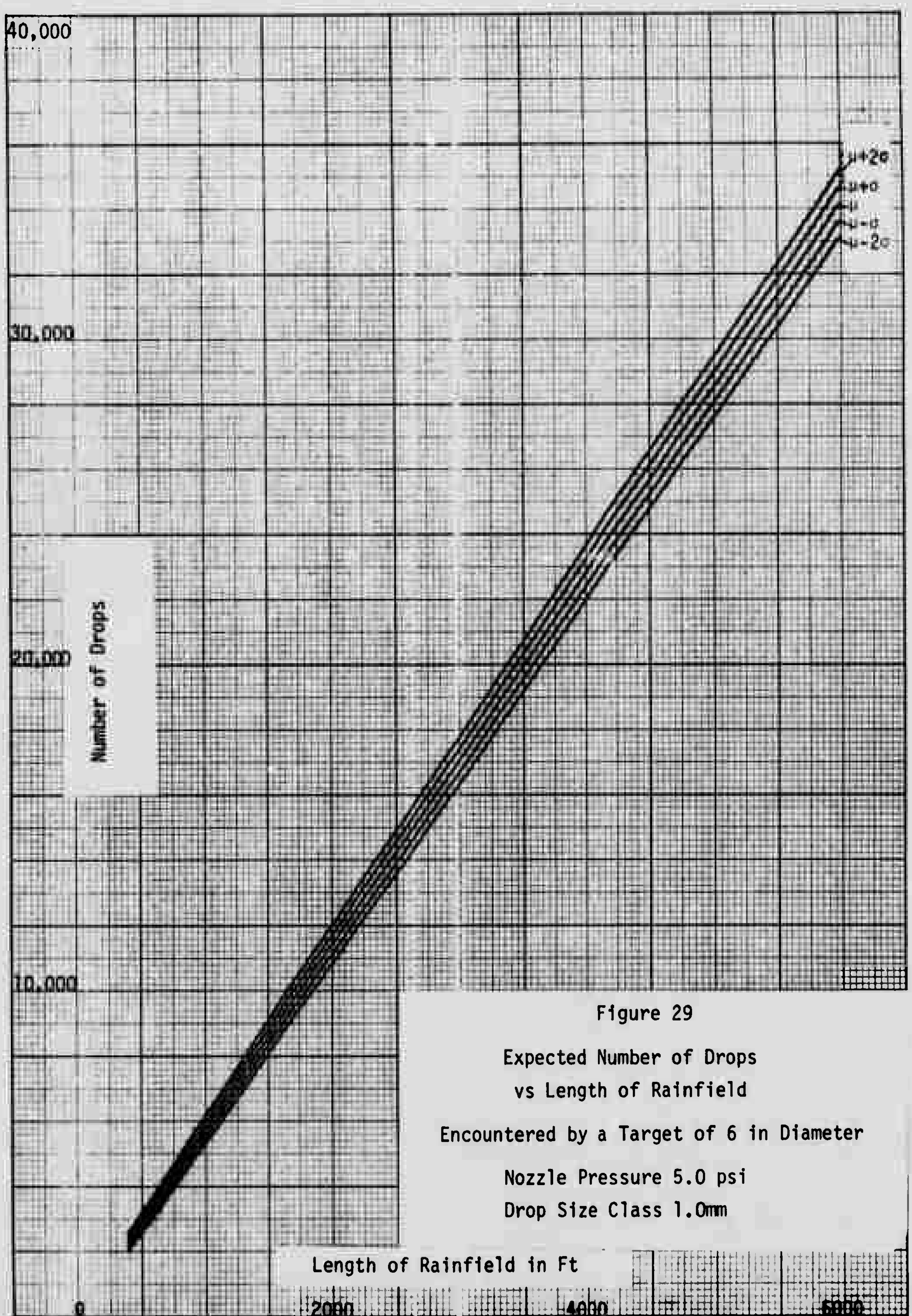


Figure 29

Expected Number of Drops
vs Length of Rainfield

Encountered by a Target of 6 in Diameter

Nozzle Pressure 5.0 psi
Drop Size Class 1.0mm

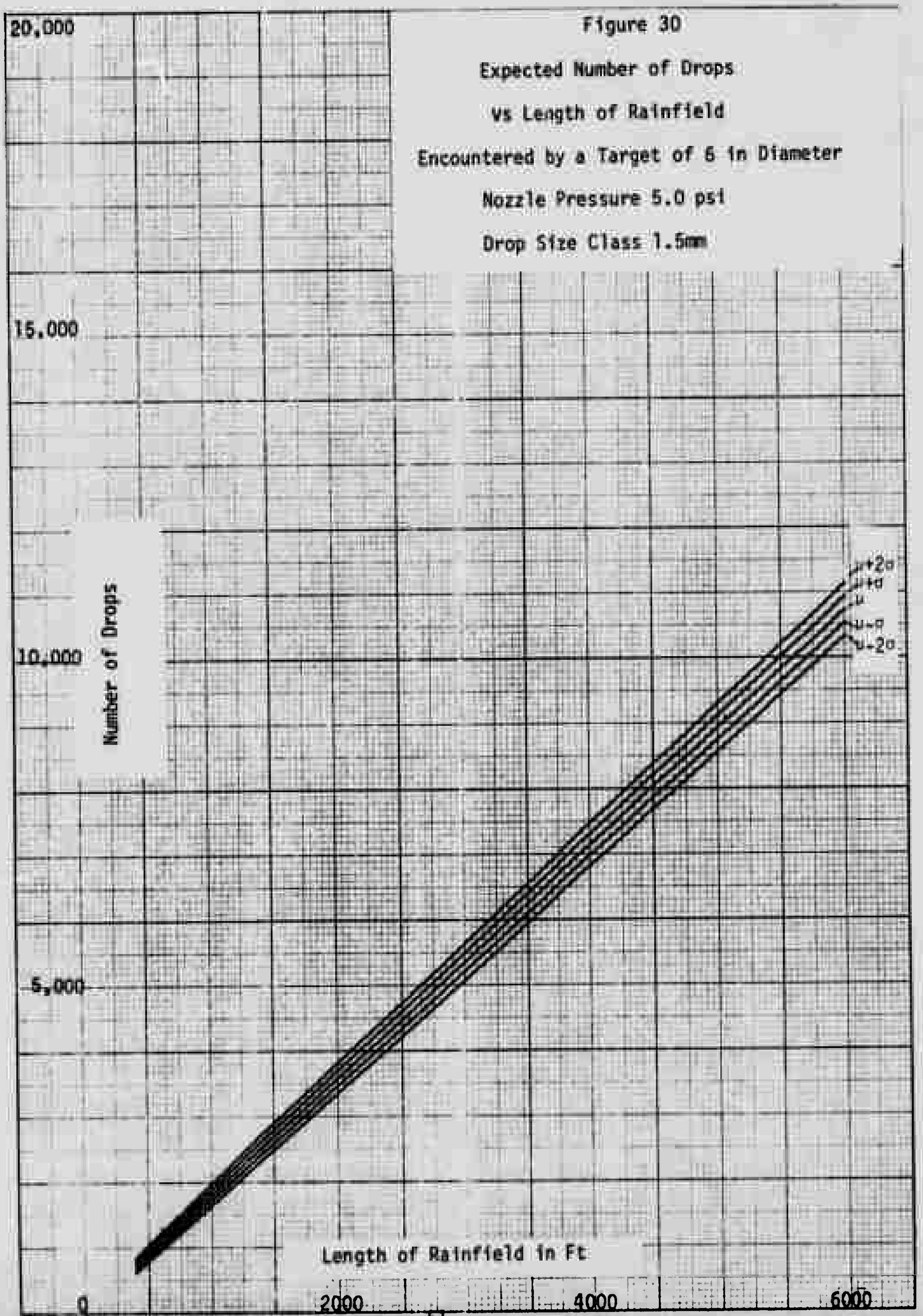


Figure 30

Expected Number of Drops

Vs Length of Rainfield

Encountered by a Target of 6 in Diameter

Nozzle Pressure 5.0 psi

Drop Size Class 1.5mm

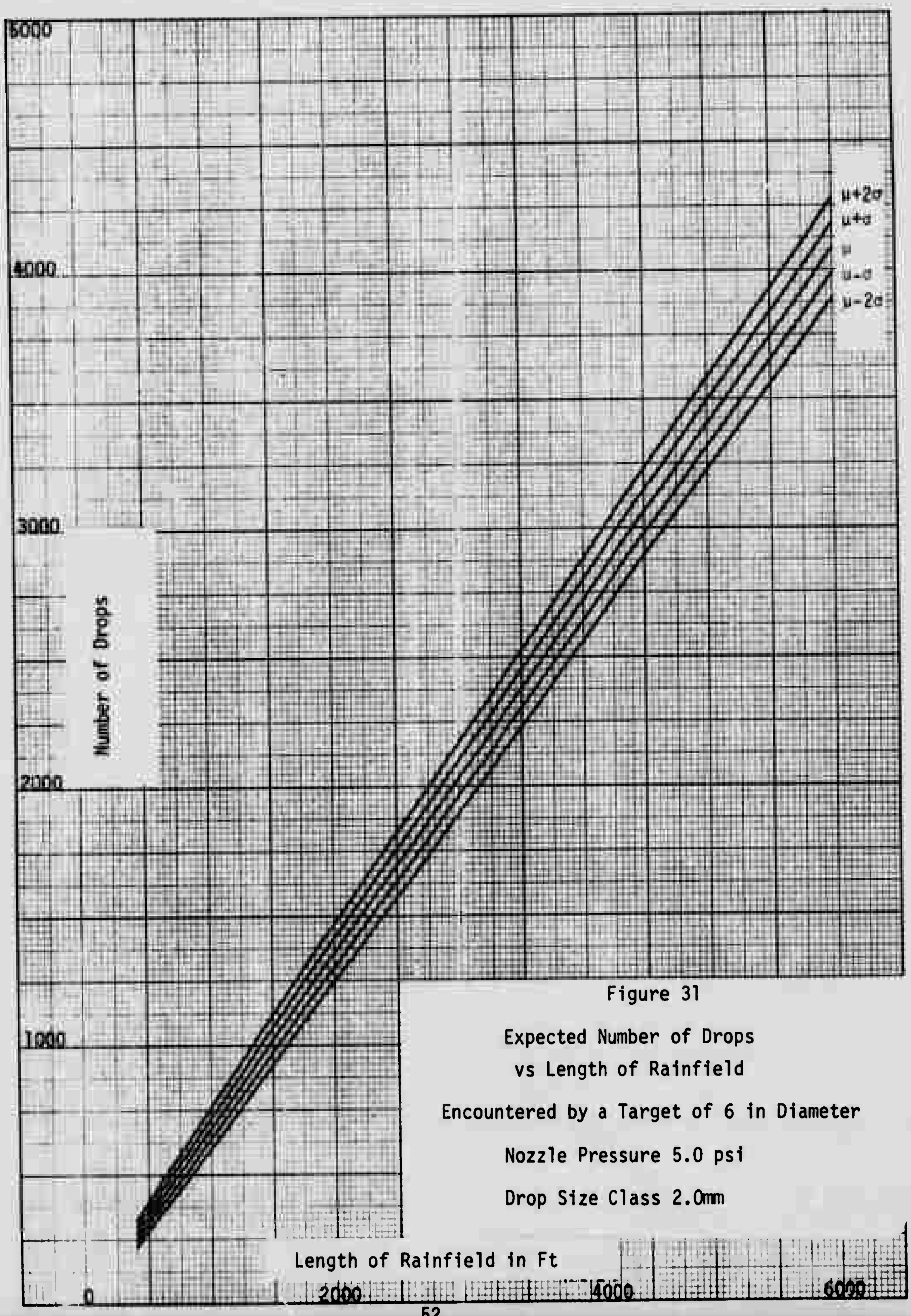


Figure 31

Expected Number of Drops
vs Length of Rainfield
Encountered by a Target of 6 in Diameter
Nozzle Pressure 5.0 psi
Drop Size Class 2.0mm

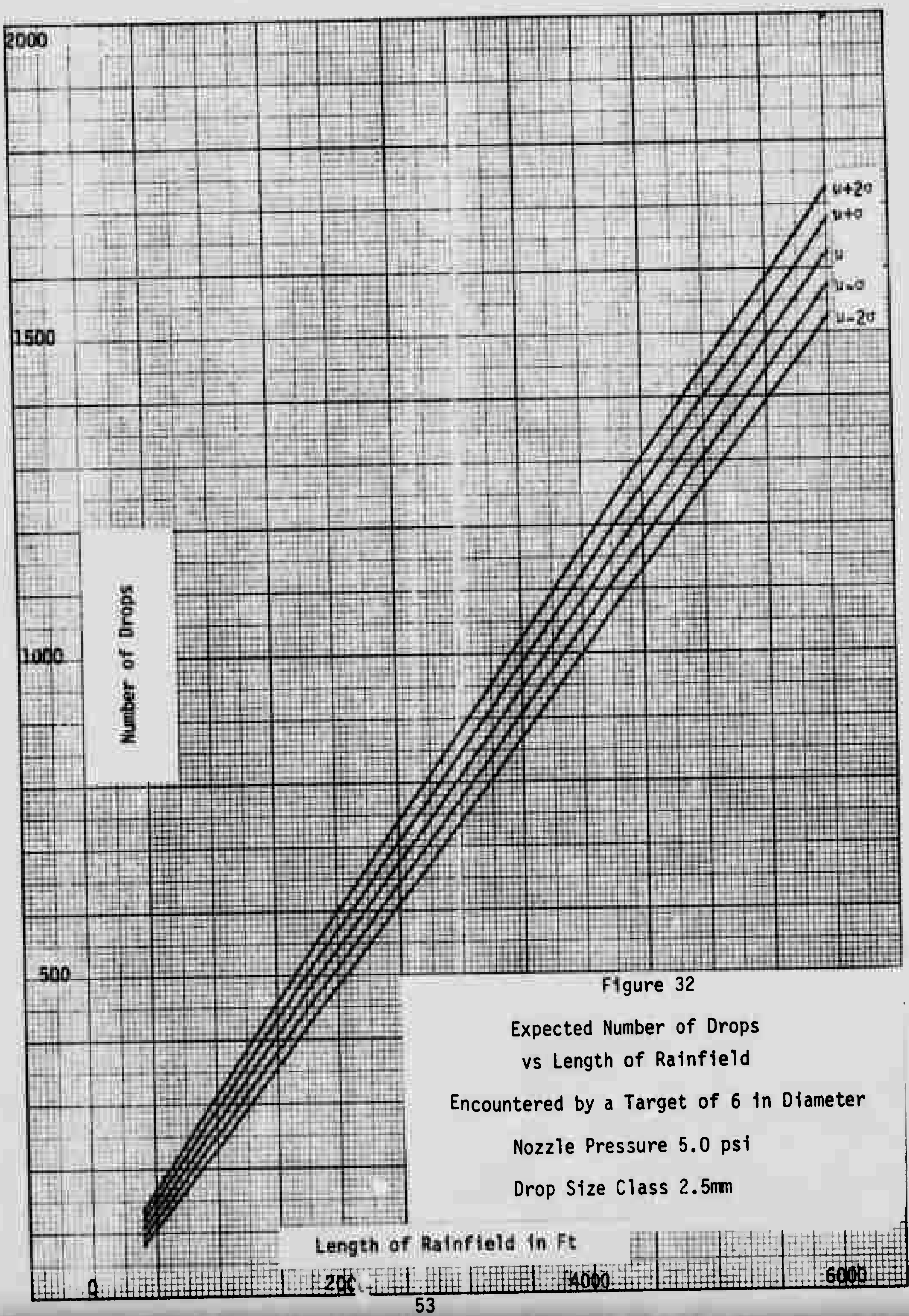


Figure 32

Expected Number of Drops
vs Length of Rainfield

Encountered by a Target of 6 in Diameter

Nozzle Pressure 5.0 psi

Drop Size Class 2.5mm

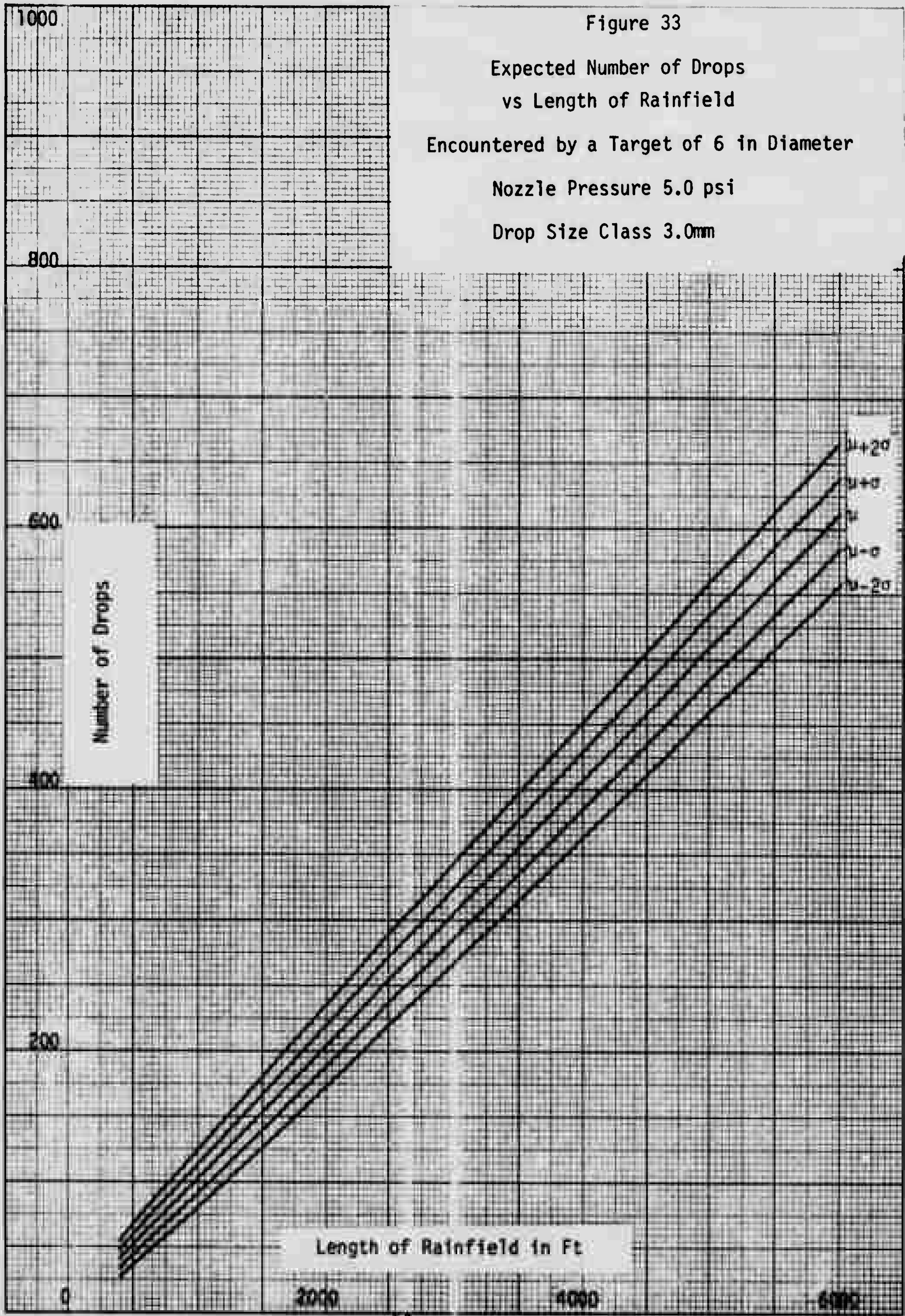


Figure 33

Expected Number of Drops
vs Length of Rainfield
Encountered by a Target of 6 in Diameter
Nozzle Pressure 5.0 psi
Drop Size Class 3.0mm

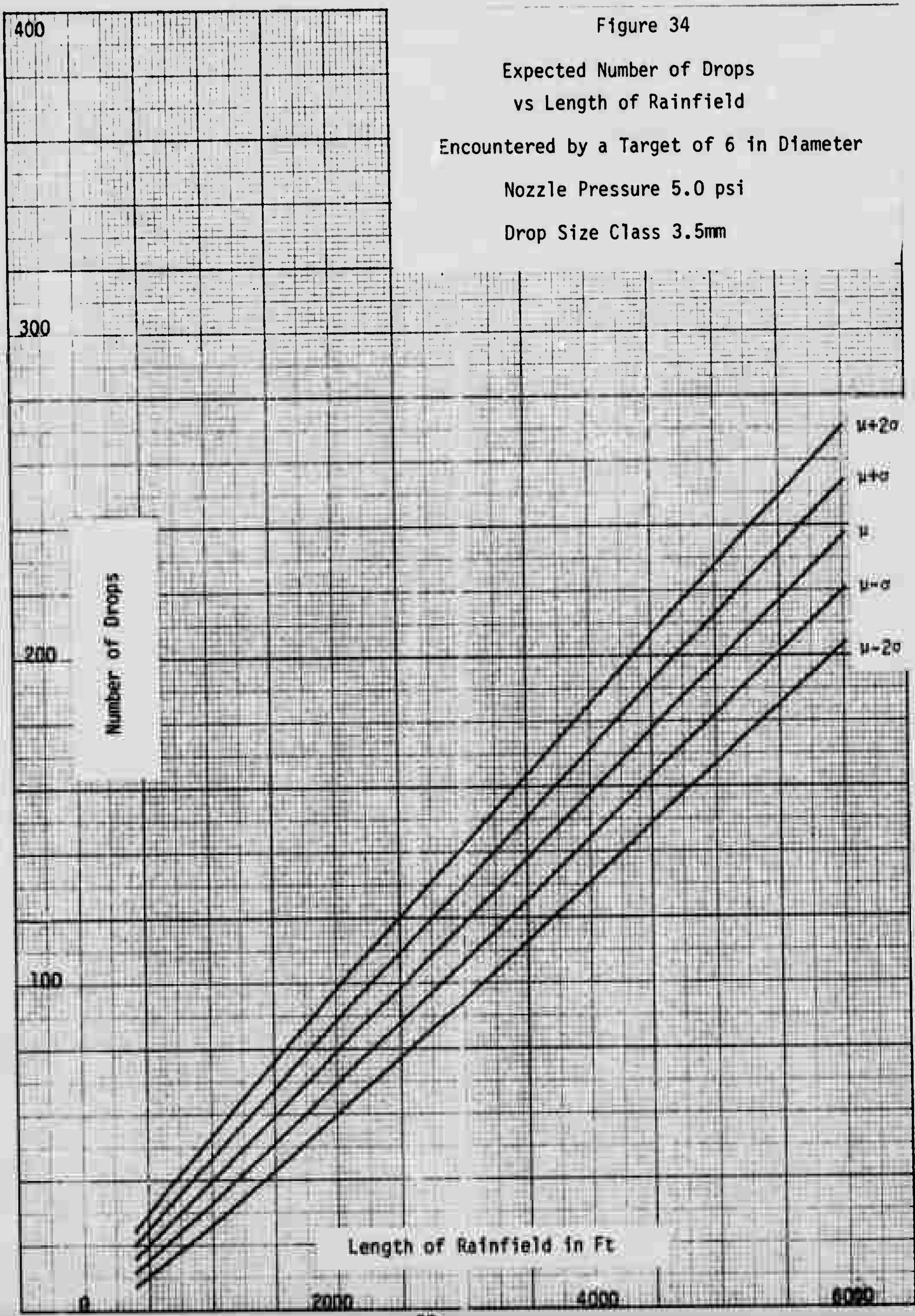
Figure 34

Expected Number of Drops
vs Length of Rainfield

Encountered by a Target of 6 in Diameter

Nozzle Pressure 5.0 psi

Drop Size Class 3.5mm



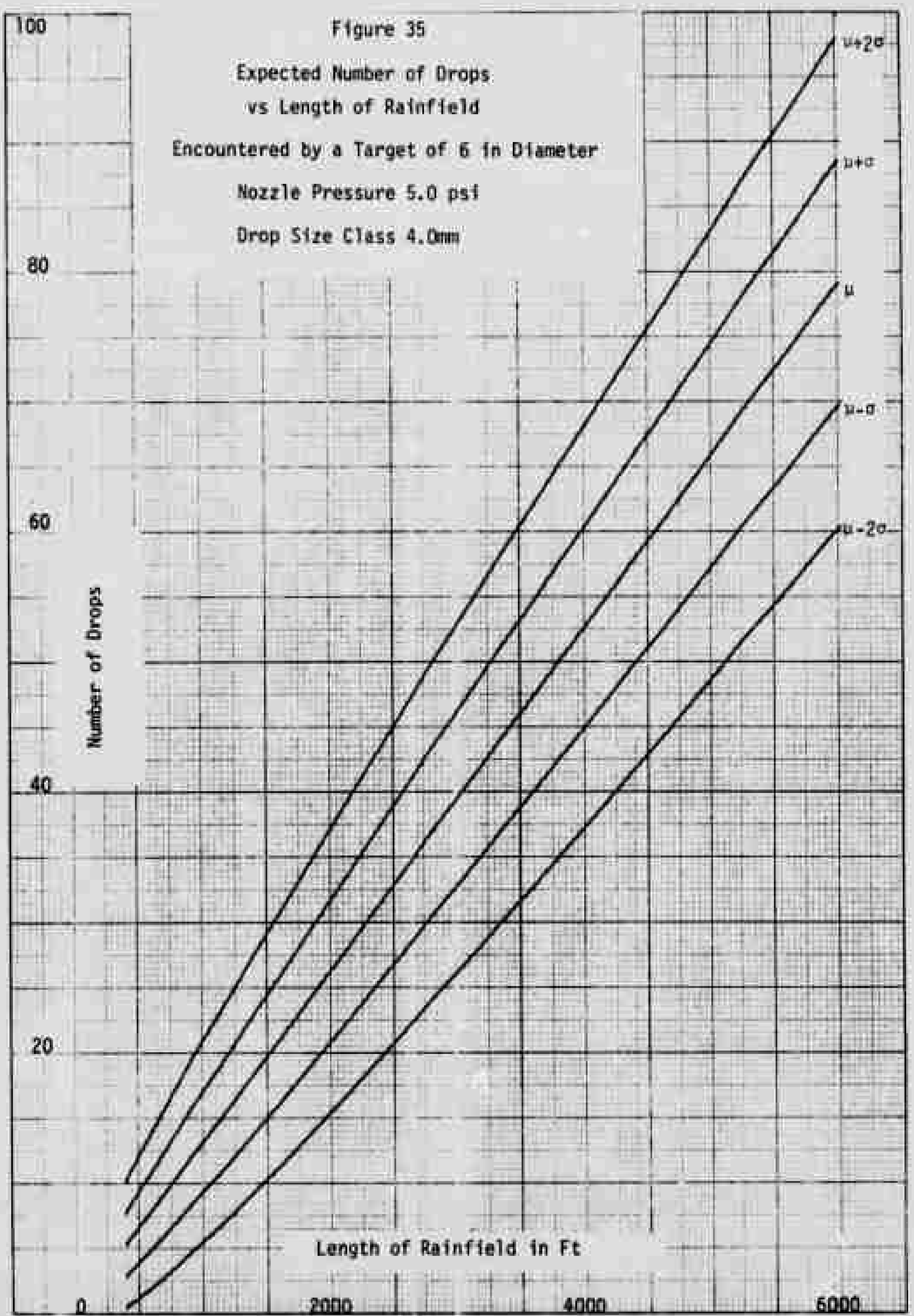


Figure 35
Expected Number of Drops
vs Length of Rainfield
Encountered by a Target of 6 in Diameter
Nozzle Pressure 5.0 psi
Drop Size Class 4.0mm
Number of Drops
Length of Rainfield in Ft
100
80
60
40
20
0
2000
4000
6000
μ+2σ
μ+σ
μ
μ-σ
μ-2σ

APPENDIX A

ARTIFICIAL RAINFIELD PHYSICAL LAYOUT

The artificial rainfield (Figure 1) provides a water spray pattern over a selectable length of the Test Track's west rail for testing of targets mounted on monorail sleds. The length of the rain field is made up of 400-ft sections which routinely form a rain simulation facility up to 6,000 ft long. If required, this length can be extended up to 18,000 ft. The rainfield starts at approximately 13,700 feet from the south end of the test track extending North. This allows sufficient length of track for acceleration of sleds before entering and for recovery after leaving the rainfield.

The rainfield is constructed chiefly from components designed for large irrigation systems. Aluminum pipes with quick-connect couplings are used for supply lines and for the manifolds of the 400-ft sprinkler sections.

The artifical rainfield consists essentially of four parts:

a. The water supply system

b. The water distribution system

c. The sprinkler system

d. The automatic control system.

<u>The water supply system</u> receives its water from the Holloman utility main line at a maximum rate of approximately 800 gallons per minute. (See Figure A1) This flow rate would be sufficient only for small sections of rainfield and, in practice, is only used for testing selected sections. A 25,000 gallon tank which is filled from the utility line supplies the water during normal rainfield operation. A 600 hp pump feeds the water into the distribution system. Two motor controlled valves, one in a return line to the tank and one in the main supply line control the pressure in the distribution system. A pump house, located beside the water tank on the east side of the track, houses the pump and all associated valves and piping. A 12-inch main line feeds the water for the rainfield from the pump house under the track to its west side where it connects to the distribution system.

<u>The water distribution system</u> (Figure A2) first divides the main line into two branches going north and south at track station 23,747 (track station is a location at the track measured in feet from its south end). Each branch starts with a manual valve allowing to cut-off either one of the branches. Immediately downstream from these valves, the lines divide into two 8-inch parallel

lines extending north to track station 24,300 and south to track station 20,290 where either pair merges into one 8-inch line continuing to track stations 31,500 and 13,840, respectively.

The sprinkler system consists of 45 sections of 400-ft length. Each section is made up of two manifolds, one equipped with 50 high risers and one with 50 low risers. The risers on each manifold are spaced 8 feet apart. High and low risers are evenly staggered such that a spacing of 4 feet between alternating high and low risers results. Figure A3 shows a rainfield cross section giving the essential dimensions. 40 sections of rainfield use manifolds of 4 inches diameter. The remaining 5 sections use manifolds of 6 inches diameter. They are located closest to the main supply line between track stations 22,496 and 24,496. These sections are intended for simulation of extremely heavy rains. Each 400 ft section can be disconnected and tilted down to the west of the track in order to avoid interference with track missions requiring larger clearance. Two remotely controlled solenoid valves (Figure A4) allow the operator to turn off either manifold of a section. A common motor controlled valve and associated pressure transducer provide the means for remote pressure control of each rainfield section.

The automatic control system is located in a blockhouse (ECHO) under the landfill of the track near track station 24,000. A control console terminates all signals from sensors. These include the position indicators of the pump house valve control motors, and the pressure transducers in the 400-ft section manifolds and the main supply line. From the control console also initiate all control signals to the valve control motors and the solenoid valves of the 400-ft manifolds. The console further contains meter displays of all pressure signals and the zero/span adjustments of the pressure transducers.

A minicomputer (PDP 8/f) with associated interface provides the means for automatic checkout, stand by, and operation of the rainfield. Through a teletypewriter it also furnishes a list of all pressure settings. By program control all rainfield sections required for a test are brought into standby status by filling them with water until a pressure just below the nozzle discharge pressure is reached. By this procedure, the considerable amount of water required to fill the lines can be obtained from the main utility line. Upon command, the computer then starts the pump and opens up the valves to their preprogrammed manifold pressures. A computer printout provides all pertinent information on manifold pressure at the time of the sled run.

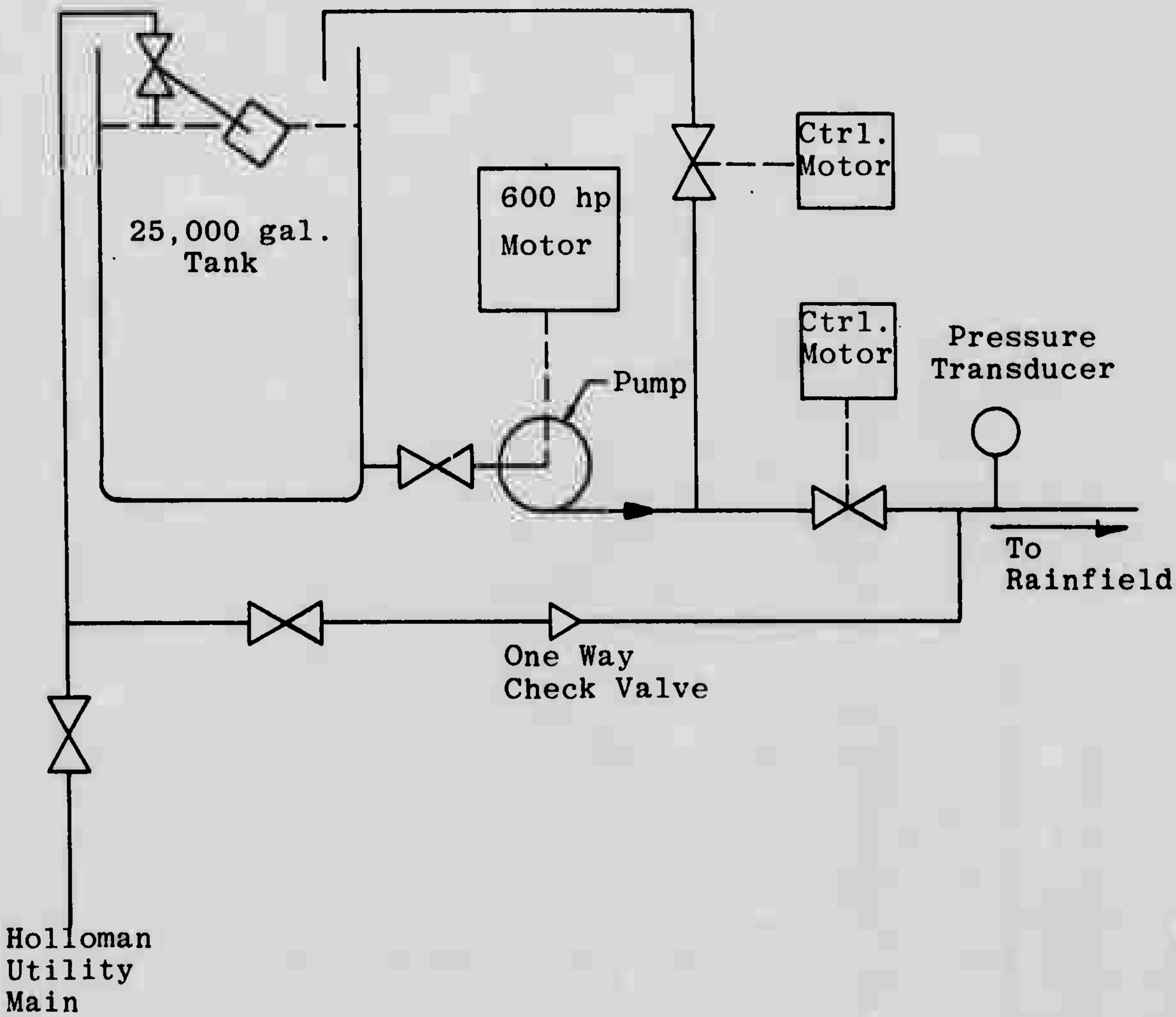


FIGURE A1

WATER SUPPLY SYSTEM

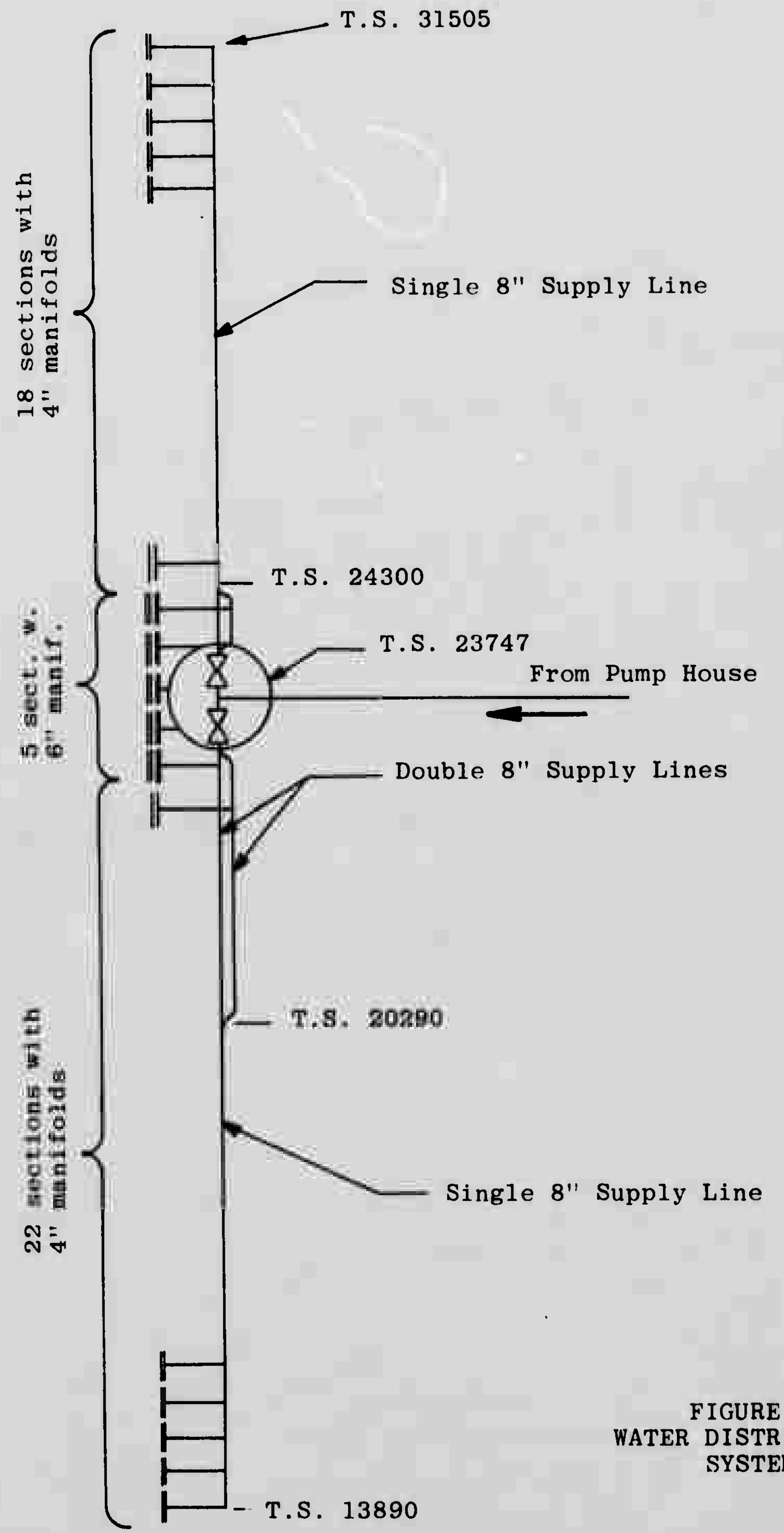


FIGURE A2
WATER DISTRIBUTION
SYSTEM

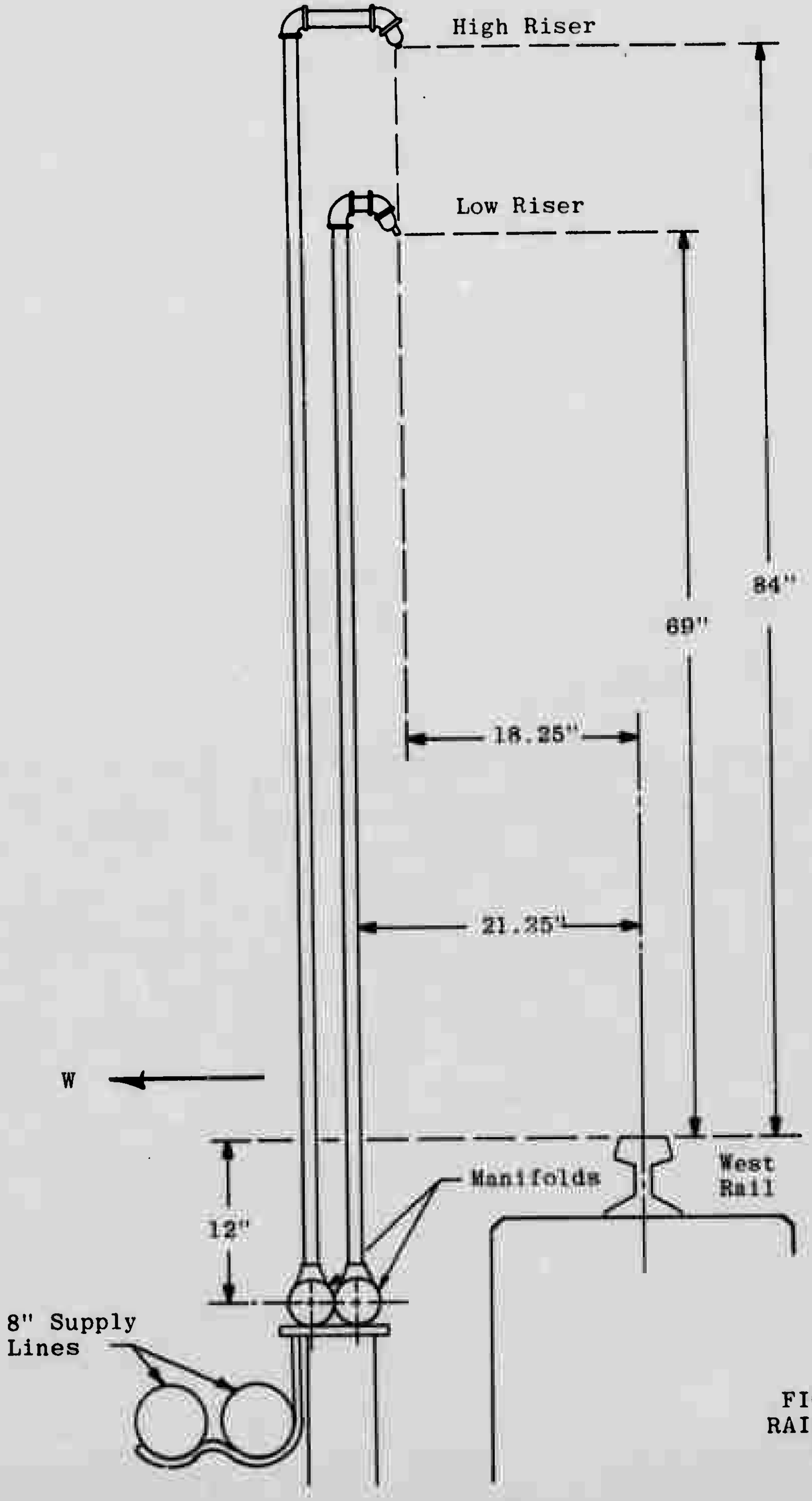


FIGURE A3
RAINFIELD CROSS
SECTION

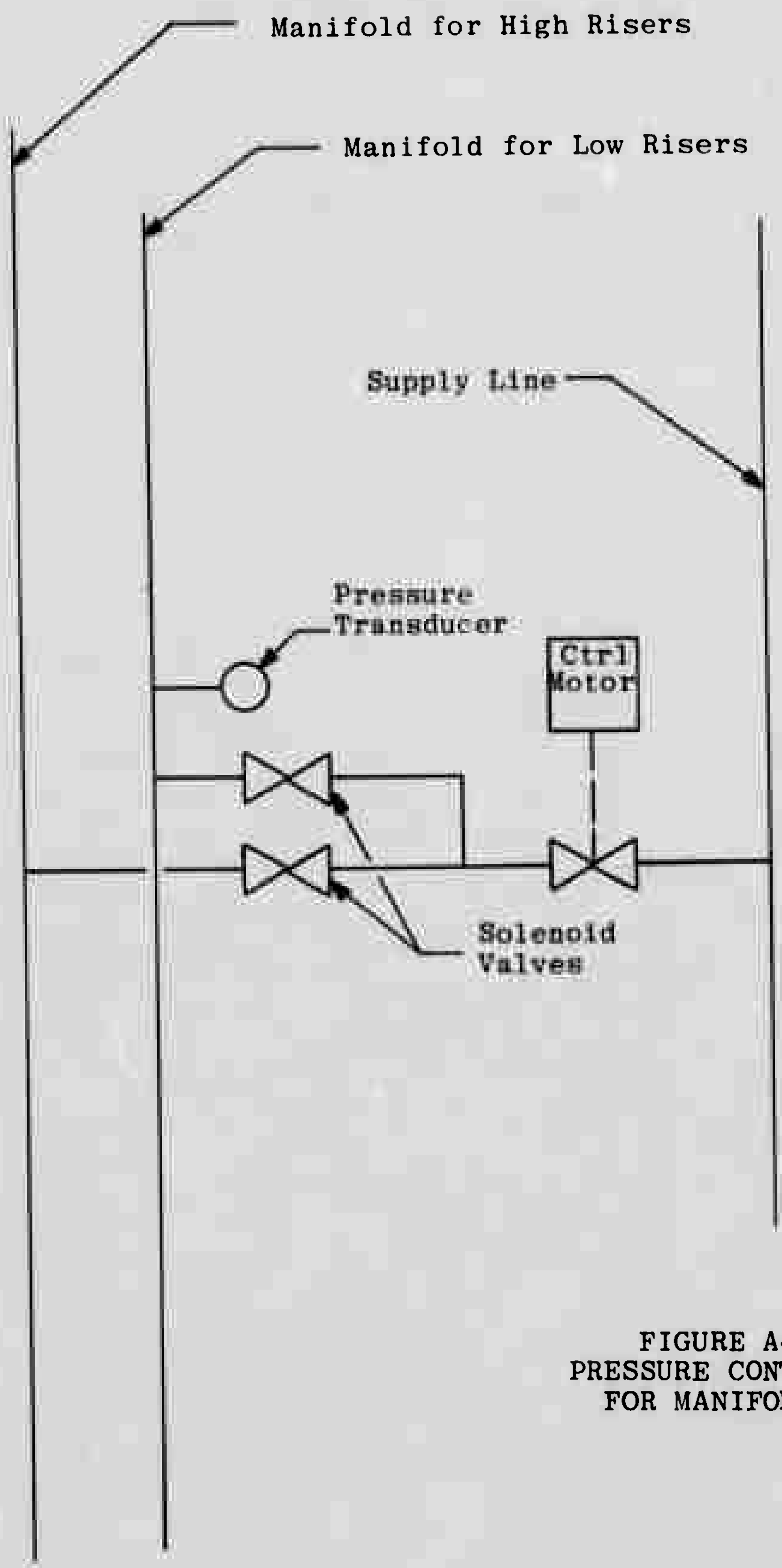


FIGURE A4
PRESSURE CONTROL
FOR MANIFOLDS

APPENDIX B

TEST FIELD PHYSICAL LAYOUT

The test field (Figure B1) duplicates one representative increment of a 400-ft section of rainfield in a wind protected shelter. The sprinkler system consists of two 20-ft long 4-inch manifolds, one equipped with two high risers and the other one with three low risers. Together they form a system of a 4 foot spaced alternating low and high risers. Low risers were equipped with Spraying System Company #1/4HH14W nozzles and high risers with Steinen #SSM151W nozzles. As the two outermost nozzles provide for the necessary spray overlap, an increment of 8-ft length representative of the track's rainfield results. Water was supplied from a large storage tank through an impeller type pump and pressure regulator. Pressure is referenced to the nozzle of the risers.

The droplet counter was kept stationary and the sprinkler system was moved relative to the counter to obtain the sample locations of Figures B2 and B3.

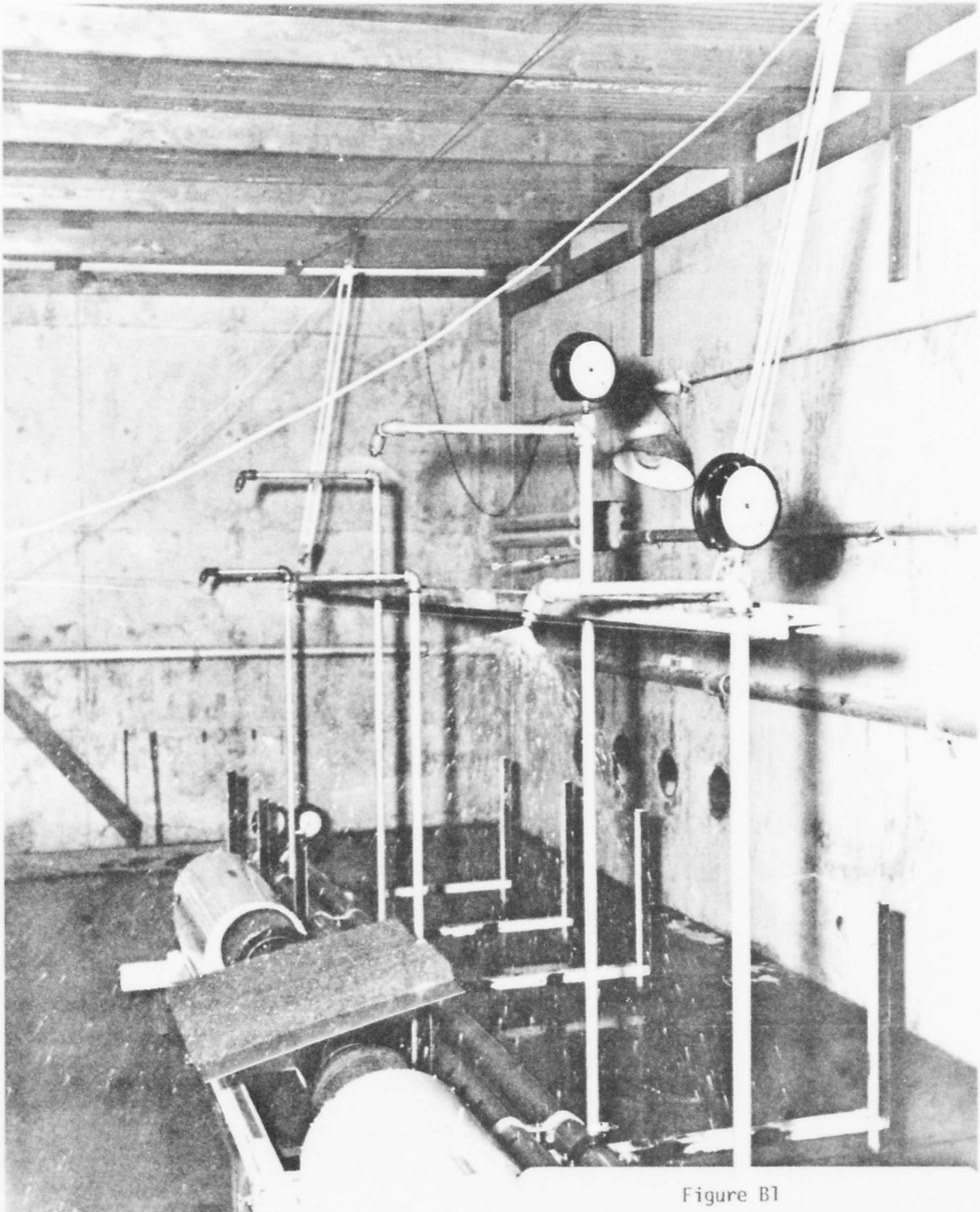


Figure B1
Test Field and Droplet Counter

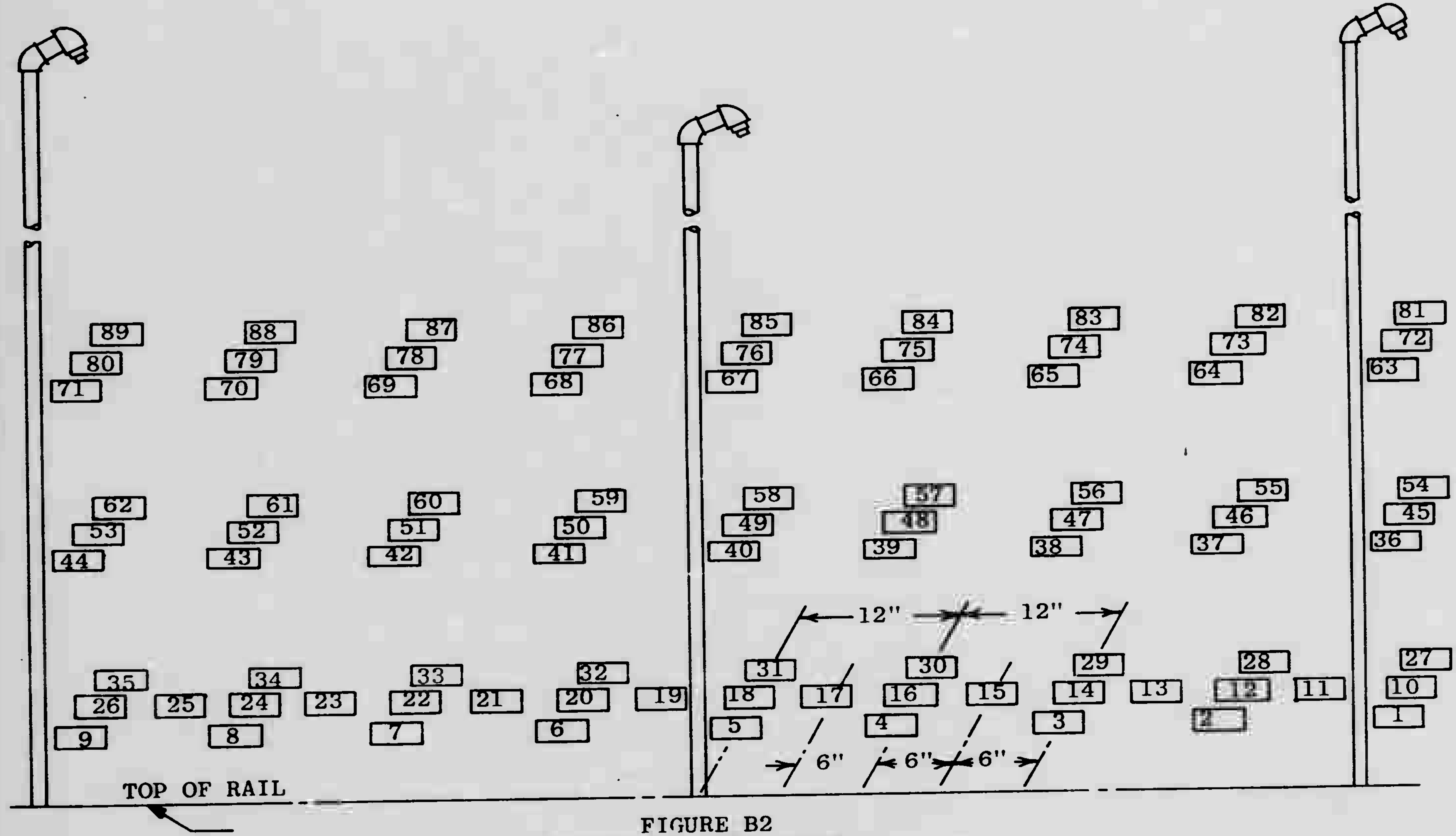


FIGURE B2
RAINFIELD TEST SETUP
SAMPLE VOLUME LOCATIONS - SIDE VIEW

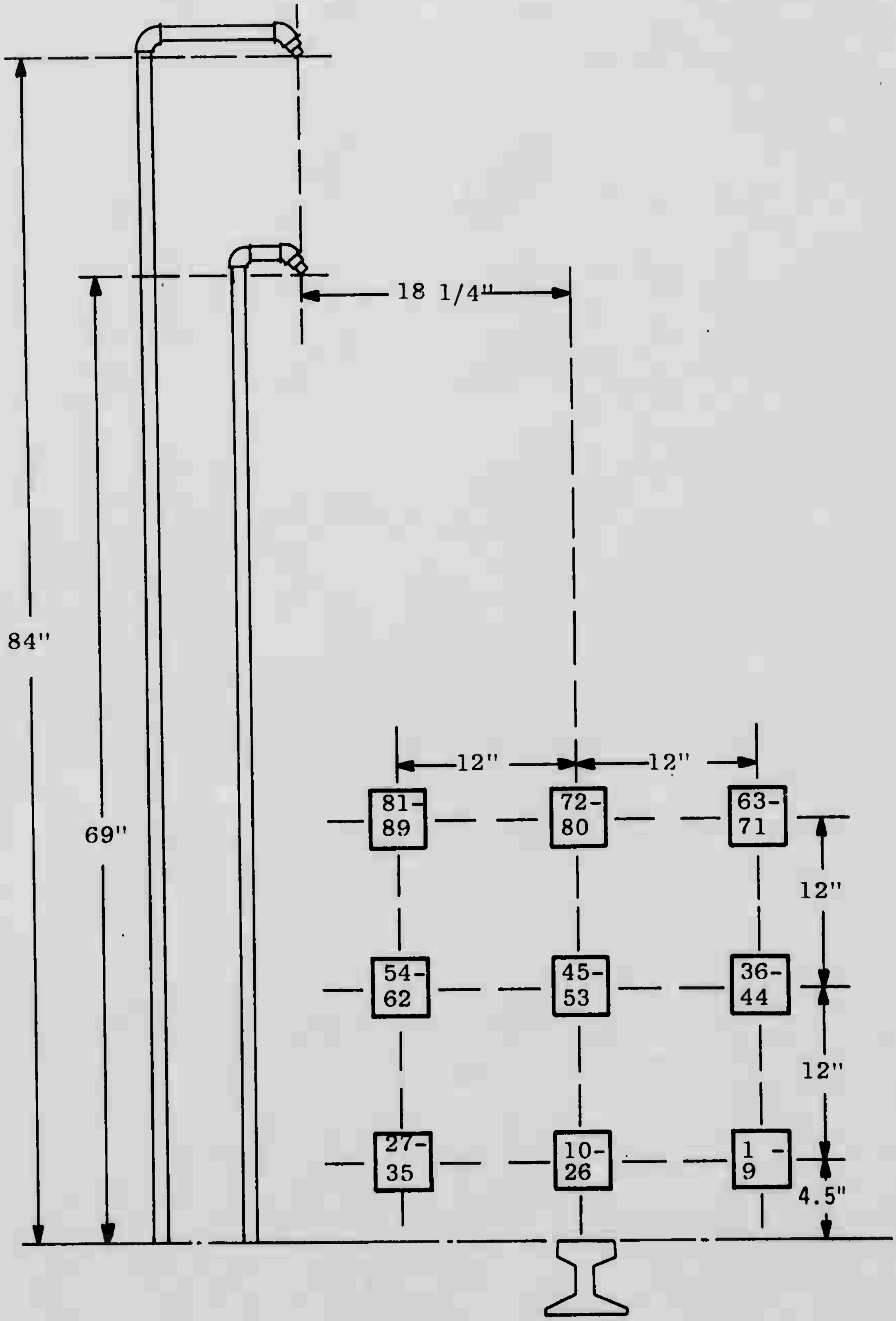


FIGURE B3

RAINFIELD TEST SETUP

SAMPLE VOLUME LOCATIONS - CROSS VIEW

APPENDIX C

ALGORITHM FOR DROPLET COUNTER EDGE CORRECTION

This process first increases the largest size droplet count dividing it by $(1 - sum_i)$, then decreases the count of all smaller droplet classes by subtracting a portion $X_i A_{ij}$ of their previous count. The process is repeated through all droplet size classes from the largest one down. The algorithm is pictured in Figure 10 and the corresponding array of coefficients is presented in Table C1.

I	$1\text{-}SUM_I$	A_{IJ}						
		J = 1	2	3	4	5	6	7
8	.91841	.00765	.00834	.00900	.00995	.01133	.01317	.01731
7	.92912	.00812	.00858	.00951	.01090	.01228	.01645	-
6	.93999	.00790	.00906	.01022	.01185	.01604	-	-
5	.95144	.00814	.00954	.01118	.01469	-	-	-
4	.96185	.00885	.01050	.01379	-	-	-	-
3	.97302	.00934	.01265	-	-	-	-	-
2	.98376	.01102	-	-	-	-	-	-
1	.99456	-	-	-	-	-	-	-

Droplet Count Correction Coefficients

Table C1

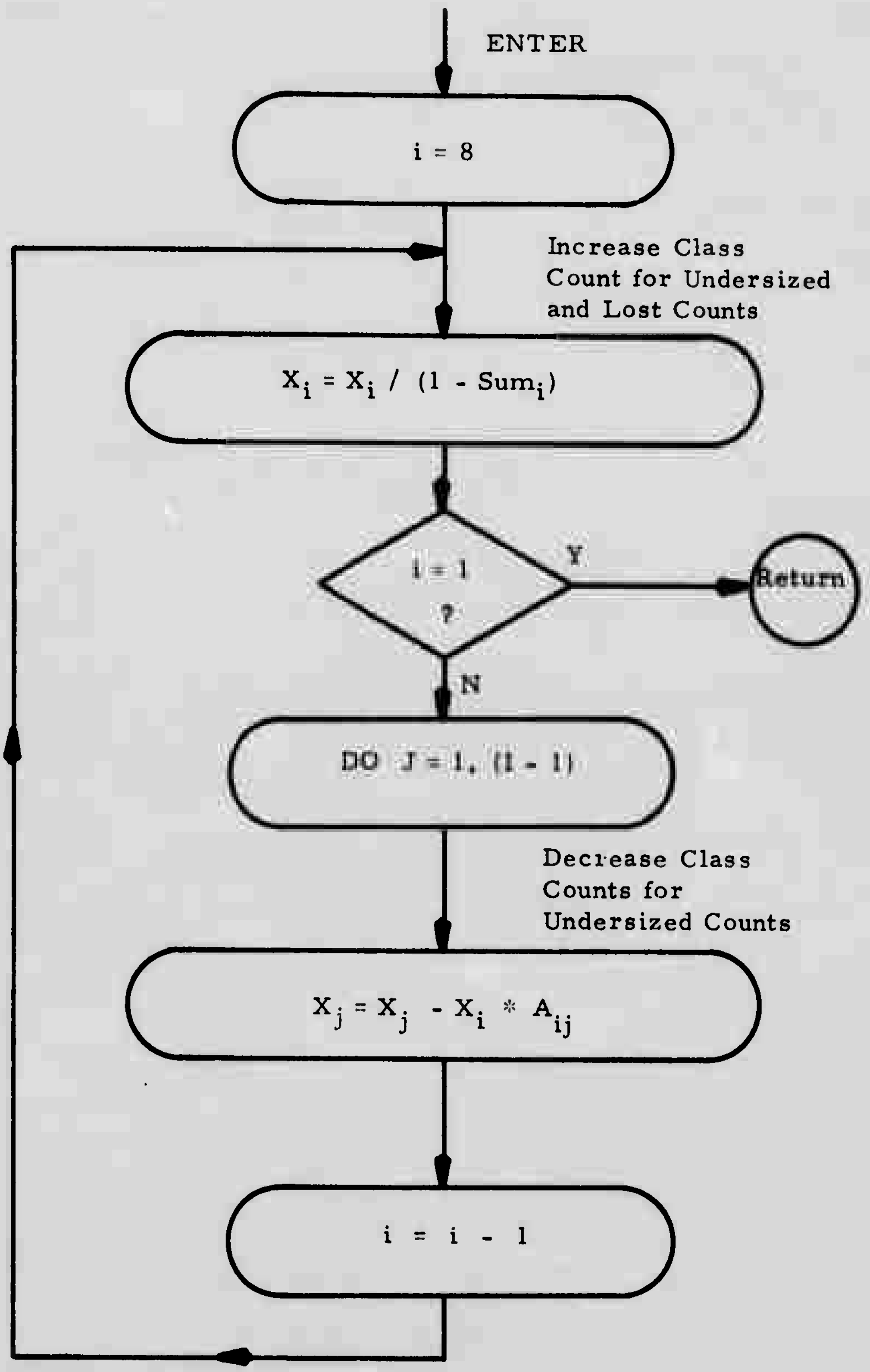


Figure C1
ALGORITHM FOR EDGE CORRECTION

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