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# Effectiveness of the Repeat Application of Chemical Dispersants on Oil

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ENVIRONMENTAL STUDIES REVOLVING FUNDS

Report no. 006

# EFFECTIVENESS OF THE REPEAT APPLICATION OF CHEMICAL DISPERSANTS ON OIL

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## SUMMARY

The primary objective of this study was to determine if changes in oil properties or chemical imbalances caused by an initial application of dispersant would reduce the effectiveness of a second application of dispersant.

For all the tests conducted, the results show that both the quantity of oil dispersed and the size distribution of the oil drops generated by the second application and mixing sequence were similar to, or better than, those from the initial application of dispersant. Therefore, it appears that the second or repeat application of dispersant is as effective as the first, at least under the conditions present in this study.

Measurements of oil properties taken during the study indicate that the dispersion process did not significantly change either the oil's density or its viscosity. These slight changes in oil properties did not reduce the effectiveness of the second application of dispersant.

The first application of dispersant resulted in a 75 - 85 % reduction in the oil-water interfacial tension just prior to the second application. Some dispersant therefore remained in the re-surfaced or undispersed oil. The results indicate that the presence of this surfactant neither reduced the effectiveness of the second application nor did it greatly improve the second dispersion.

## RESUME

Cette étude visait avant tout à déterminer si une première application de dispersant réduirait l'efficacité d'un second épandage en altérant les propriétés physico-chimiques du pétrole.

Lors de tous les essais, les quantités de pétrole dispersées de nouveau et la répartition des grosseurs relatives des goutelettes ont égalé ou surpassé ce qui avait résulté du premier arrosage. Sous les conditions de cette étude du moins, une seconde application de dispersant produit des résultants aussi efficaces qu'une première.

Les mesures recueillies ne démontrent aucun changement significatif de la densité et de la viscosité par la dispersion. Les faibles modifications des propriétés de la nappe n'ont pas diminué l'efficacité du deuxième épandage de dispersant.

Immédiatement avant le second traitement, la tension à la surface de séparation entre le pétrole et l'eau avait été diminuée de 75% à 85%. Une certaine quantité de dispersant était donc restée dans le pétrole redistribué encore homogène. Les résultants démontrent que ces résidus n'amoindrissent pas l'efficacité de la deuxième application ni n'améliorent le rendement de la seconde dispersion.

# INTRODUCTION

When a chemical dispersant is applied to an oil slick and only partially removes the oil from the surface, it is important to know, during a countermeasures operation, whether a second application will be effective in dispersing the remaining oil. It is possible that dispersant application subsequent to the first will not be effective due to chemical property changes in the remaining surface oil. To determine the validity of this suggestion, large-scale laboratory tests were executed in which oil slick dispersal efficiencies were measured after the first and second applications of a chemical dispersant. A total of seven tests were completed to study the effectiveness of the repeat application of dispersants.

## TEST PROCEDURE

The test facility and apparatus used for this evaluation were designed specifically to study oil dispersions on a meso-scale level.

The test basin has an overall length, depth, and width of 11 m, 1.2 m, and 1.2 m, respectively. A three-horsepower variable speed d.c. motor and cable drive mechanism are used to tow mixing devices, spray booms, and monitoring equipment across the water surface. These components are visible in Plate 1 (bottom left corner). The linear bearing shaft and towing cart used in this application are also evident. Deceleration of the cart is accomplished by the weight and elevated pulley arrangement seen near the far end of the tank (left side, Plate 2). An unobstructed view of the dispersed oil is possible through the glass front of the main tank section.

Gravity-fed water sampling ports, located at five different depths (2 cm, 12 cm, 25 cm, 50 cm, and 75 cm), have been built into the back of the central portion of the tank. Two sets of sampling tubes provide separate networks for the photographic documentation of oil drop size and for water sample collection (see Plate 2).

The photographic set-up used for recording the drop size distributions of the dispersed cloud is shown as Plate 3. Photographs of dispersions are taken at a high shutter speed (1/1000th of a second) with a constant flow of water passing through the cells to a nearby drain. The scale for these photos is established by photographing a 10 x 10 mm grid with the identical camera settings used in the drop size pictures. The negatives of both the scale and the oil drops are then printed in an 8 x 10 format resulting in a magnification of about 20 times. The size distribution of the oil drops are then determined through the use of a digitizing tablet and micro-computer data acquisition and processing system.

Plate 1. Overall view of test basin.

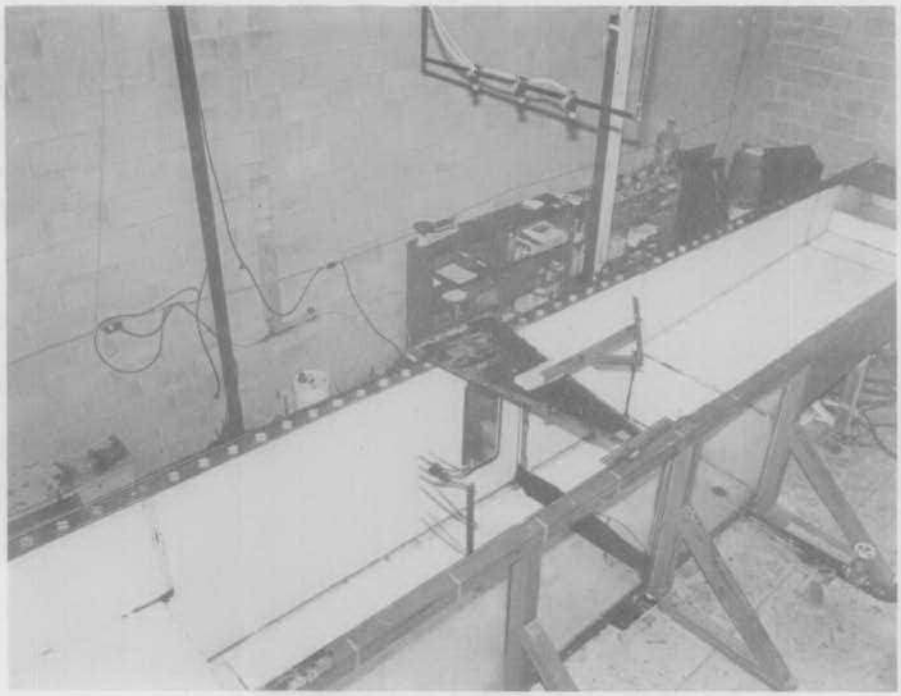


Plate 2. Centre portion of test basin.

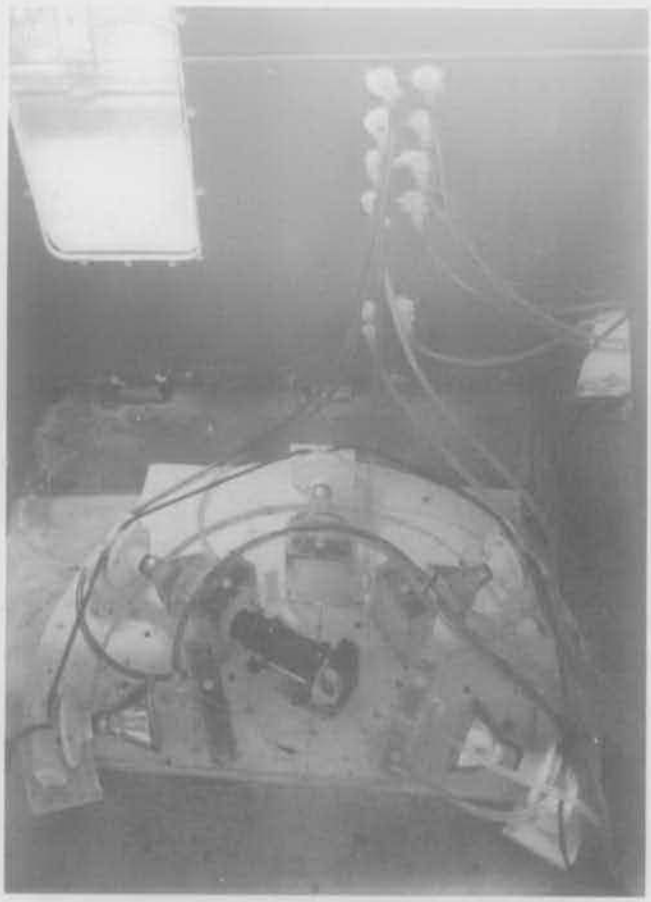


Plate 3. Set-up for drop size photography.

Concentrations of oil in the water are measured to allow an accurate calculation of the quantity of oil dispersed in each test. Water samples are taken from gravity-fed sampling tubes which constantly flow to a drain during the testing (Plate 4). The oil in each sample is then extracted with a colourless solvent and the solvent and oil solutions are analysed for oil content using a spectrophotometer. The concentration of oil in the water sample is then calculated using the known volumes of sample and solvent, and the concentration of oil-in-solvent.

Dispersants were applied via a gear pump at 100 psi through nozzles attached to an overhead boom (see Plates 1 and 2, top of photos).

A video camera (VHS recorder) was used to record the events of each test. The video record was used to calculate the speed of the towing cart and to provide a permanent visual record of each generated dispersion for purposes of comparison.

Two test procedures were used. The first test sequence was chosen to simulate the simple process of oil being initially "dispersed", then re-surfacing to be hit again by dispersant. The only alteration in the second protocol is the addition of a background mixing of the water in the test tank. This turbulence was added to suspend a portion of the oil, dispersed by the first application, in the water column.

## 3.1 PROCEDURE I

Step 1: Oil was applied to the water surface in the test tank.

Step 2: Immediately prior to the first application of dispersant, a surface sample of oil and water was taken to determine the oil's density, viscosity, and surface tension characteristics.

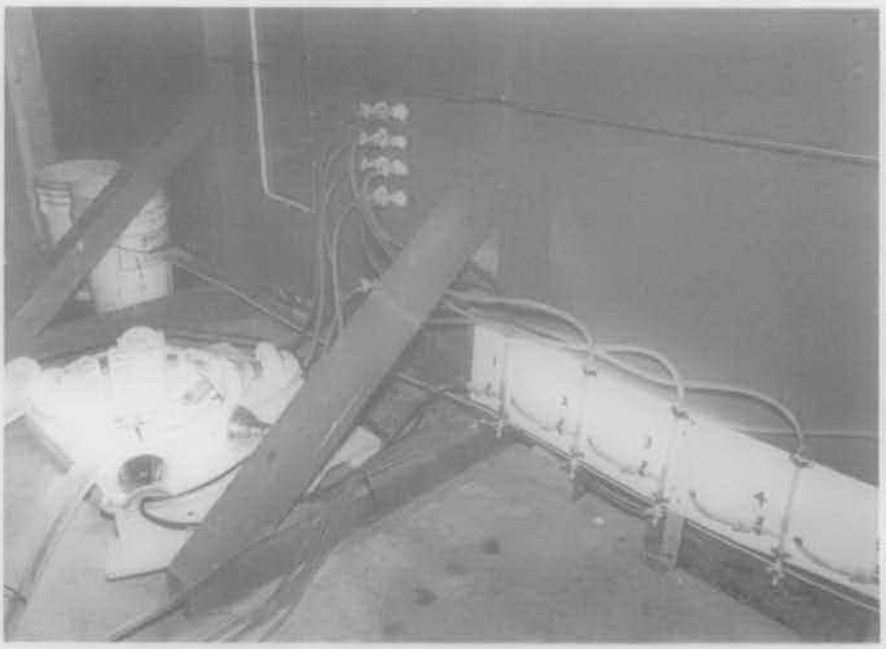


Plate 4. Sampling network.

Step 3: Dispersant was applied to the oil and the mixture agitated by a high-pressure water jet mixing system. The use of this system to generate the dispersion provided a very high level of control on the mixing energy and hence, on the resulting dispersion.

Step 4: The efficiency of the initial dispersion was measured by taking water samples for oil concentrations and photographing oil droplets for drop size distributions immediately after the dispersion.

Step 5: The dispersed oil was allowed to re-surface after the dispersion and the apparatus was readied for the second application.

Step 6: Twenty to 30 minutes after the time of the initial dispersion another surface sample of oil and water was taken for oil density, oil viscosity, and surface tension measurements.

Step 7: The second application of dispersant was applied, followed by the same level of mixing energy.

Step 8: The efficiency of the second dispersion was recorded.

PROCEDURE II

The second test procedure was identical to the first except for the following modification.

Step 5: A background level of mixing was applied to the water in the tank to hold the smaller of the dispersed oil drops in suspension in the water.

## FIXED CONDITIONS DURING TESTING

The seven tests were conducted with the following parameters held constant or within the range noted:

| | |
|---|---|
| * Water temperature | $1^{o}$ - $5^{o}C$ |
| * Air temperature | $15^{o}C$ |
| * Oil type | Alberta Mixed Blend Crude |
| * Initial oil thickness | 0.5 mm |
| * Dispersant type | COREXIT 9527 |
| * Dispersant application | 1:100 |
| * Dispersant drop size | Constant: ≐ 750 μm volume mean diameter |
| * Mixing energy | High pressure water: 1000 psi, 4 gpm |
| * Background mixing level (for Procedure II) | Constant: provided by recirculating pump and diffuser piping. |

# TEST RESULTS AND DISCUSSION

The following sections summarize the data collected during the course of the study and outline the significance of the findings with regard to the objective of the work; viz., to determine the effectiveness of the repeat application of dispersants. The properties of the surface oil prior to each dispersion, the oil drop size distributions of the dispersions and the oil-in-water concentrations generated by each dispersant application/mixing sequence are reported.

## OIL PROPERTIES DURING TESTING

The oil properties that were measured during the testing are summarized in Table 1. The "before" information refers to the property of the oil prior to the first application of dispersant and mixing energy; the "after" properties were measured just prior to the second application of dispersant and mixing energy. These measurements were recorded to determine if any significant property changes were occurring after the first dispersant and mixing sequence that could affect the success of the second application.

As can be seen in Table 1, oil density and viscosity increased only slightly after the first dispersion. These small changes should not significantly affect the performance of the second application of dispersant.

Some dispersant remained with the oil that resurfaced after the first application. This is apparent from the lower interfacial tensions measured prior to the second application. The lower oil-water interfacial tensions should only serve to improve the dispersant's effectiveness in the second application.

TABLE I

Summary of oil properties during testing

| Test condition | Oil density | | Oil viscosity | | Oil-water interfacial tension | |
|---|---|---|---|---|---|---|
| | Before[a] | After[b] | Before | After | Before | After |
| Procedure I: No. Background Mixing | | | | | | |
| Test 1 | 0.85 | 0.860 | 9.8 | 12.8 | 20.5 | 5.7 |
| Test 2 | 0.85 | 0.863 | 7.6 | 9.2 | 18.2 | 11.6 |
| Test 3 | 0.85 | 0.863 | 9.0 | 9.3 | 22.5 | 3.1 |
| Test 4 | 0.85 | 0.863 | 8.2 | 9.5 | 18.4 | 4.8 |
| Procedure II: With Background Mixing | | | | | | |
| Test 1 | 0.86 | 0.857 | 10.2 | 11.3 | 9.2 | 1.4 |
| Test 2 | 0.84 | 0.857 | 7.7 | 8.6 | 15.0 | 1.6 |
| Test 3 | 0.85 | N/A | 8.2 | N/A | 13.4 | N/A |

N/A - not available: samples not taken.

a "Before" refers to the property before the 1st application of dispersant/mixing energy.

b "After" refers to the property after the 1st application of dispersant/mixing energy and before the 2nd application.

## OIL DISPERSION DROP SIZES

Figures 1 and 2 summarize the volume mean oil drop diameters for each of the dispersions generated during the testing. Figure 1 illustrates these "averages" for the upper water layer (level #1 sample port located 2 cm below the water's surface) and Figure 2 for level #2 (located 12 cm below the surface). In all cases the volume mean drop diameter generated by the second application sequence was lower than, or very similar to, the initial dispersion's mean. Identical mixing energy was applied after each application of dispersant. It would appear, therefore, that the second application was at least as effective as the first in lowering the oil-water interfacial tension thus allowing the mixing energy to generate similar drop size distributions.

Figures 3 and 4 illustrate the general shape of the size distributions of the oil drops generated during the testing (see Appendix A for the complete set of drop size distributions measured for the study). Again, the size distributions from the two dispersant application and mixing sequences were similar in all cases. The presence of one or two large oil drops can skew the drop volume distributions significantly which should be taken into account when comparing the distributions.

The similarities of shapes of these distributions also confirm that a uniform amount and type of mixing energy was applied during the testing.

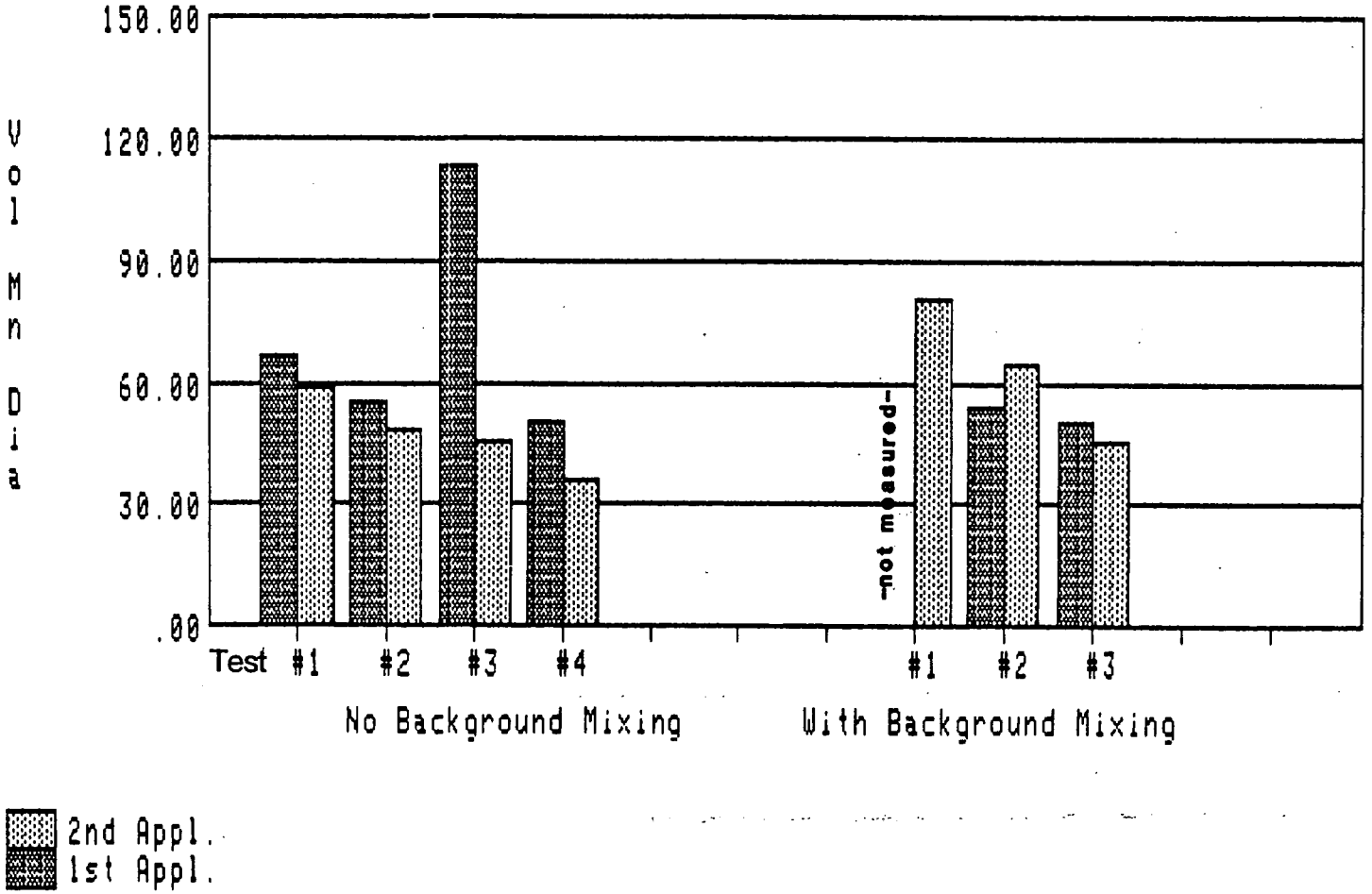



Figure 1. Volume mean drop diameter comparison: level #1.

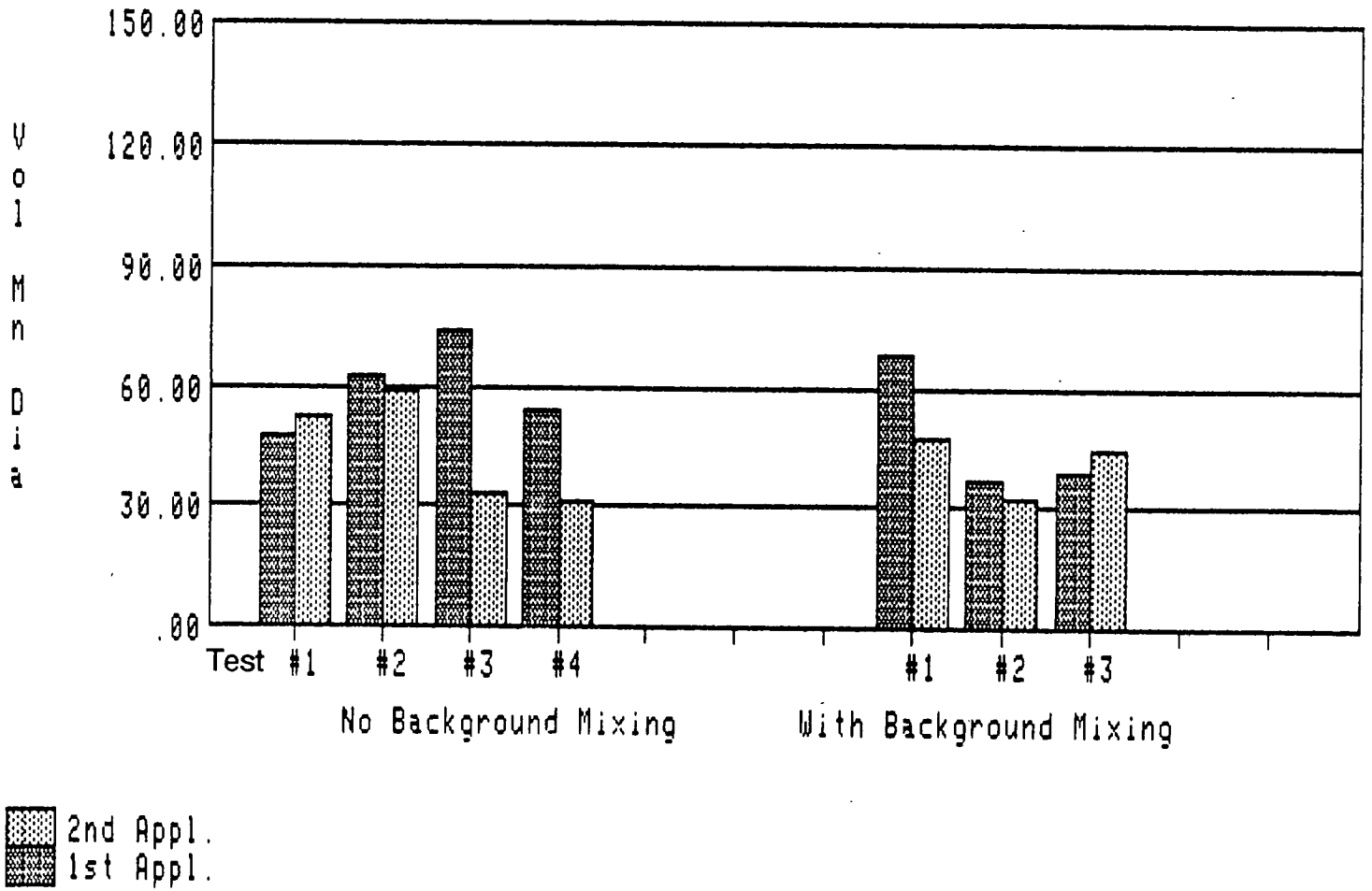



Figure 2. Volume mean drop diameter comparison: level #2.

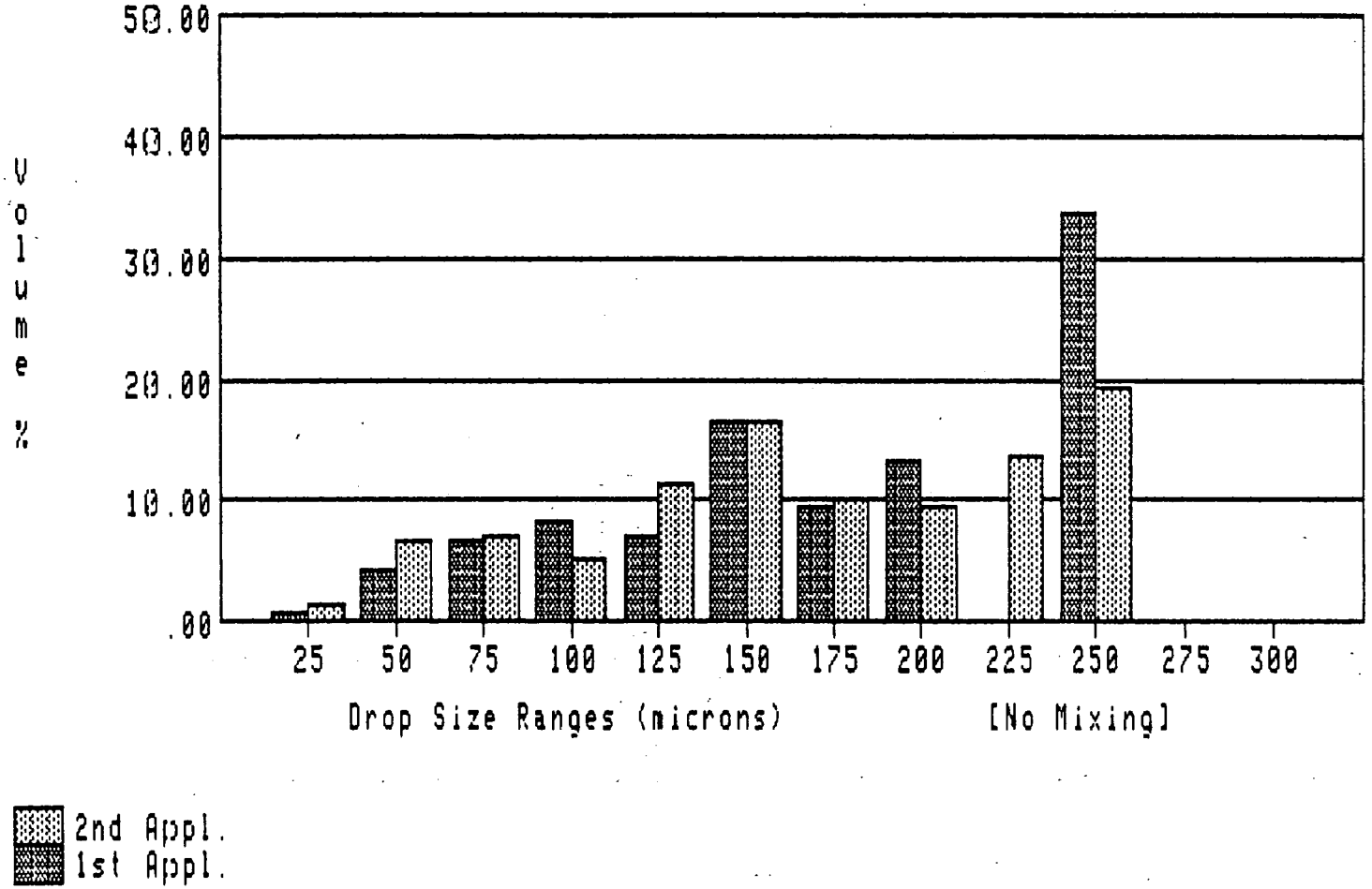



Figure 3. Example oil drop size distribution comparison: no background mixing.

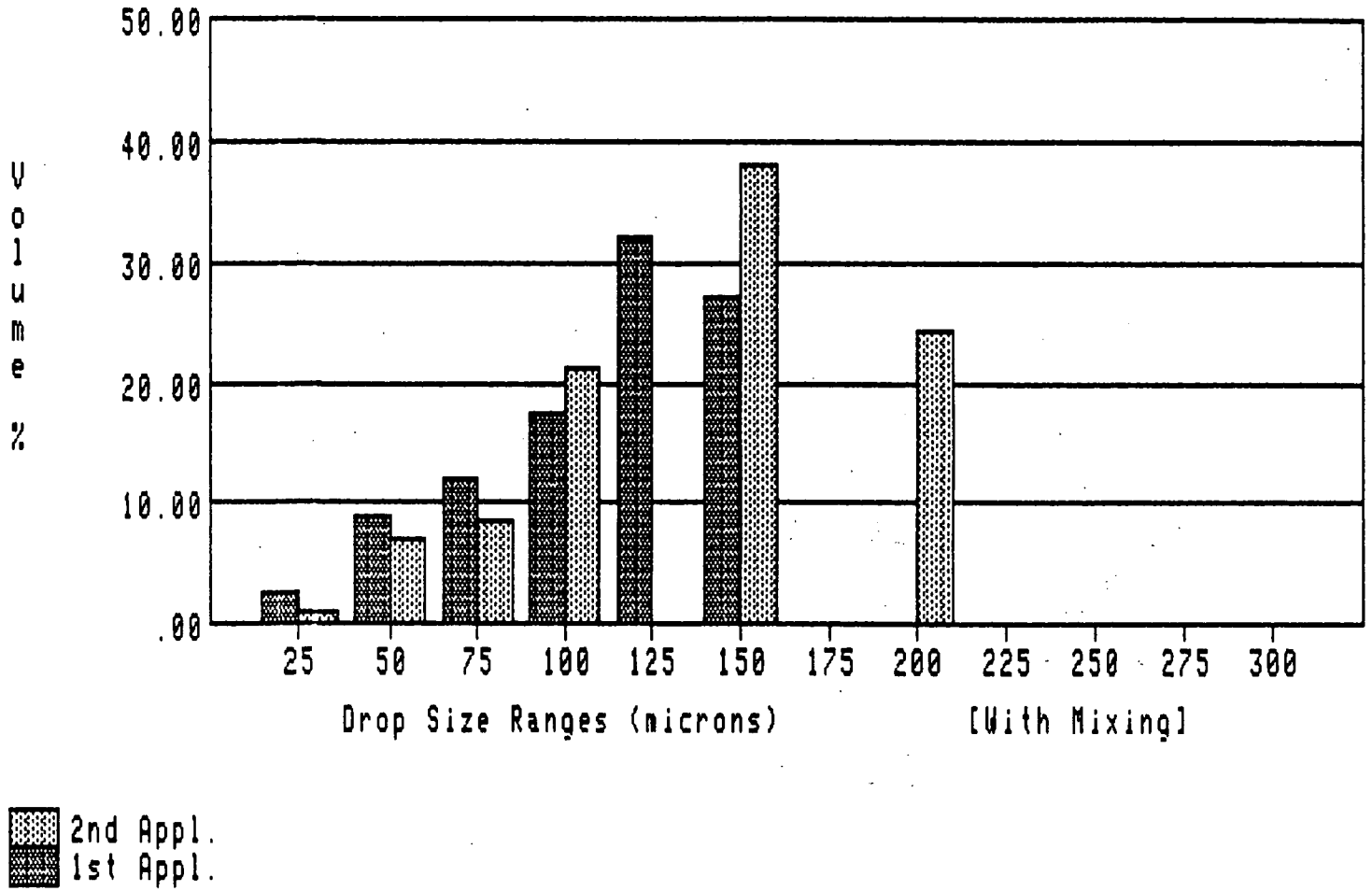



Figure 4. Example oil drip size distribution comparison: with background mixing.

## OIL CONCENTRATIONS IN WATER COLUMN

Peak concentrations of oil in the water column were measured immediately after each dispersant application and mixing sequence. For this purpose, water samples were taken from depths of 2 cm, 12 cm, and 25 cm. A comparison of the concentrations measured for the first and second application then serves as another measure of the effectiveness of the second application of dispersant. Because there is a slight difference in the interpretation of the results from the two test procedures they are discussed separately.

### Test Procedure I

In this test procedure all oil was allowed to return to the surface prior to the second dispersing sequence. If the dispersant were to work as effectively in the second application, the oil concentrations in the water after each dispersion should be similar. The concentrations measured during this phase of the testing are summarized graphically in Figure 5. A comparison of the oil concentrations generated by the first and second dispersion sequences are made for the two upper sample levels (2 cm and 12 cm depths). In all four tests the concentration of oil in the water column after the second dispersant application was higher than for the initial dispersion. (The high concentration measured at level 1, second application, for the first test in this sequence may be the result of an experimental error.) The 20 to 30 minute delay between dispersions was ample time for the majority of the oil dispersed in the first application to rise back to the surface. This was confirmed visually during each test. Therefore, it seems that the second dispersant application was at least as effective as the first in this series of tests.

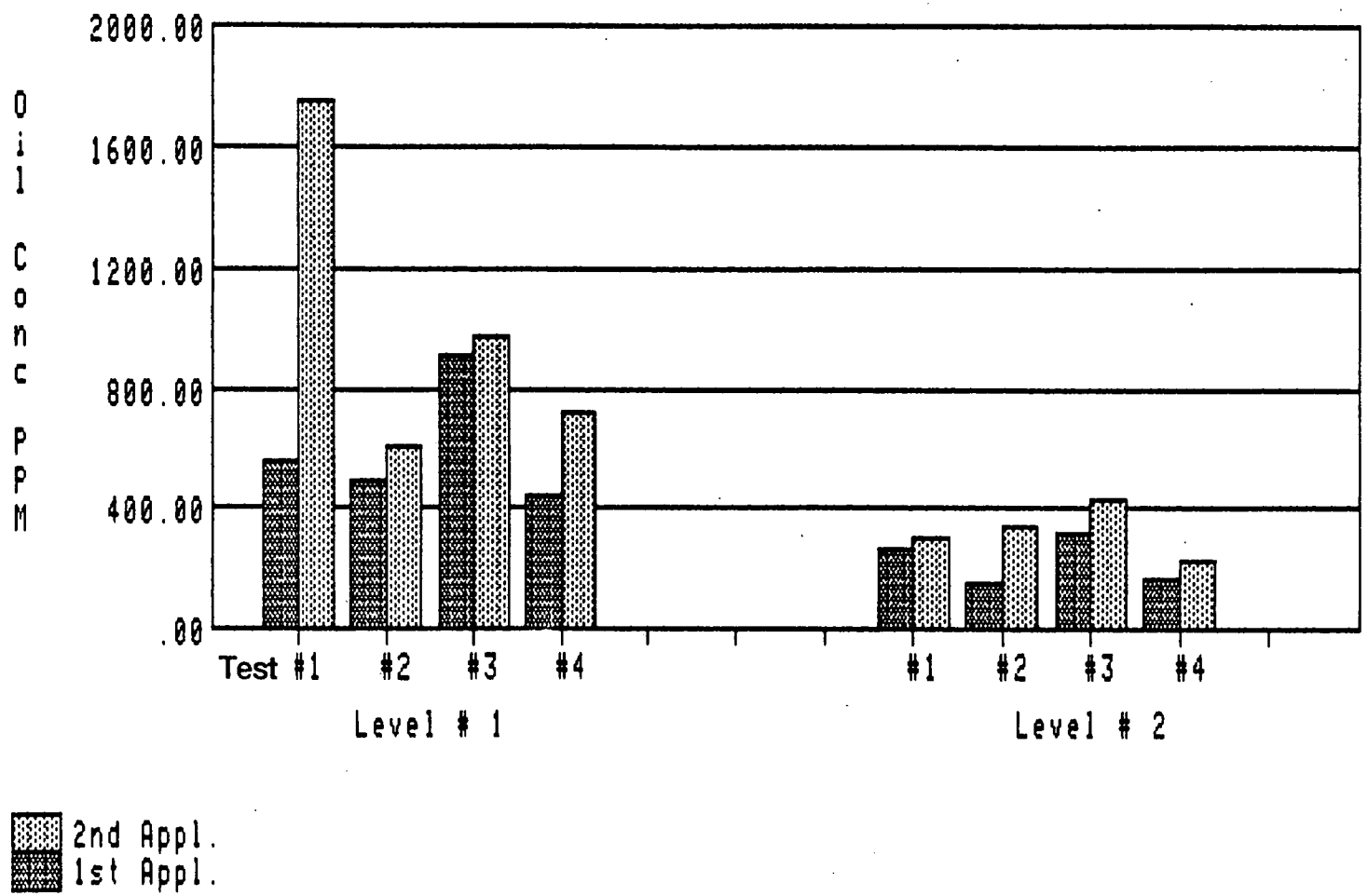



Figure 5. Oil concentration comparison: no background mixing.

Test Procedure II

In this test procedure a background level of mixing was generated in the water column to hold some of the oil from the initial dispersion in suspension in the water column. Therefore, oil concentrations measured after the second dispersion should be higher than that measured from the first application (some oil from first dispersion is held in water by the background mixing).

The background mixing was created by recirculating the water in the tank through a diffuser piping system. Unfortunately, this mixing made it difficult to control the uniformity of the surface oil slick from test to test. The oil slick was allowed to equilibrate prior to the first application of dispersant but the initial oil thickness over the centre of the tank was difficult to control. For this reason the magnitudes of the oil concentrations measured during this portion of the testing are not consistent from test to test. However, the trend which developed within each test is significant.

The oil concentrations measured in this phase of the testing are summarized in Figure 6. However, the results from the first test of this type must be omitted from the discussion because its results were severely affected when, after the first dispersion sequence in this test, the laboratory's overhead furnace fan started and herded most of the oil away from the centre of the tank. As a result very little oil was dispersed in the second dispersant application mixing sequence.

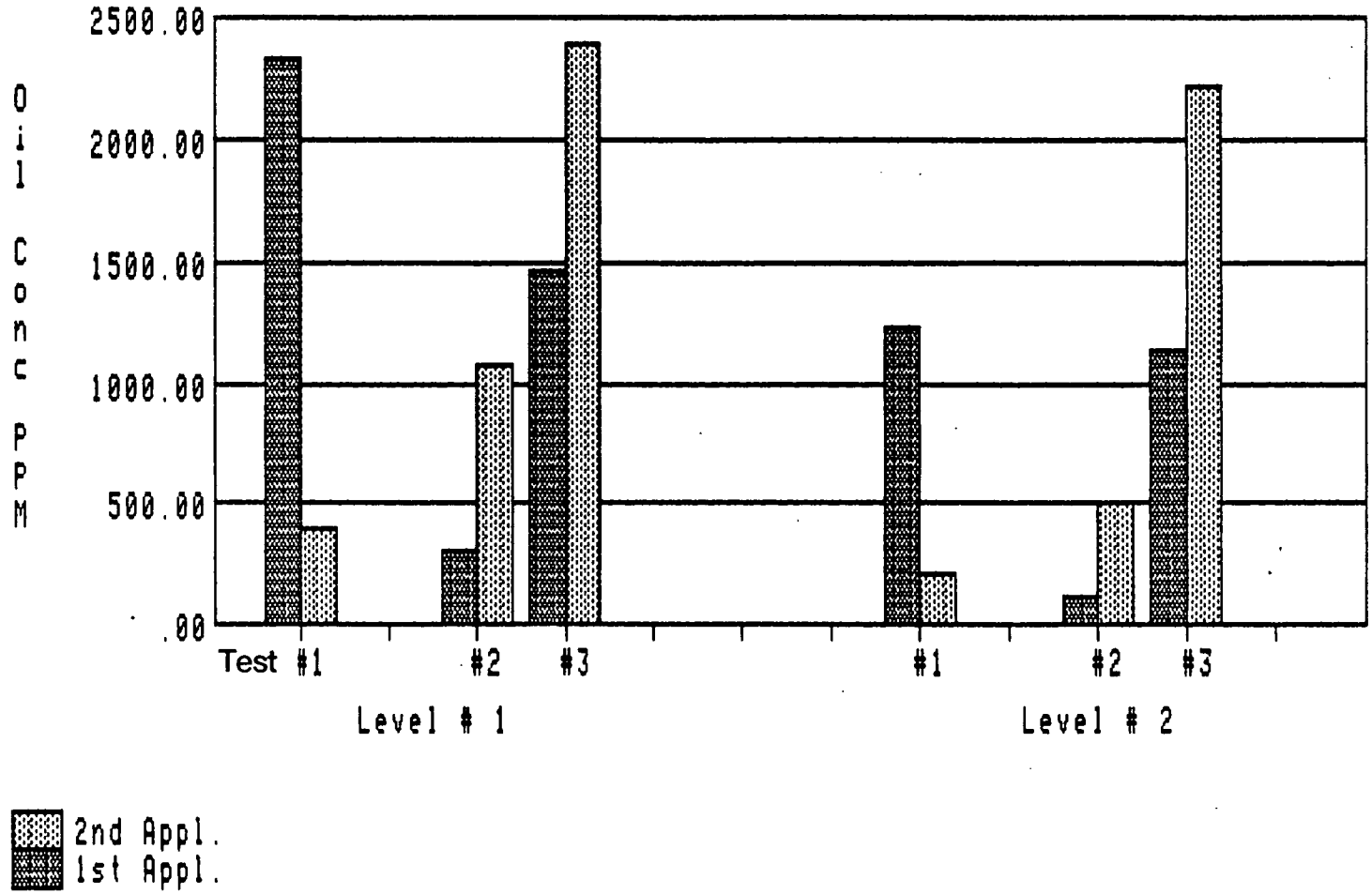



Figure 6. Oil concentration comparison: with mixing

For the remaining two tests the following simple observation can be made. The second dispersant application mixing sequence dispersed at least as much oil as the first application. In fact, the results indicate that the second sequence dispersed as much oil as the first even if it is assumed that all of the oil from the first application was held in the water by the background mixing. This result is demonstrated in Figure 7 in which the concentrations from the initial sequence have been subtracted from the concentrations measured in the second application. Because some of the oil dispersed in the first application will have risen back to the surface prior to the second application it is likely that the quantity dispersed by the second sequence is in fact greater than that indicated in Figure 7. Regardless of the exact quantity dispersed in the second application it is apparent from this concentration data that the repeat application was at least as effective as the first.

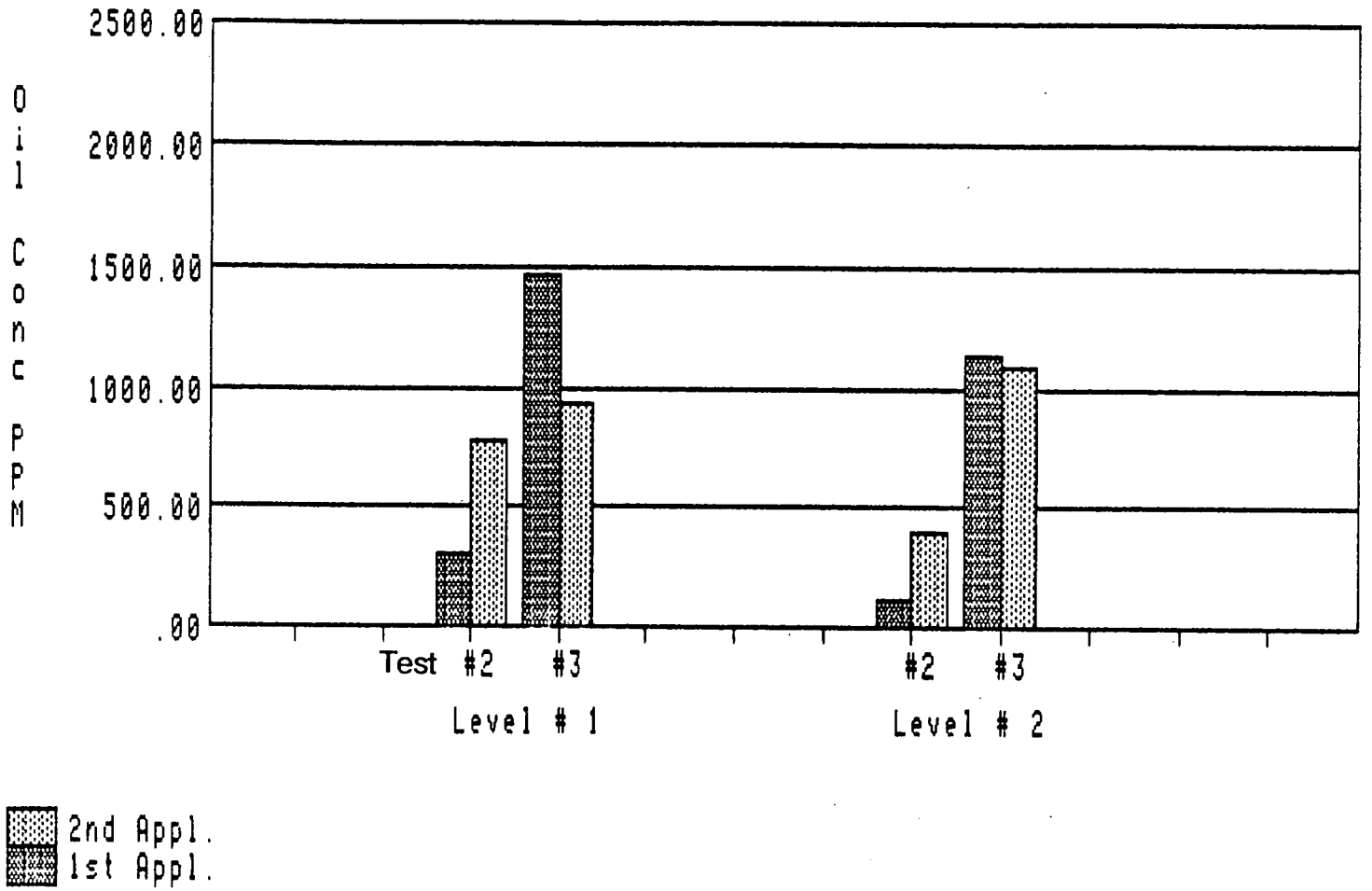



Figure 7. Oil concentration comparison: 2nd application concentration minus 1st application concentration.

## Appendix A

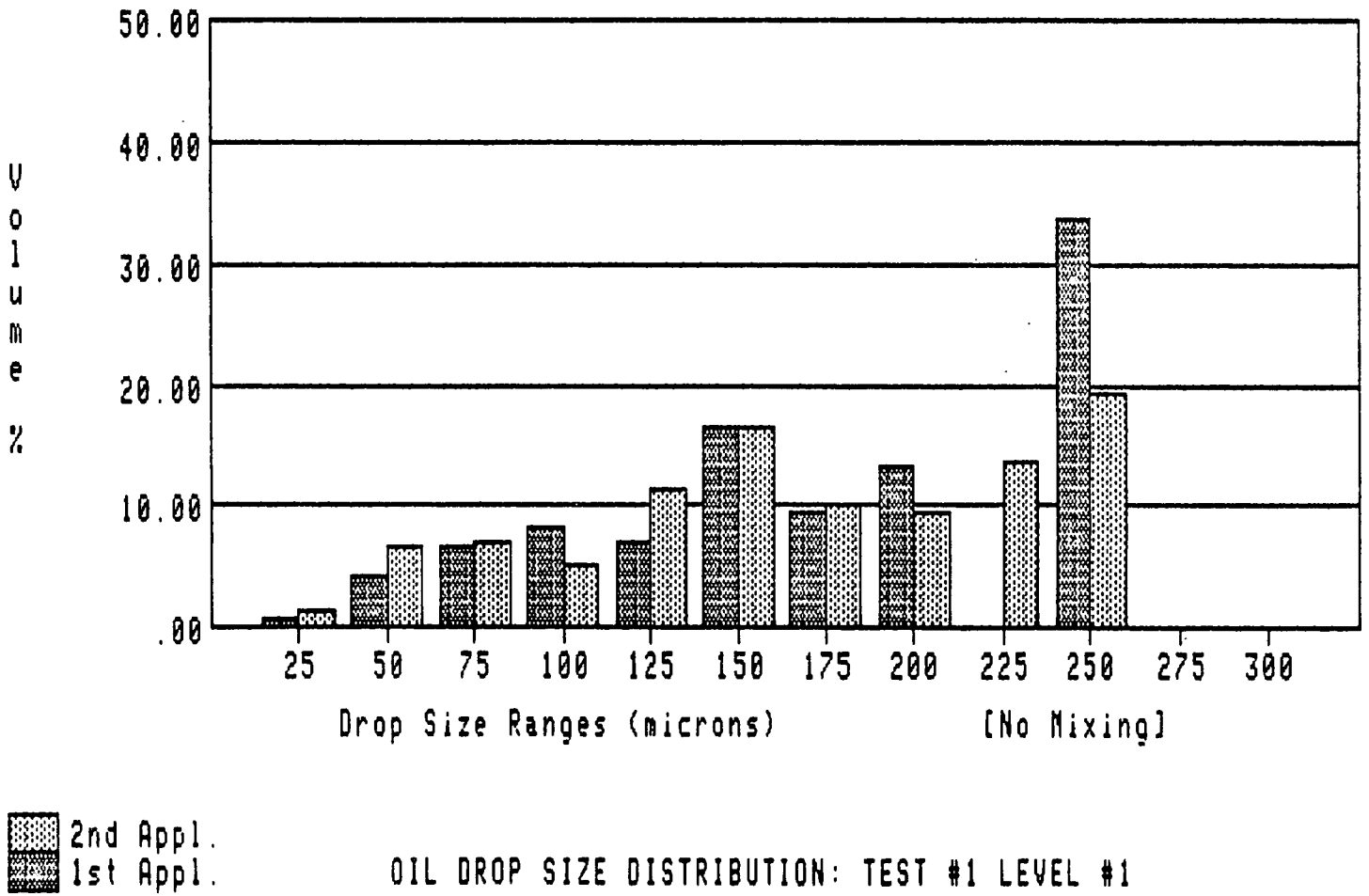
### STUDY DATA ON DROP SIZE DISTRIBUTIONS

Oil drop size distributions were measured at the upper two sampling levels immediately after each dispersion/mixing sequence. Comparisons of the distributions generated by the 1st and 2nd applications for the upper sample level are provided in the following bar charts. Tabular accounts of the distributions are also presented. The tabular versions are labelled in the upper right corner with an identifiction code that is interpreted in the following way.

D181A1: The test occurred on December 18; it was the 1st test on that day; A refers to this 1st dispersant application; 1 refers to the sampling level.

No Background Mixing Tests

| Test Designation In Report | Data Sheets Code |
|---|---|
| Test #1 | D181 |
| Test #2 | D183 |
| Test #3 | D211 |
| Test #4 | D212 |




OIL DROP SIZE DISTRIBUTION: TEST #1 LEVEL #1

Date of Run [D/M/Y] : 18/12/84 D181A1 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 246.8
Minimum Drop Size : 7.1
Ave Drop Size(D10) : 35.0
Vol Mean Dia (D30) : 66.0
Sauter Mn Dia(D32) : 120.8

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 74 | 47.7 | 47.7 | .83 | .83 |
| 25.- 50. | 54 | 34.8 | 82.6 | 4.27 | 5.09 |
| 50.- 75. | 13 | 8.4 | 91.0 | 6.64 | 11.73 |
| 75.- 100. | 6 | 3.9 | 94.8 | 8.40 | 20.14 |
| 100.- 125. | 2 | 1.3 | 96.1 | 7.02 | 27.16 |
| 125.- 150. | 3 | 1.9 | 98.1 | 16.32 | 43.48 |
| 150.- 175. | 1 | .6 | 98.7 | 9.39 | 52.87 |
| 175.- 200. | 1 | .6 | 99.4 | 13.39 | 66.26 |
| 200.- 225. | 0 | 0.0 | 99.4 | 0.00 | 66.26 |
| 225.- 250. | 1 | .6 | 100.0 | 33.74 | 100.00 |

TOTAL # DROPS - 155 TOTAL OIL VOLUME (ML) = .00002332
NUMBER OF DROPS REJECTED FROM DIST. = 0

Date of Run [D/M/Y] : 18/12/84 D181B1 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########################################################################

GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 236.8
Minimum Drop Size : 5.0
Ave Drop Size(D10) : 31.8
Vol Mean Dia (D30) : 58.6
Sauter Mn Dia(D32) : 108.4

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 165 | 48.0 | 48.0 | 1.27 | 1.27 |
| 25.- 50. | 135 | 39.2 | 87.2 | 6.60 | 7.86 |
| 50.- 75. | 23 | 6.7 | 93.9 | 6.96 | 14.82 |
| 75.- 100. | 6 | 1.7 | 95.6 | 5.06 | 19.88 |
| 100.- 125. | 6 | 1.7 | 97.4 | 11.44 | 31.32 |
| 125.- 150. | 4 | 1.2 | 98.5 | 16.44 | 47.76 |
| 150.- 175. | 2 | .6 | 99.1 | 10.02 | 57.77 |
| 175.- 200. | 1 | .3 | 99.4 | 9.37 | 67.14 |
| 200.- 225. | 1 | .3 | 99.7 | 13.68 | 80.82 |
| 225.- 250. | 1 | .3 | 100.0 | 19.18 | 100.00 |

TOTAL # DROPS - 344 TOTAL OIL VOLUME (ML) = .00003624
NUMBER OF DROPS REJECTED FROM DIST. = 2

Date of Run [D/M/Y] : 18/12/84 D181A2 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########################################################################

GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 171.8
Minimum Drop Size : 10.1
Ave Drop Size(D10) : 32.2
Vol Mean Dia (D30) : 47.8
Sauter Mn Dia(D32) : 72.3

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 73 | 39.5 | 39.5 | 2.05 | 2.05 |
| 25.- 50. | 85 | 45.9 | 85.4 | 15.90 | 17.95 |
| 50.- 75. | 18 | 9.7 | 95.1 | 15.36 | 33.31 |
| 75.- 100. | 5 | 2.7 | 97.8 | 15.69 | 49.00 |
| 100.- 125. | 2 | 1.1 | 98.9 | 14.69 | 63.69 |
| 125.- 150. | 1 | .5 | 99.5 | 11.20 | 74.89 |
| 150.- 175. | 1 | .5 | 100.0 | 25.11 | 100.00 |

TOTAL # DROPS - 185 TOTAL OIL VOLUME (ML) = .00001058
NUMBER OF DROPS REJECTED FROM DIST. = 0

Date of Run [D/M/Y] : 18/12/84 D181B2 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

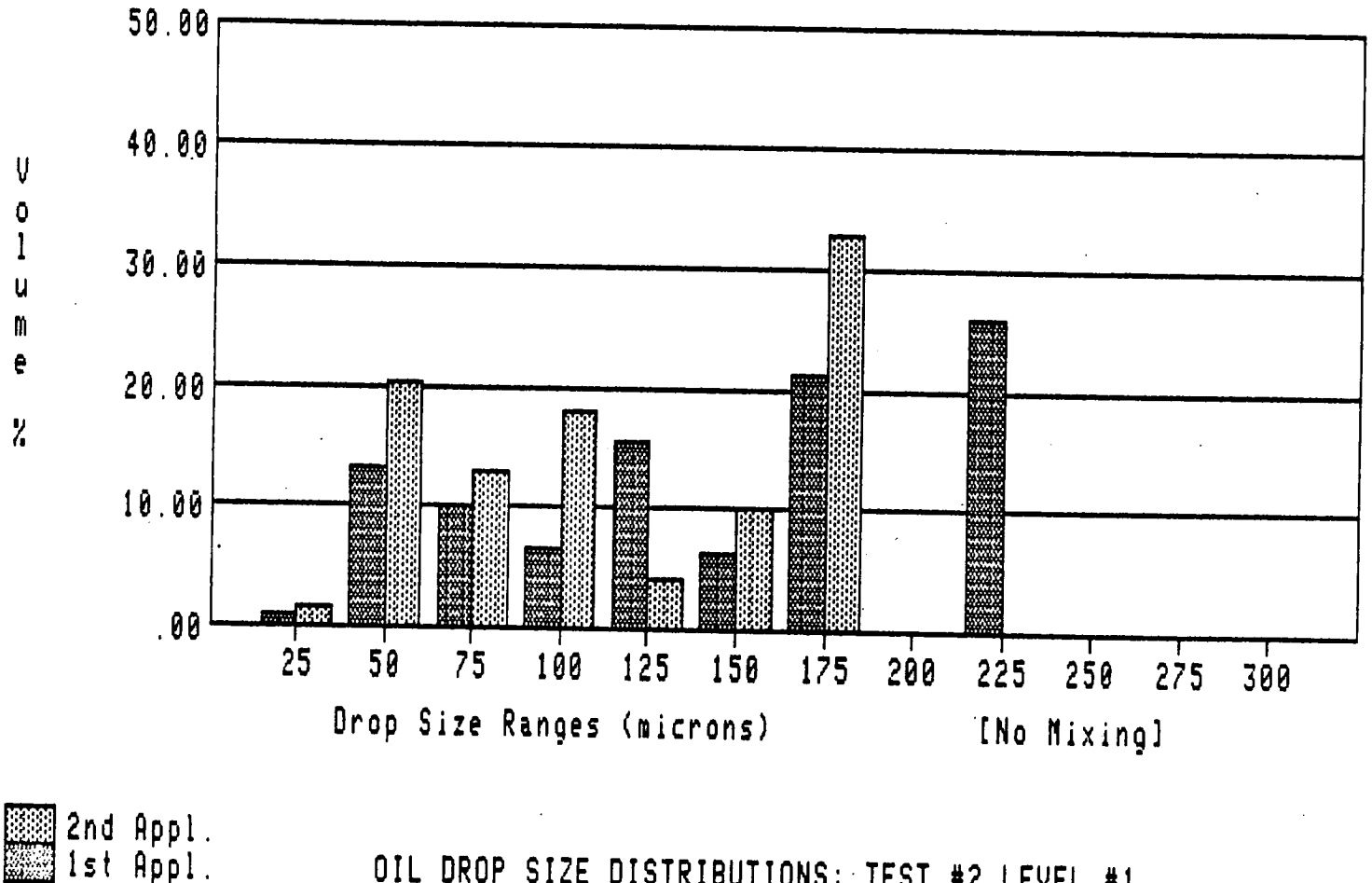
GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 221.5
Minimum Drop Size : 5.0
Ave Drop Size(D10) : 31.4
Vol Mean Dia (D30) : 52.0
Sauter Mn Dia(D32) : 91.4

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 135 | 40.2 | 40.2 | 1.74 | 1.74 |
| 25.- 50. | 162 | 48.2 | 88.4 | 12.19 | 13.93 |
| 50.- 75. | 23 | 6.8 | 95.2 | 8.13 | 22.06 |
| 75.- 100. | 9 | 2.7 | 97.9 | 11.33 | 33.39 |
| 100.- 125. | 3 | .9 | 98.8 | 7.60 | 40.99 |
| 125.- 150. | 1 | .3 | 99.1 | 4.25 | 45.24 |
| 150.- 175. | 1 | .3 | 99.4 | 8.87 | 54.11 |
| 175.- 200. | 0 | 0.0 | 99.4 | 0.00 | 54.11 |
| 200.- 225. | 2 | .6 | 100.0 | 45.89 | 100.00 |

TOTAL # DROPS - 336 TOTAL OIL VOLUME (ML) = .00002478
NUMBER OF DROPS REJECTED FROM DIST. = 0




OIL DROP SIZE DISTRIBUTIONS: TEST #2 LEVEL #1

Date of Run [D/M/Y] : 18/12/84 D183A1 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########################################################################

GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 217.4
Minimum Drop Size : 10.1
Ave Drop Size(D10) : 35.3
Vol Mean Dia (D30) : 55.0
Sauter Mn Dia(D32) : 88.5

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 73 | 30.4 | 30.4 | 1.16 | 1.16 |
| 25.- 50. | 131 | 54.6 | 85.0 | 13.21 | 14.37 |
| 50.- 75. | 22 | 9.2 | 94.2 | 10.20 | 24.57 |
| 75.- 100. | 5 | 2.1 | 96.3 | 6.66 | 31.23 |
| 100.- 125. | 5 | 2.1 | 98.3 | 15.51 | 46.74 |
| 125.- 150. | 1 | .4 | 98.8 | 6.31 | 53.05 |
| 150.- 175. | 2 | .8 | 99.6 | 21.15 | 74.20 |
| 175.- 200. | 0 | 0.0 | 99.6 | 0.00 | 74.20 |
| 200.- 225. | 1 | .4 | 100.0 | 25.80 | 100.00 |

TOTAL # DROPS - 240 TOTAL OIL VOLUME (ML) = .00002086
NUMBER OF DROPS REJECTED FROM DIST. = 1

Date of Run [D/M/Y] : 18/12/84 D183B1 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########################################################################

GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 161.0
Minimum Drop Size : 10.1
Ave Drop Size(D10) : 34.5
Vol Mean Dia (D30) : 48.7
Sauter Mn Dia(D32) : 70.9

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 55 | 26.1 | 26.1 | 1.57 | 1.57 |
| 25.- 50. | 128 | 60.7 | 86.7 | 20.20 | 21.77 |
| 50.- 75. | 17 | 8.1 | 94.8 | 13.11 | 34.87 |
| 75.- 100. | 7 | 3.3 | 98.1 | 17.86 | 52.73 |
| 100.- 125. | 1 | .5 | 98.6 | 4.17 | 56.90 |
| 125.- 150. | 1 | .5 | 99.1 | 10.26 | 67.16 |
| 150.- 175. | 2 | .9 | 100.0 | 32.84 | 100.00 |

TOTAL # DROPS - 211 TOTAL OIL VOLUME (ML) = .00001280
NUMBER OF DROPS REJECTED FROM DIST. = 0

Date of Run [D/M/Y] : 18/12/84 D183A2 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

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GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 252.1
Minimum Drop Size : 5.0
Ave Drop Size(D10) : 33.5
Vol Mean Dia (D30) : 62.1
Sauter Mn Dia(D32) : 118.0

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 99 | 43.2 | 43.2 | 1.18 | 1.18 |
| 25.- 50. | 103 | 45.0 | 88.2 | 6.70 | 7.89 |
| 50.- 75. | 13 | 5.7 | 93.9 | 5.39 | 13.28 |
| 75.- 100. | 4 | 1.7 | 95.6 | 4.19 | 17.47 |
| 100.- 125. | 4 | 1.7 | 97.4 | 8.12 | 25.59 |
| 125.- 150. | 2 | .9 | 98.3 | 10.21 | 35.80 |
| 150.- 175. | 1 | .4 | 98.7 | 7.61 | 43.41 |
| 175.- 200. | 1 | .4 | 99.1 | 11.15 | 54.56 |
| 200.- 225. | 1 | .4 | 99.6 | 16.24 | 70.80 |
| 225.- 250. | 0 | 0.0 | 99.6 | 0.00 | 70.80 |
| 250.- 275. | 1 | .4 | 100.0 | 29.20 | 100.00 |

TOTAL # DROPS - 229 TOTAL OIL VOLUME (ML) = .00002872
NUMBER OF DROPS REJECTED FROM DIST. = 0

Date of Run [D/M/Y] : 18/12/84 D183B2 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

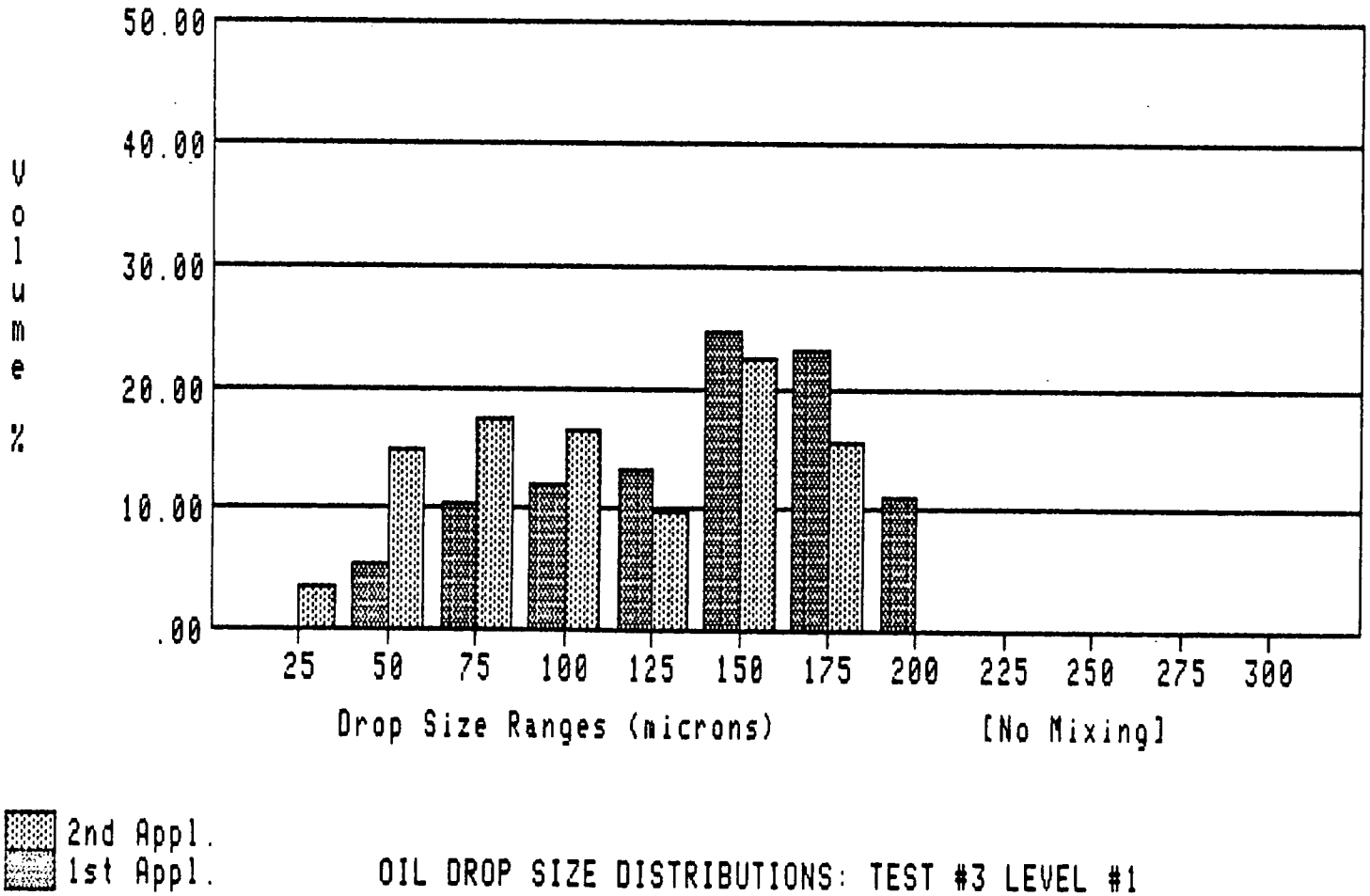
GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 231.8
Minimum Drop Size : 0.0
Ave Drop Size(D10) : 35.3
Vol Mean Dia (D30) : 58.9
Sauter Mn Dia(D32) : 101.5

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 86 | 34.8 | 34.8 | 1.12 | 1.12 |
| 25.- 50. | 123 | 49.8 | 84.6 | 9.88 | 11.00 |
| 50.- 75. | 24 | 9.7 | 94.3 | 10.20 | 21.20 |
| 75.- 100. | 7 | 2.8 | 97.2 | 7.45 | 28.65 |
| 100.- 125. | 1 | .4 | 97.6 | 2.36 | 31.01 |
| 125.- 150. | 2 | .8 | 98.4 | 8.60 | 39.61 |
| 150.- 175. | 0 | 0.0 | 98.4 | 0.00 | 39.61 |
| 175.- 200. | 3 | 1.2 | 99.6 | 35.65 | 75.26 |
| 200.- 225. | 0 | 0.0 | 99.6 | 0.00 | 75.26 |
| 225.- 250. | 1 | .4 | 100.0 | 24.74 | 100.00 |

TOTAL # DROPS - 247 TOTAL OIL VOLUME (ML) = .00002638
NUMBER OF DROPS REJECTED FROM DIST. = 0




OIL DROP SIZE DISTRIBUTIONS: TEST #3 LEVEL #1

Date of Run [D/M/Y] : 21/12/84 D211A1 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########################################################################

GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 183.4
Minimum Drop Size : 9.9
Ave Drop Size(D10) : 56.5
Vol Mean Dia (D30) : 78.7
Sauter Mn Dia(D32) : 106.7

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 14 | 12.4 | 12.4 | .20 | .20 |
| 25.- 50. | 53 | 46.9 | 59.3 | 5.44 | 5.63 |
| 50.- 75. | 22 | 19.5 | 78.8 | 10.30 | 15.93 |
| 75.- 100. | 10 | 8.8 | 87.6 | 12.11 | 28.04 |
| 100.- 125. | 5 | 4.4 | 92.0 | 13.25 | 41.28 |
| 125.- 150. | 5 | 4.4 | 96.5 | 24.46 | 65.74 |
| 150.- 175. | 3 | 2.7 | 99.1 | 23.08 | 88.82 |
| 175.- 200. | 1 | .9 | 100.0 | 11.18 | 100.00 |

TOTAL # DROPS - 113 TOTAL OIL VOLUME (ML) = .00002888

NUMBER OF DROPS REJECTED FROM DIST. = 4

Date of Run [D/M/Y] : 21/12/84 D211B1 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

GENERAL OIL DROP SIZE INFO (MICRONS)

| | |
|---|---|
| Maximum Drop Size | 160.5 |
| Minimum Drop Size | 5.0 |
| Ave Drop Size(D10) | 29.3 |
| Vol Mean Dia (D30) | 45.5 |
| Sauter Mn Dia(D32) | 71.5 |

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 152 | 53.7 | 53.7 | 3.65 | 3.65 |
| 25.- 50. | 102 | 36.0 | 89.8 | 14.88 | 18.53 |
| 50.- 75. | 18 | 6.4 | 96.1 | 17.28 | 35.81 |
| 75.- 100. | 6 | 2.1 | 98.2 | 16.52 | 52.32 |
| 100.- 125. | 2 | .7 | 98.9 | 9.84 | 62.16 |
| 125.- 150. | 2 | .7 | 99.6 | 22.33 | 84.50 |
| 150.- 175. | 1 | .4 | 100.0 | 15.50 | 100.00 |

TOTAL # DROPS - 283 TOTAL OIL VOLUME (ML) = .00001396

NUMBER OF DROPS REJECTED FROM DIST. = 1

Date of Run [D/M/Y] : 21/12/84 D211A2 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 193.4
Minimum Drop Size : 5.0
Ave Drop Size(D10) : 46.4
Vol Mean Dia (D30) : 73.6
Sauter Mn Dia(D32) : 113.8

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 45 | 25.3 | 25.3 | .43 | .43 |
| 25.- 50. | 88 | 49.4 | 74.7 | 6.79 | 7.22 |
| 50.- 75. | 22 | 12.4 | 87.1 | 7.00 | 14.22 |
| 75.- 100. | 8 | 4.5 | 91.6 | 7.53 | 21.75 |
| 100.- 125. | 6 | 3.4 | 94.9 | 12.85 | 34.60 |
| 125.- 150. | 1 | .6 | 95.5 | 3.02 | 37.62 |
| 150.- 175. | 4 | 2.2 | 97.8 | 26.01 | 63.63 |
| 175.- 200. | 4 | 2.2 | 100.0 | 36.37 | 100.00 |

TOTAL # DROPS - 178 TOTAL OIL VOLUME (ML) = .00003712
NUMBER OF DROPS REJECTED FROM DIST. = 1

Date of Run [D/M/Y] : 21/12/84 D211B2 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########################################################################

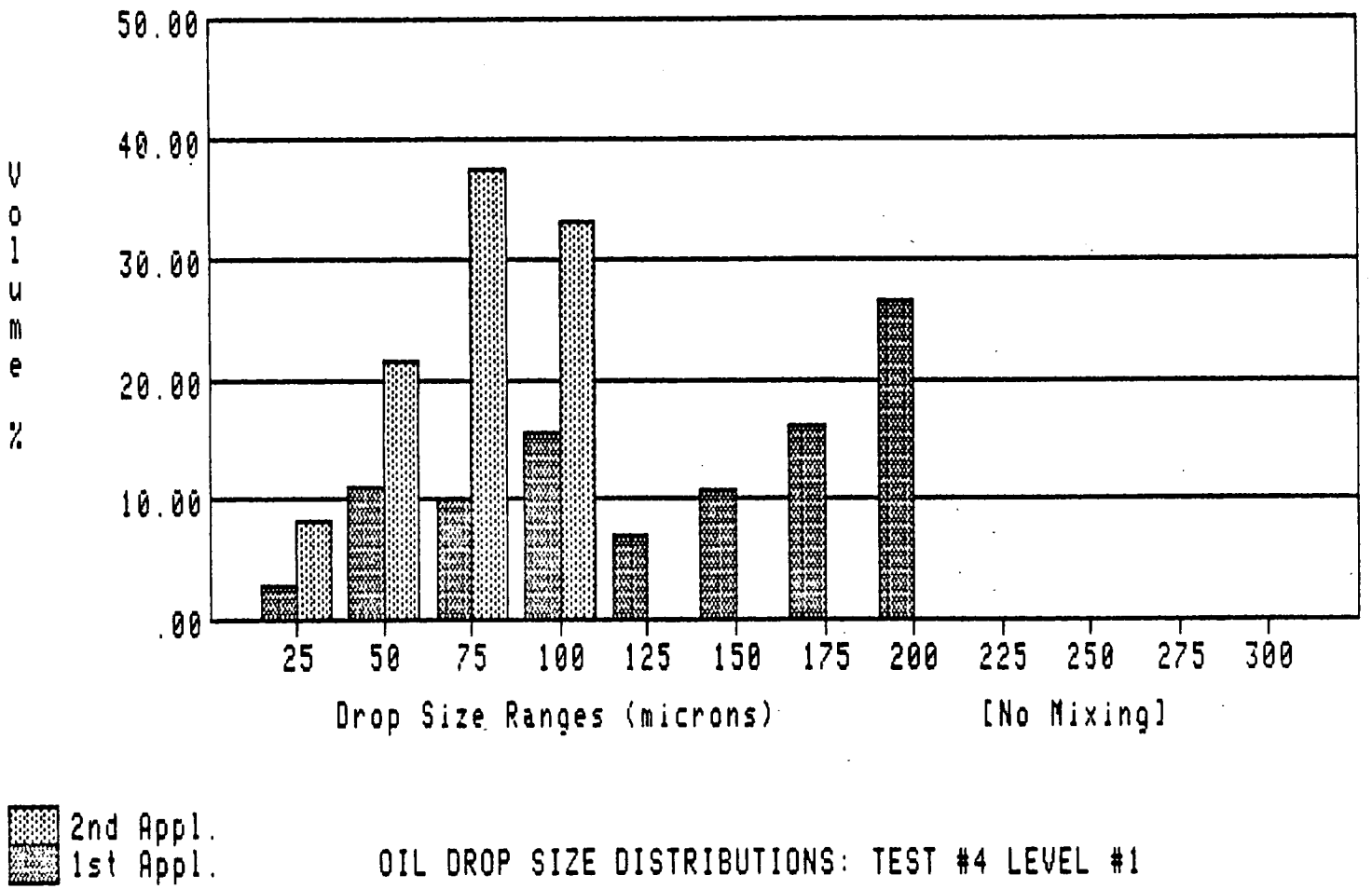
GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 114.0
Minimum Drop Size : 5.0
Ave Drop Size(D10) : 22.5
Vol Mean Dia (D30) : 33.6
Sauter Mn Dia(D32) : 50.9

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 160 | 75.5 | 75.5 | 10.77 | 10.77 |
| 25.- 50. | 41 | 19.3 | 94.8 | 20.04 | 30.81 |
| 50.- 75. | 7 | 3.3 | 98.1 | 26.86 | 57.67 |
| 75.- 100. | 3 | 1.4 | 99.5 | 23.95 | 81.62 |
| 100.- 125. | 1 | .5 | 100.0 | 18.38 | 100.00 |

TOTAL # DROPS - 212 TOTAL OIL VOLUME (ML) = .00000422
NUMBER OF DROPS REJECTED FROM DIST. = 0




OIL DROP SIZE DISTRIBUTIONS: TEST #4 LEVEL #1

Date of Run [D/M/Y] : 21/12/84 D212A1 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 193.3
Minimum Drop Size : 7.0
Ave Drop Size(D10) : 30.0
Vol Mean Dia (D30) : 50.2
Sauter Mn Dia(D32) : 86.2

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 117 | 54.2 | 54.2 | 2.78 | 2.78 |
| 25.- 50. | 76 | 35.2 | 89.4 | 10.96 | 13.74 |
| 50.- 75. | 13 | 6.0 | 95.4 | 10.23 | 23.96 |
| 75.- 100. | 6 | 2.8 | 98.1 | 15.51 | 39.47 |
| 100.- 125. | 1 | .5 | 98.6 | 6.98 | 46.45 |
| 125.- 150. | 1 | .5 | 99.1 | 10.89 | 57.34 |
| 150.- 175. | 1 | .5 | 99.5 | 16.22 | 73.56 |
| 175.- 200. | 1 | .5 | 100.0 | 26.44 | 100.00 |

TOTAL # DROPS - 216 TOTAL OIL VOLUME (ML) = .00001431
NUMBER OF DROPS REJECTED FROM DIST. = 0

Date of Run [D/M/Y] : 21/12/84 D212B1 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

GENERAL OIL DROP SIZE INFO (MICRONS)

| | |
|---|---|
| Maximum Drop Size | 94.2 |
| Minimum Drop Size | 5.0 |
| Ave Drop Size(D10) | 25.1 |
| Vol Mean Dia (D30) | 36.1 |
| Sauter Mn Dia(D32) | 51.0 |

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 141 | 69.8 | 69.8 | 8.24 | 8.24 |
| 25.- 50. | 42 | 20.8 | 90.6 | 21.40 | 29.64 |
| 50.- 75. | 14 | 6.9 | 97.5 | 37.38 | 67.02 |
| 75.- 100. | 5 | 2.5 | 100.0 | 32.98 | 100.00 |

TOTAL # DROPS - 202 TOTAL OIL VOLUME (ML) = .00000498

NUMBER OF DROPS REJECTED FROM DIST. = 1

Date of Run [D/M/Y] : 21/12/84 D212A2 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

GENERAL OIL DROP SIZE INFO (MICRONS)

| | |
|---|---|
| Maximum Drop Size | 139.6 |
| Minimum Drop Size | 5.0 |
| Ave Drop Size(D10) | 33.9 |
| Vol Mean Dia (D30) | 53.5 |
| Sauter Mn Dia(D32) | 82.4 |

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 67 | 49.3 | 49.3 | 2.19 | 2.19 |
| 25.- 50. | 50 | 36.8 | 86.0 | 10.81 | 13.00 |
| 50.- 75. | 8 | 5.9 | 91.9 | 8.95 | 21.95 |
| 75.- 100. | 4 | 2.9 | 94.9 | 14.22 | 36.17 |
| 100.- 125. | 4 | 2.9 | 97.8 | 28.81 | 64.98 |
| 125.- 150. | 3 | 2.2 | 100.0 | 35.02 | 100.00 |

TOTAL # DROPS - 136 TOTAL OIL VOLUME (ML) = .00001090

NUMBER OF DROPS REJECTED FROM DIST. = 2

Date of Run [D/M/Y] : 21/12/84 D212B2 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

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GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 89.2
Minimum Drop Size : 4.9
Ave Drop Size(D10) : 22.1
Vol Mean Dia (D30) : 31.0
Sauter Mn Dia(D32) : 43.9

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 179 | 71.6 | 71.6 | 11.84 | 11.84 |
| 25.- 50. | 60 | 24.0 | 95.6 | 29.98 | 41.83 |
| 50.- 75. | 8 | 3.2 | 98.8 | 29.62 | 71.45 |
| 75.- 100. | 3 | 1.2 | 100.0 | 28.55 | 100.00 |

TOTAL # DROPS - 250 TOTAL OIL VOLUME (ML) = .00000390
NUMBER OF DROPS REJECTED FROM DIST. = 1

With Background Mixing

| Test Designation In Report | Data Sheet Code |
|---|---|
| Test #1 | J231 |
| Test #2 | J241 |
| Test #3 | J251 |

Date of Run [D/M/Y] : 23/01/85 J231A2 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 120.3
Minimum Drop Size : 24.5
Ave Drop Size(D10) : 58.4
Vol Mean Dia (D30) : 67.6
Sauter Mn Dia(D32) : 77.5

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 1 | 4.2 | 4.2 | .20 | .20 |
| 25.- 50. | 10 | 41.7 | 45.8 | 8.59 | 8.79 |
| 50.- 75. | 6 | 25.0 | 70.8 | 19.85 | 28.64 |
| 75.- 100. | 6 | 25.0 | 95.8 | 47.88 | 76.52 |
| 100.- 125. | 1 | 4.2 | 100.0 | 23.48 | 100.00 |

TOTAL # DROPS - 24 TOTAL OIL VOLUME (ML) = .00000388
NUMBER OF DROPS REJECTED FROM DIST. = 0

Date of Run [D/M/Y] : 23/01/85 J231B2 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

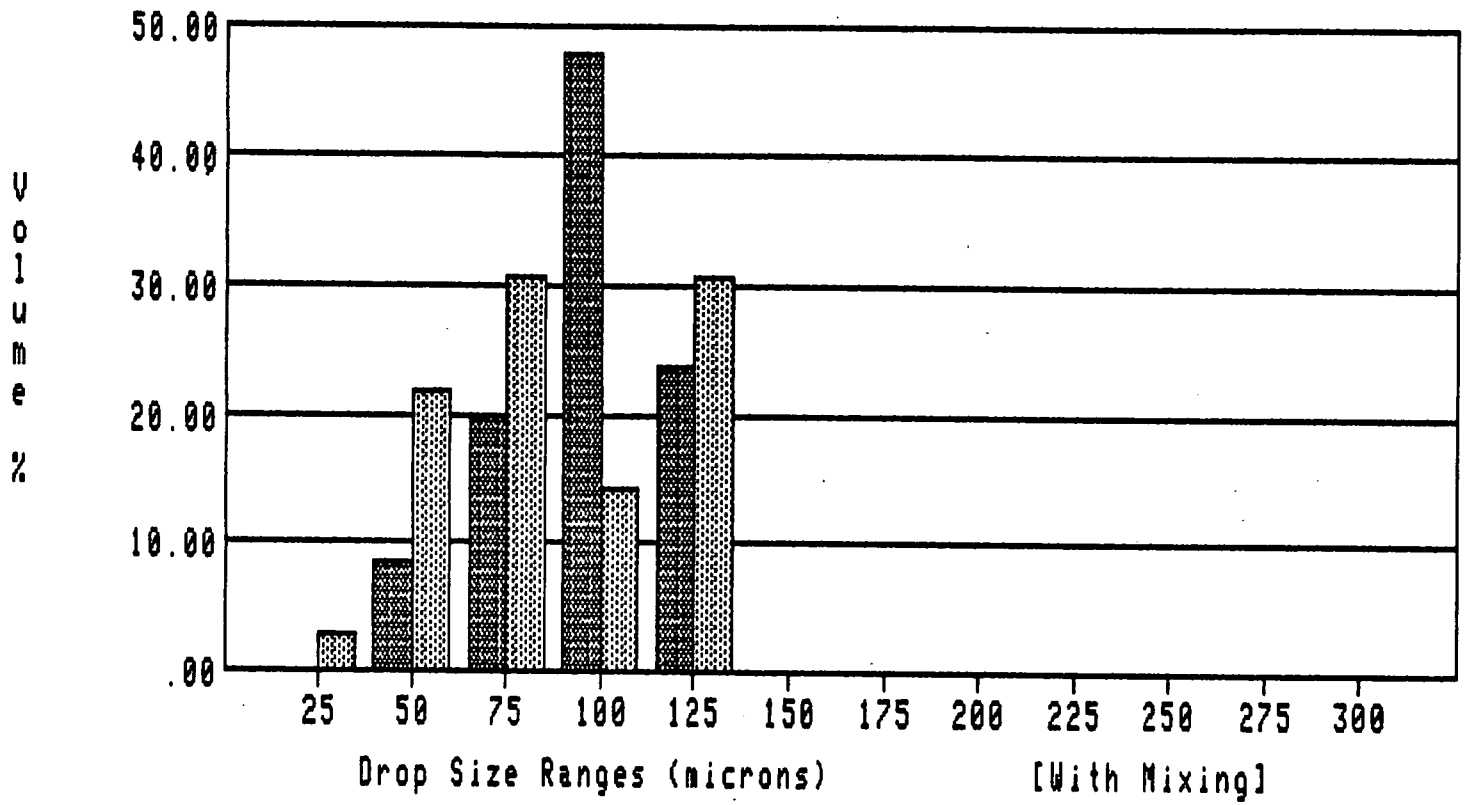
GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 111.1
Minimum Drop Size : 9.6
Ave Drop Size(D10) : 36.5
Vol Mean Dia (D30) : 47.1
Sauter Mn Dia(D32) : 60.5

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 28 | 34.6 | 34.6 | 3.06 | 3.06 |
| 25.- 50. | 38 | 46.9 | 81.5 | 21.78 | 24.84 |
| 50.- 75. | 11 | 13.6 | 95.1 | 30.39 | 55.22 |
| 75.- 100. | 2 | 2.5 | 97.5 | 14.18 | 69.40 |
| 100.- 125. | 2 | 2.5 | 100.0 | 30.60 | 100.00 |

TOTAL # DROPS - 81 TOTAL OIL VOLUME (ML) = .00000443
NUMBER OF DROPS REJECTED FROM DIST. = 0




OIL DROP SIZE DISTRIBUTIONS: TEST #1 LEVEL #2

Date of Run [D/M/Y] : 23/01/85 J231A3 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 120.2
Minimum Drop Size : 6.8
Ave Drop Size(D10) : 27.7
Vol Mean Dia (D30) : 44.4
Sauter Mn Dia(D32) : 69.1

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 49 | 69.0 | 69.0 | 4.51 | 4.51 |
| 25.- 50. | 13 | 18.3 | 87.3 | 10.36 | 14.87 |
| 50.- 75. | 5 | 7.0 | 94.4 | 17.00 | 31.87 |
| 75.- 100. | 2 | 2.8 | 97.2 | 21.04 | 52.91 |
| 100.- 125. | 2 | 2.8 | 100.0 | 47.09 | 100.00 |

TOTAL # DROPS - 71 TOTAL OIL VOLUME (ML) = .00000325

NUMBER OF DROPS REJECTED FROM DIST. = 0

Date of Run [D/M/Y] : 23/01/85 J231B1 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

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GENERAL OIL DROP SIZE INFO (MICRONS)

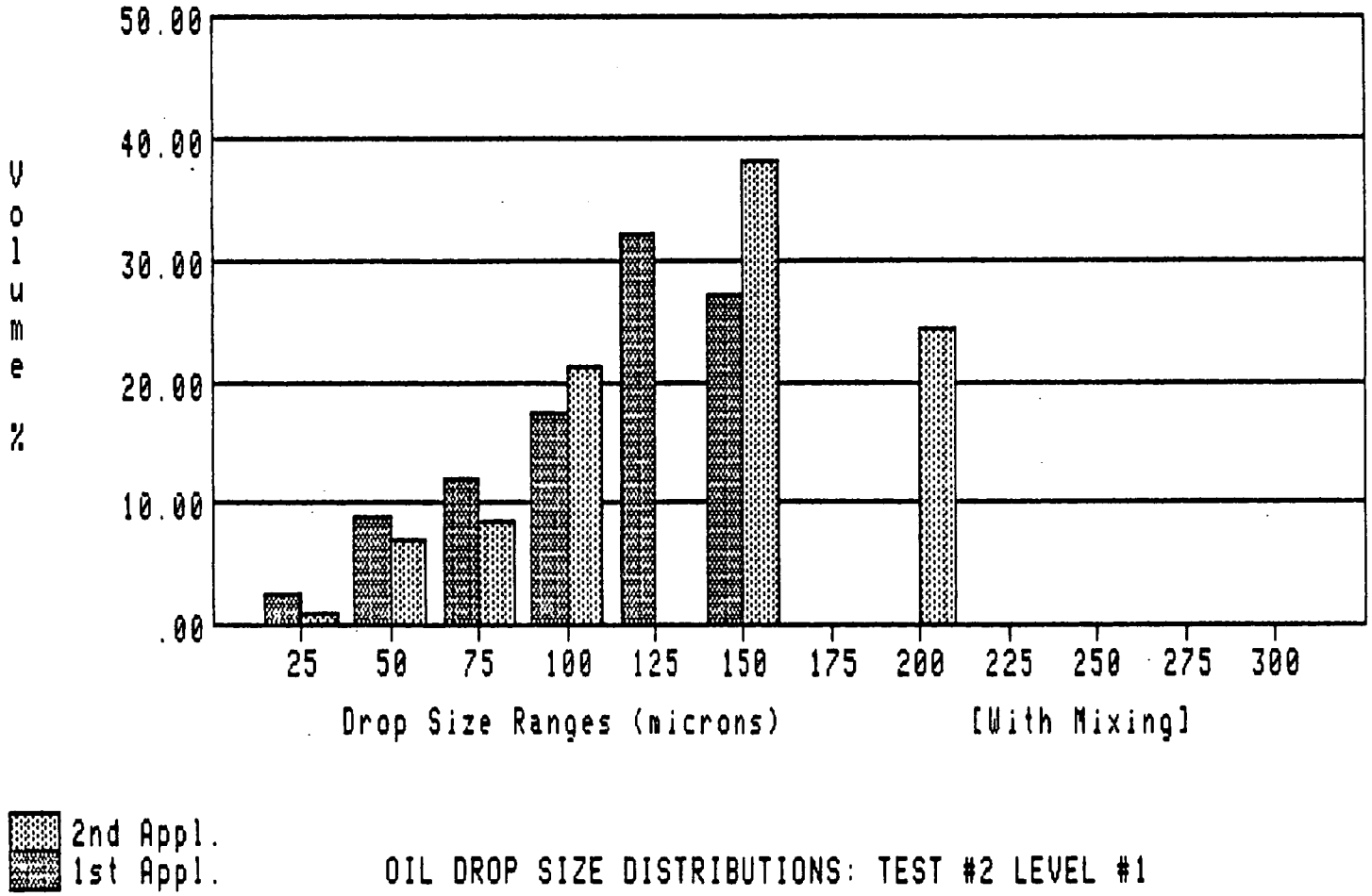
Maximum Drop Size : 105.9
Minimum Drop Size : 14.4
Ave Drop Size(D10) : 68.4
Vol Mean Dia (D30) : 80.7
Sauter Mn Dia(D32) : 90.9

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 1 | 20.0 | 20.0 | .11 | .11 |
| 25.- 50. | 1 | 20.0 | 40.0 | 4.24 | 4.35 |
| 50.- 75. | 0 | 0.0 | 40.0 | 0.00 | 4.35 |
| 75.- 100. | 2 | 40.0 | 80.0 | 50.41 | 54.76 |
| 100.- 125. | 1 | 20.0 | 100.0 | 45.24 | 100.00 |

TOTAL # DROPS - 5 TOTAL OIL VOLUME (ML) = .00000137

NUMBER OF DROPS REJECTED FROM DIST. = 0




OIL DROP SIZE DISTRIBUTIONS: TEST #2 LEVEL #1

Date of Run [D/M/Y] : 24/01/85 J241A1 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########################################################################

GENERAL OIL DROP SIZE INFO (MICRONS)

| | |
|---|---|
| Maximum Drop Size | : 139.5 |
| Minimum Drop Size | : 4.8 |
| Ave Drop Size(D10) | : 34.8 |
| Vol Mean Dia (D30) | : 54.4 |
| Sauter Mn Dia(D32) | : 81.8 |

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 61 | 57.0 | 57.0 | 2.74 | 2.74 |
| 25.- 50. | 28 | 26.2 | 83.2 | 8.90 | 11.64 |
| 50.- 75. | 8 | 7.5 | 90.7 | 11.88 | 23.51 |
| 75.- 100. | 4 | 3.7 | 94.4 | 17.27 | 40.79 |
| 100.- 125. | 4 | 3.7 | 98.1 | 32.04 | 72.82 |
| 125.- 150. | 2 | 1.9 | 100.0 | 27.18 | 100.00 |

TOTAL # DROPS - 107 TOTAL OIL VOLUME (ML) = .00000902

NUMBER OF DROPS REJECTED FROM DIST. = 1

Date of Run [D/M/Y] : 24/01/85 J241B1 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 175.3
Minimum Drop Size : 4.8
Ave Drop Size(D10) : 39.6
Vol Mean Dia (D30) : 64.3
Sauter Mn Dia(D32) : 99.1

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 39 | 46.4 | 46.4 | 1.07 | 1.07 |
| 25.- 50. | 26 | 31.0 | 77.4 | 6.97 | 8.04 |
| 50.- 75. | 8 | 9.5 | 86.9 | 8.57 | 16.60 |
| 75.- 100. | 7 | 8.3 | 95.2 | 21.20 | 37.80 |
| 100.- 125. | 0 | 0.0 | 95.2 | 0.00 | 37.80 |
| 125.- 150. | 3 | 3.6 | 98.8 | 38.04 | 75.84 |
| 150.- 175. | 0 | 0.0 | 98.8 | 0.00 | 75.84 |
| 175.- 200. | 1 | 1.2 | 100.0 | 24.16 | 100.00 |

TOTAL # DROPS - 84 TOTAL OIL VOLUME (ML) = .00001168
NUMBER OF DROPS REJECTED FROM DIST. = 1

Date of Run [D/M/Y] : 24/01/85 J241A2 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

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GENERAL OIL DROP SIZE INFO (MICRONS)

| | |
|---|---|
| Maximum Drop Size | 86.5 |
| Minimum Drop Size | 4.8 |
| Ave Drop Size(D10) | 29.2 |
| Vol Mean Dia (D30) | 36.6 |
| Sauter Mn Dia(D32) | 45.4 |

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 17 | 44.7 | 44.7 | 6.19 | 6.19 |
| 25.- 50. | 20 | 52.6 | 97.4 | 59.03 | 65.22 |
| 50.- 75. | 0 | 0.0 | 97.4 | 0.00 | 65.22 |
| 75.- 100. | 1 | 2.6 | 100.0 | 34.78 | 100.00 |

TOTAL # DROPS - 38 TOTAL OIL VOLUME (ML) = .00000098

NUMBER OF DROPS REJECTED FROM DIST. = 0

Date of Run [D/M/Y] : 24/01/85 J241B2 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

GENERAL OIL DROP SIZE INFO (MICRONS)

| | |
|---|---|
| Maximum Drop Size | 91.5 |
| Minimum Drop Size | 4.8 |
| Ave Drop Size(D10) | 23.6 |
| Vol Mean Dia (D30) | 32.1 |
| Sauter Mn Dia(D32) | 43.2 |

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 103 | 74.6 | 74.6 | 13.64 | 13.64 |
| 25.- 50. | 27 | 19.6 | 94.2 | 35.22 | 48.86 |
| 50.- 75. | 7 | 5.1 | 99.3 | 34.32 | 83.19 |
| 75.- 100. | 1 | .7 | 100.0 | 16.81 | 100.00 |

TOTAL # DROPS - 138 TOTAL OIL VOLUME (ML) = .00000239

NUMBER OF DROPS REJECTED FROM DIST. = 0

Date of Run [D/M/Y] : 24/01/85 J241A3 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

GENERAL OIL DROP SIZE INFO (MICRONS)

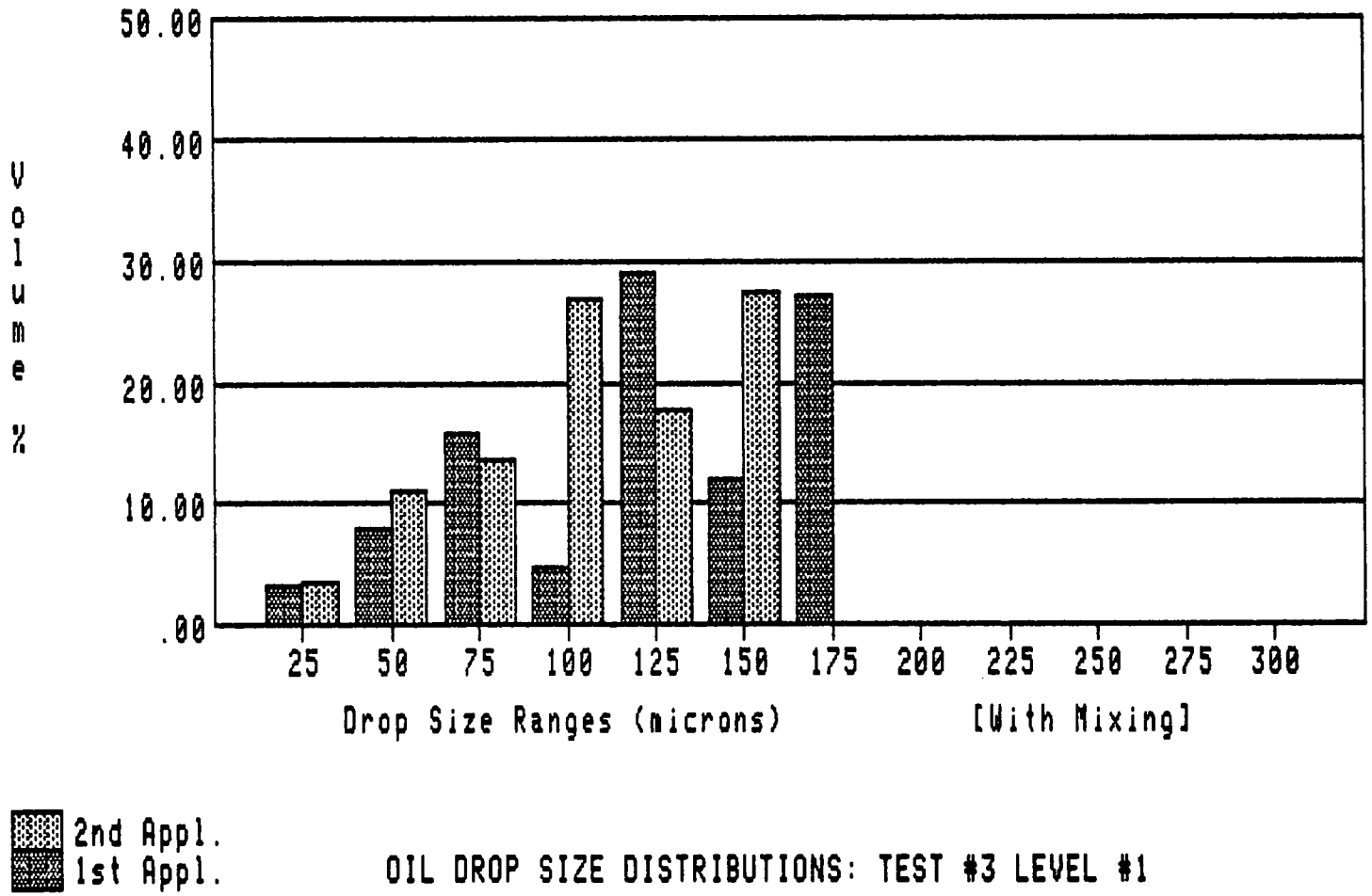
| | |
|---|---|
| Maximum Drop Size | 96.2 |
| Minimum Drop Size | 4.8 |
| Ave Drop Size(D10) | 26.6 |
| Vol Mean Dia (D30) | 37.7 |
| Sauter Mn Dia(D32) | 52.8 |

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 31 | 67.4 | 67.4 | 8.25 | 8.25 |
| 25.- 50. | 11 | 23.9 | 91.3 | 24.72 | 32.97 |
| 50.- 75. | 3 | 6.5 | 97.8 | 31.09 | 64.06 |
| 75.- 100. | 1 | 2.2 | 100.0 | 35.94 | 100.00 |

TOTAL # DROPS - 46 TOTAL OIL VOLUME (ML) = .00000130

NUMBER OF DROPS REJECTED FROM DIST. = 0




OIL DROP SIZE DISTRIBUTIONS: TEST #3 LEVEL #1

Date of Run [D/M/Y] : 25/01/85 J251A1 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 164.0
Minimum Drop Size : 9.6
Ave Drop Size(D10) : 30.5
Vol Mean Dia (D30) : 50.0
Sauter Mn Dia(D32) : 82.1

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 76 | 58.5 | 58.5 | 3.27 | 3.27 |
| 25.- 50. | 37 | 28.5 | 86.9 | 8.09 | 11.36 |
| 50.- 75. | 11 | 8.5 | 95.4 | 15.78 | 27.15 |
| 75.- 100. | 1 | .8 | 96.2 | 4.74 | 31.89 |
| 100.- 125. | 3 | 2.3 | 98.5 | 28.90 | 60.79 |
| 125.- 150. | 1 | .8 | 99.2 | 12.10 | 72.90 |
| 150.- 175. | 1 | .8 | 100.0 | 27.10 | 100.00 |

TOTAL # DROPS - 130 TOTAL OIL VOLUME (ML) = .00000852
NUMBER OF DROPS REJECTED FROM DIST. = 0

Date of Run [D/M/Y] : 25/01/85 J251B1 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 144.7
Minimum Drop Size : 4.8
Ave Drop Size(D10) : 27.6
Vol Mean Dia (D30) : 45.9
Sauter Mn Dia(D32) : 73.5

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 202 | 68.7 | 68.7 | 3.61 | 3.61 |
| 25.- 50. | 57 | 19.4 | 88.1 | 10.99 | 14.60 |
| 50.- 75. | 16 | 5.4 | 93.5 | 13.60 | 28.20 |
| 75.- 100. | 12 | 4.1 | 97.6 | 26.69 | 54.89 |
| 100.- 125. | 4 | 1.4 | 99.0 | 17.72 | 72.61 |
| 125.- 150. | 3 | 1.0 | 100.0 | 27.39 | 100.00 |

TOTAL # DROPS - 294 TOTAL OIL VOLUME (ML) = .00001490
NUMBER OF DROPS REJECTED FROM DIST. = 0

Date of Run [D/M/Y] : 25/01/85 J251A2 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

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GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 140.7
Minimum Drop Size : 4.8
Ave Drop Size(D10) : 25.8
Vol Mean Dia (D30) : 39.3
Sauter Mn Dia(D32) : 60.0

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 89 | 65.9 | 65.9 | 6.03 | 6.03 |
| 25.- 50. | 34 | 25.2 | 91.1 | 21.31 | 27.34 |
| 50.- 75. | 10 | 7.4 | 98.5 | 25.82 | 53.16 |
| 75.- 100. | 0 | 0.0 | 98.5 | 0.00 | 53.16 |
| 100.- 125. | 1 | .7 | 99.3 | 12.87 | 66.03 |
| 125.- 150. | 1 | .7 | 100.0 | 33.97 | 100.00 |

TOTAL # DROPS - 135 TOTAL OIL VOLUME (ML) = .00000429
NUMBER OF DROPS REJECTED FROM DIST. = 0

Date of Run [D/M/Y] : 25/01/85 J251B2 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########################################################################

GENERAL OIL DROP SIZE INFO (MICRONS)

Maximum Drop Size : 91.7
Minimum Drop Size : 9.6
Ave Drop Size(D10) : 35.3
Vol Mean Dia (D30) : 44.1
Sauter Mn Dia(D32) : 54.2

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 38 | 34.2 | 34.2 | 2.63 | 2.63 |
| 25.- 50. | 53 | 47.7 | 82.0 | 28.75 | 31.37 |
| 50.- 75. | 15 | 13.5 | 95.5 | 36.04 | 67.42 |
| 75.- 100. | 5 | 4.5 | 100.0 | 32.58 | 100.00 |

TOTAL # DROPS - 111 TOTAL OIL VOLUME (ML) = .00000499
NUMBER OF DROPS REJECTED FROM DIST. = 2

Date of Run [D/M/Y] : 25/01/85 J251B3 DAT

Type of Mixing System : HIGH PRESSURE WATER : 1000 PSI

Dispersant to Oil Ratio : 1:100

Track Speed [M/S] : .25

##########

GENERAL OIL DROP SIZE INFO (MICRONS)

| | |
|---|---|
| Maximum Drop Size | 77.8 |
| Minimum Drop Size | 0.0 |
| Ave Drop Size(D10) | 24.7 |
| Vol Mean Dia (D30) | 34.0 |
| Sauter Mn Dia(D32) | 45.8 |

OIL DROP SIZE DISTRIBUTIONS

| Range | # of Drops | % of Drops | % Less Than | Vol % | % Vol Less |
|---|---|---|---|---|---|
| 0.- 25. | 111 | 67.7 | 67.7 | 9.14 | 9.14 |
| 25.- 50. | 37 | 22.6 | 90.2 | 25.18 | 34.32 |
| 50.- 75. | 15 | 9.1 | 99.4 | 58.40 | 92.71 |
| 75.- 100. | 1 | .6 | 100.0 | 7.29 | 100.00 |

TOTAL # DROPS - 164 TOTAL OIL VOLUME (ML) = .00000338

NUMBER OF DROPS REJECTED FROM DIST. = 3

## Appendix B

### STUDY DATA ON OIL CONCENTRATIONS

Table B-1 summarizes the in-water oil concentrations measured immediately after each dispersant application and mixing sequence conducted during the study.

TABLE B-1: Oil concentration summary

| Test | Measured oil concentration | | | | | |
|---|---|---|---|---|---|---|
| | First application | | | Second application | | |
| | Level #1 | Level #2 | Level #3 | Level #1 | Level #2 | Level #3 |
| No background mixing | | | | | | |
| #1 Dec 18-A | 562 | 272 | 44 | 1751 | 306 | - |
| #2 Dec 18-B | 487 | 159 | - | 608 | 345 | - |
| #3 Dec 21-A | 912 | 313 | - | 964 | 432 | - |
| #4 Dec 21-B | 447 | 168 | - | 725 | 231 | - |
| With mixing | | | | | | |
| #1 Jan 23 | 2330 | 1230 | 574 | 395 | 212 | 191* |
| #2 Jan 24 | 295 | 111 | 145 | 1070 | 512 | 163 |
| #3 Jan 25 | 1458 | 1134 | 305 | 2396 | 2221 | 486 |

* Note: Oil was herded from centre of tank prior to the second application of dispersant in this test.