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Physics Ref.	PH.1504
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Date	17th October, 1960.

Mr. J.D. Pennington,
J.W. Roberts Ltd.

SUBJECT

An investigation of the Health Hazard associated with the Limpet asbestos cement spray process.

OBJECT

To measure the size distribution and concentration of airborne dust released during the application of Limpet asbestos cement.

INTRODUCTION

Dust measurements on the Limpet Spray-Fibre process have been carried out in the past (Ref. 1) but, in view of the attention focused on this problem more recently, up-to-date information is required to assist in assessing the health risk.

For the purpose of initiating this enquiry, measurements were carried out at J.W. Roberts Ltd. (Horwich) on an experimental scale and also on site. The sites chosen were the "Empress of Canada" while on the stocks at the Vickers-Armstrong shipyard, Newcastle-on-Tyne, and the new Research Laboratories of Pilkington Bros. Ltd. at Latham Park. Wherever possible, two grades of material were considered.

CONCLUSIONS

At this stage the conclusions must of necessity be of a tentative nature. In some of the tests it was only possible to carry out single measurements and it is therefore impossible to estimate the accuracy of the results. Again, a number of comparison tests were carried out in which replication was possible but, although the results yielded mean values which were in accordance with expectation, failed to achieve statistical significance.

It is also necessary to point out that this enquiry has evoked a number of major issues. For instance, it is by no means certain that the sampling equipment employed (the standard T.B.A. dust sampling apparatus i.e. the Casella thermal precipitator) was appropriate to the task.

1. For LB.3, the airborne dust concentration measured in the spray booth at Horwich was about 5,000 particles per c.c.
2. For LW.25, the airborne dust concentration measured received in the spray booth at Horwich was 2,000 particles per c.c.
3. The dust concentrations measured on board ship at Vickers-Armstrong shipyard ranged from roughly 6,000 particles/c.c. (for damped LW.25) to 14,000 particles/c.c. (for undamped LB.3).
4. The estimated dust concentrations for LW.25 sprayed on the selected building site (at Latham Park) ranged from 140 particles/c.c. to 520 particles/c.c. for seven samples with one further sample yielding a value of 1,400 particles/c.c.

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5. The effect of using the damping mechanism was studied on board ship and, although lower dust counts were obtained, the apparent improvement was not statistically significant. Furthermore the reduction in dust level as measured was in any case disappointing.

6. Rather surprisingly, dust measurements made at J.W. Roberts Ltd. failed to reveal an improvement when pre-damping was used.

7. In the case of blue fibre, damping seems to have been largely effective in the $\frac{1}{2}\mu$ - 1μ range and to some extent in the 5μ to 10μ range. There is also some indication that pre-damping white fibre has produced a coarser size grading due to the suppression of fines.

8. Experiments carried out at Horwich suggest that, after spraying has ceased, the dust content of the atmosphere in the spray area soon reaches a safe level. In the case of blue fibre a period of ten minutes is probably sufficient while an interval of twenty minutes should suffice for the white grade.

9. Results from tests carried out some years ago suggest that no difficulty is involved in distinguishing between asbestos and cement particles when viewed under the microscope. (Ref. 1) It can only be assumed that this was carried out on an arbitrary basis because we have been so far unsuccessful.

RECOMMENDATIONS

1. As these tests have cast some doubt upon the suitability of the thermal precipitator for sampling in atmospheres where the dust concentration is changing rapidly, settlement methods should be investigated before any further work is contemplated.

2. As an alternative the Hexhlet mass sampler might be studied in more detail. This instrument has already been used by J.W.R. Ltd. with some success, but for basic investigations the instrument would need to be calibrated for each quality of spray fibre, to take into account differences in size distribution.

SUMMARY

Samples of airborne dust in the region of Limpet spray machines have been obtained while operating at J.W. Roberts Ltd. and on site. Two grades of spray fibre were considered (LB.3 and LW.25) and the effect of damping and predamping has been examined. Total concentrations and size distributions have been determined.

DETAILED REPORT

The tests described here were commenced on 25th February 1960 and deal with the examination of the dusty conditions in evidence during the Limpet spraying operation. Samples of the atmosphere were taken in the spray booth at J.W. Roberts Ltd. (Horwich) and also on selected sites; arrangements were made to take samples from the "Empress of Canada" prior to launching and from the new Research Laboratories being constructed at Latham Park for Pilkington Bros. Ltd.

The sampling equipment used was that used in routine dust surveys at Rochdale and Hindley Green viz; the Casella thermal precipitator. Samples were taken for two qualities of spray fibre, LB.3 and LW.25, without using the damping mechanism. Further samples were taken to assess the effect of damping and also to discover the effect of using pre-damped fibre. A test was carried out on each quality to obtain some idea of the rate of sedimentation after spraying had ceased.

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Each sample was incinerated at 500°C to remove any extraneous carbonaceous matter present and then examined under the Vickers Projection Microscope used as a monocular microscope employing a dark ground reference with a 4 mm objective. By means of these counts the size distribution of each sample was determined and the dust concentration calculated.

Further tests were carried out in the laboratory in an attempt to distinguish between asbestos and cement particles using a polaroid system and phase contrast methods. These were unsuccessful. Another method, viz; the stain dispersion technique, is being investigated.

DETAILS OF TESTS

Test (1) On 25th February, 1960, five atmospheric samples were taken at J.W. Roberts Ltd. (Horwich) under the following conditions:-

(i) Spray directed onto the wall.
(ii) Five minutes after completing operation (i)
(iii) Spray directed onto the ceiling.
(iv) Five minutes after completing operation (iii)
(v) Spray directed onto the wall using pre-damped fibre.

The fibre used was LW.25.

Test (2) On 27th April 1960 twelve atmospheric samples were taken in duplicate on board the "Empress of Canada". Six samples were taken for blue fibre and six for white fibre. In each case half of the samples were taken with the damping mechanism in operation and the rest without.

Test (3) A series of samples was taken while spraying was being carried out in a new building erected at Latham Park in the morning of 10th August 1960. There was a strong air current passing through the spray area so two samples were taken upstream of the operator and two downstream; in each case measurements were made in duplicate i.e. using two thermal precipitators.

Test (4) In the afternoon of 10th August 1960, five samples were obtained at J.W. Roberts Ltd. (Horwich). The programme was the same as in Test (1) but, on this occasion, the fibre used was LB.3.

Test (5) Duplicate size analyses were obtained for a sample of Portland cement taken from a bag which was in the Rochdale works. Coning and quartering was used to reduce the bulk sample and petroleum jelly was used as a dispersing agent.

RESULTS

Test 1 LW.25 at J.W.R. Ltd.

The total concentrations and concentrations in each of the stated size ranges appear in Table I. Table II is a summary of the size distributions which are also shown pictorially in Figure 1. It can be seen that pre-damping appears to have little or no effect on the total dust concentration nor on the size distribution of the airborne dust.

Test 2 Samples from the "Empress of Canada".

The results of these tests appear in Tables 3 & 4 in Figure 2. Samples 1-3 and 7-9 were taken with the damping mechanism in use. Samples 4-6 and 10-12 were taken with the damping mechanism out of action. From Table 3 the following results have been calculated.

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Comparison of Blue and White Fibre

Mean concentration obtained for blue fibre = 11,600 ± 1,100 p/cc.
Mean concentration obtained for white fibre = 9,100 ± 1,600 p/cc.

"Student's" t-test was applied to the difference between these means and the difference was found to be significant at the 1% level.

Effect of Damping

Mean concentration observed for damped fibre (both grades)
= 9,700 ± 1,300 p/cc.
Mean concentration observed for undamped fibre (both grades)
= 11,000 ± 1,700 p/cc.

The difference between the two means obtained here would be expected to occur about once in ten occasions as a result of pure chance where no real difference existed. There is, therefore, only a slight indication that damping has been effective in reducing the dust level.

Considering the two grades of fibre separately the following results were obtained :-

White fibre

Mean concentration obtained for damped white fibre = 8,400 ± 1,000 p/cc.
Mean concentration obtained for undamped white fibre = 9,700 ± 3,500 p/cc.

The difference between these mean values would be expected to occur on almost one in five occasions where no real difference exists and must therefore be considered to be not significant.

Blue fibre

Mean concentration observed for damped blue fibre = 11,000 ± 2,100 p/cc.
Mean concentration observed for undamped blue fibre = 12,200 ± 1,400 p/cc.

The difference obtained could be expected to occur on one out of nine occasions as a result of random fluctuations and is therefore scarcely significant.

Size distribution

Significance tests were also carried out grade by grade and have been taken into account in the conclusions.

Test 3 Samples from Latham Park

The results obtained from these tests appear in Tables 5 & 6. The size distributions appearing in Table 6 have been plotted in Figure 3. Samples 1 & 2 were taken upstream of the operator and samples 3 & 4 downstream of the operator.

It can be seen from Table 6 and Figure 3 that there appears to be no real difference between the samples taken upstream from those taken downstream with respect to size distribution. From the point of view of total dust concentration, there again appears to be good agreement in each direction if the value of 1,437.9 p/cc. is discounted. There is good reason for believing that this particular sample was contaminated.

* The concentrations quoted in this section have been rounded off to the nearest 100 p/cc. The limits shown are 95% confidence limits and have been quoted to serve as an indication of accuracy; the t-test has been performed separately and does not involve these limits.

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Test 4 Samples taken for LB.3 at J.W.R. Ltd.

The results obtained appear in Tables 7 & 8 and size distributions are depicted in Figure 4.

Tests 1-4

The results of these tests are summarised in Figure 5.

Test 5 Size analysis of Portland Cement

The cumulative size distributions obtained for the two sub-samples considered are shown in Table 9 together with a mean size distribution. In each case at least 625 particles were counted in order to give a random counting error of $\pm$ 2%; the magnitude of the other errors involved is not known.

DISCUSSION OF RESULTS

The results obtained to date must be regarded with some reservation. In general, it would appear that too few samples were taken. At Newcastle, however, twelve samples were taken in duplicate (i.e. using two sampling units) and, even so, it is difficult to pronounce judgement on the results. It was disappointing to find that in these tests the two sampling units used showed differences in the measurement of dust concentrations. Unfortunately, this was not expected beforehand, and, consequently, the figures obtained are subject to an extra source of variation.

Sampling Method

The sampling instrument used has found acceptance for routine dust surveys but may not be suitable for this purpose. It is quite possible that, as a result of sedimentation of particles during the tests, the concentrations measured are over-estimates of the true values.

Latham Park Samples

The size distributions obtained for these samples are not in agreement with other samples obtained for LW.25. It is quite possible that the larger particles were accepted by the precipitator because of their high settling rates whereas the smaller particles were swept away by the air current present.

Reference

J. W. Roberts Ltd.

'Limpet' Asbestos Spray Machines by J. S. Evans - 17th March 1960.

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APPENDIX

TABLE I

Measured Concentration of Airborne Dust in Particles/co
obtained for LW.25 at J.W.R. Ltd.

Sample No.	Source	Size Ranges						
		½-1μ	1-2μ	2-5μ	5-10μ	10-20μ	>20μ	To
1	Spray onto wall	1466.0	623.2	351.8	99.4	26.0	10.2	25
2	5 mins. after sample 1	1150.1	179.2	56.7	6.3	-	2.9	1
3	Spray onto ceiling	1476.2	287.8	147.2	43.2	11.2	7.2	19
4	5 mins. after sample 3	990.3	179.9	89.7	25.0	14.4	14.9	1
5	Spray onto wall (pre-damped)	1195.4	360.5	208.3	43.4	46.8	43.4	1

Eastern District of Ontario

TABLE II

Size Distribution of Airborne Dust - Percentage by number
LW.25 at J.W.R. Ltd.

Sample No.	Source	Size Ranges					
		½-1μ	1-2μ	2-5μ	5-10μ	10-20μ	>20μ
1	Spray onto wall	56.7	24.3	13.7	3.9	1.0	0.4
2	5 mins. after sample 1	82.3	12.9	4.1	0.5	-	0.2
3	Spray onto ceiling	74.8	14.6	7.4	2.2	0.6	0.4
4	5 mins. after sample 3	75.4	13.7	6.8	1.9	1.1	1.1
5	Spray onto wall (pre-damped)	62.9	19.0	11.0	2.3	2.5	2.3

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TABLE III

Samples from the "Empress of Canada"

Measured Concentration of Airborne Dust in Particles/cc.

Blue Asbestos Cement									White Asbestos Cement							
Sample No.	Size Ranges						Total	Sample No.	Size Ranges						Total	
	½-1 μ	1-2 μ	2-5 μ	5-10 μ	10-20 μ	> 20			½-1 μ	1-2 μ	2-5 μ	5-10 μ	10-20 μ	> 20		
1	4626.0	1920.0	1404.0	254.8	45.2	24.0	8274.0	7	7985.5	627.9	109.2	11.3	4.2	9.7	8747.8	
	6844.0	2552.0	1428.0	484.0	228.0	84.0	11620.0		8124.0	707.2	70.7	17.7	-	8.8	8928.4	
2	6753.6	3427.2	1890.6	562.2	100.8	25.8	12760.2	8	6132.0	560.0	95.2	44.8	16.8	16.8	6865.6	
	5838.0	1963.5	1564.5	609.0	162.8	105.0	10242.7		8145.5	565.1	259.6	122.2	35.6	45.8	9173.8	
3	4704.0	2730.0	1738.8	445.2	71.1	21.3	9710.4	9	6832.0	420.0	224.0	61.6	28.0	16.8	7582.4	
	6983.2	2716.0	2303.3	1023.1	360.1	126.0	13511.7		7896.0	767.0	358.2	78.4	44.8	89.6	9234.0	
4	7971.6	3095.1	2104 5	533.7	134.4	81.2	13920.5	10	5333.4	579.9	140.9	37.9	16.3	5.4	6113.8	
	7184.8	2923.2	1394.4	408.8	173.6	117.6	12202.4		9497.6	739.2	252.0	61.6	28.0	78.4	10656.8	
5	5824.2	2216.1	1637.1	266.8	14.8	44.5	10003.5	11	10792.7	561.6	92.6	34.7	5.8	5.8	11493.2	
	7610.4	3337.6	1388.8	364.0	156.8	84.0	12941.6		12657.8	915.3	191.2	127.5	75.3	34.8	14001.9	
6	6907.8	2443.2	1584.0	225.0	108.0	81.0	11349.0	12	5164.9	189.3	40.3	11.2	5.6	11.2	5422.5	
	7347.2	3248.0	1652.0	364.0	117.6	44.8	12773.6		9805.6	784.0	117.6	61.6	5.6	11.2	10785.6	

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TABLE IV

Samples from the "Empress of Canada"

Size Distributions of Airborne Dust Percentage By Number.

Blue Asbestos Cement							White Asbestos Cement					
Sample Number	Size Ranges ½-1 μ	1-2 μ	2-5 μ	5-10 μ	10-20 μ	>20 μ	Sample Number	Size Ranges ½-1 μ	1-2 μ	2-5 μ	5-10 μ	10-20 μ
1	55.8	23.2	17.0	3.1	0.6	0.3	7	91.2	7.2	1.3	0.1	0.1
	58.9	21.9	12.3	4.2	2.0	0.7		91.0	7.9	0.8	0.2	-
2	52.9	26.9	14.8	4.4	0.8	0.2	8	89.3	8.2	1.4	0.7	0.2
	56.9	19.2	15.3	5.9	1.6	1.0		88.8	6.2	2.8	1.3	0.4
3	48.5	28.1	17.9	4.6	0.7	0.2	9	90.2	5.5	2.9	0.8	0.4
	51.7	20.1	17.0	7.6	2.7	0.9		85.5	8.3	3.9	0.8	0.5
4	57.3	22.2	15.1	3.8	1.0	0.6	10	87.2	9.5	2.3	0.6	0.3
	58.9	23.9	11.4	3.4	1.4	1.0		89.1	6.9	2.4	0.6	0.3
5	58.2	22.2	16.4	2.7	0.1	0.4	11	93.8	4.9	0.8	0.3	0.1
	58.8	25.8	10.7	2.8	1.2	0.7		90.4	6.5	1.4	0.9	0.5
6	60.9	21.5	13.9	2.0	1.0	0.7	12	95.3	3.5	0.7	0.2	0.1
	57.5	25.4	12.9	2.9	0.9	0.4		90.8	7.3	1.1	0.6	0.1

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Table V Amosite (LW 25) Samples from Latham Park

Measured Concentration of Airborne Dust in Particles /co

Sample Number	Size Ranges						Total
	½-1 μ	1-2 μ	2-5 μ	5-10 μ	10-20 μ	>20 μ	
1	130.6	57.6	75.8	16.8	11.0	28.3	320.1
	396.0	96.0	26.0	4.0	-	0.8	522.8
2	75.5	25.4	35.0	2.4	1.9	3.8	144.0
	144.4	73.0	61.4	18.7	5.3	15.4	318.2
3	128.6	47.3	37.8	6.8	4.2	7.9	232.6
	1100.4	211.0	67.2	14.8	14.8	29.7	1437.9
4	161.8	77.8	48.0	23.0	4.8	23.0	338.4
	222.7	71.1	86.4	32.6	13.4	49.0	475.2

Table VI Amosite (LW 25) Samples from Latham Park

Size Distributions of Airborne Dust - Percentage by Number

Sample Number	Size Ranges					
	½-1 μ	1-2 μ	2-5 μ	5-10 μ	10-20 μ	> 20 μ
1	40.8	18.0	23.7	5.3	3.4	8.8
	75.7	18.4	4.9	0.8	-	0.2
2	52.4	17.7	24.3	1.7	1.3	2.6
	45.4	22.9	19.3	5.9	1.7	4.8
3	55.3	20.3	16.3	2.9	1.8	3.4
	76.5	14.7	4.7	1.0	1.0	2.1
4	47.8	23.0	14.2	6.8	1.4	6.8
	46.8	15.0	18.2	6.9	3.8	10.3

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Table VII

L.B.3 at J.W.R. Ltd.

Measured Concentration of Airborne Dust in Particles/ cc.

Sample Number	Source	Size Ranges						
		½-1μ	1-2μ	2-5 μ	5-10μ	10-20μ	>20μ	Tot
1.	Spray onto wall.	1395.7	1425.9	1546.4	491.4	412.9	387.2	56
2.	5 mins after sample 1.	305.2	259.2	214.0	91.6	59.2	78.0	10
3.	Spray onto roof	1333.8	1222.7	1567.0	589.3	122.0	255.9	50
4.	5 mins.after sample 3.	550.4	368.4	522.9	135.2	76.6	79.9	17
5.	Spray onto wall (predamped)	1821.7	1731.8	1727.5	615.8	424.8	414.2	67

Table VIII

L.B.3 at J.W.R. Ltd.

Size Distribution of Airborne Dust - Percentage by Number

Sample Number	Source	Size Ranges					
		½-1μ	1-2μ	2-5μ	5-10μ	10-20μ	>20μ
1.	Spray onto wall	24.7	25.2	27.3	8.7	7.3	6.8
2.	5 mins after sample 1.	30.3	25.7	21.3	9.1	5.9	7.7
3.	Spray onto roof	26.2	24.0	30.8	11.6	2.4	5.0
4.	5 mins after sample 3.	31.7	21.3	30.2	7.8	4.4	4.6
5.	Spray onto wall (predamped)	27.1	25.7	25.6	9.1	6.3	6.2

Tests 1-4

The results of these tests are summarized in Figure 5.

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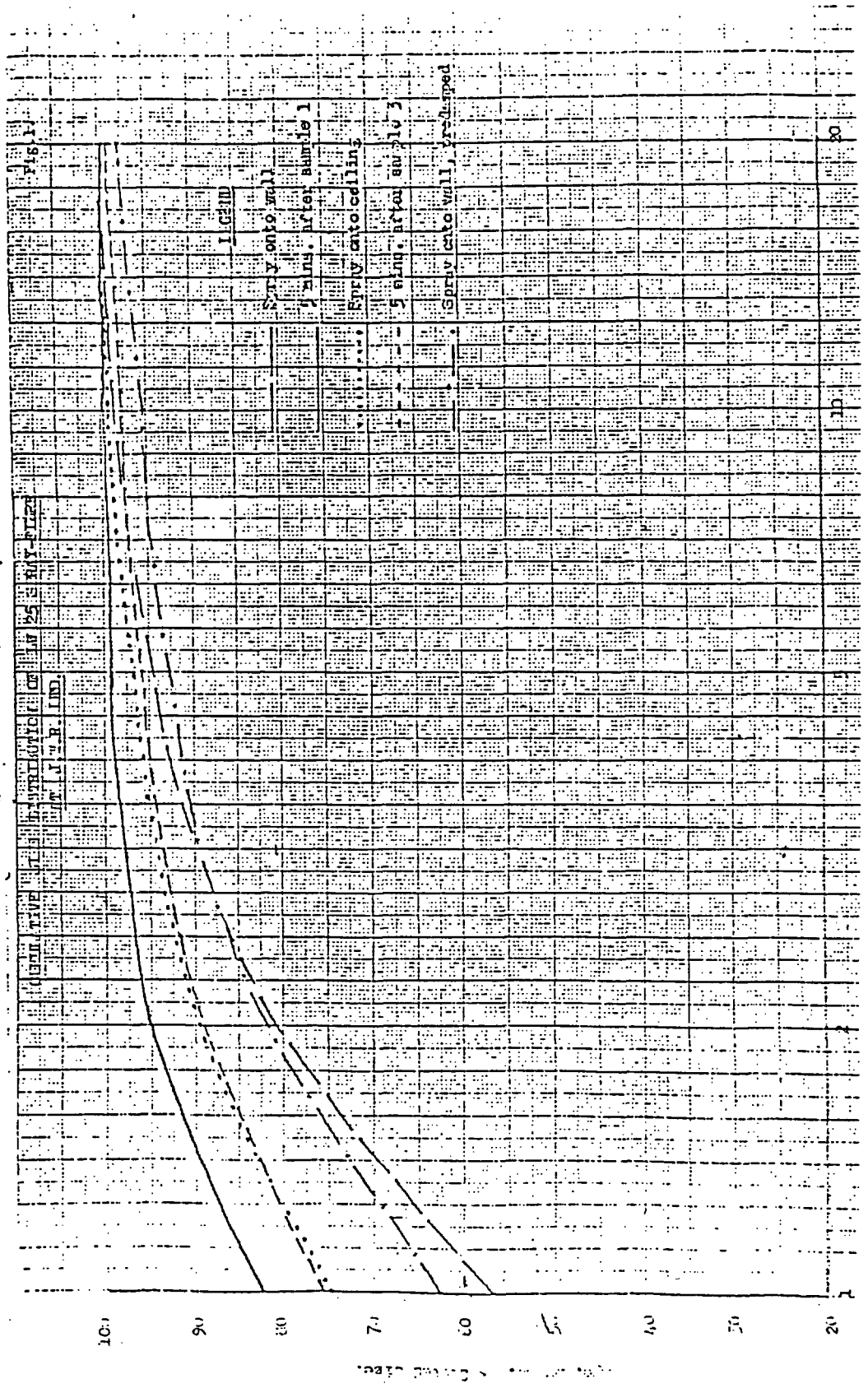
Table IX

Size Analysis of Portland Cement

Size (μ)	% age by No. < Stated Size		
	Sub-sample 1	Sub-sample 2	Mean Analysis
1	58.6	44.4	51.5
2	81.6	74.1	77.9
5	96.9	92.4	94.7
10	99.3	97.7	98.5
20	99.7	99.4	99.6
∞	100.0	100.0	100.0

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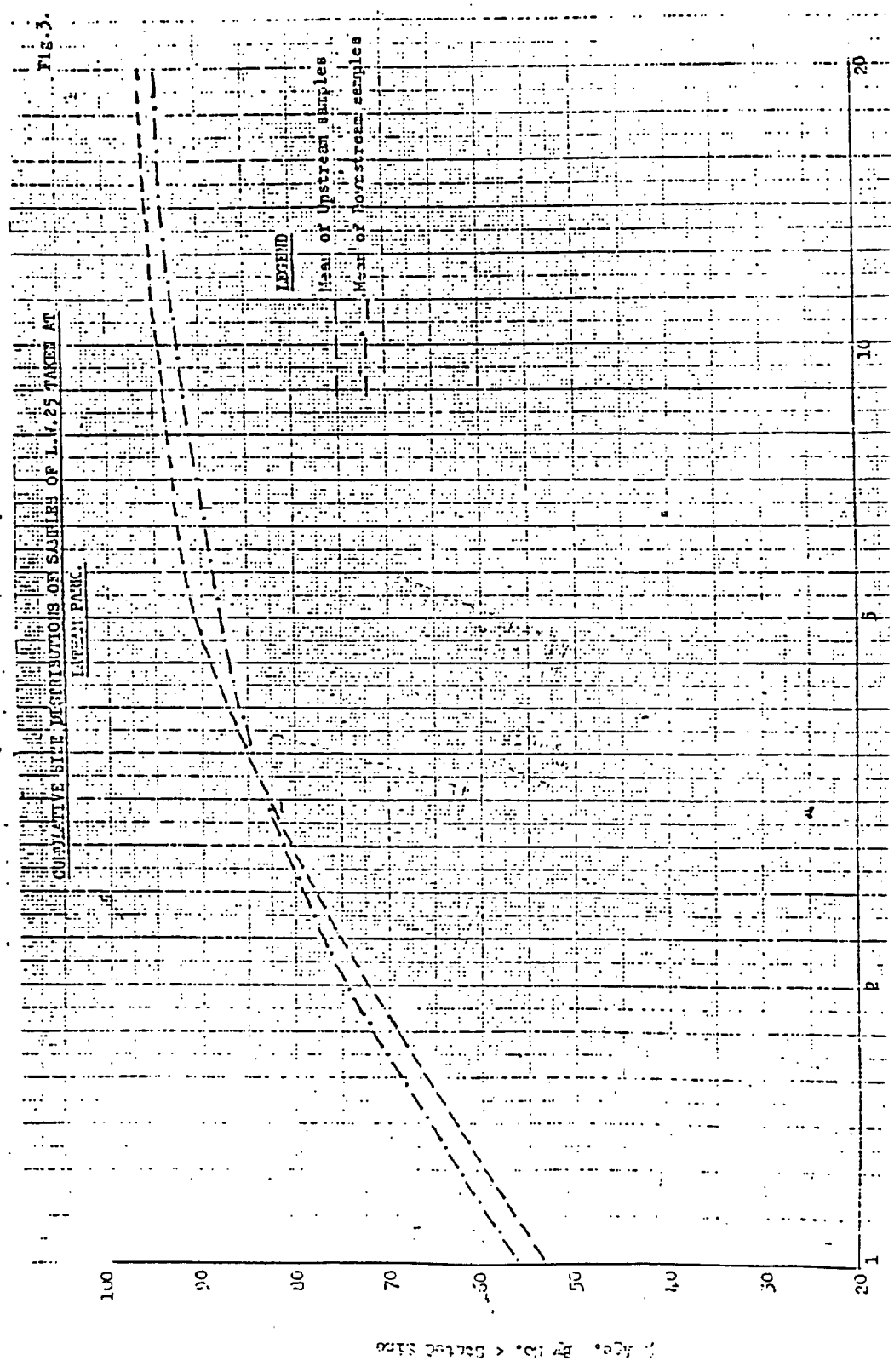


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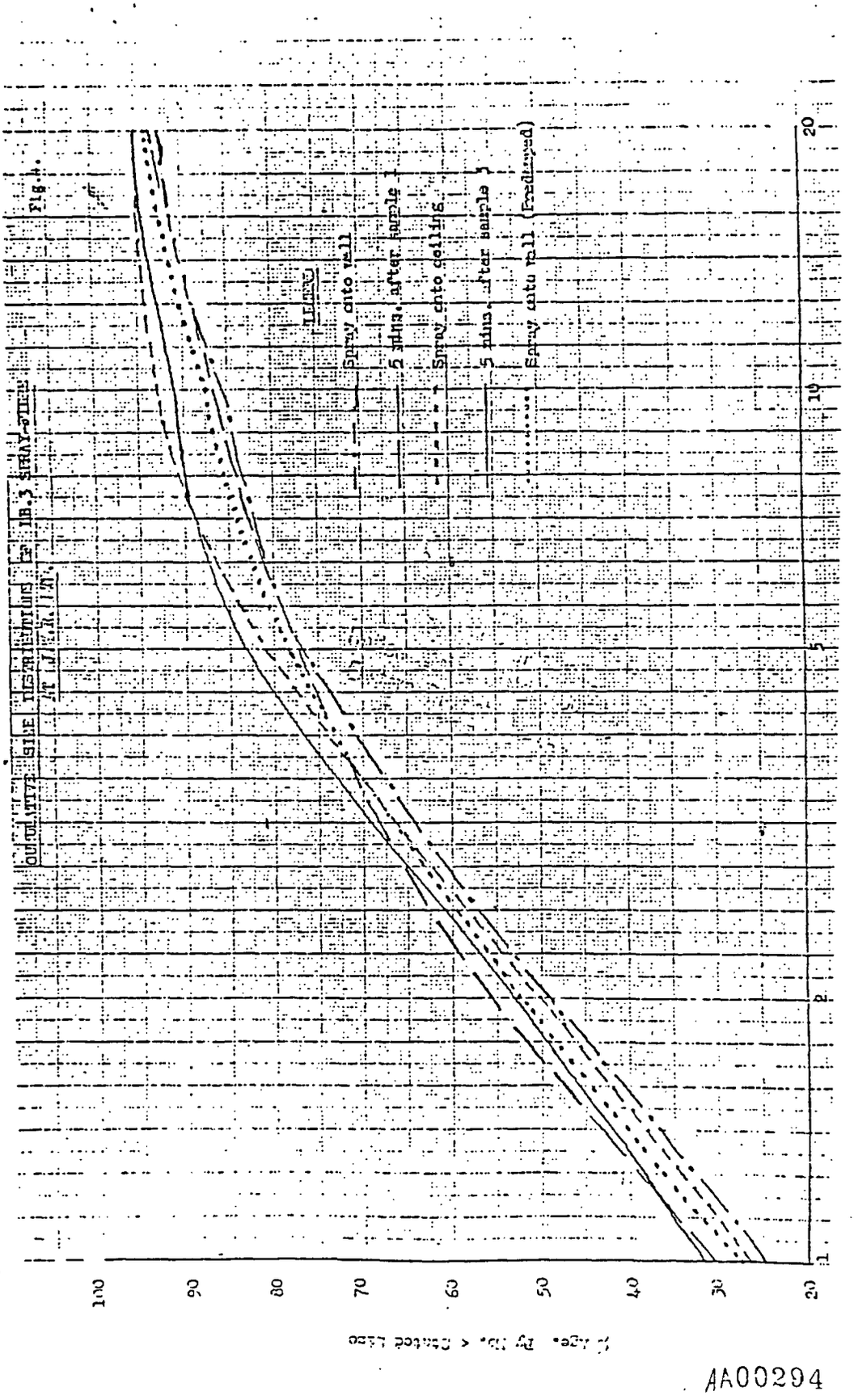
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Fig. 4.
Spray onto wall
5 min. after sample 1
Spray onto ceiling
5 plus. ...ter sample 2
Spray onto wall (Readjusted)
20
10
5
2
1
100
90
80
70
60
50
40
30
20

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