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**CANADA CENTRE FOR MINERAL AND ENERGY TECHNOLOGY
(Former Mines Branch)**

BENEFICIATION OF COKING COAL FOR
SOUTHLAND CONTRACTORS, INC.,
NASHVILLE, TENN., U.S.A.

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April 1976

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ENERGY RESEARCH PROGRAM

ENERGY RESEARCH LABORATORIES

REPORT ERP/ERL 76 - ³⁶37(IR)

ERP/ERL 76-36(IR)

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by

Jan Visman*

SUMMARY

The coal submitted for this investigation was crushed to minus 1/4-in. and separated in a 10 tph pilot plant designed on the principles of the CANMET process. Four tests were run, one on each of three seam sections and another on a mixture of these sections blended in proportion to their relative abundance.

Results of the tests confirm the conclusion drawn from a study of washability characteristics of size fractions of the raw coal that, a sulfur content of 1% or less cannot be attained on an on-going basis because of the natural variability of the mean sulfur and ash contents and the distribution of sulfur and ash over the density fractions.

The test results indicate that the break-even point for a two-product separation is reached for a yield of 61%. A coking-coal grade product with 1.24% sulfur and 7.8% ash was obtained at 37.6% yield for the mixture.

For the mixture the separation efficiency of the process corresponds to a probable error $r=0.02$ for 1/4-in. x 28 mesh at cutpoint d_p 1.285, and $r=0.11$ for 1/4-in. x 0 at $d=1.31$. Its relationship with yields and ash/sulfur contents over a range of cutpoints (1.30 to 1.80) is shown graphically by means of performance evaluation curves (Figures 1 to 9) for the various seam sections and for the mixture of these sections.

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INTRODUCTION

The first discussion regarding the applicability of the CANMET process for the beneficiation of coking coal for Southland Contractors, Inc., was held at the office of the Stirling Processing Co. in Pittsburgh, on December 2, 1975.

As a result of this meeting and a subsequent visit to the Western Research Laboratory in Edmonton on December 16 by company officials, samples of uncrushed raw coal collected by Warner Laboratories were sent to Edmonton and received on February 18, 1976. Basic data on these coal samples are presented in Table 1. The samples consisted of a green-coded series of 10 bbl of coal from seam 5, a red-coded series of 10 bbl from seam 6, and a yellow-coded series of 10 bbl labelled "Item 7" representing a composite sample of seams 1,2,3 and 4 and including three thin partings between these seams.

An aliquot mixture of Items 5, 6 and 7 was composited and processed. The remaining quantities of Items 5, 6 and 7 were processed separately.

Meanwhile, from the results of on-going work on the sub-samples being analysed at Warner Labs, it became clear that the requirements for ash content of the clean coal (max. 8%) and the requirements for sulfur content of prime coking coal (max. 1.0%) could only be met under favourable conditions because of the relatively high and variable sulfur content of the raw coal and its occasional high ash content.

It was agreed for this reason that the plant would make a three-product separation: clean coal, middlings and reject, with optional further treatment of the middlings.

The tests were run on March 23/24, 1976, witnessed by Mr. Forrest H. King, President, Southland Contractors Inc., and a number of visitors.

The products were shipped by truck on April 12, with the exception of 8 drums of middlings (2 from each test) that were held over pending a decision regarding further treatment of these products at a later date.

THE RAW MATERIAL

The Washability Curves¹⁾

The analyses of the various seams comprises 303 data sheets (not included) that have been condensed to 42 washability curves presented in Appendix A of this report (Figures 1A to 7F).

Each set of washability curves represents the float-sink data for the ash content and sulfur content of six size fractions for each of the six seam sections called "Items" numbered 1 to 6. An extra set (Item No. 7) represents the data obtained from a bulk sample that included seams 1 to 4, plus three partings with thicknesses of 2-1/2, 5 and 2-1/2 in. respectively.

The washability curves demonstrate firstly, that the total ash contents of the various size fractions range from 8% to 23% (average = 14.6% as indicated by the bottom end of the cumulative washability curves marked 1. For sulfur the range is 0.8 to 2.9% (average = 1.16%). These are weighted averages. Secondly, the washability curves show how the ash and sulfur constituents are distributed over the various float-sink fractions. An example that shows how to read the washability curves for finding say, the ash content and sulfur content of the floats at 1.40 and 1.60 sp gr, is demonstrated in Figure 12.

The real value of the washability curves lies in the quick answers they provide regarding the optimum yield (weight recovery) and the optimum grind required for making the maximum profit per ton run (run-of-mine) of feed to the plant. For example, Figure 1A of Appendix A represents the washability data for the raw coal ground to minus 2 in. The cumulative float curve (No. 1) for the ash content shows that, in order to obtain a clean coal with 8% ash, a yield of only 38% can be had. Compare this to the curve for the 1/4-in. x 0 fraction of the same coal in Figure 1D - the yield at 8% ash is 72%. The reason for this increase in yield is that the coarse fraction of 2 x 1/4-in. contains much

1) An example of how to read the washability curves is presented in Figure 12.

intergrown coal and shale, as indicated by Figure 1B where no coal of 8% ash is shown to exist. The conclusion then is that, in order to improve the yield for No. 1 seam, the 1/2 x 1/4-in. coal fraction should be crushed to minus 1/4-inch to liberate the coal and shale so that these can then be separated from one another.

Excess of fines(28 mesh x 0) should be avoided by the right choice of crusher for two reasons: 1) the cost of cleaning fine particles is higher than the cost of cleaning coarser coal , and 2) there is only a slight improvement in yield (from 72 to 76%) as a comparison of fractions 1/4-in. x 0 (Fig. 1D) and 28 mesh x 0 (Fig. 1F) shows.

The Ash Characteristics

The average ash content of the mixture (5 + 6 + 7) was 14.57% as found from the samples. The variability of the raw coal ash content is dominated by the upper four seams(Item 7) and moderated by seam 6. This seam section (36 inches thick) is low in ash(6.71%) and therefore tends to be less variable as well.

As Fig. 9.1 shows, the floats at 1.60 sp gr with an ash content of 7.7% comprise 87% of the 2-in. x 0 mixture; the sinks at 1.60 contain 62% ash. This indicates that the mixture can be cleaned to less than 8% ash without having to be crushed to less than 2 inch.

The Sulfur Characteristics

The mean sulfur content of the mixture ranged from 1.16 to 1.74% as found from four combinations of Items 5, 6 and 7 (Table 1).

The lowest sulfur content was found from the analysis of the 2-in. x 0 of seams 5 and 6 (Appendix A, Figs. 5A and 6A) in combination with Item 7 for 2-in. x 0 (see Appendix A, Fig. 7.1A). The latter sample (Item 7) contained 0.83% sulfur. It is noted that the calculation of plant settings for processing this coal was based on the assumption that the raw mixture contained only 1.16% sulfur. However, the sulfur content of the raw mixture actually tested was 1.84%, and that prevented a reduction of the clean coal sulfur content to less than 1 percent. Another high

Table 1 - Basic Data on Coal
Samples as received (condensed from Analyses by
Warner Laboratories)

Seam ("Item")	Thickness of seams		Ash %	Sulfur %	Dry wt (net) of coal, lb	Color Code	Reference to figures
	in.	in %					
1 1)	6	6.9	17.50	2.89		-	App. A, 1A
2 1)	15	17.1	9.51	2.32		-	App. A, 2A
3 1)	9	10.3	17.60	1.36		-	App. A, 3A
4 1)	10 1/2	12.0	11.37	1.27		-	App. A, 4A
5 1)	11	12.6	15.30	1.53	4565	green	App. A, 5A
6 1)	36	41.1	6.71	1.51	4527	red	App. A, 6A
Total	87 1/2	100.0					
7 ²⁾	50 1/2 ²⁾		20.04 ¹⁾ 12.98 ³⁾	0.83 ¹⁾ 1.92 ³⁾	4528	yellow	App. A, 7.1A App. A, 7.2
5 + 6 + 7			10.69 ⁴⁾ 9.95 ⁵⁾ 14.57 ⁶⁾ 14.18 ⁷⁾	1.70 ⁴⁾ 1.74 ⁵⁾ 1.16 ⁶⁾ 1.18 ⁷⁾			App. A, 8.1 App. A, 8.2 App. A, 9.1 App. A, 9.2

NOTES

- 1) Data refer to 2" x 0 composite.
- 2) Natural mixture of items 1,2,3 and 4, including three partings of 2.5", 5", 2.5"
- 3) Mixture of items (1,2,3,4) without partings, calculated for 1/4" x 0.
- 4) Mixture of all items without partings, calculated for 2" x 0.
- 5) Mixture of all items without partings, calculated for 1/4" x 0.
- 6) Mixture of all items with partings, calculated for 2" x 0.
- 7) Mixture of all items with partings, calculated for 1/4" x 0.

sulfur content(1.74%) was found from a calculation based on analyses for the 1/4-in. x 0 fraction of seams 5 and 6 (Appendix A; Figs. 5D and 6D in combination with Items 1,2,3 and 4 for 1/4-in. x 0(Appendix A; Figs. 1D, 2D, 3D, 4D), partings excluded. The latter group of four samples was found to contain 1.92% sulfur, a figure higher by more than one percent than the above 0.83% for 2-in. x 0 and its equivalent 0.73% for 1/4-in. x 0.

Two more combinations (5+6+7) were calculated for 2-in. x 0 and 1/4-in. x 0 as an indication of differences between size fractions. For 2-in. x 0, the sulfur content was 1.70% when using high-sulfur data and for 1/4-in. x 0, the sulfur content was 1.18% when using low-sulfur data.

It is obvious that the mean sulfur contents of the raw coal show variations that make the continuous production of prime coking coal with less than 1.0 percent sulfur problematic.

An important question "What is the expected variability of the raw coal sulfur content within each seam as mining operations progress?" remains outside the scope of this report because it would require core analyses from a comprehensive drilling survey not now available. Yet, it is certain that lateral variations in sulfur content will occur and that these will, more than likely, have a detrimental effect on the recovery of prime coking coal for the following reasons. To begin with, the washability data demonstrate that the amount of prime coking coal with less than 1.0% sulfur is very limited. This is indicated in Table 2 where the sulfur contents of the lightest coal fraction(1.30 sp gr floats) are listed. Only one of the seams(No. 4) has a sulfur content of less than 1.0 percent for the floats at 1.30. This seam is only 10-1/2 inches thick. The weighted mean sulfur content shows significantly lower values for the 28 mesh x 0 fractions, indicating that in order to liberate the intergrown sulfur, the raw coal would have to be finely ground, well below the normal top size of 1/8-in. that is readily acceptable to the coke industry. Apart from this size restriction, the coal could be effectively cleaned in this form, be it at a higher cost. Another point worth noting is that the middlings(1.45-2.00 sp gr) are high in sulfur even when ground to minus 28 mesh. Therefore, the recovery of clean coal will be limited to the amount of coal minus

1.45 sp gr available in the raw coal. The overall prospects as far as sulfur reduction is concerned are not favorable for producing substantial amounts of prime coking coal from this deposit. From the analytical work done on the four seams (Item 7) it is evident that the variability poses a risk that cannot be evaluated without doing further work involving a drilling survey. However, a coking coal can be produced for blending with other coals of complementary composition.

Table 2 - Sulfur in Floats at 1.30

Seam No.	2-in. x 0	1/4-in. x 0	28 mesh x 0
1	1.64	1.56	1.21
2	1.27	1.31	1.08
3	1.11	1.23	0.88
4	0.96	0.78	0.33
5	1.23	1.12	0.85
6	1.07	1.19	0.80
Weighted Mean, % S	1.15	1.18	0.82
Item 7	0.70	0.64	0.64

PERFORMANCE EVALUATION

Before the crushed raw coal samples were processed, calculations were made to evaluate in advance the expected yields, ash contents, and sulfur contents of the products for a range of cutpoints (d_p).

The efficiency of separation, expressed by the probable error (r) and as determined from previous experience with similar coals¹⁾ was assumed to range from $r=0.08$ for 1/4-in. x 28 mesh to $r=0.12$ for 1/4-in.

1) See Technical Bulletin, TB 141 (attached), Fig. 9 and p 14.

x 0, depending on the relative abundance of slimes present. It is noted that these r-values apply to Compound Water Cyclones of 8-in. diameter (CWC-8) as well as to the larger CWC-24 treating the same coal with a proportionally larger top size of 3/4-in. or more. As it is the intention to clean raw coal with a top size of 2-in., the estimates calculated for the pilot plant can be regarded as a conservative guide for what is expected of the commercial plant.

The performance evaluation curves²⁾ showing the expected values for ash, sulfur, etc. for the six seam sections and the Mixture (Items 5 + 6 + 7) are presented in Figures 1 to 9.2. An example of how to read this type of graph is illustrated in Fig. 1 which represents the characteristics of Item 1. See also Table 1 and Fig. 1A (Appendix A) for details.

The example illustrates that when the plant is cleaning Item No. 1 (17.50% ash) and is adjusted to make a 75% yield, an actual ash content of 13.9% can be expected for the clean coal with a corresponding reject ash content of 28%. The sulfur content (2.89% in Table 1) will be reduced to 2.52% in the clean coal, leaving 3.9% in the reject. The cut-point is 1.53 sp gr. It is noted that the reduction in sulfur from 2.89 to 2.52, or 0.37%, is found from the float-sink curve for sulfur and therefore represents the theoretical maximum reduction. The reason for this high expectation is that the removal of pyritic sulfur approaches the theoretical level because the free, fine pyrite filters readily through the cyclone bed and reports to the reject with the coarse pyrite. Some allowance should be made for small losses in the order of 0.1% of pyritic sulfur being discharged with the overflow product.

Performance evaluation curves are given for individual seam sections in,

Figs. 1 to 4 (Items 1 to 4); 2-in. x 0

Figs. 5 to 6 (Items 5 to 6); 2-in. x 0 and 1/4-in. x 0

Fig. 7 (Item 7); 2-in. x 0 and 1/4-in. x 0

Figs. 8 to 9.2 (Mixture); 2-in. x 0 and 1/4-in. x 0

These figures demonstrate that the clean coal ash contents for individual Items vary between 4 and 12% and that sulfur contents vary

2) Described in TB 141, Fig. 3 and p 7.

between 0.9 and 1.4%, with the exception of Item 1 which at 2.5% sulfur is quite high. For the mixture, the expected clean coal ash contents range from 6 to 8% and sulfur contents from 0.8 to 1.3%.

It is seen from Figures 9.1 and 9.2 that recovery of prime coking coal is possible, but that the joint requirement of 8% ash and 1% sulfur is met only once out of three times. In the other cases, either the ash content or the sulfur content is too high.

THE PLANT

In an earlier publication, Technical Bulletin 141(1), a description of the CANMET(EMR) process is presented on p 12 and a general flow-sheet is shown in Fig. 6 on p 27. Since the publication of TB 141 in 1971, the process has been field-tested and to date, approx 175,000 tons of raw material have been processed in a 100 tph plant. The four-section concept has been proved economical in its present form as shown in Fig. 10 and permits compact construction at a fraction of the capital cost of comparable conventional wash plants. This compact structure is an inherent synergistic feature of the process and a visible indication of the overall effectiveness of the CANMET process.

In its present form the Cleaning Section has a separate slimes circuit for cleaning the recirculating water that is bled from the main CW Cyclone circuit as shown in Fig. 11. The slimes circuit is equipped with elongated CW Cyclones, especially designed for cleaning coal slimes.

The Drying Section has remained unchanged. In the Water Recovery Section, a bottom-fed thickener has been added to the cyclonic flocculator-clarifier equipment to replace the bulkier inclined settler previously used for clay removal.

In the proposed commercial plant, the equipment of these sections is "stacked" so that spills of solids and/or water are automatically by-passed and fed back with minimal losses in down-time. In other words, the proposed plant structure is built high and narrow in order that gravity can be utilized to the maximum for dealing with spills such as are bound to occur from time to time.

This principle has been followed in the pilot plant although

not to the extent possible in the field, because the height available here is only 36 feet. Other than that, the pilot plant presents a true replica of a commercial plant on a smaller scale and, as mentioned above on p 7, its results can be directly expressed in terms applicable to the full-scale plant.

THE TEST

The pilot plant was tested with four relatively small samples (1 to 2 tons each), the mixture first, then the three individual seam sections No. 5, 6, and 7. A three-product separation was made to produce a low-ash, low-sulfur clean coal, a middlings product, and a high-ash, high sulfur reject. The reject was produced in two separate size fractions labelled coarse reject and fine reject.

The settings of the vortex finders and other pertinent adjustments were as follows.

	Main CWC Circuit		Slimes Circuit	
	CWC I	CWC II	CWC I	CWC II
Compound Cone Type	L	M	L	M
CWC Type	Elongated 2-in.	Standard	Elongated 4-in.	Standard
Vortex Finder Clearance	5 in.	3/4 in.	7 in.	3/8 in.
Throughput of feed solids	10 tph			
Duration of trials	7 to 11 minutes			
Feed inlet pressure:	Main CWC circuit-25 psi slimes circuit- 18 psi			
Oil used:	Special Furnace Oil Mixture (Shell)			
Flocculants used:	Dow MG 700 + Alchem 603			

Incremental samples were collected from each product during the test. A portion of the middlings (8 bbl) was retained for further testing later on. The remaining products were shipped to Stirling Processing for

analysis at Warner Labs and for coking trials. The test results are condensed in Table 3 and the error curves of the primary cuts are presented on Figures 13 to 16 for two size fractions (1/4-in. x 28 mesh and 1/4-in. x 0). The partition numbers of these error curves are listed in Table 4.

DISCUSSION OF RESULTS

The main objective, i.e. to attain sharp separation by the plant as such when making a coking-coal grade product, was accomplished as shown by the distribution curves for the primary cut of the four samples. Figures 13 to 16 represent, firstly, the distribution curves for the entire 1/4-in. x 0 product. The cutpoints vary from 1.29 to 1.34 (average $d_p = 1.31$), and the probable errors vary from 0.09 to 0.13 (average $r = 0.11$). Another yardstick of separation sharpness, the area under the curve (Error Area) ranges from 75 to 87 sq cm (average = 76). In judging these results, it is noted that the 1/4-in. x 0 feed contained from 39.5 to 46.2% of 28 mesh x 0 slimes (average 42%). These slimes influence the distribution curve of the plant to a considerable degree. Therefore, a second set of distribution curves representing the 1/4-in. x 28 mesh fraction is also presented on Figures 13 to 16 with partition numbers, etc. in Table 4.

The results show that the EMR plant is capable of cleaning 1/4-in. x 28 mesh coal at cutpoints ranging from 1.27 to 1.31 (average 1.285) with probable errors ranging from 0.02 to 0.07 (average 0.033). These results are excellent. They compare favorably with those obtained from heavy-medium cyclones, firstly because of the very low probable error attained in the presence of large amounts of slimes and secondly, because of the very low cutpoint which is required for the recovery of low-sulfur coal contained in the 1.30 floats fraction. For cutpoints higher than 1.30, the probable error is expected to be somewhat higher, approaching an average $r = 0.07$.

The problem that stands in the way of making a profitable operation lies as mentioned above in the unfavorable composition and variability of the raw coal. The sulfur and ash are finely intergrown

Table 3 - Test Data

Item (5+6+7)	Coal	Middlings	Coarse Refuse	Fine Refuse	Feed	Total
<u>Mixture</u>						M+R (calc) Ash: 22.1% Sulfur: 1.98% Fig.9.1-8.1-16
Wt (wet) lb	1529	2354	143	453	4268	
Moisture %	9.12	21.09	21.19	26.56	4.38	
Wt (dry) lb	1389.6	1857.5	112.7	332.7	4081.1	3693
Wt %	37.6	50.3	3.1	9.0	100 %	
Ash % (Dry)	7.83	22.03	36.59	17.39	15.66	(16.72 calcd)
% Sulfur "	1.24	1.84	3.49	2.21	1.84	(1.70 calcd)
<u>Item 5 Green</u>						M+R (calc) Ash: 24.5% Sulfur: 1.96% Fig. 5.1-13
Wt (wet) lb	1590	2044	169	603	3968	
Moisture %	10.84	21.60	14.97	22.53	3.89	
Wt (dry) lb	1417.6	1603	144	467	3814	3632
Wt %	39.0	44.1	4.0	12.9	100 %	
Ash % (Dry)	6.15	24.40	38.92	20.43	16.08	(17.35 calcd)
% Sulfur "	1.21	1.76	2.29	2.52	1.55	(1.66 calcd)
<u>Item 6 Red</u>						M+R (calc) Ash:13.1%(6.2) Sul:2.47%(6.2) Fig. 6.2-14
Wt (wet) lb	1233	1234	182	460	2970	
Moisture %	8.52	22.61	10.11	25.80	4.03	
Wt (dry) lb	1128	955	164	341	2850	2588
Wt %	43.6	36.9	6.3	13.2	100 %	
Ash % (Dry)	5.49	11.63	22.72	12.75	8.40	(9.80 calcd)
% Sulfur "	1.34	2.12	3.81	2.79	1.76	(1.97 calcd)
<u>Item 7 Yellow</u>						M+R (calc) Ash: 28.5% Sulfur: 1.78% Fig.7.1-7.2-15
Wt (wet) lb	982	1275	84	457	2414	
Moisture %	8.50	15.74	22.52	66.15	4.55	
Wt (dry) lb	899	1074	65	155	2304	2193
Wt %	41.0	49.0	3.0	7.0	100 %	
Ash % (Dry)	8.57	28.96	49.77	15.79	20.91	(20.30 calcd)
% Sulfur "	1.21	1.56	4.56	2.17	1.57	(1.55 calcd)

Table 4 - Partition Numbers

Seam Section Size →	Item 5 (Green)		Item 6 (Red)		Item 7 (Yellow)		Mixture (5 6 7)	
	1/4 x 28	1/4 x 0	1/4 x 28	1/4 x 0	1/4 x 28	1/4 x 0	1/4 x 28	1/4 x 0
Floats 1.30	59.2	53.1	64.1	47.0	59.9	39.9	68.5	54.0
1.30-1.35	60.4	45.2	80.2	77.1	47.1	37.3	64.9	48.0
1.35-1.40	83.8	65.0	91.1	78.6	74.4	57.5	88.6	68.1
1.40-1.50	84.7	70.1	95.9	87.0	85.6	69.8	93.7	70.4
1.50-1.60	100	71.6	100	82.2	95.4	88.6	95.0	83.8
1.60-1.80	100	80.9	100	91.9	100	86.7	100	84.8
1.80-2.00	100	90.3	100	82.1	100	92.9	100	86.5
Sinks 2.00	100	93.6	100	100	100	93.0	100	91.5
Cutpoint	1.27	1.29	1.27	1.27	1.30	1.34	1.30	1.31
Prob. error	0.02%	0.13	0.02	0.09	0.07	0.11	0.02	0.11
Error Area	20	87	16	66	27	75	15	76
Size Distribution	59.0	100.0	53.8	100.0	58.6	100.0	60.5	100.0

in all specific gravity fractions except the 1.30 floats of some of the seam sections.

A possible solution is indicated from the washability curves by the fact that sulfur and ash can be liberated by grinding the coal to minus 28 mesh after the low-sulfur coal and the finished reject have been removed. In other words, by grinding and then processing the middlings, a coking grade product can be produced. The profitability of grinding one-half of the raw coal to minus one-half millimeter is questionable. However, it is worthwhile to investigate the possibility of using the Slimes Section for this purpose in conjunction with partial froth flotation and a cage-mill as a grinder.

The only alternative solution is that a market be found where the middlings can be sold at a minimum fob price of \$15 per short ton, the break-even price under conditions reported on Table 3 for the mixture (Items 5+6+7). It is not an attractive solution compared to the one first-mentioned where a high yield of coking coal is recovered from the middlings and sold at more than double the price.

Additional flotation would also improve the fine reject which was produced during the test runs on the four coals. It is estimated that back-up flotation for this product will increase the overall yield by approximately 4% for the mixture (Items 5+6+7).

Finally, with regard to the performance evaluation (PE) curves 1 to 9, the question may be asked as to how the predicted results for the 1/4-in. x 0 coal compared to those actually obtained. To this end, the "reject" of the primary cut which consists of middlings, coarse reject, and fine reject, was calculated from the data on Table 3 and is shown as M+R (calc) in the last column of the same table. The corresponding points are plotted on the relevant Figures mentioned above, and are shown as circled points, the circles having diameters giving an indication of the precision (maximum error) of the points in question. Note that the points for sulfur are read from the ash abscissa which indicates a scale that is 10 times enlarged as far as sulfur is concerned. Therefore, the circles indicating precision for sulfur ($\sim 0.1\%$) are larger than those indicating the precision of the ash content ($\sim 0.5\%$).

The graphs show that there is general agreement between actual

and predicted values when taking into consideration the fact the PE curves were calculated on the basis of ash and sulfur contents that differ here and there from the composition of the coals that were actually tested.

CONCLUSION AND RECOMMENDATIONS

1. The raw coal submitted for testing is inherently unsuitable for making prime coking coal with less than 1.0% sulfur, unless the larger part of it is ground to minus 28 mesh.
2. As far as sulfur reduction of a 2-in. x 0 mine-run mixture (5+6+7) is concerned, the economic prospects are not favorable for an ongoing production of substantial recovery of coking coal unless a market for middlings is available at a base price of minimum \$15/ton.
3. The test results confirm that for this coal, separation efficiency of the CANMET process plant as such is equal to the best systems of coal preparation, witness the average probable error of 0.033 at an average cutpoint of 1.285 for the 1/4-in. x 28 mesh fraction.
4. For improvement of the fine reject, flotation is recommended as a back-up operation.
5. It is recommended that an additional test on the middlings be done to investigate the possibility of upgrading this material to prime coking-coal grade by selective grinding and retreatment, hand in hand with a cost-benefit study.

461510

10 X .10 TO THE CENTIMETER 18 X 25 CM. KEUFFEL & ESSER CO. MADE IN U.S.A.

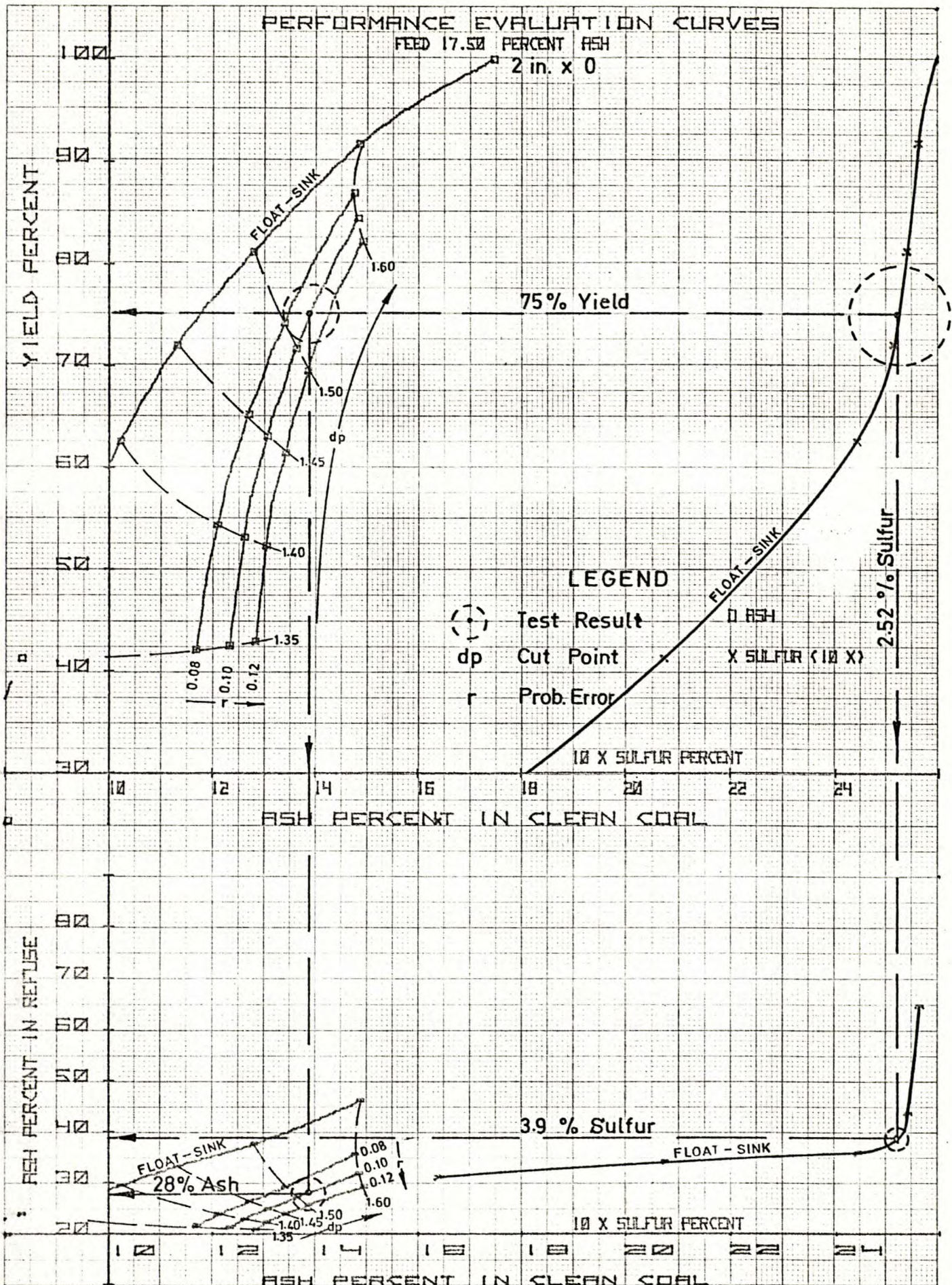


FIGURE 1 ITEM 1 - CHANNEL SAMPLE (6 in.)

461510

10 X 10 TO THE CENTIMETER
KODAK SAFETY FILM
KODAK SAFETY FILM CO. WASHINGTON, D.C.

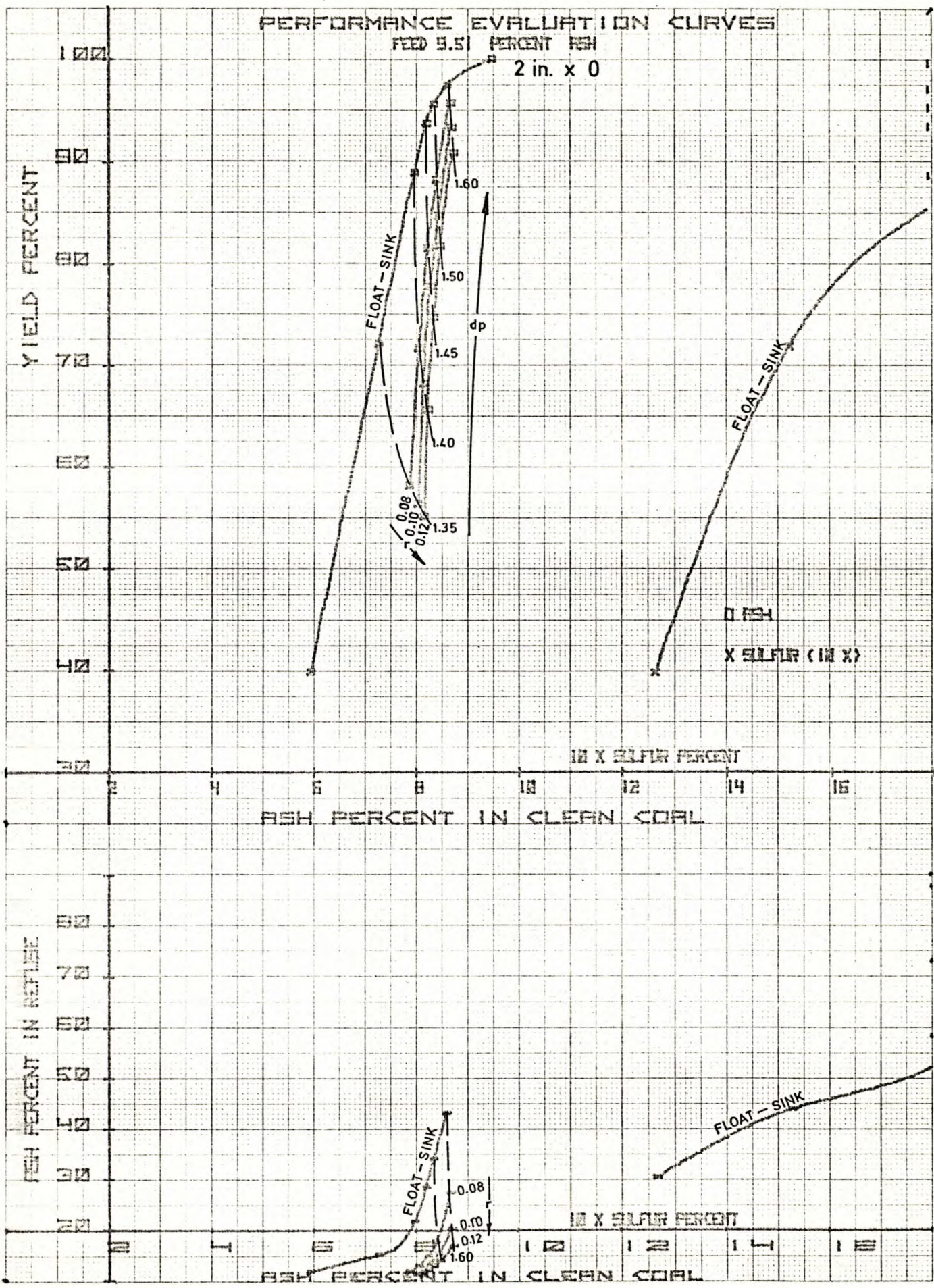


FIGURE 2 ITEM 2 - CHANNEL SAMPLE (15 in.)

461510

12 X 10 TO THE CENTIMETER 10 X 25 CM
MILFORD & SONS CO. MADE IN U.S.A.

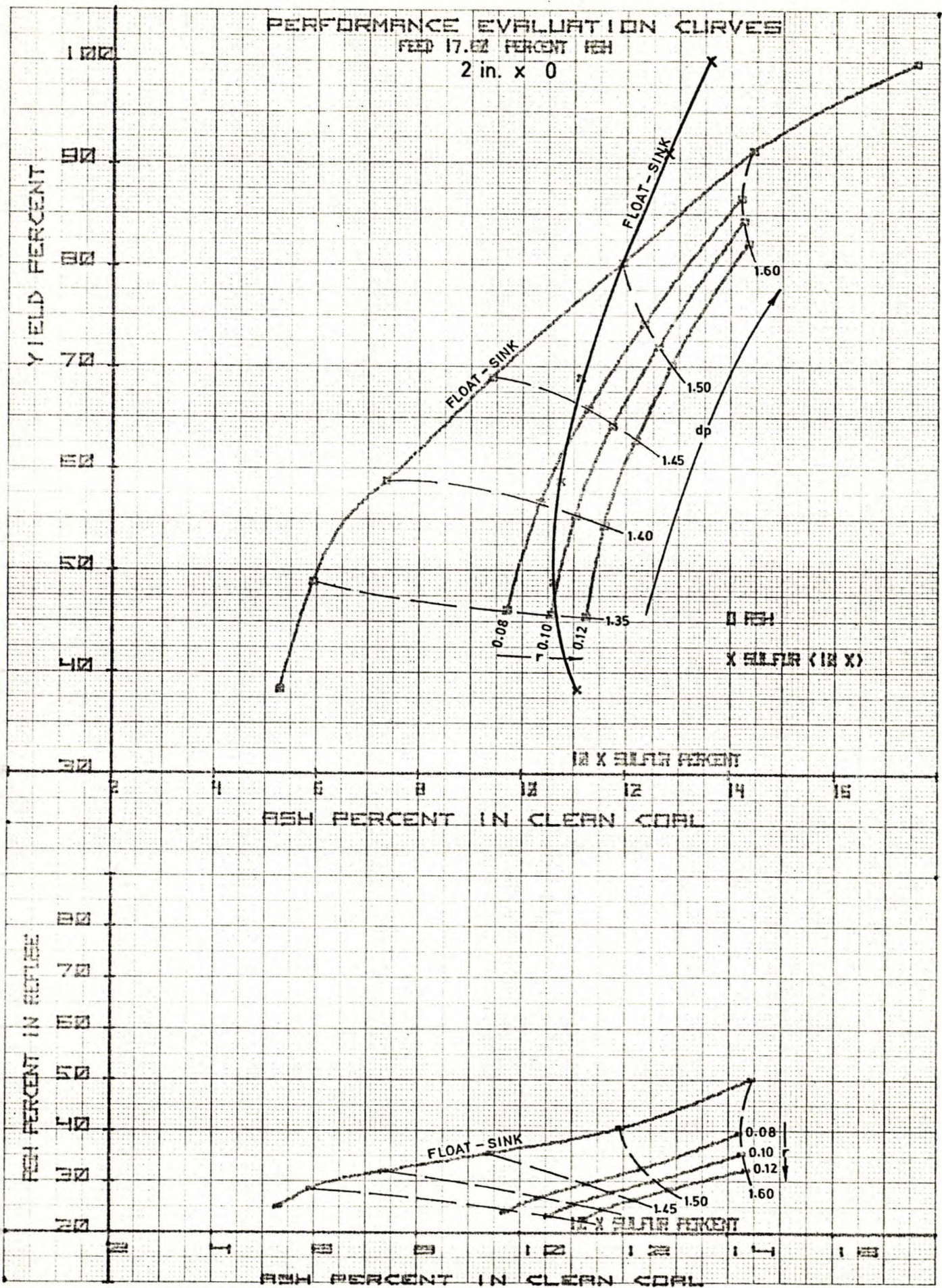


FIGURE 3 ITEM 3 - CHANNEL SAMPLE (9 in.)

461510

K₁₅ 10 X 10 TO THE CENTIMETER 10 X 10 CM KEUFFEL & ESSER CO. MADE IN U.S.A.

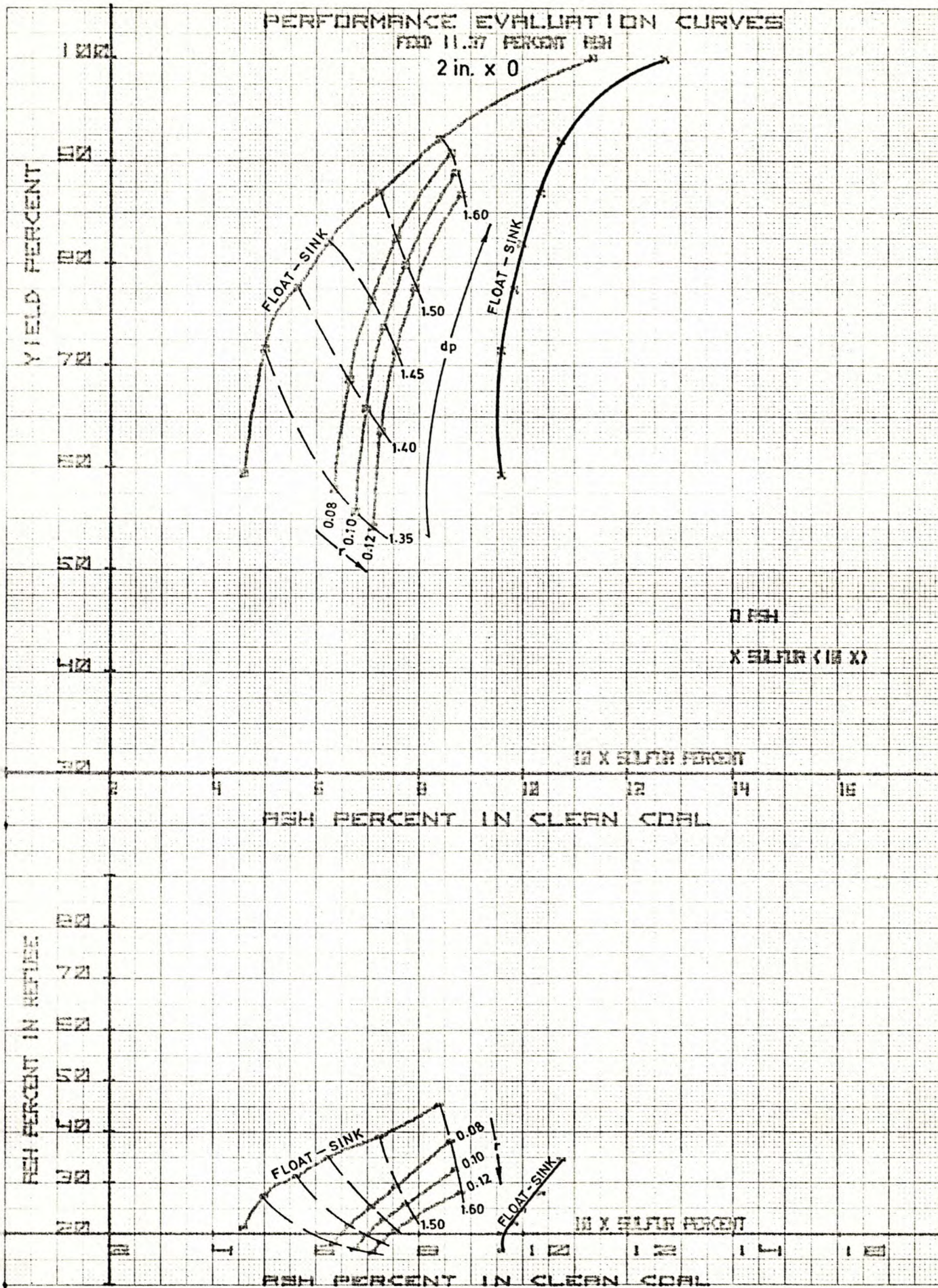


FIGURE 4 ITEM 4 - CHANNEL SAMPLE (10 1/2 in.)

461510

SCALE 10 X 10 TO THE CENTIMETER IS X 25 CM.
MADE AT OPTEL & ESSER CO. MADE IN U.S.A.

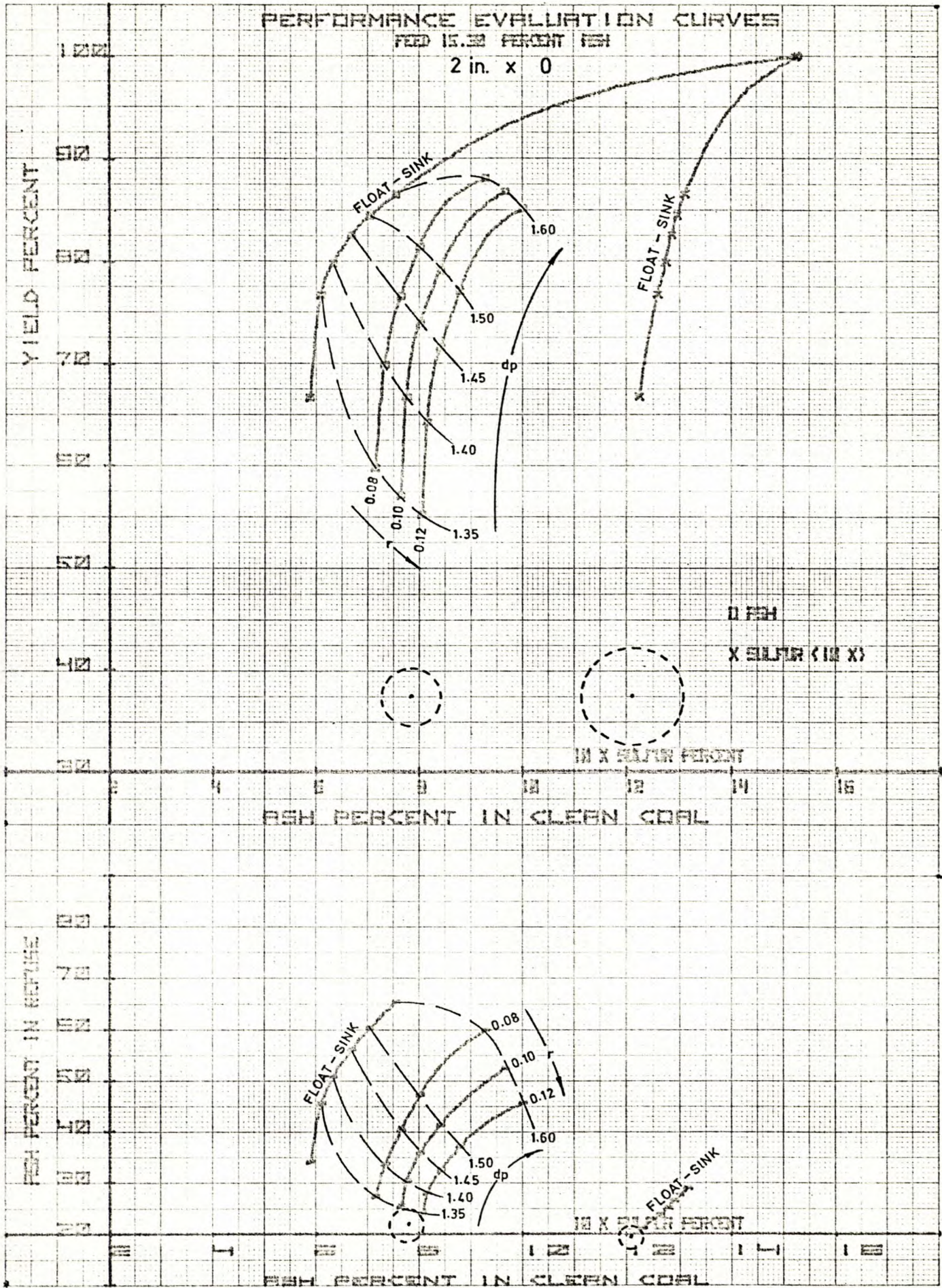


FIGURE 5.1 ITEM 5 - CHANNEL SAMPLE (11 in.)

461510

K&S 10 X 10 TO THE CENTIMETER KEUFFEL & ESSER CO. MADE IN U.S.A.

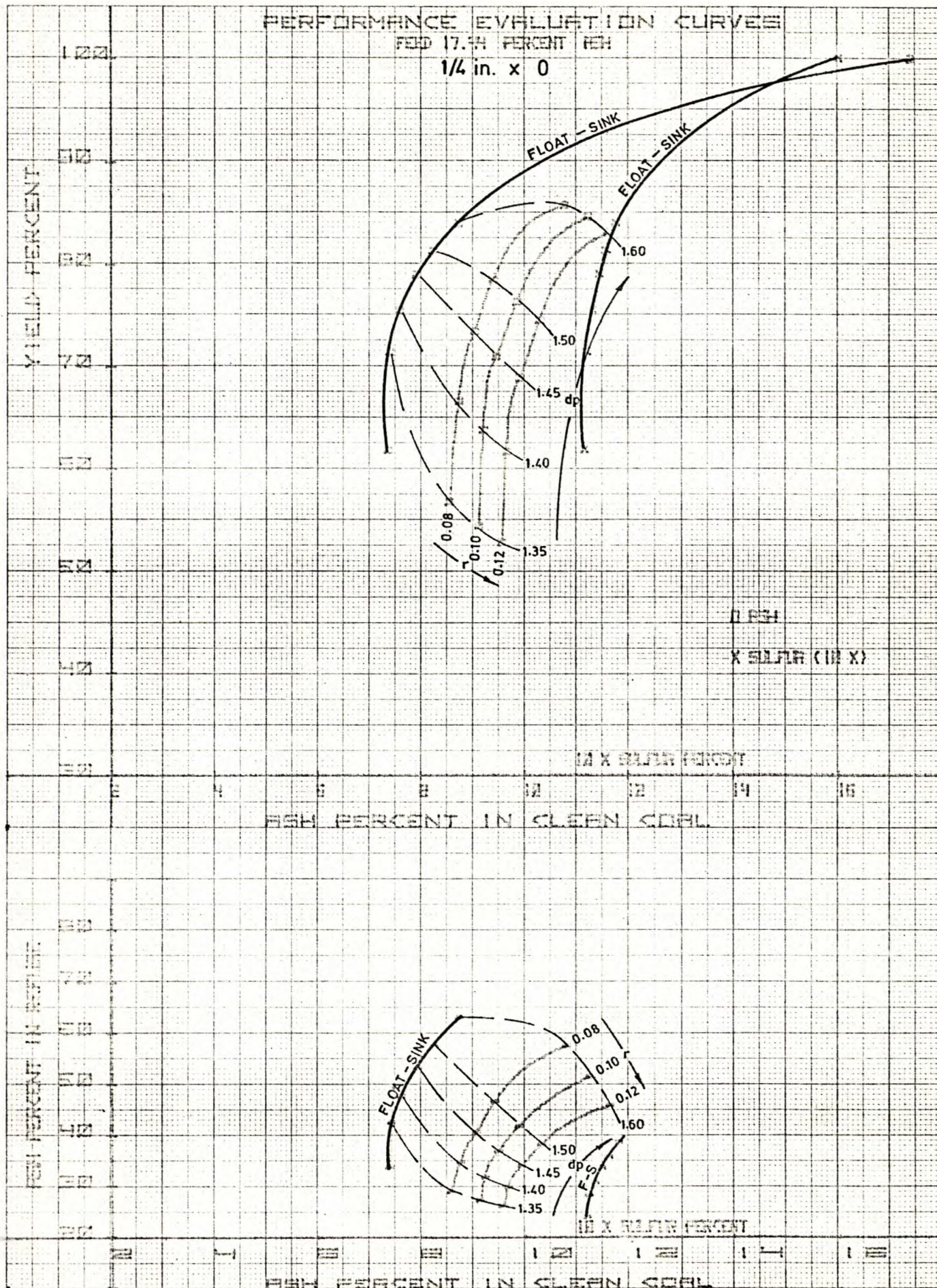


FIGURE 5.2 ITEM 5 - CHANNEL SAMPLE

461510.

1/2 X 10 TO THE CENTIMETER 1/8 X 25 CM
MILITARY & ASSOCIATED CO. MADE IN U.S.A.

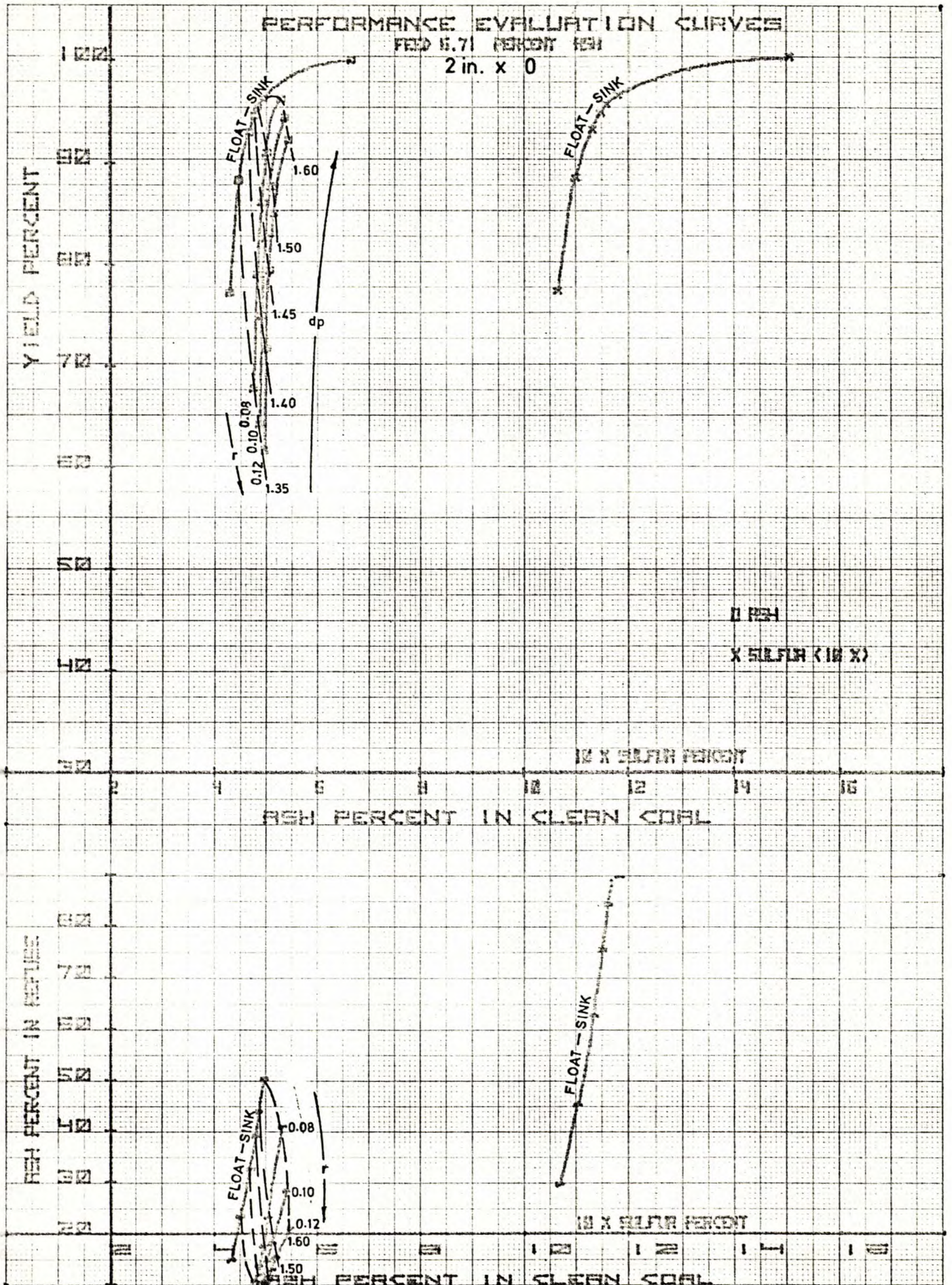


FIGURE 6.1 ITEM 6 - CHANNEL SAMPLE (36 in.)

461510

NO. 10 X 10 TO THE CENTIMETER
KODAK SAFETY FILM
KODAK SAFETY FILM

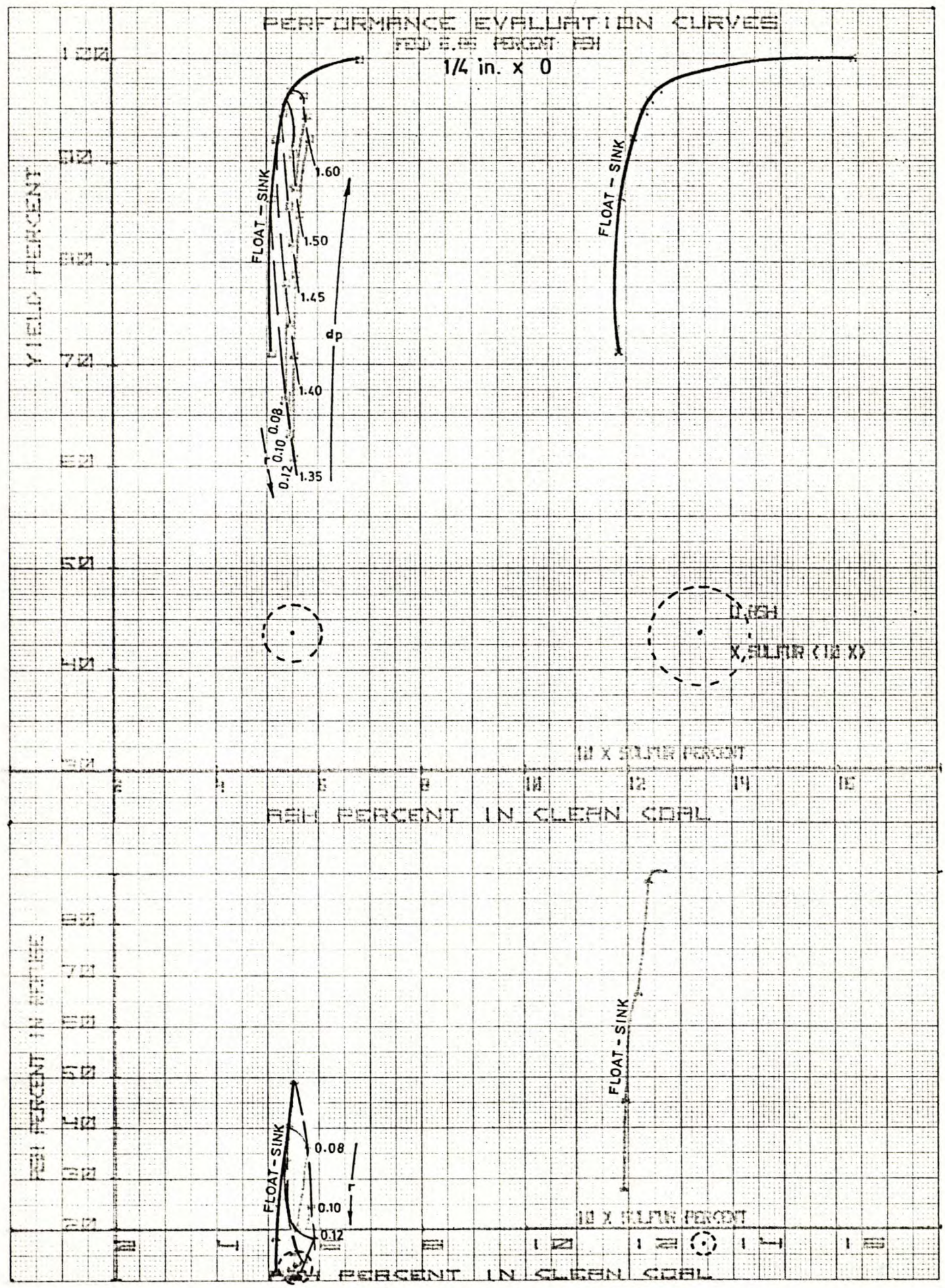


FIGURE 6.2 ITEM 6 - CHANNEL SAMPLE

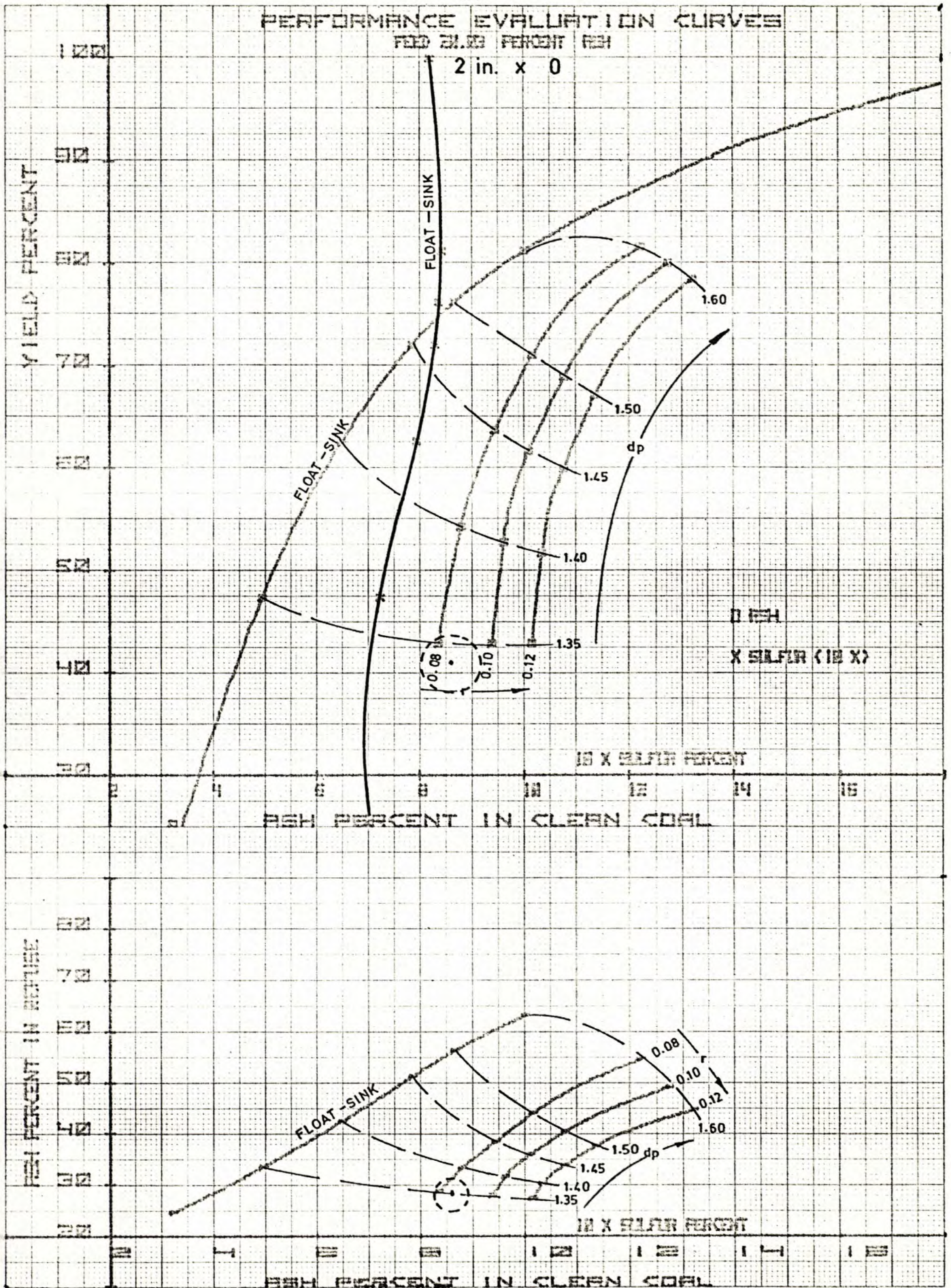


FIGURE 7.1 ITEM 7 - CHANNEL SAMPLE (1+2+3+4) - LOW SULFUR (50 1/2 in.)

461510

10 X TO THE CENTIMETER BY X FROM
FUEL SYSTEMS CO. MARIETTA

461510

10 X 10 TO THE CENTIMETER
KODAK SAFETY FILM
KODAK SAFETY FILM

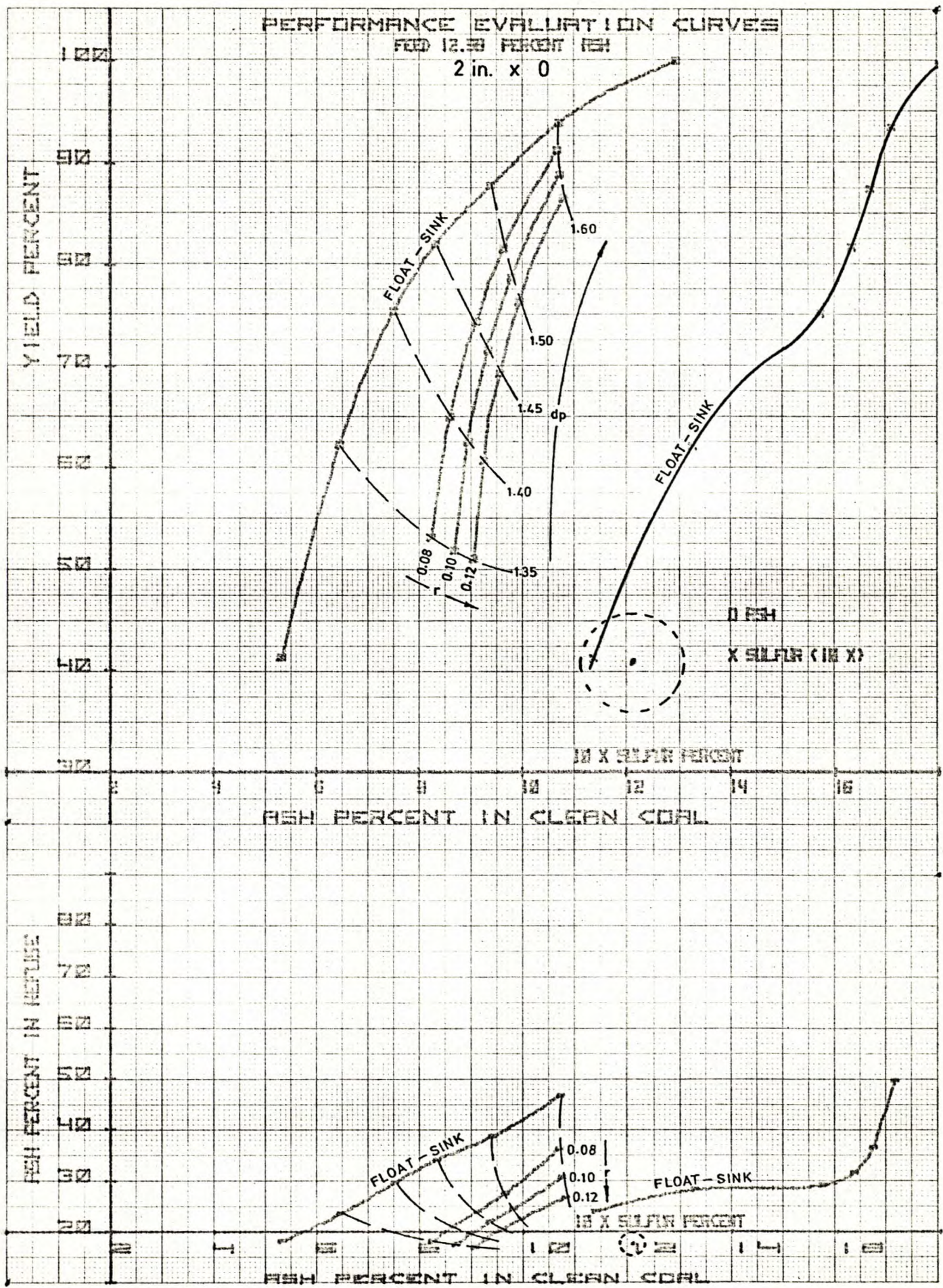


FIGURE 7.2 ITEMS (1+2+3+4) HIGH SULFUR (PARTINGS EXCLUDED) - (40 1/2 in.)

461510

No. 10 X 10 TO THE CENTIMETER
NEUFEL & ESSER CO. MADE IN U.S.A.

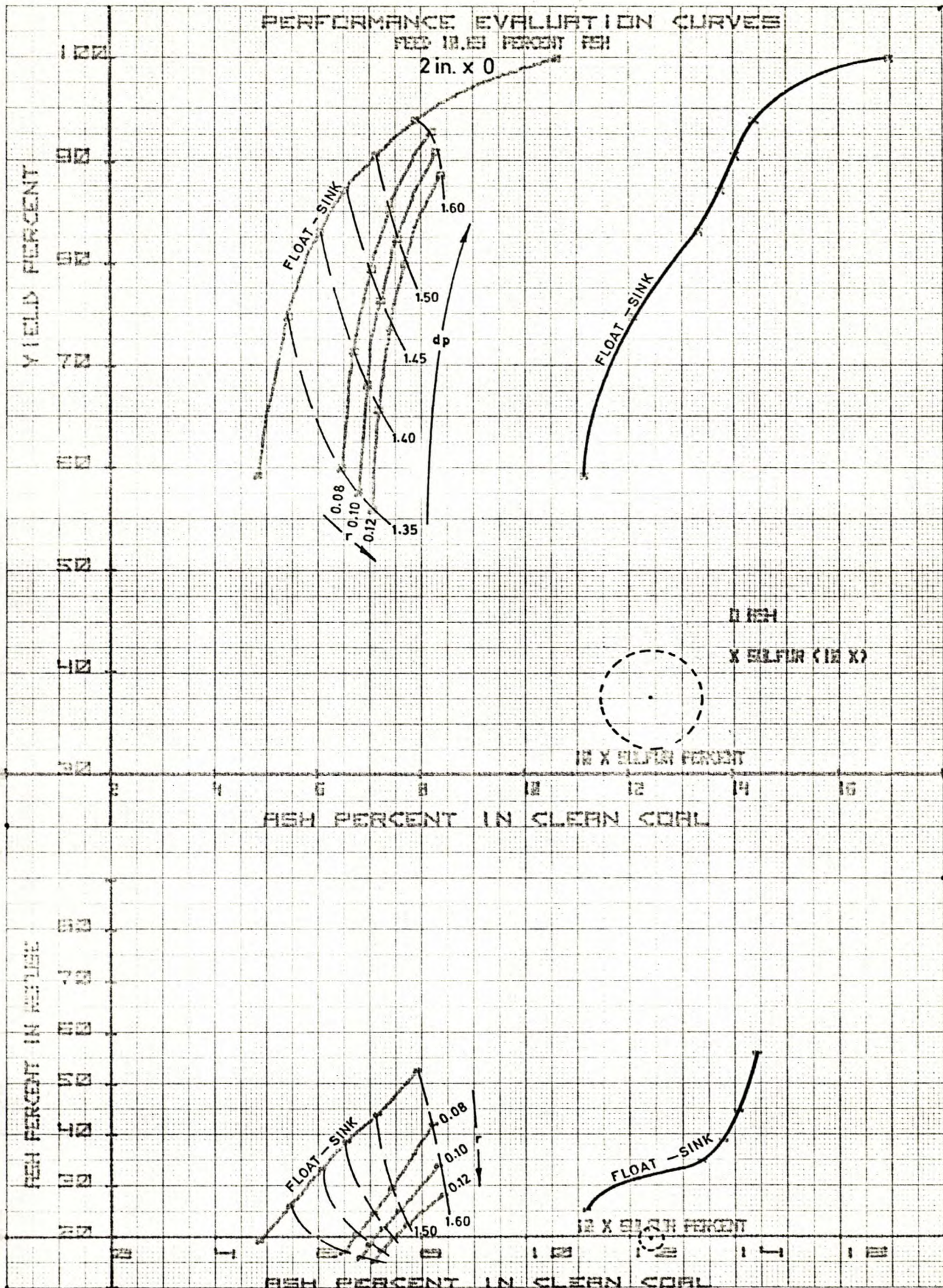


FIGURE 8.1 MIXTURE (1+2+3+4) +5+6 (97 1/2 in., partings included)

461510

10 X 10 TO THE CENTIMETER
KEUFFEL & ESSER CO. MADE IN U.S.A.

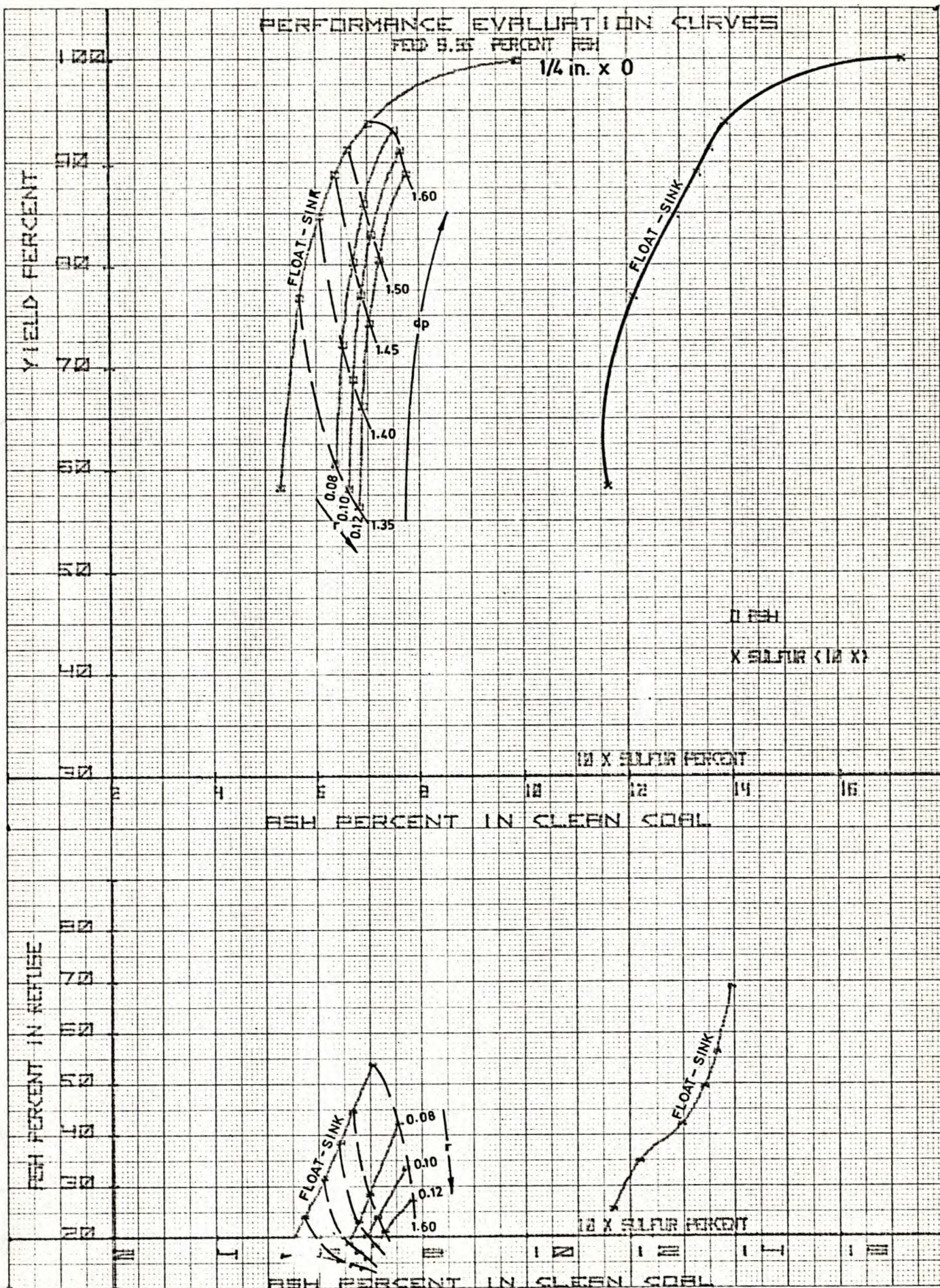


FIGURE 8.2 MIXTURE (1+2+3+4) +5+6

461510.

10 X 10 TO THE CENTIMETER 18 X 25 CM
KLEUFEL & ESSER CO. MADE U.S.A.

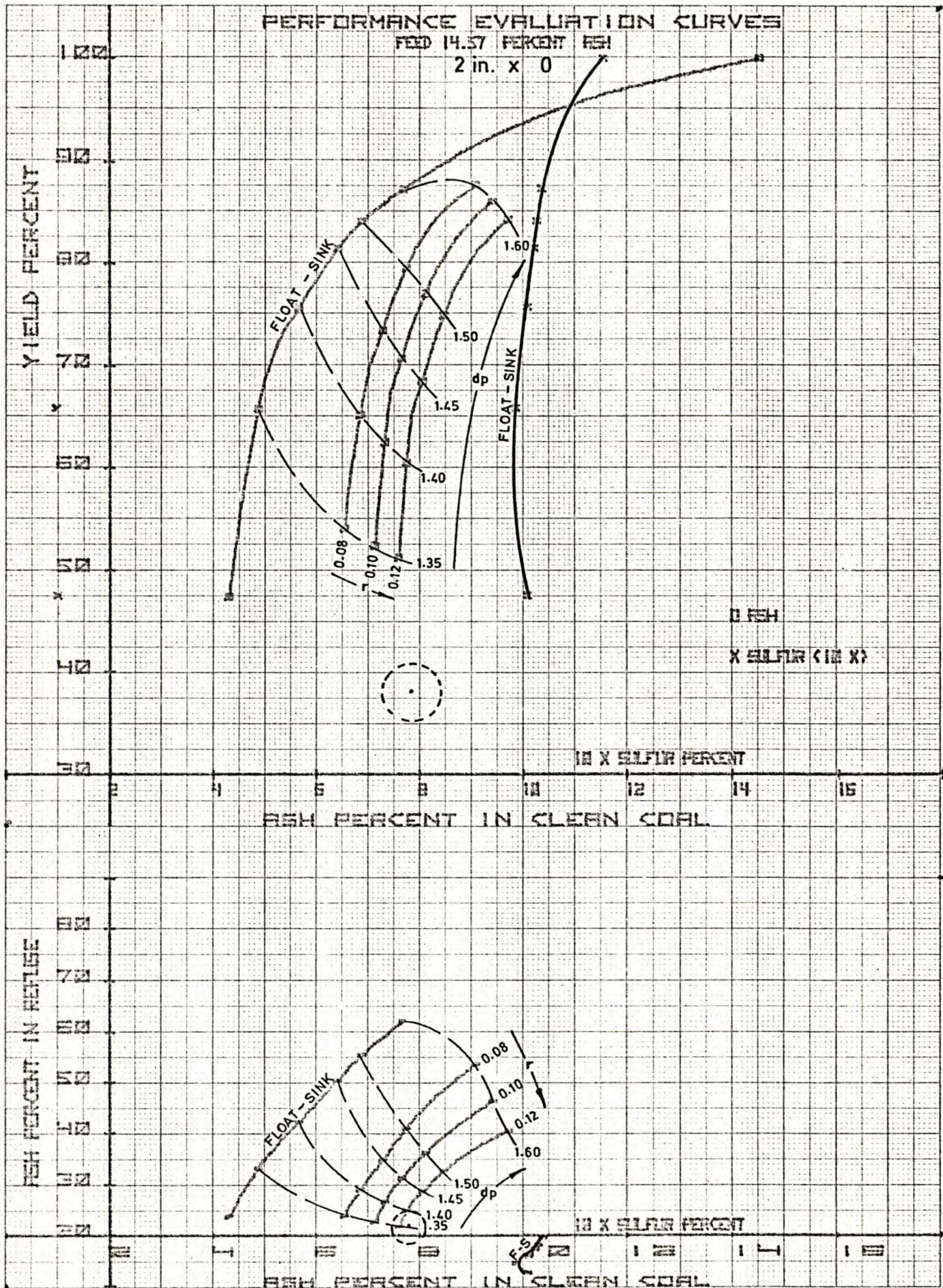


FIGURE 9.1 MIXTURE (5+6+7) (97 1/2 in.)

46 1510

10 X 10 TO THE CENTIMETER
KEUFFEL & ESSER CO. MADE IN U.S.A.

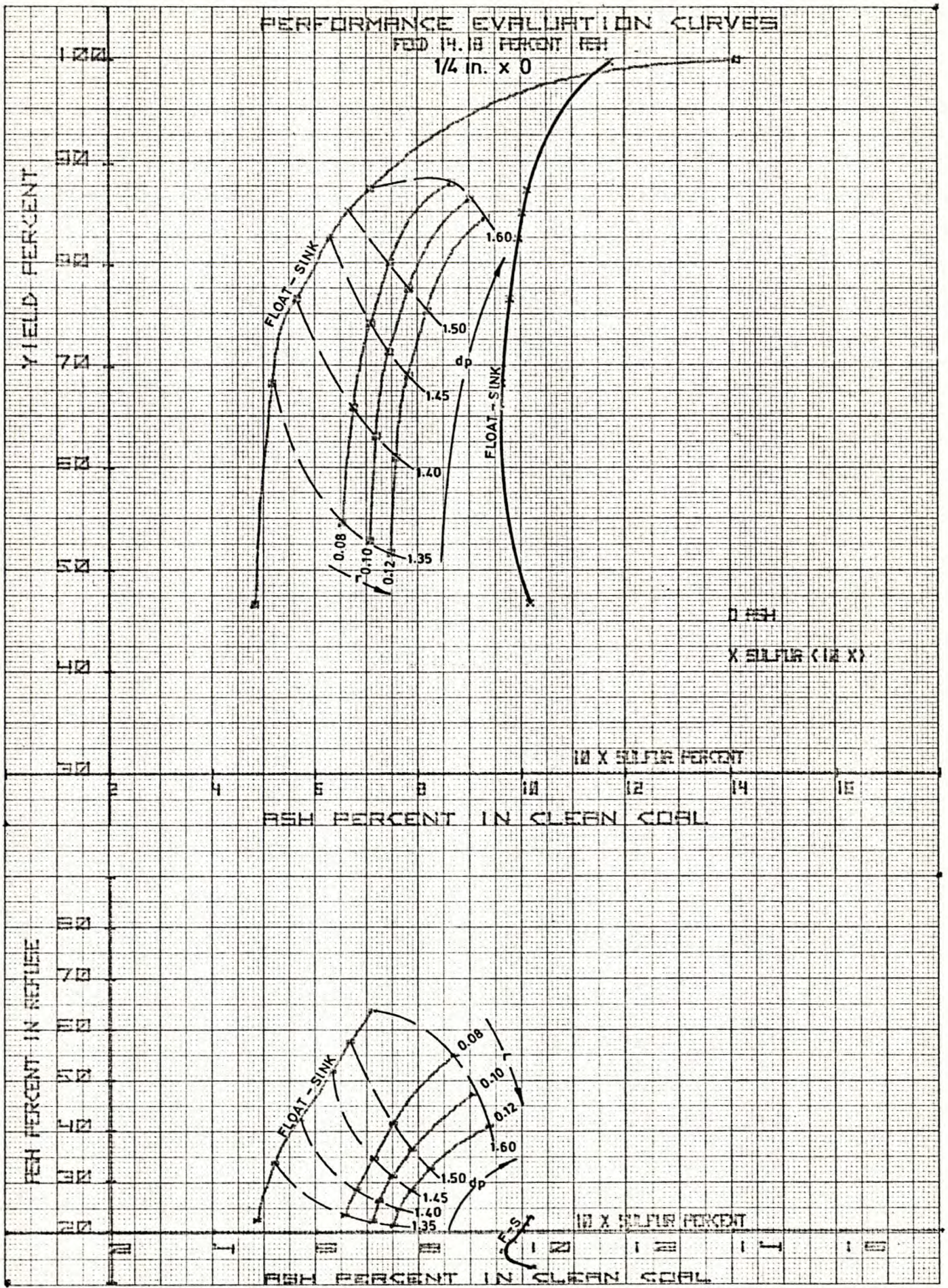
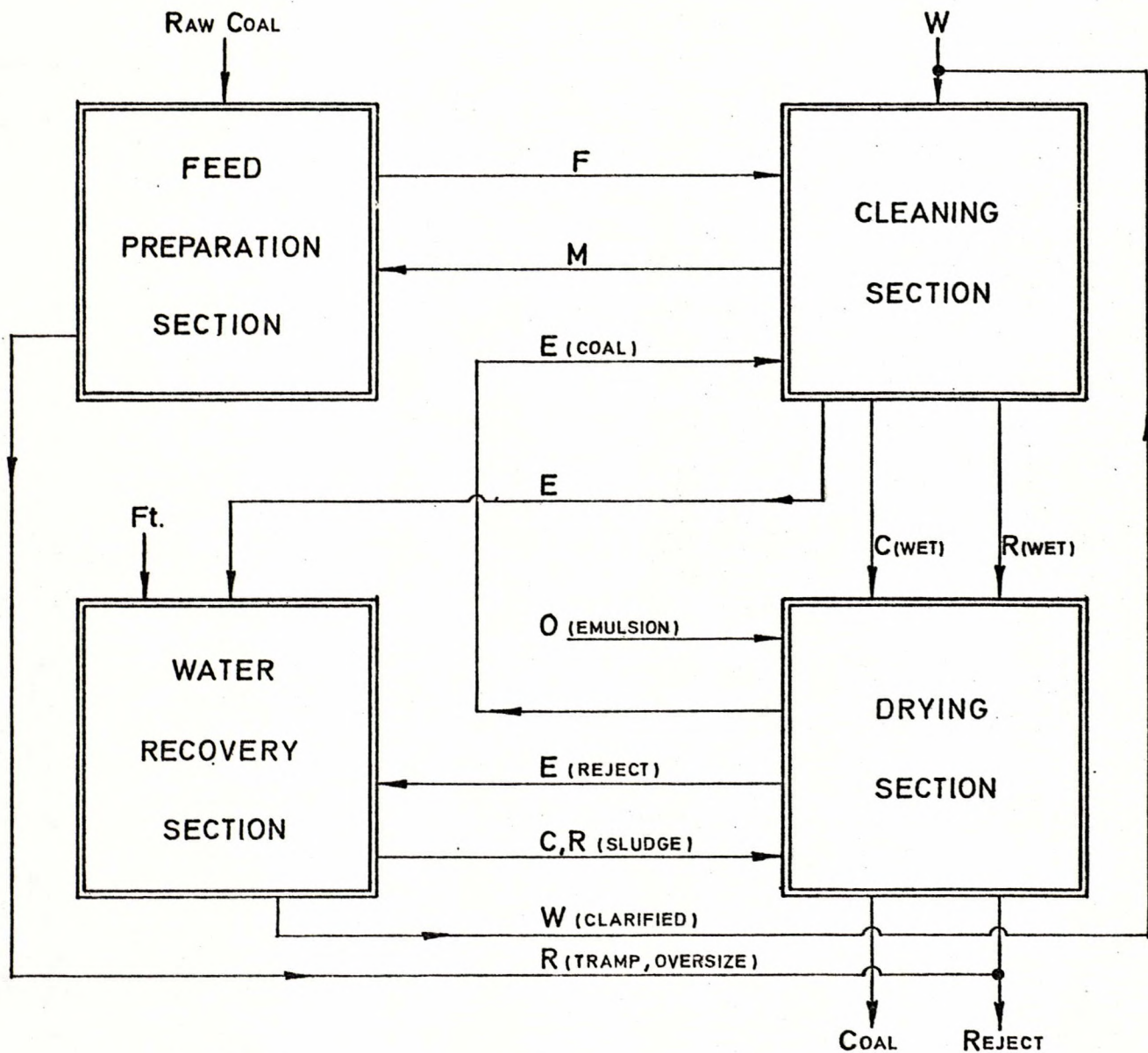


FIGURE 9.2 MIXTURE (5+6+7)

MODULAR E.M.R. COAL PROCESSING PLANT
GENERAL FLOWSHEET



LEGEND

- F = WASHERY FEED
- C = CLEAN COAL
- M = MIDLINGS
- R = REJECT
- E = EFFLUENT
- W = WATER
- Ft. = FLOCCULANT
- O = FUEL OIL

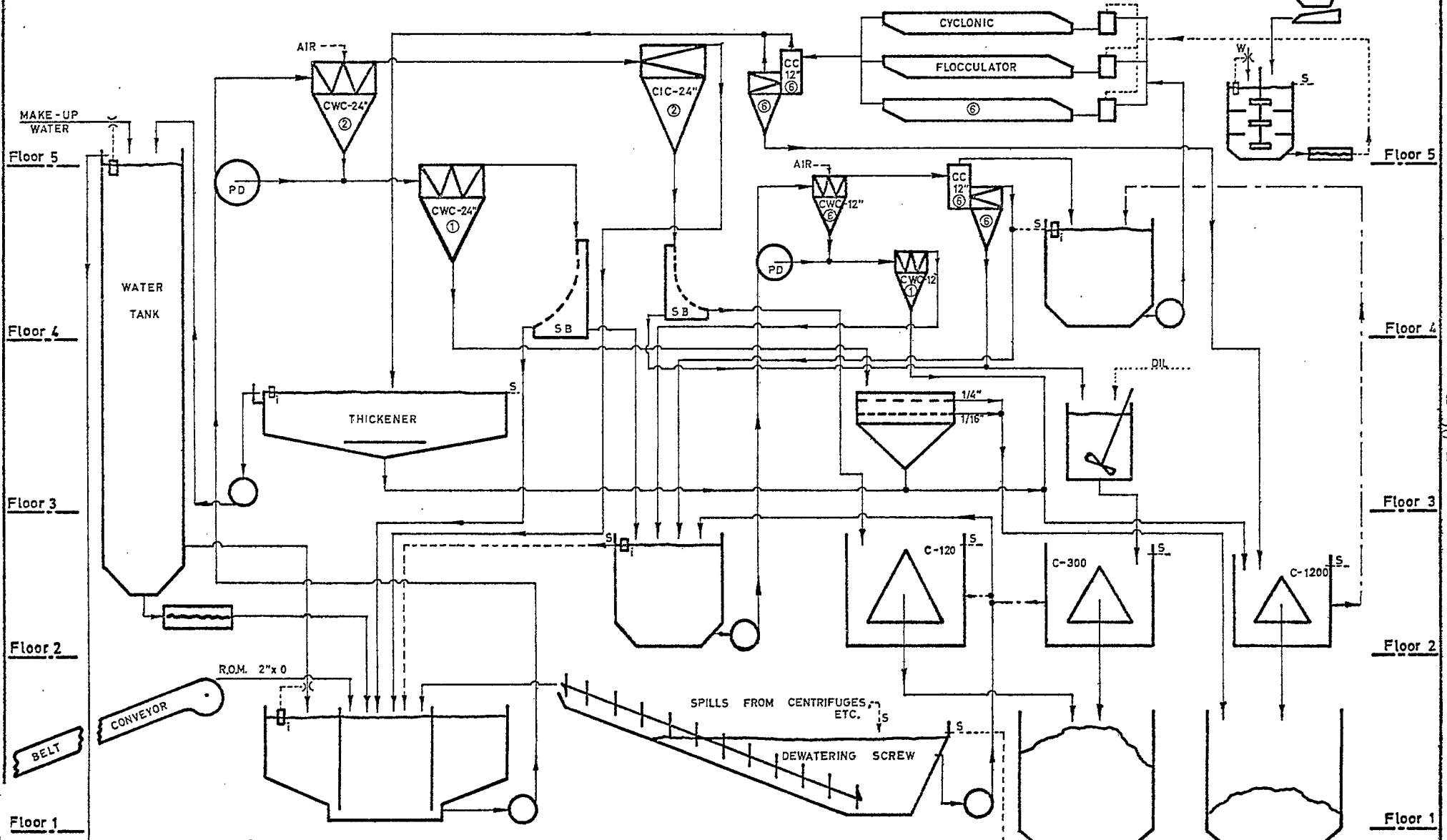
DEPARTMENT OF ENERGY, MINES
& RESOURCES — CANADA

WESTERN RESEARCH LABORATORY
EDMONTON — ALBERTA, APRIL 1975

FIGURE 10

General Flowsheet

MODULAR EMR PLANT (250 tph cap.) for processing mine-run coal (2"x0)



LEGEND

C = CENTRIFUGE	PD = PULP DIVIDER
CC = CYLINDRICAL CYCLONE	W = WATER
CWC = COMPOUND WATER CYCLONE	S = SPILL
CIC = CLASSIFIER CYCLONE	I = LEVEL INDICATOR

FIGURE 11

WASHABILITY CURVES

1-CUM FLAT
2-CUM REJECT
3-CUM BUNK
4-CUM HEAVY
5-ASH
X SULFUR (12 X)

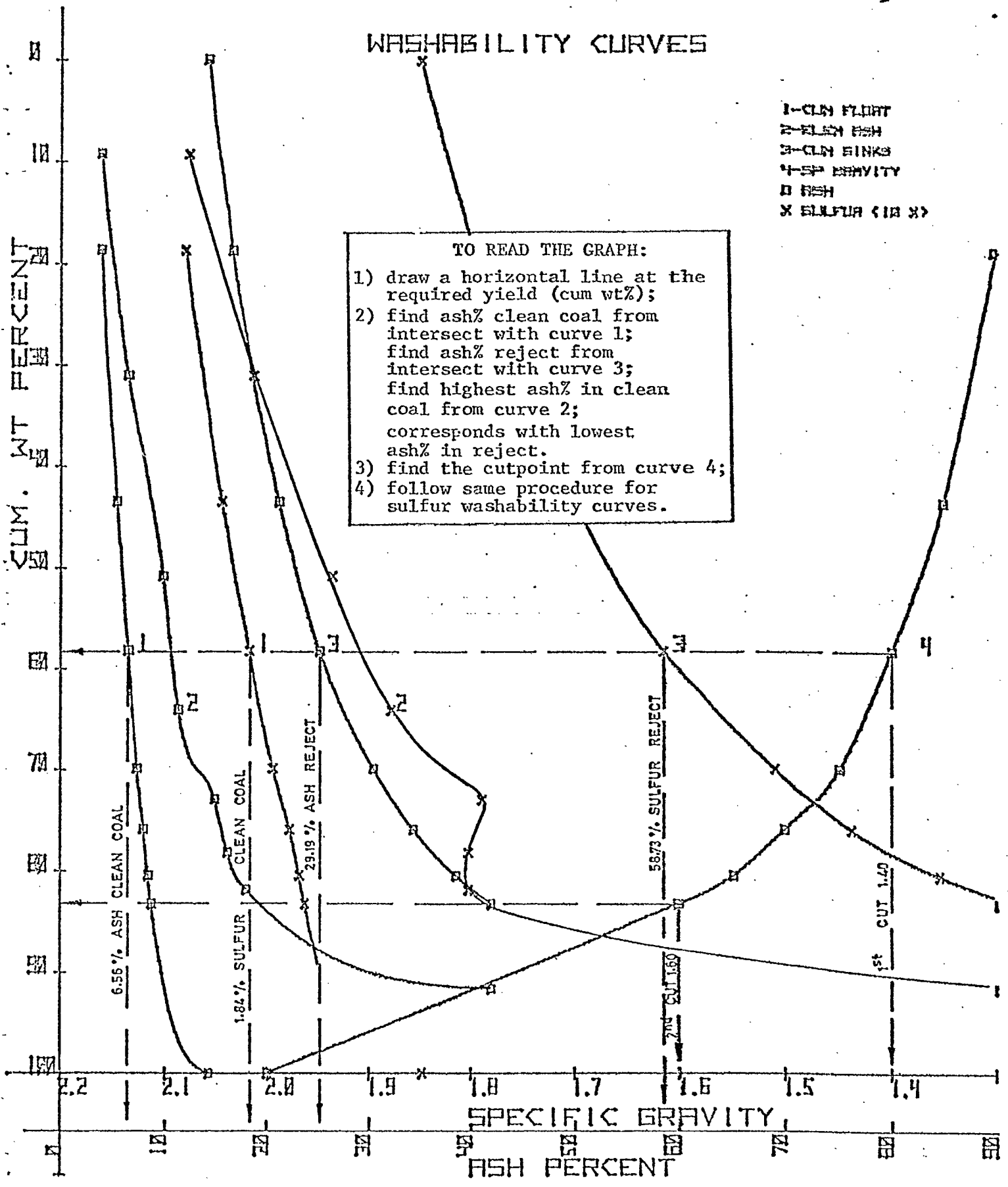


FIGURE A.1 - HOW TO READ A WASHABILITY GRAPH

46 1510

10 X 10 TO THE CENTIMETER 10 X 25 CM
 KLUFFEL & LUSHER CO. MADE IN U.S.A.

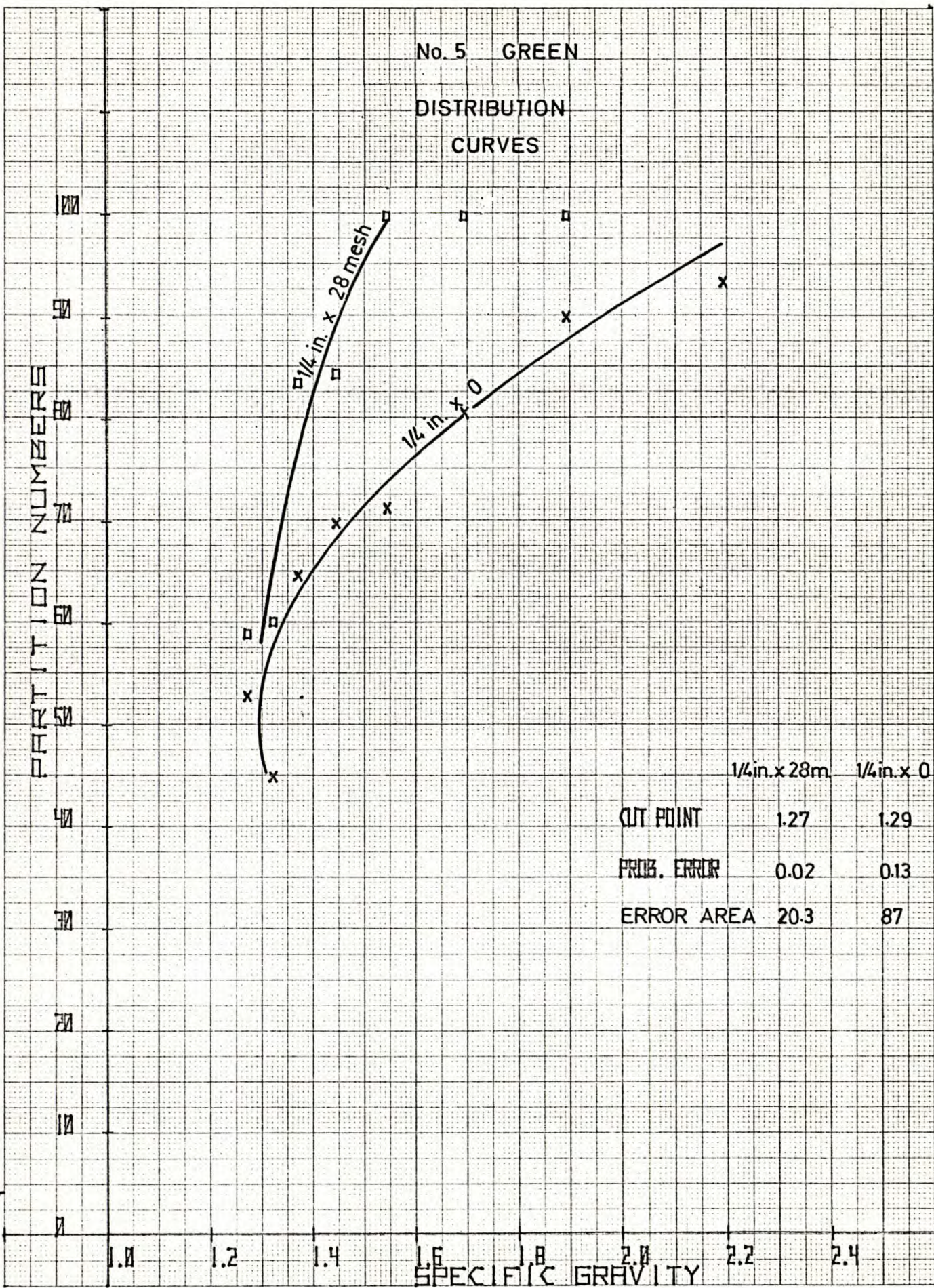


FIGURE 13

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
KODAK SAFETY FILM & SUPPLY CO. MADE IN U.S.A.

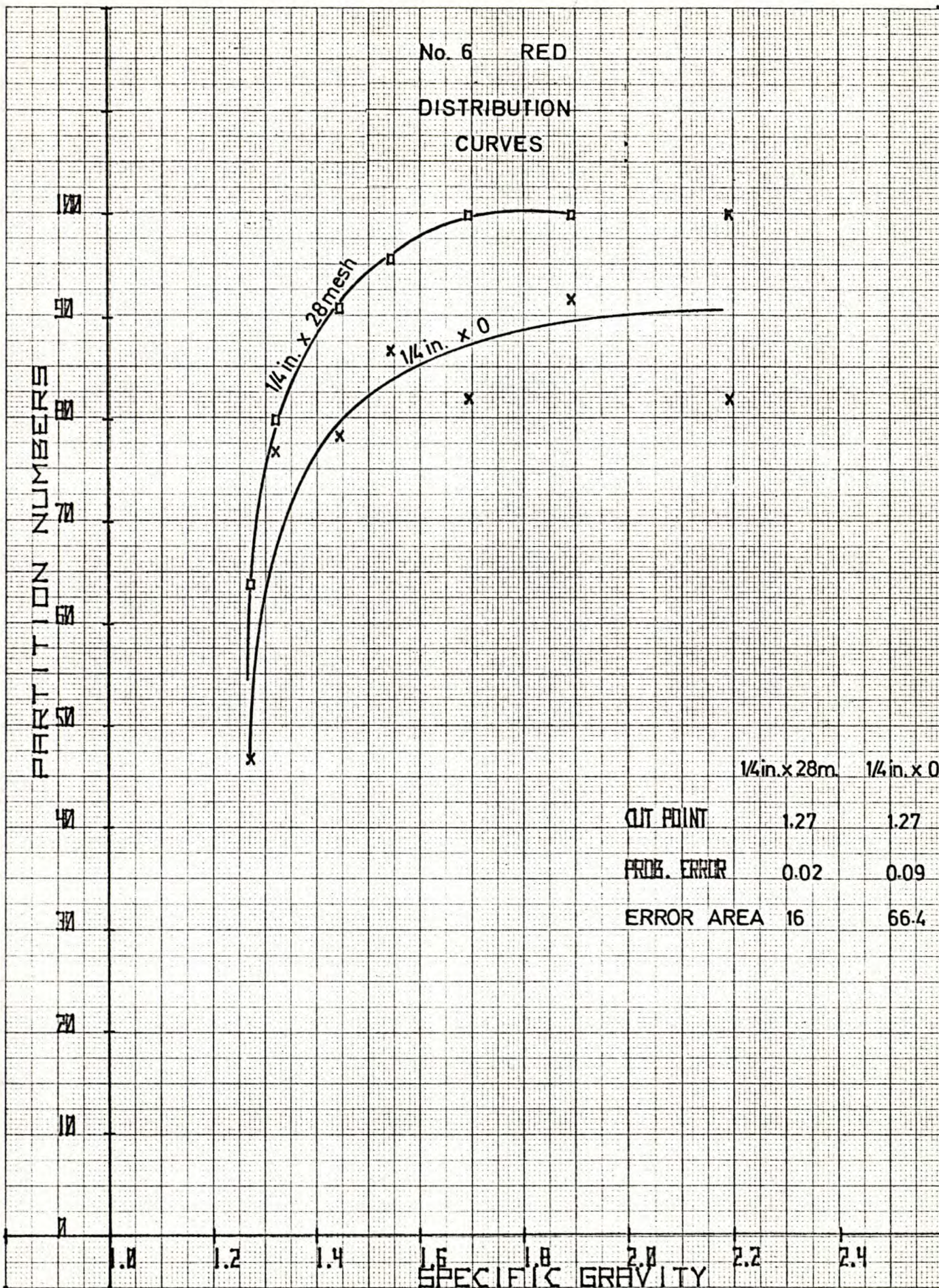


FIGURE 14

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM
KALUFEL & ESSER CO. MADE IN U.S.A.

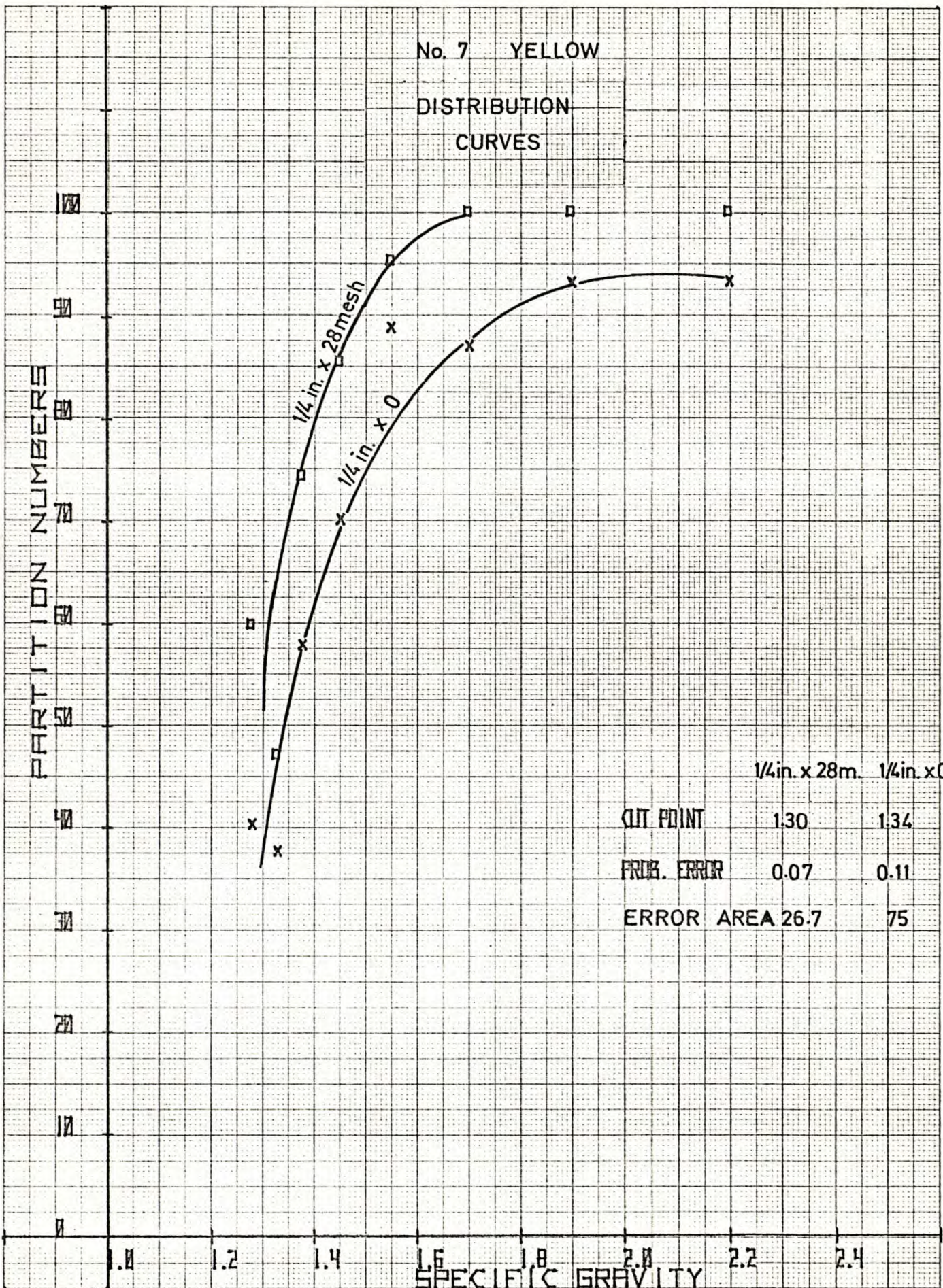


FIGURE 15

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
KLEUFEL & LESSER CO. MADE IN U.S.A.

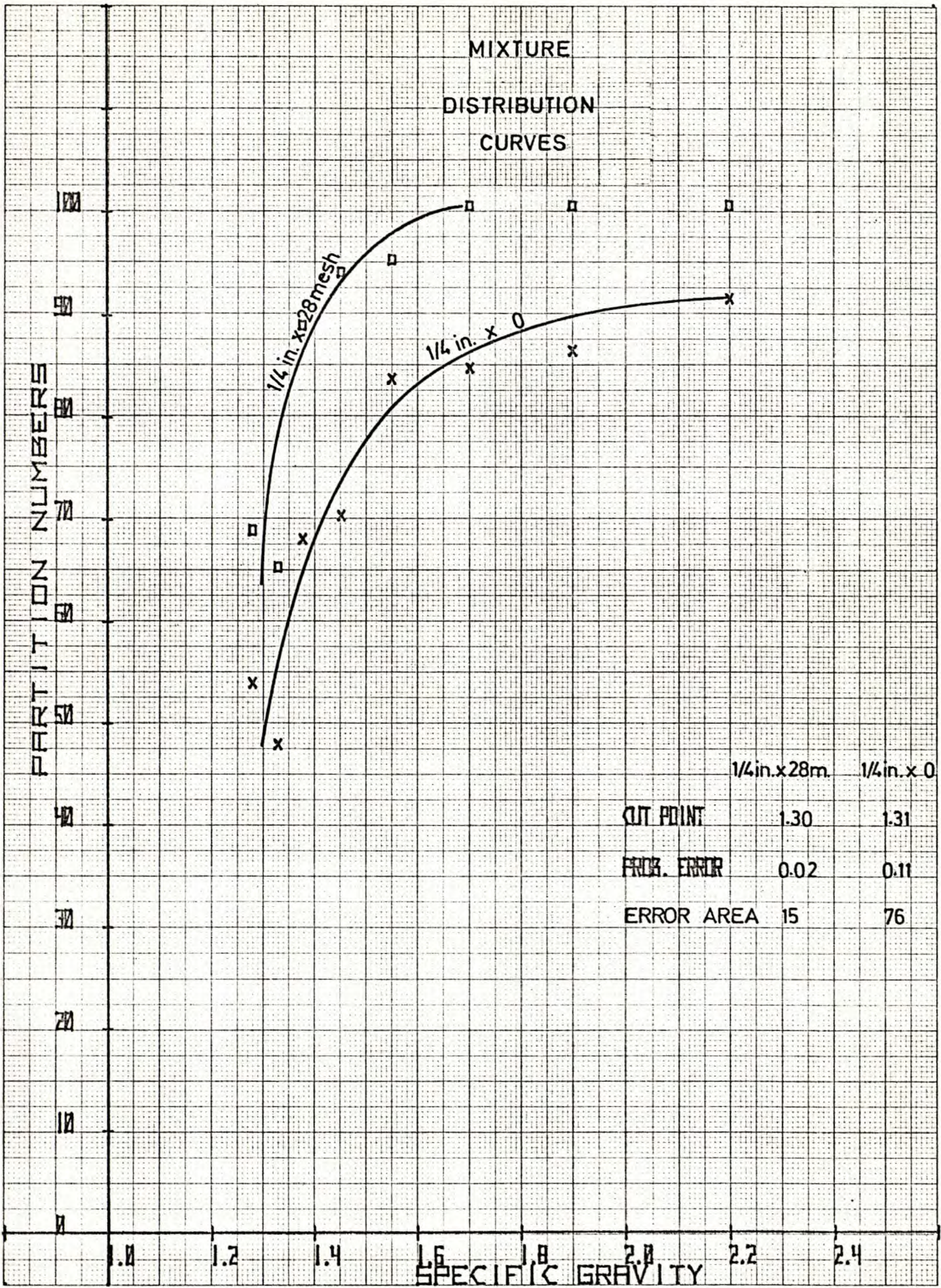


FIGURE 16

APPENDIX A

Washability Curves of

Channel Samples, Items 1-7.

NOTE: Figure numbers 1, 2....7 correspond with Channel Samples of Seams ("Items") 1,2,...7. Alphabetical indices A,B,C,D,E,F correspond with size fractions 2×0 ; $2 \times \frac{1}{4}$; 2×28 in; $\frac{1}{4} \times 0$; $\frac{1}{4} \times 28$ in; 28 in. $\times 0$; respectively

46 1510

10 X 10 TO THE CENTIMETER 10 X 25 CM.
KLEFFEL & ESSER CO. MADE IN U.S.A.

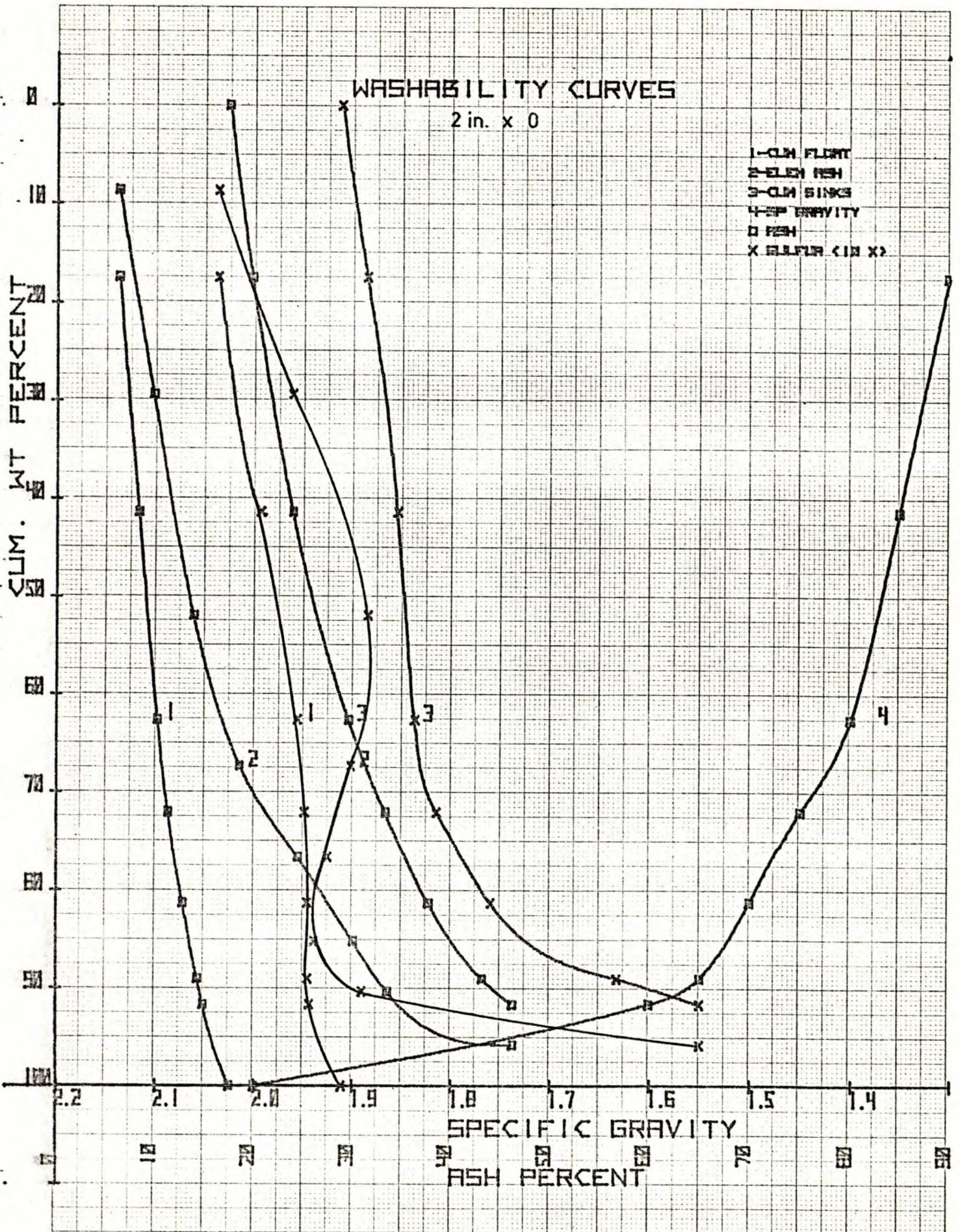


FIGURE 1A ITEM 1 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
KODAK SAFETY FILM KODAK SAFETY FILM

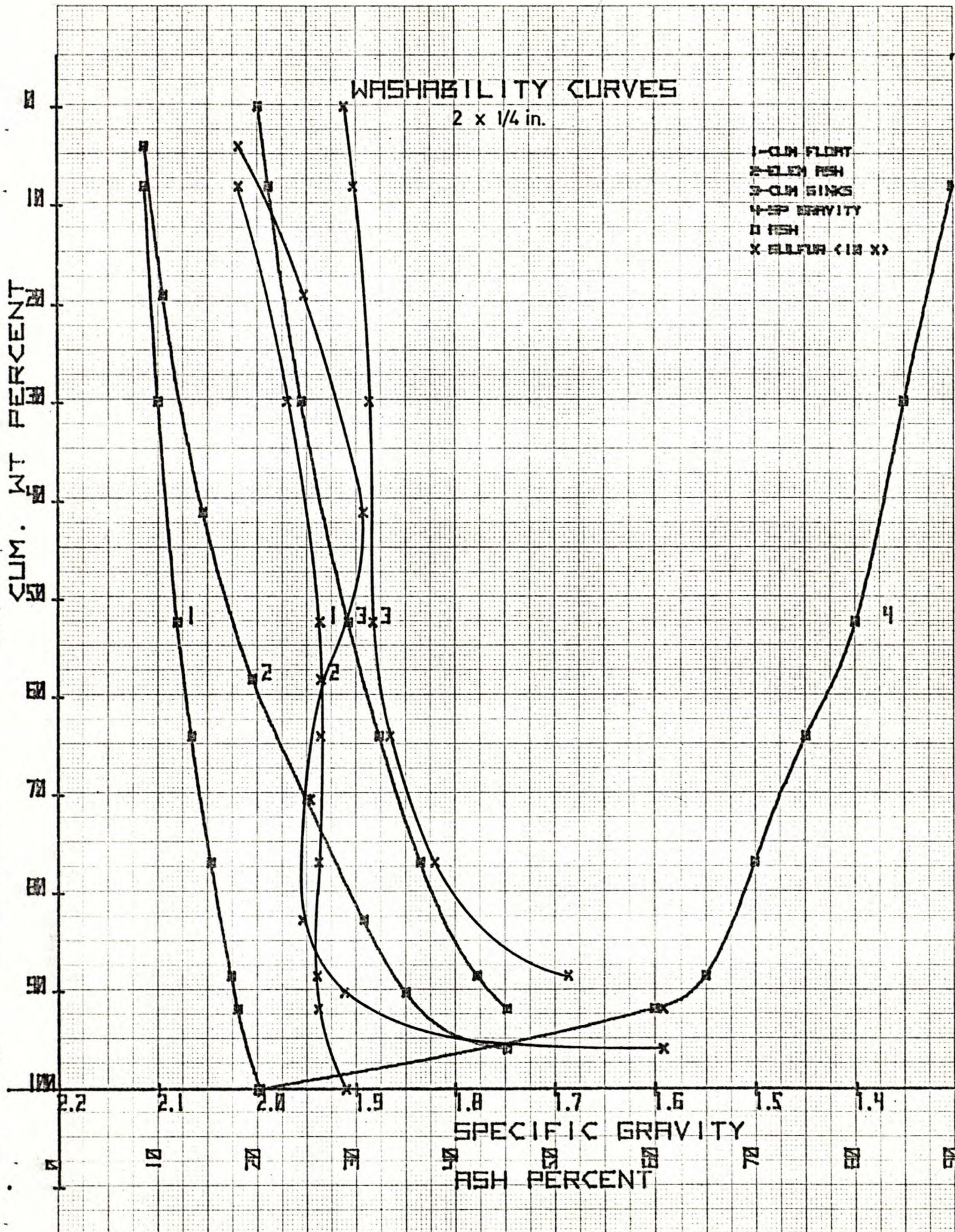


FIGURE 1B ITEM 1 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 10 X 25 CM.
NEUFEL & ESSER CO. MADE IN U.S.A.

WASHABILITY CURVES

2 in. x 28 mesh

- 1-0% FLINT
- 2-10% FLINT
- 3-0% FLINT
- 4-0% GRAVITY
- 10%
- X 20% (10 X)

CUM. WT PERCENT

SPECIFIC GRAVITY
ASH PERCENT

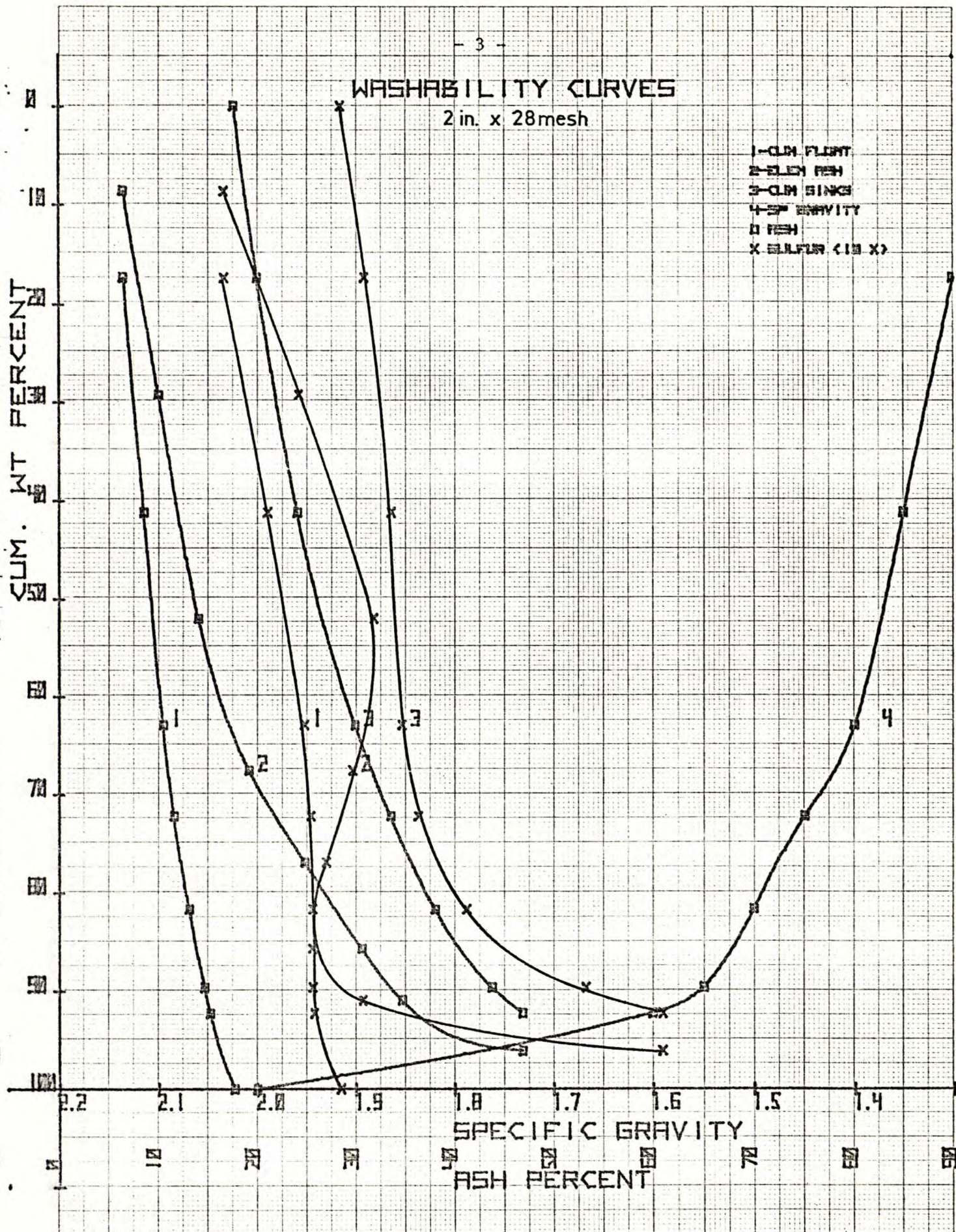


FIGURE 1C ITEM 1 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
MUEHL & LESSER CO. MADE IN U.S.A.

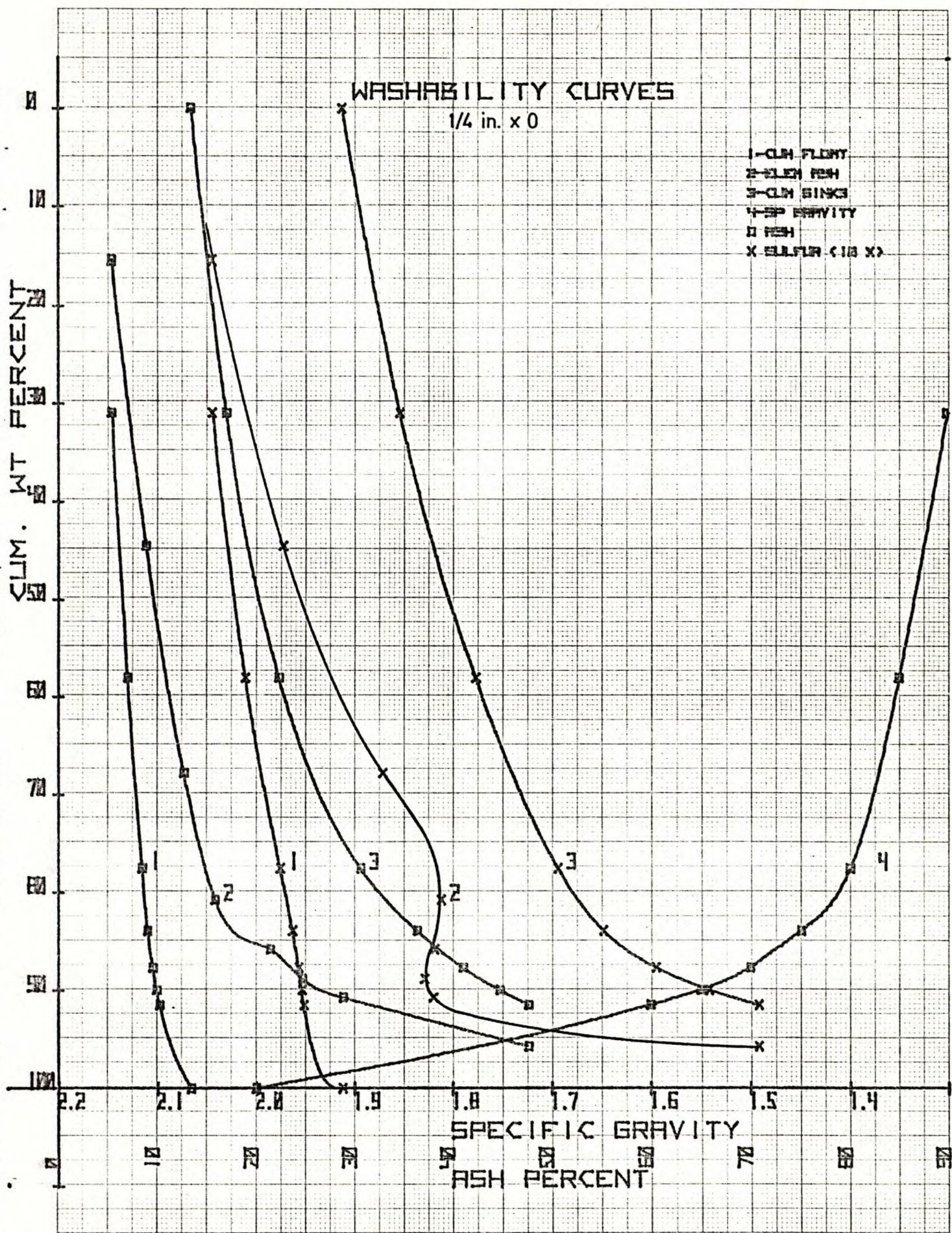


FIGURE 1D ITEM 1 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER IS X 25 CM. NEUPHILL & LEISER CO. MADE IN U.S.A.

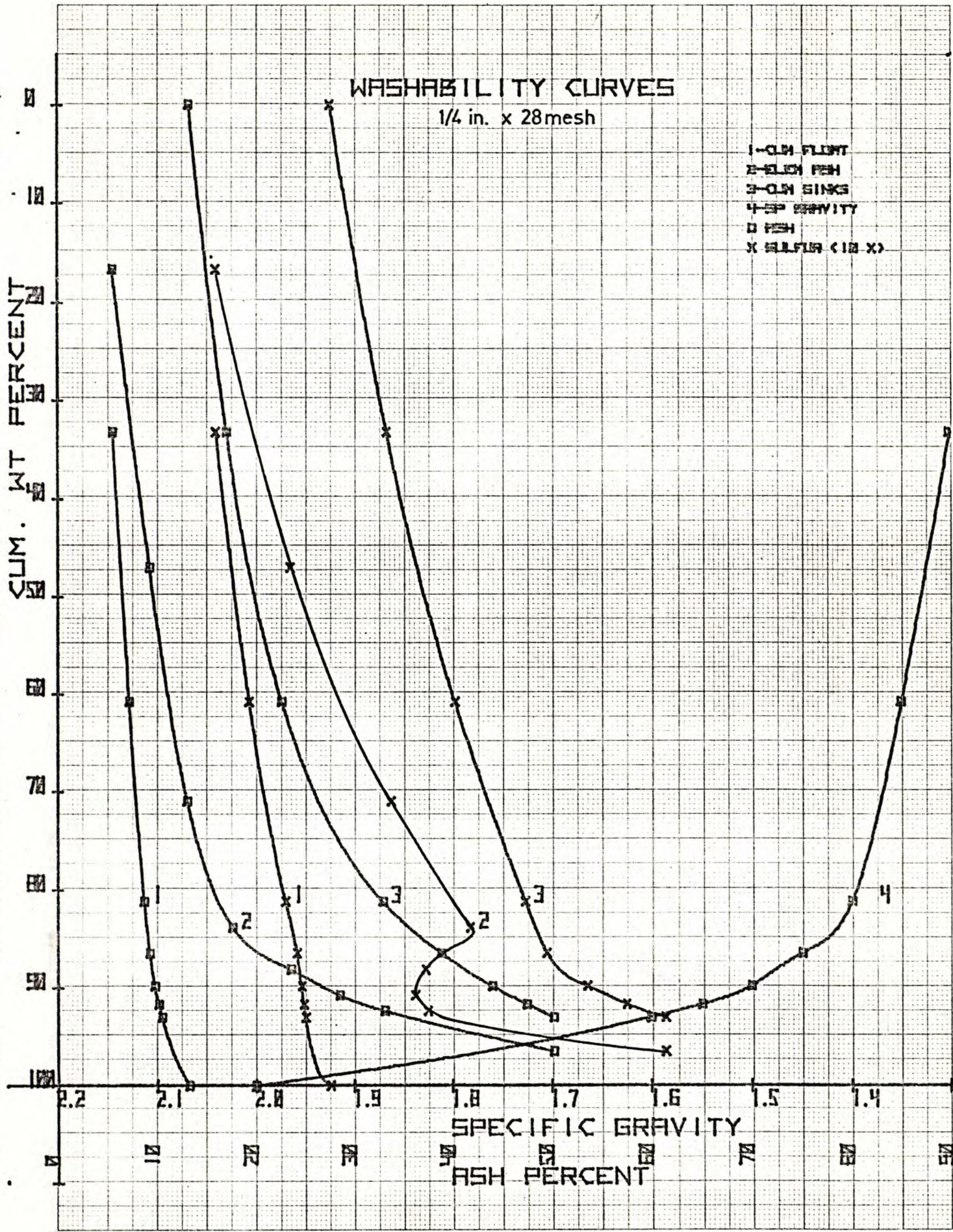


FIGURE 1E ITEM 1 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 10 X 25 CM.
NATIONAL BUREAU OF STANDARDS

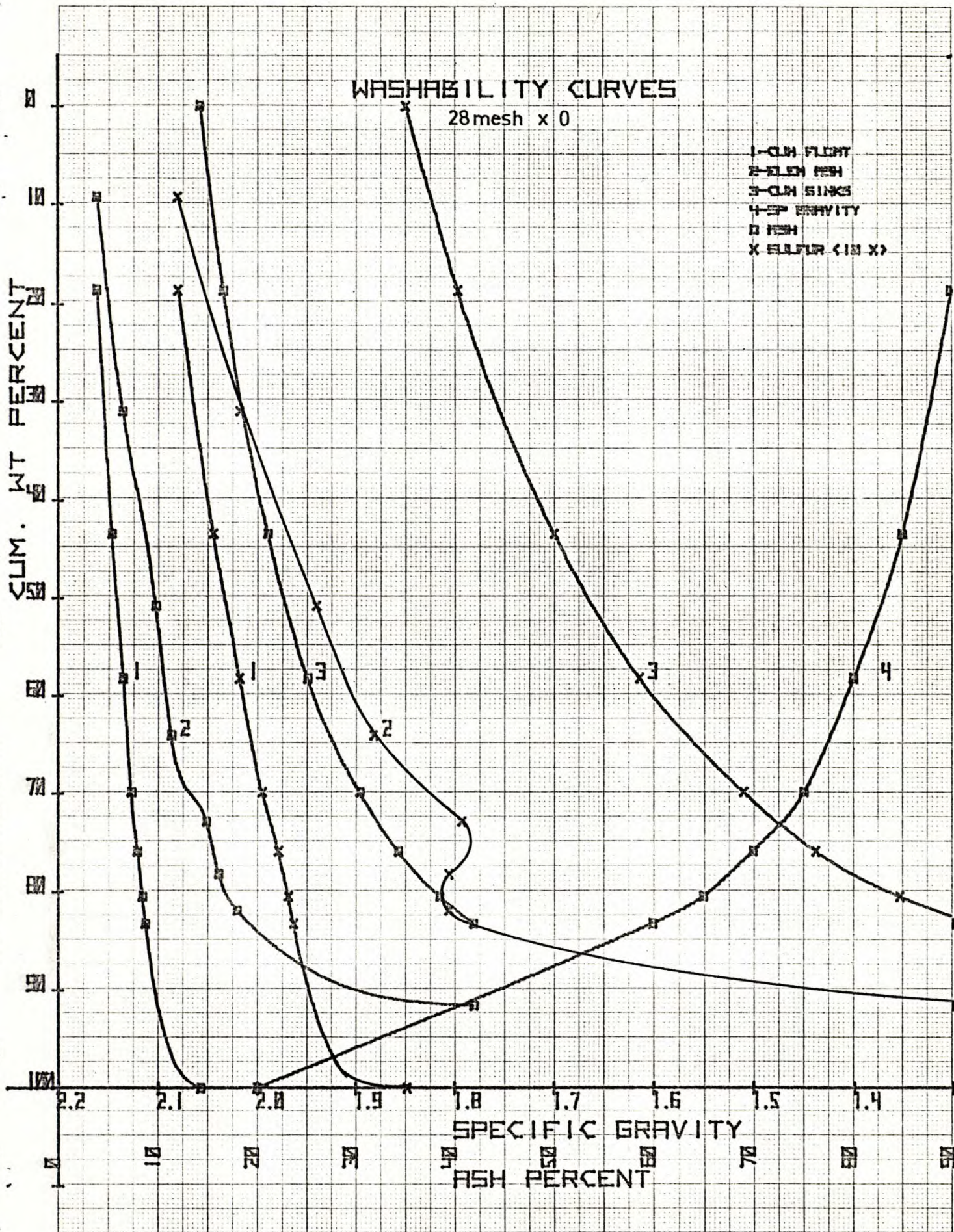


FIGURE 1F ITEM 1 - CHANNEL SAMPLE

46 1510

10 X 10 TO THE CENTIMETER 19 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

WASHABILITY CURVES

2 in. x 0

- 1-0.1 FLIGHT
- 2-0.15 FISH
- 3-0.15 SINKS
- 4-0.15 GRAVITY
- FISH
- × SULFUR (10 X)

CUM. WT PERCENT

SPECIFIC GRAVITY

ASH PERCENT

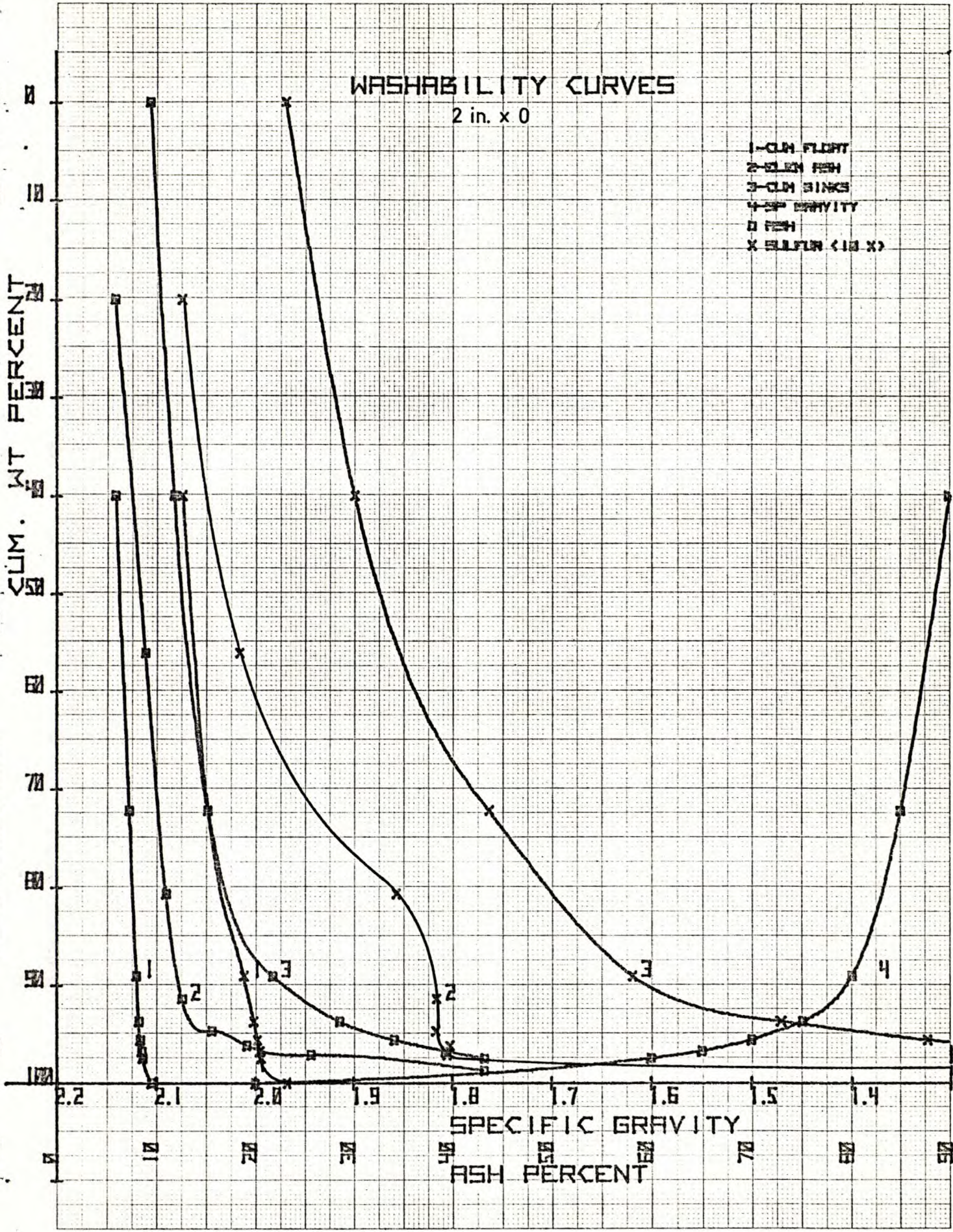


FIGURE 2A ITEM 2 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
KOPPEL & ESSER CO. BALDWIN, U.S.A.

WASHABILITY CURVES

2 x 1/4 in.

- 1-0.075 FLUAT
- 2-0.075 ASH
- 3-0.075 SINK
- 4-SP GRAVITY
- FINE
- X SULFUR (10 X)

CUM. WT PERCENT

SPECIFIC GRAVITY

ASH PERCENT

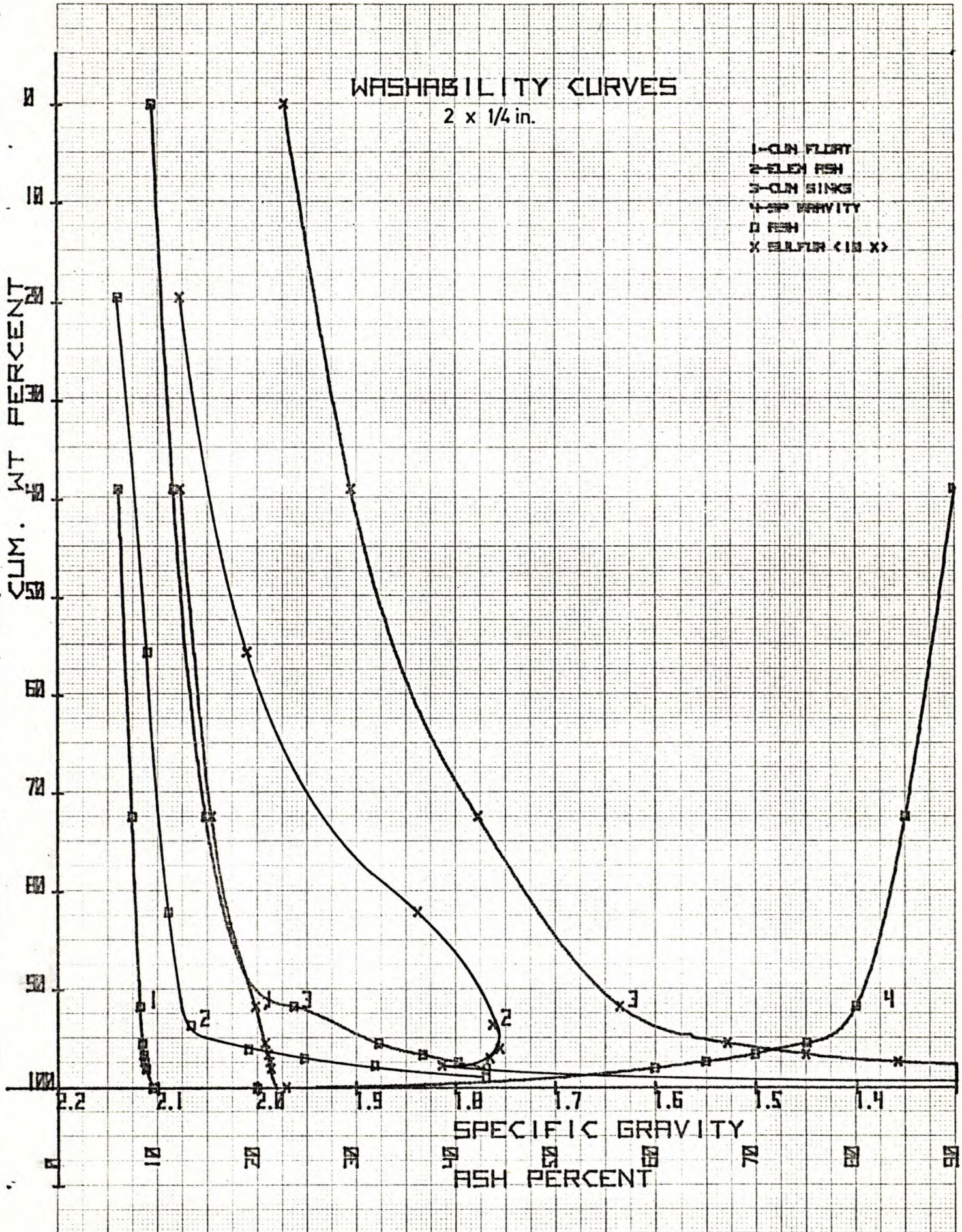


FIGURE 2B ITEM 2 - CHANNEL SAMPLE

461510

SCALE 1/4" X 10 TO THE CENTIMETER 1/8" X 25 CM.
KLOPFEL & LINSER CO. MADE IN U.S.A.

WASHABILITY CURVES

2 in. x 28 mesh

- 1 - ON FLOAT
- 2 - ON ASH
- 3 - ON SINKS
- 4 - ON GRAVITY
- - FINE
- x - RELATIVE x

CUM. WT PERCENT

SPECIFIC GRAVITY
ASH PERCENT

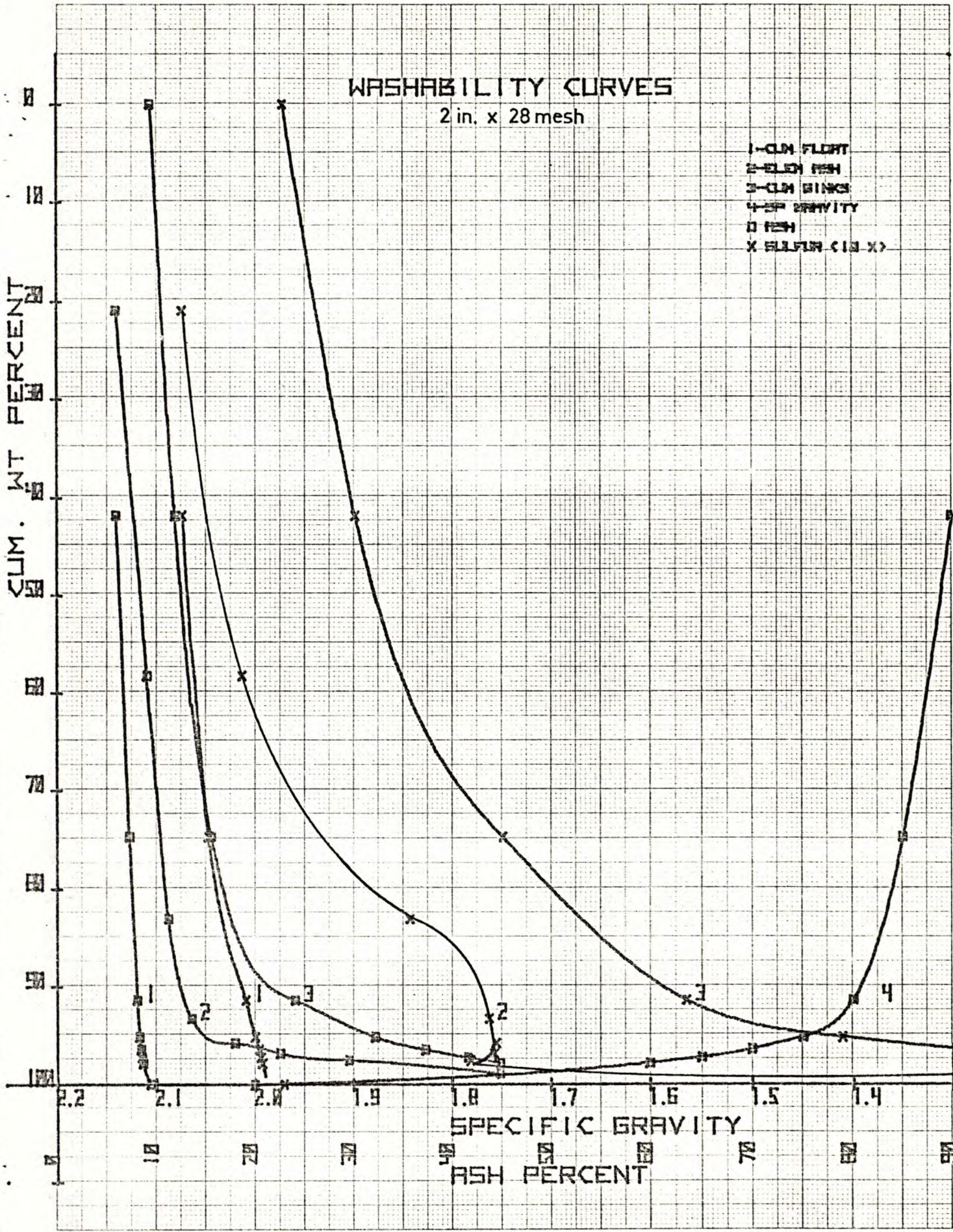


FIGURE 2C ITEM 2 - CHANNEL SAMPLE

461510

NO. 10 X 10 TO THE CENTIMETER 10 X 25 CM. ALUPEL'S ESSER CO. MADE IN U.S.A.

WASHABILITY CURVES

1/4 in. x 0

- 1 - HIGH FLIGHT
- 2 - HIGH FINE
- 3 - HIGH BULK
- 4 - HIGH GRAVITY
- - FINE
- x - BULKY (10 x)

CUM. WT PERCENT

100
90
80
70
60
50
40
30
20
10
0

SPECIFIC GRAVITY

ASH PERCENT

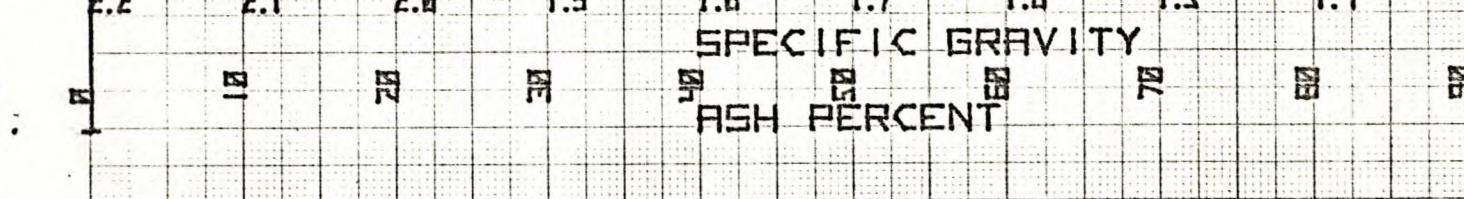


FIGURE 2D ITEM 2 - CHANNEL SAMPLE

461510

K&S 10 X 10 TO THE CENTIMETER 18 X 25 CM.
KUFFEL & ESSER CO. MADE IN U.S.A.

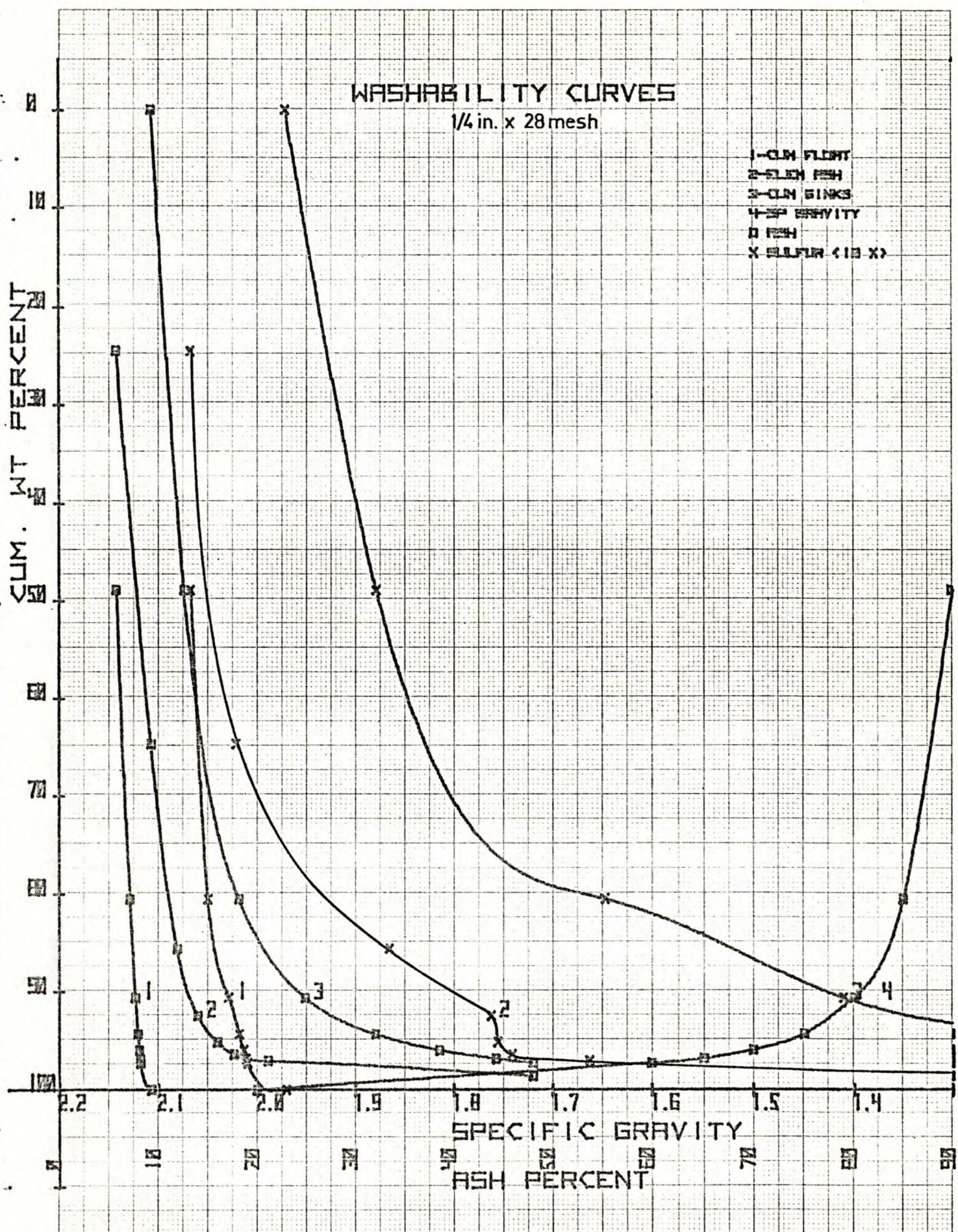


FIGURE 2E ITEM 2 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 16 X 16 CM
K&E KLUEPFEL & ESSER CO. MADE IN U.S.A.

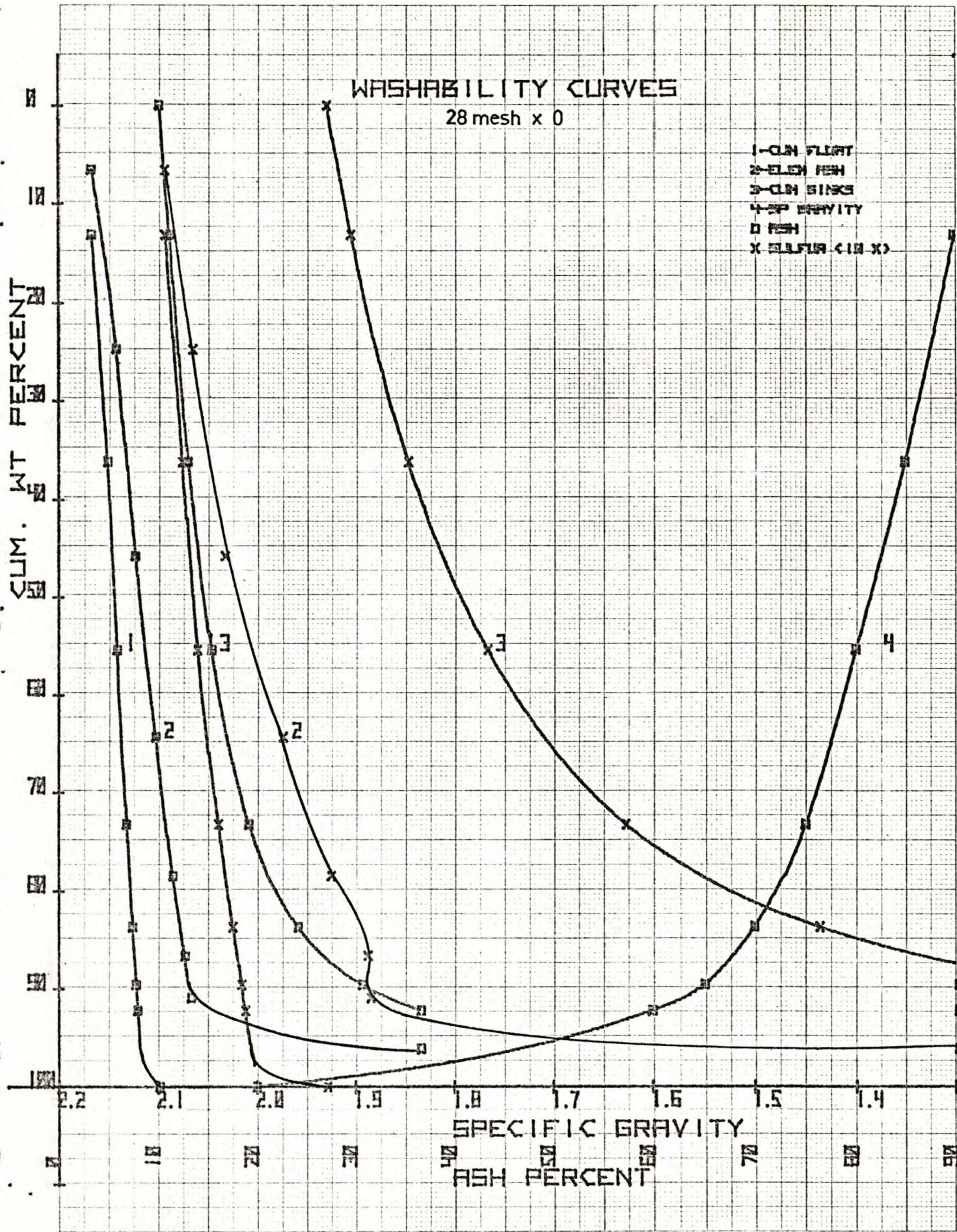


FIGURE 2F ITEM 2 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 10 X 20 CM
KLEUFEL & ESSER CO. MILWAUKEE

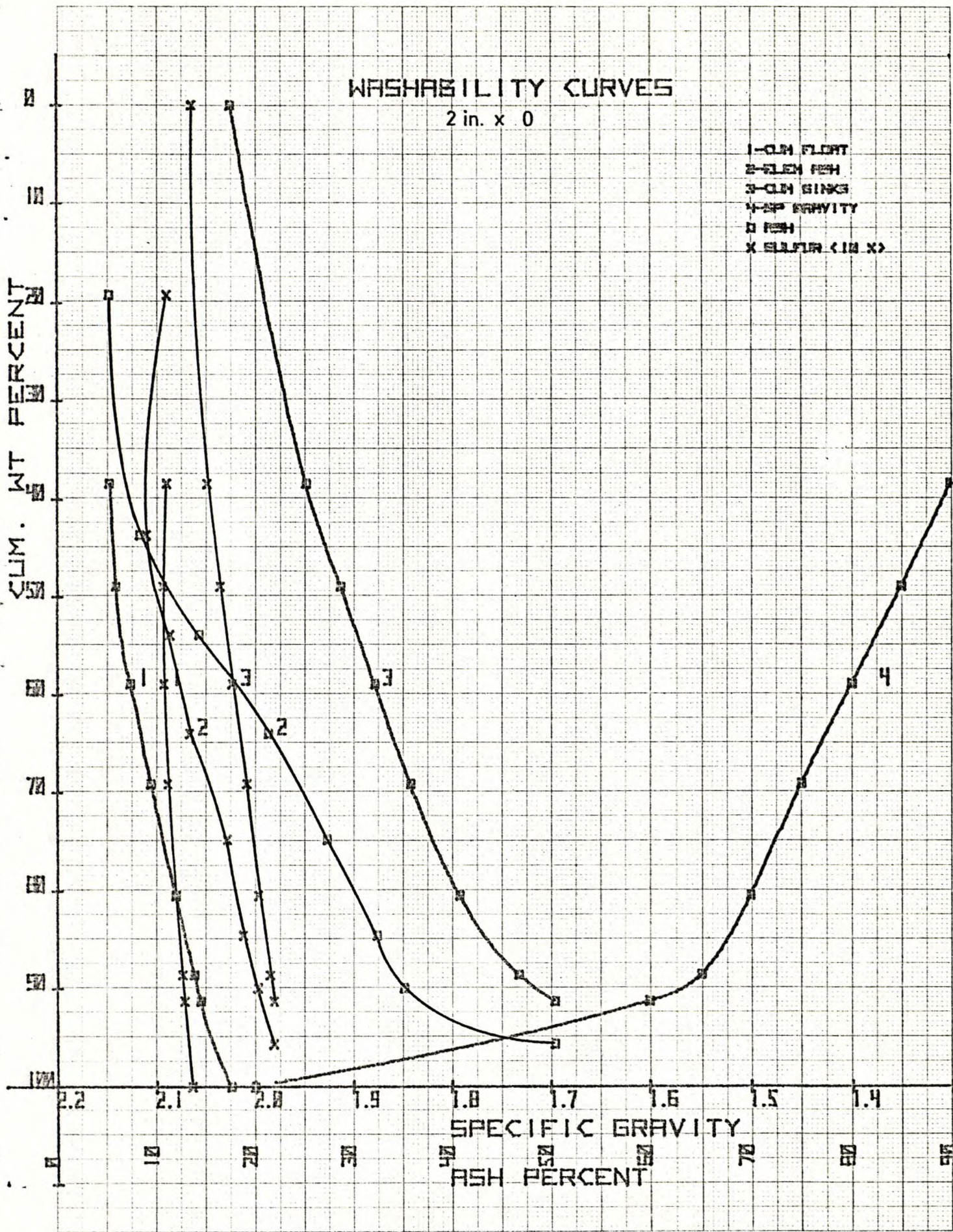


FIGURE 3A ITEM 3 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 10 X 25 CM
NEUFEL & ESSER CO. MADE IN U.S.A.

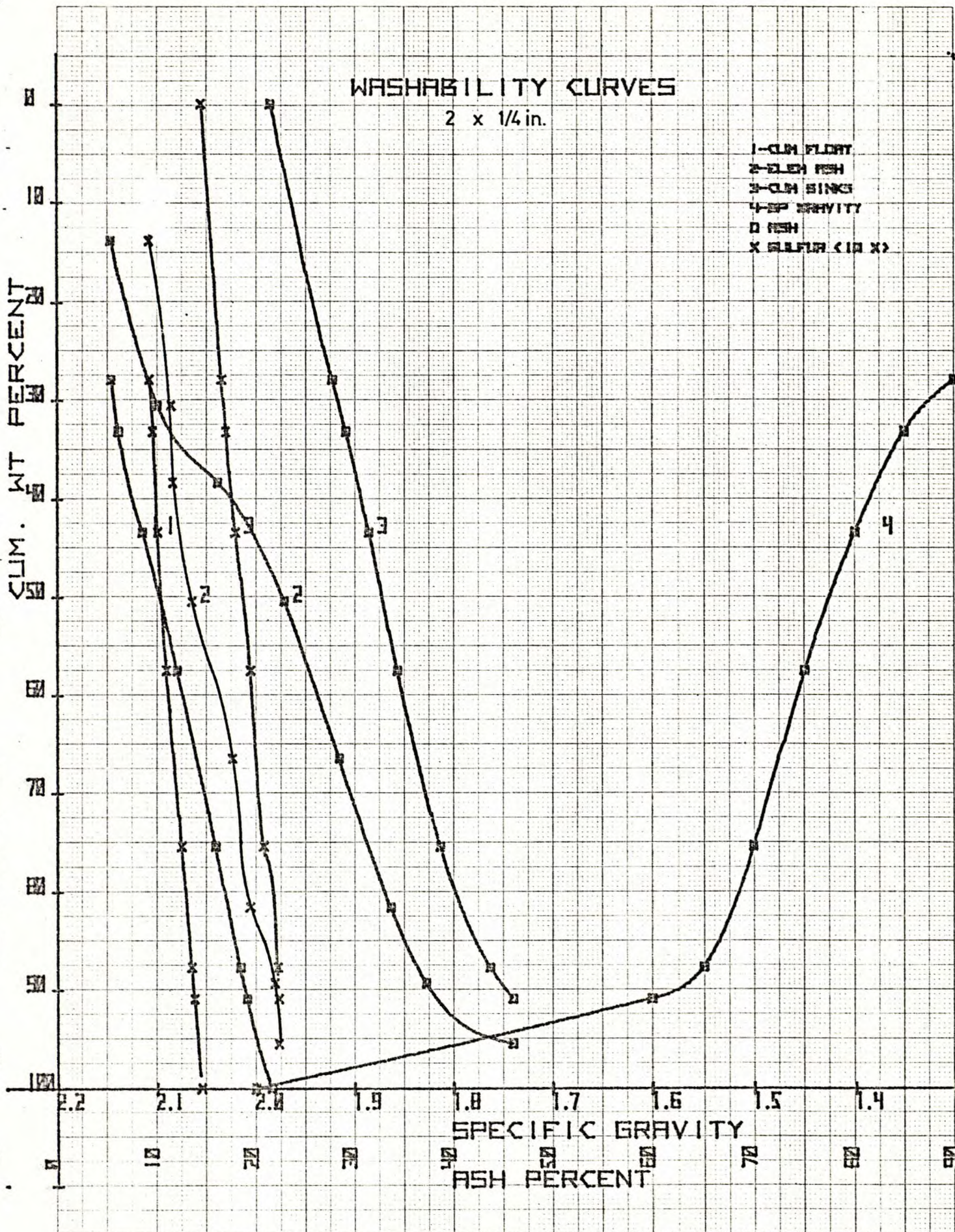


FIGURE 3B - ITEM 3 - CHANNEL SAMPLE

46 1510

10 X 10 TO THE CENTIMETER KEUFFEL & ESSER CO. MADE IN U.S.A.

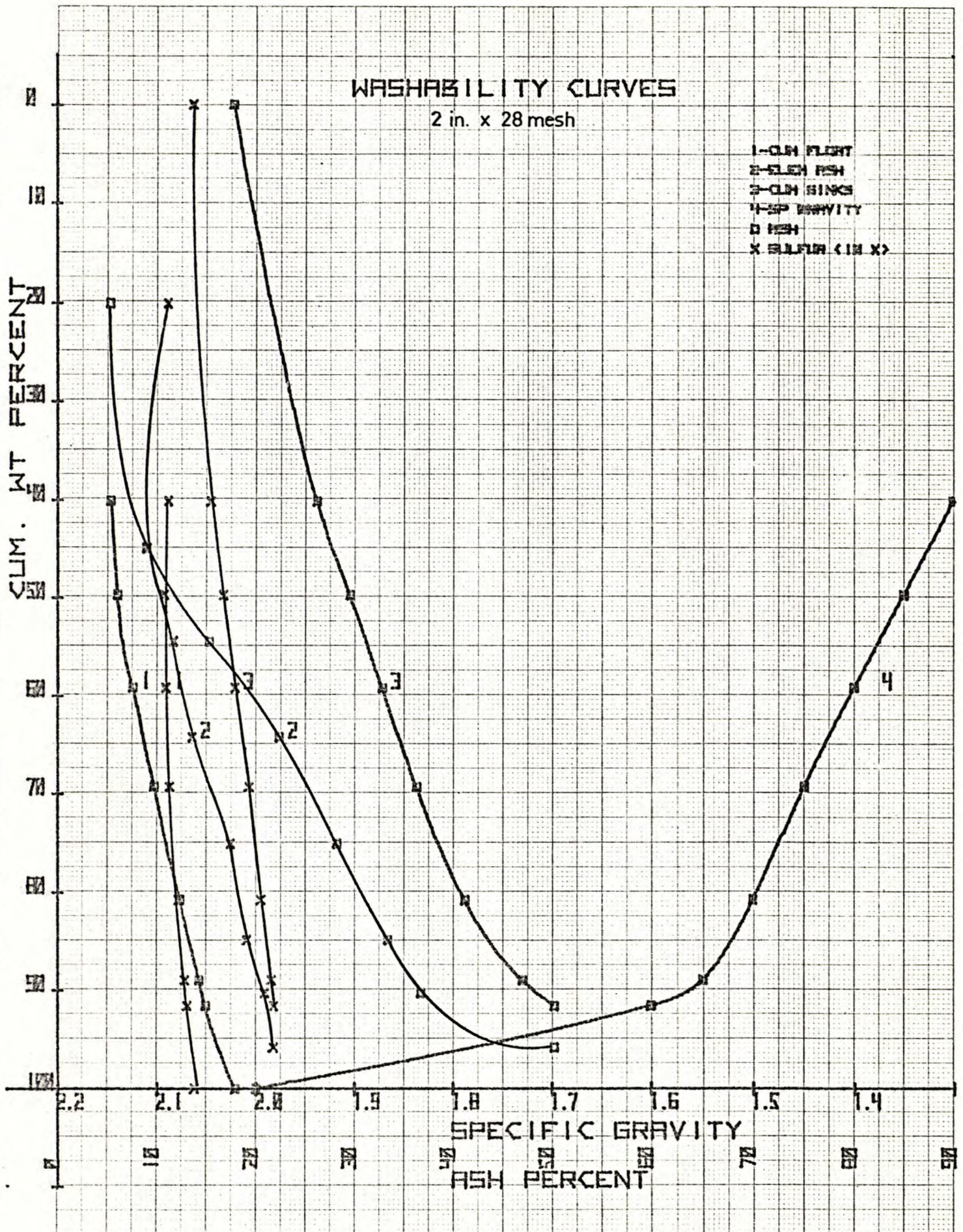


FIGURE 3C ITEM 3 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM
KEUFEL & ESSER CO. MADE IN U.S.A.

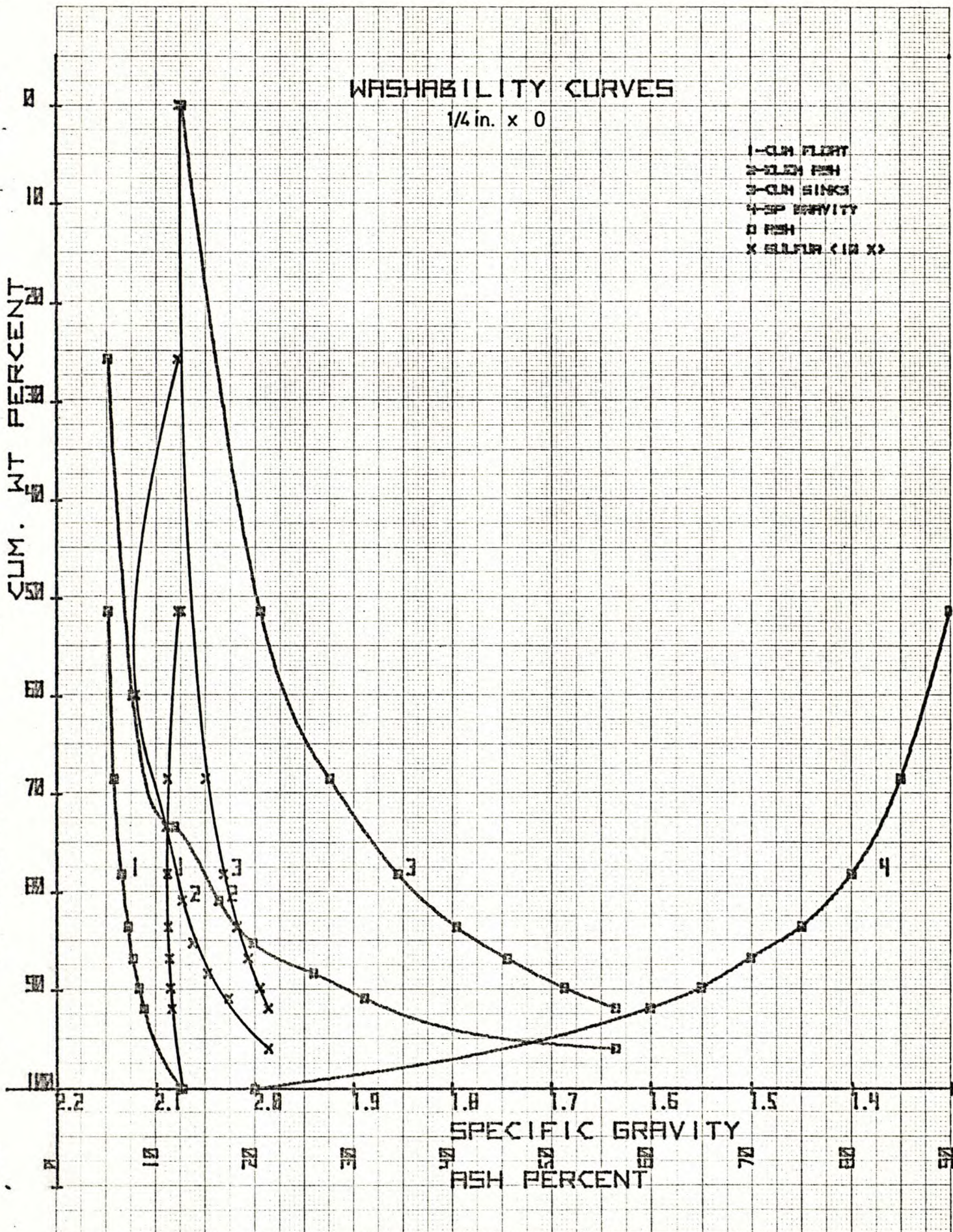


FIGURE 3D ITEM 3 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFEL & ESSER CO. MADE IN U.S.A.

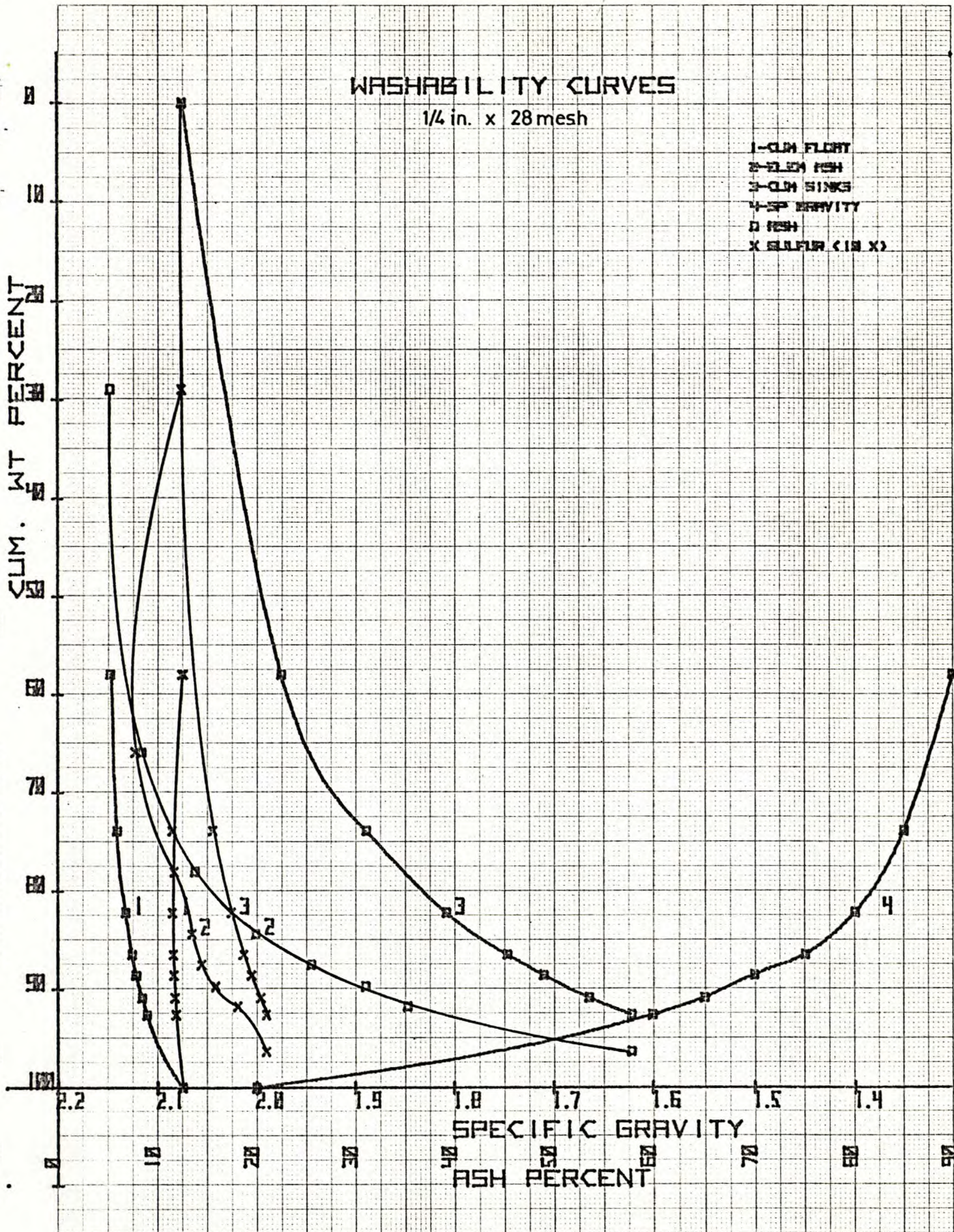


FIGURE 3E ITEM 3 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
KOPPEL & ESSER CO. MADE IN U.S.A.

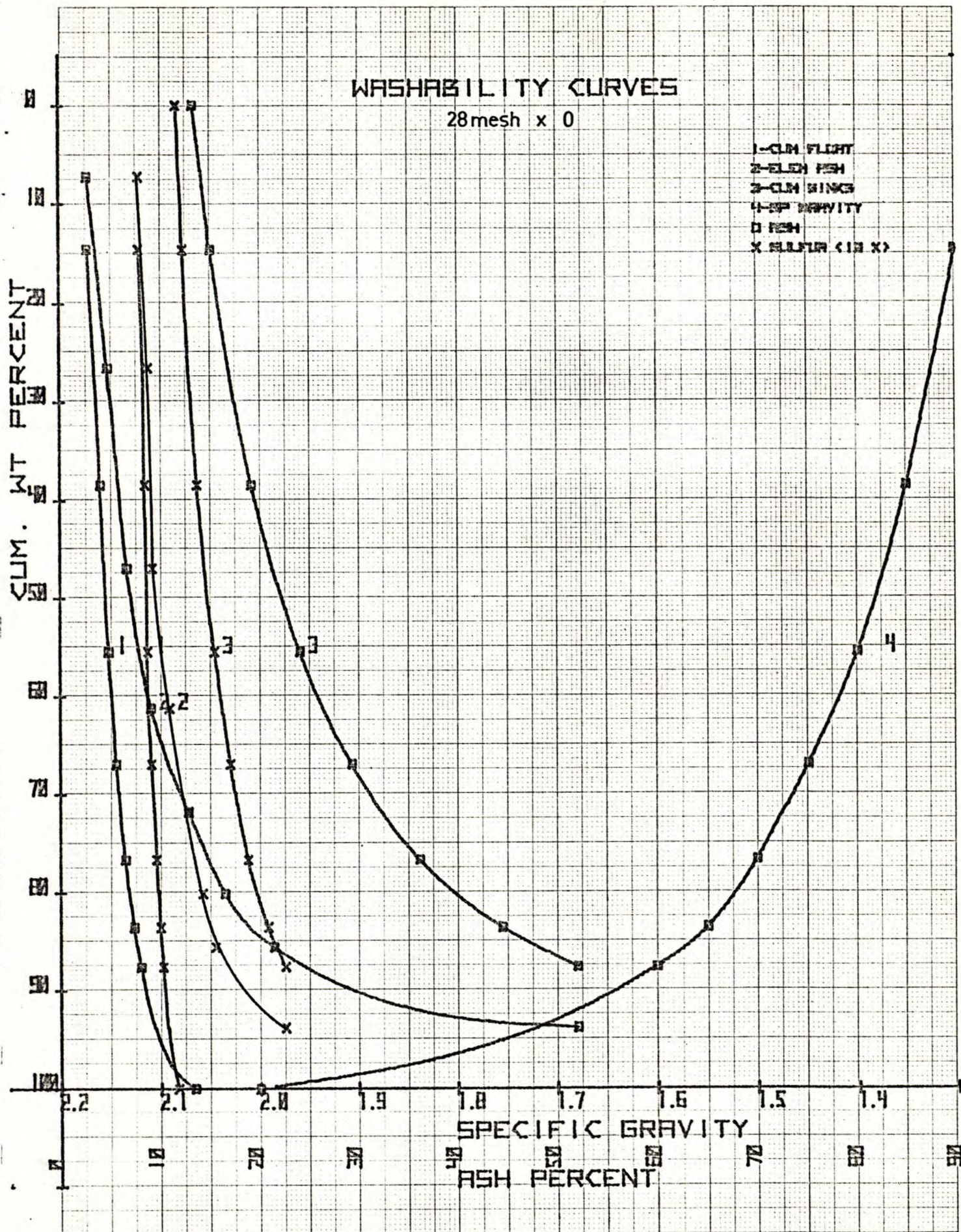


FIGURE 3F ITEM 3 - CHANNEL SAMPLE

46 1510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

WASHABILITY CURVES

2 in. x 0

- 1-0.08 FLIGHT
- 2-0.075 FINE
- 3-0.075 FINE
- 4-0.075 FINE
- FINE
- x FINE (10 x)

CUM. WT PERCENT

SPECIFIC GRAVITY

ASH PERCENT

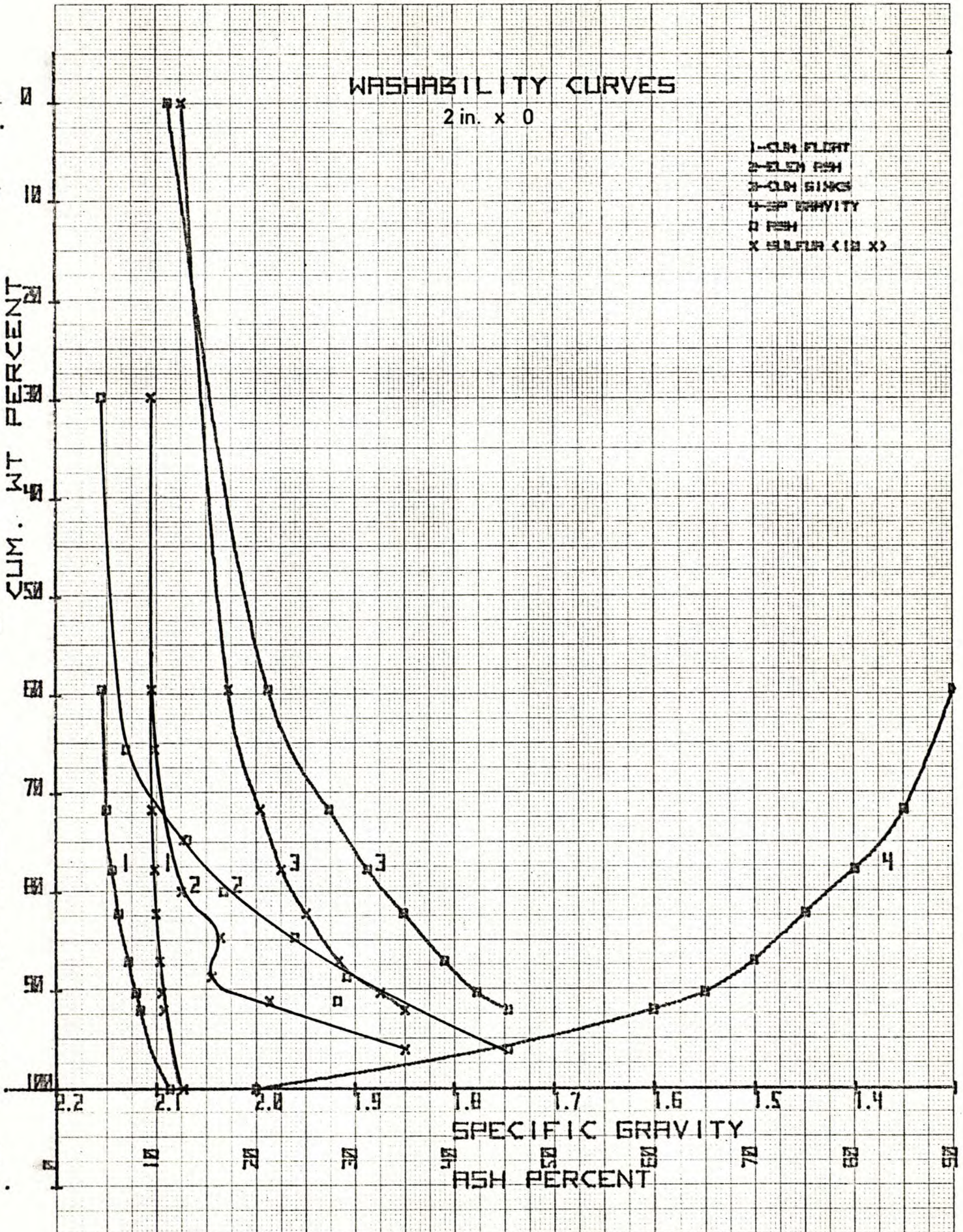


FIGURE 4A ITEM 4 CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 10 X 25 CM.
NEUPFEL & LESSER CO. MADE IN U.S.A.

WASHABILITY CURVES

2 x 1/4 in.

- 1-CM FLOTT
- △ 2-CM FISH
- 3-CM SINKS
- ▽ 4-IP GRAVITY
- ◇ FISH
- × SULFUR < 18 X >

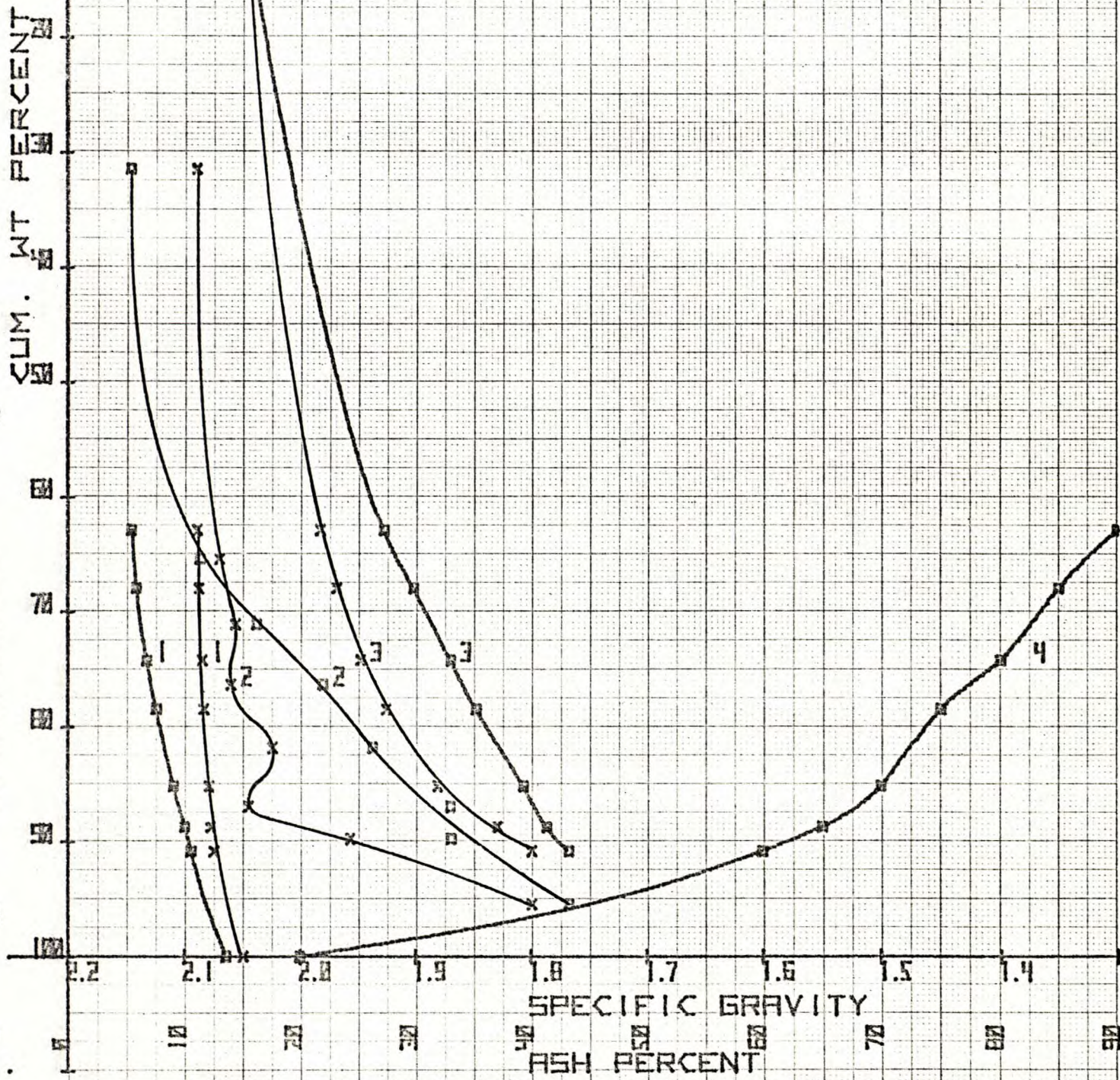


FIGURE 4B ITEM 4 - CHANNEL SAMPLE

461510

1.0 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

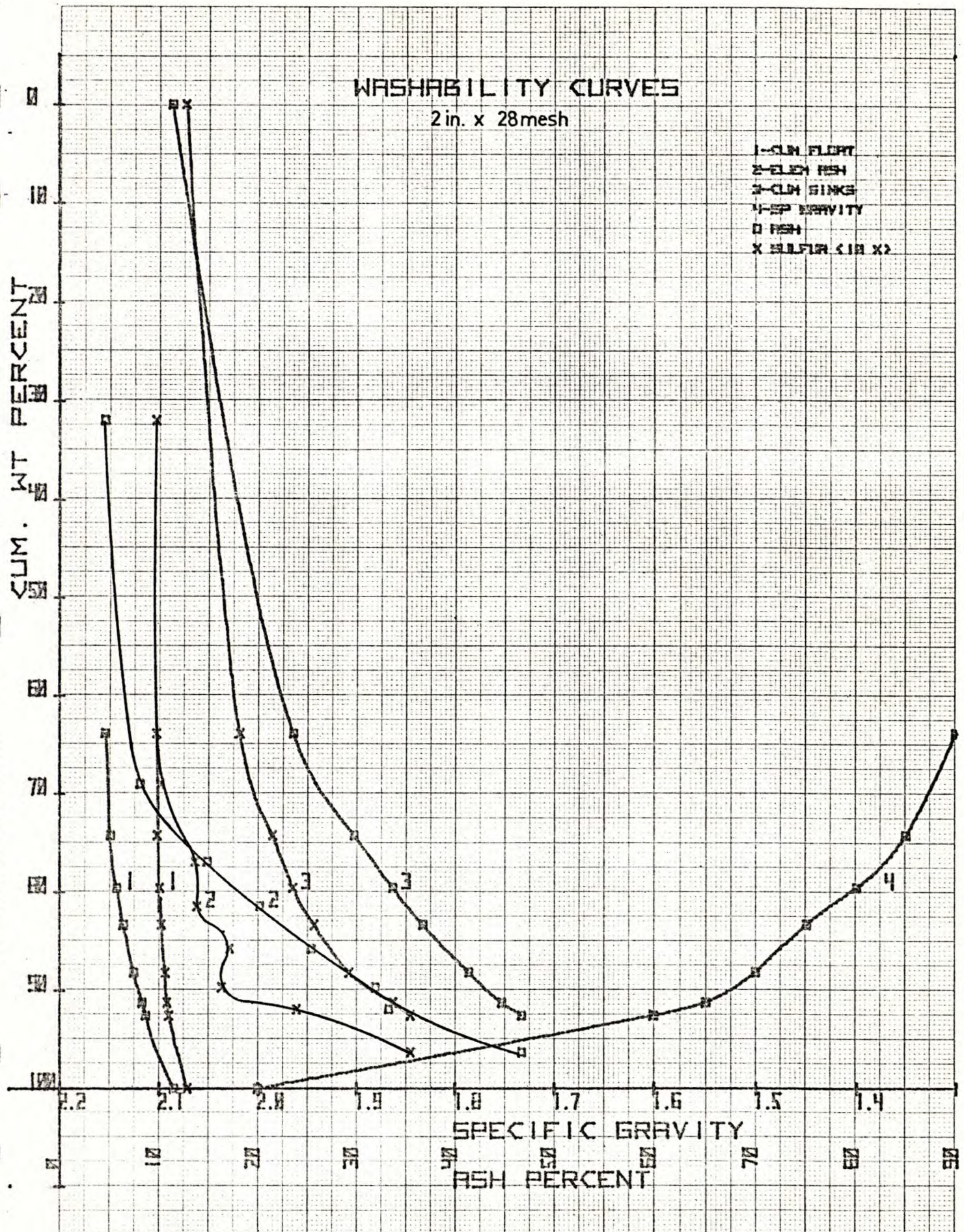


FIGURE 4C ITEM 4 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
K&E KROFFEL & SPIER CO. MFG. U.S.A.

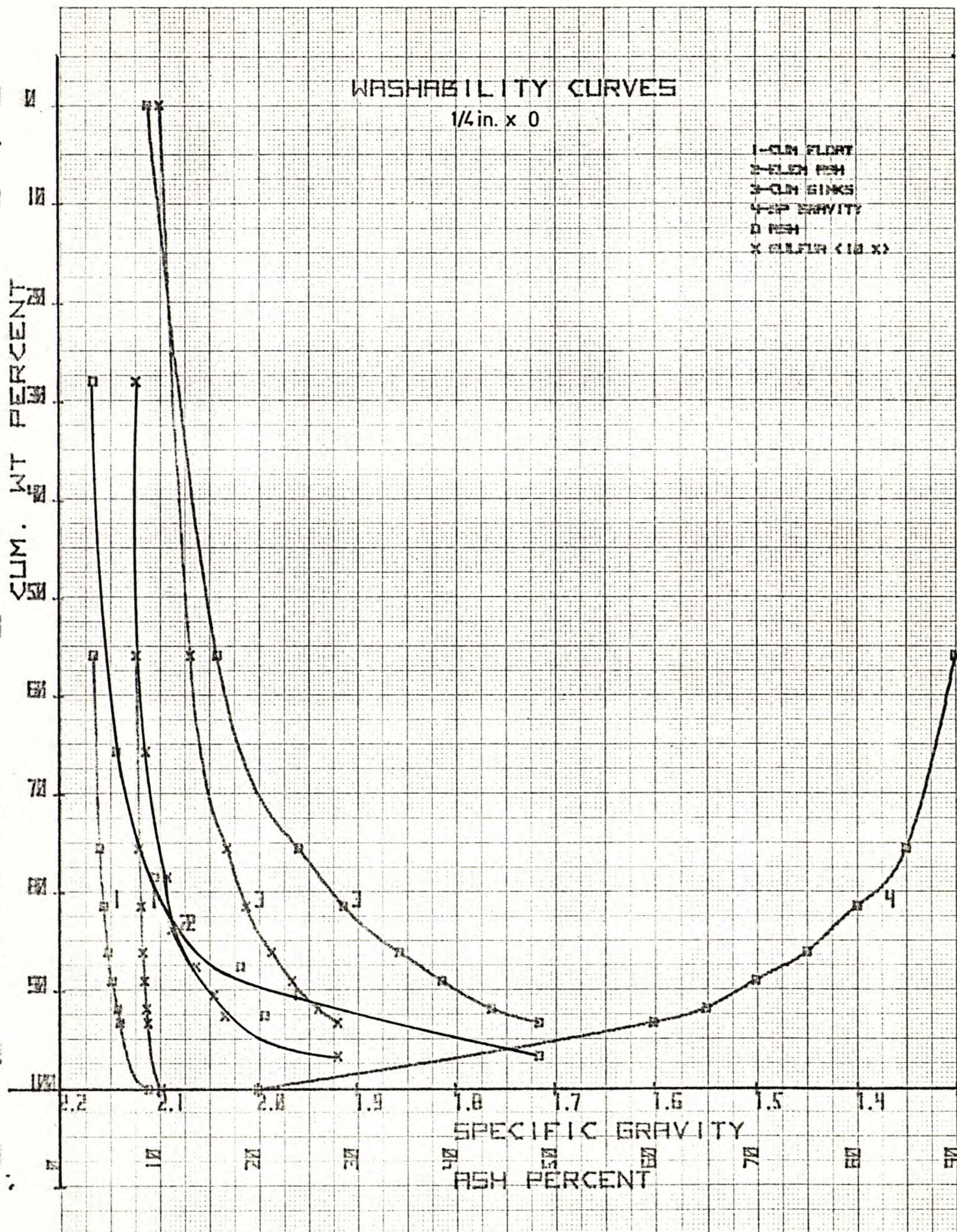


FIGURE 4D ITEM 4 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 19 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

WASHABILITY CURVES

1/4 in. x 28mesh

- 1-CLAY FLOAT
- 2-CLAY FIN
- 3-CLAY SINKS
- 4-SP GRAVITY
- FIN
- X SILICA (13 X)

CUM. WT PERCENT

SPECIFIC GRAVITY

SPECIFIC GRAVITY

ASH PERCENT

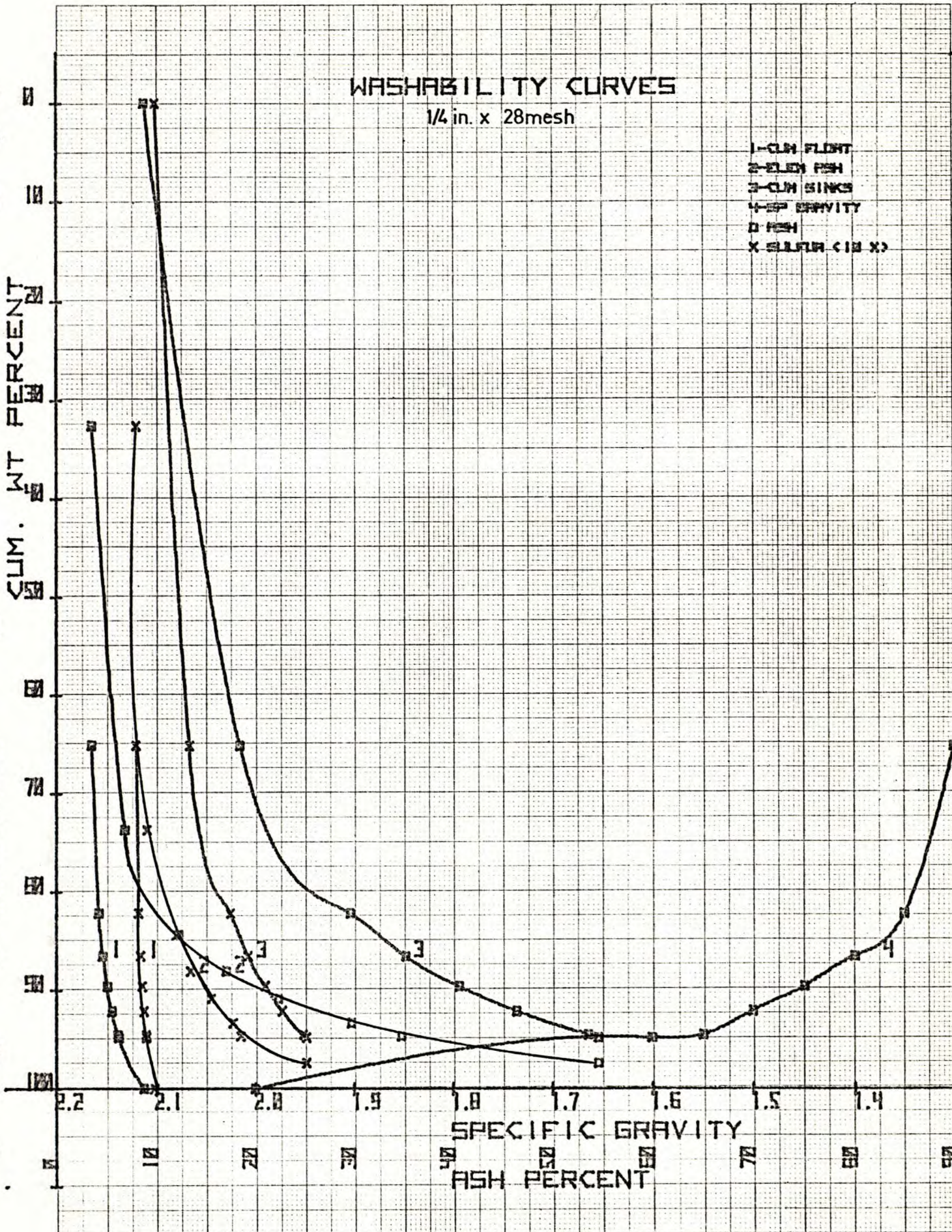


FIGURE 4E ITEM 4 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 10 X 25 CM. KEUFFEL & ESSER CO. MADE IN U.S.A.

WASHABILITY CURVES

28 mesh x 0

- FLOT
- FLOT
- △ FLOT
- ▽ FLOT
- ◇ FLOT
- × FLOT (10 X)

CUM. WT PERCENT

SPECIFIC GRAVITY

ASH PERCENT

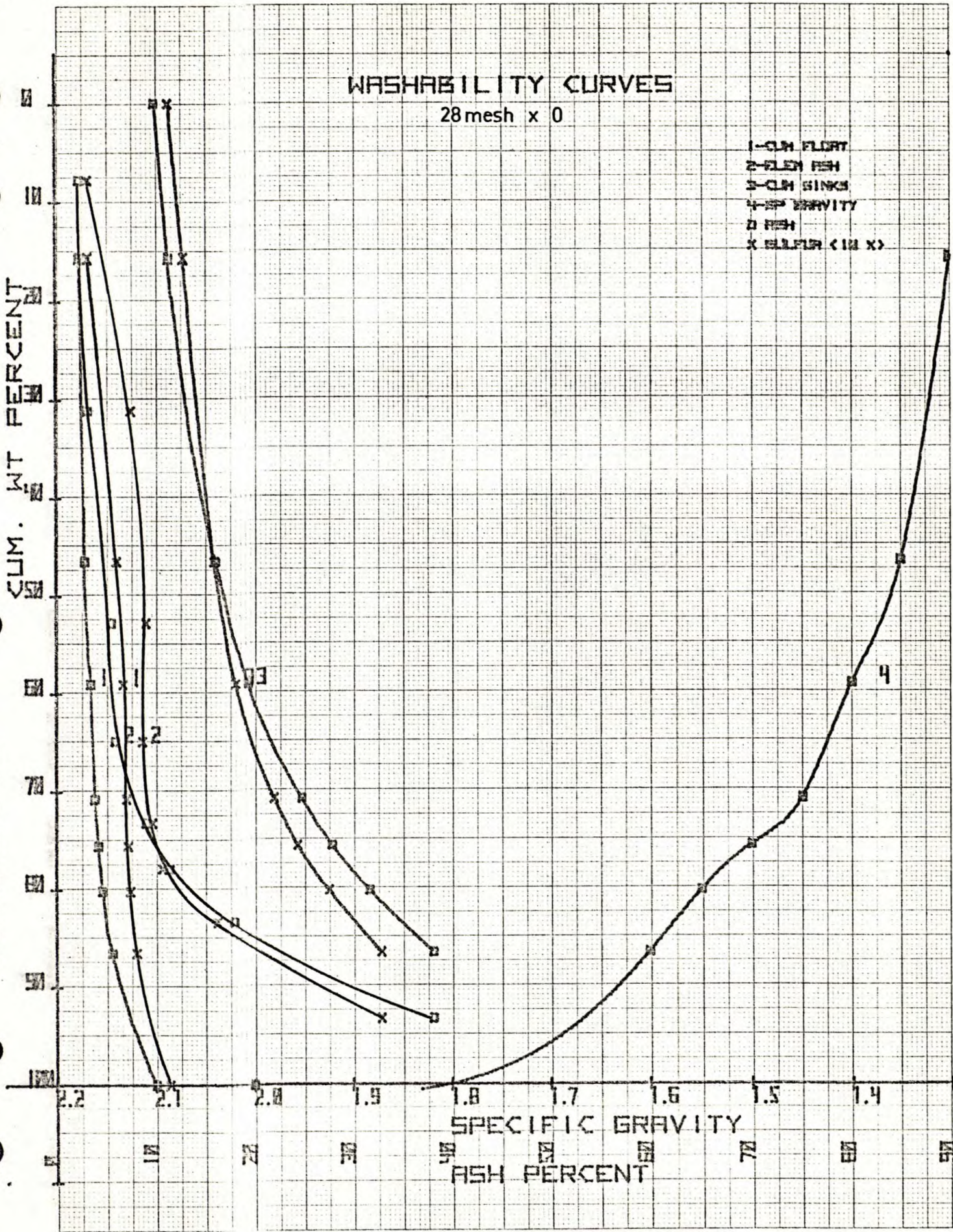


FIGURE 4F ITEM 4 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

WASHABILITY CURVES

2 in. x 0

- ON FLOT
- FINE FINE
- ON SINK
- ON GRAVITY
- FINE
- x SULFUR (10x)

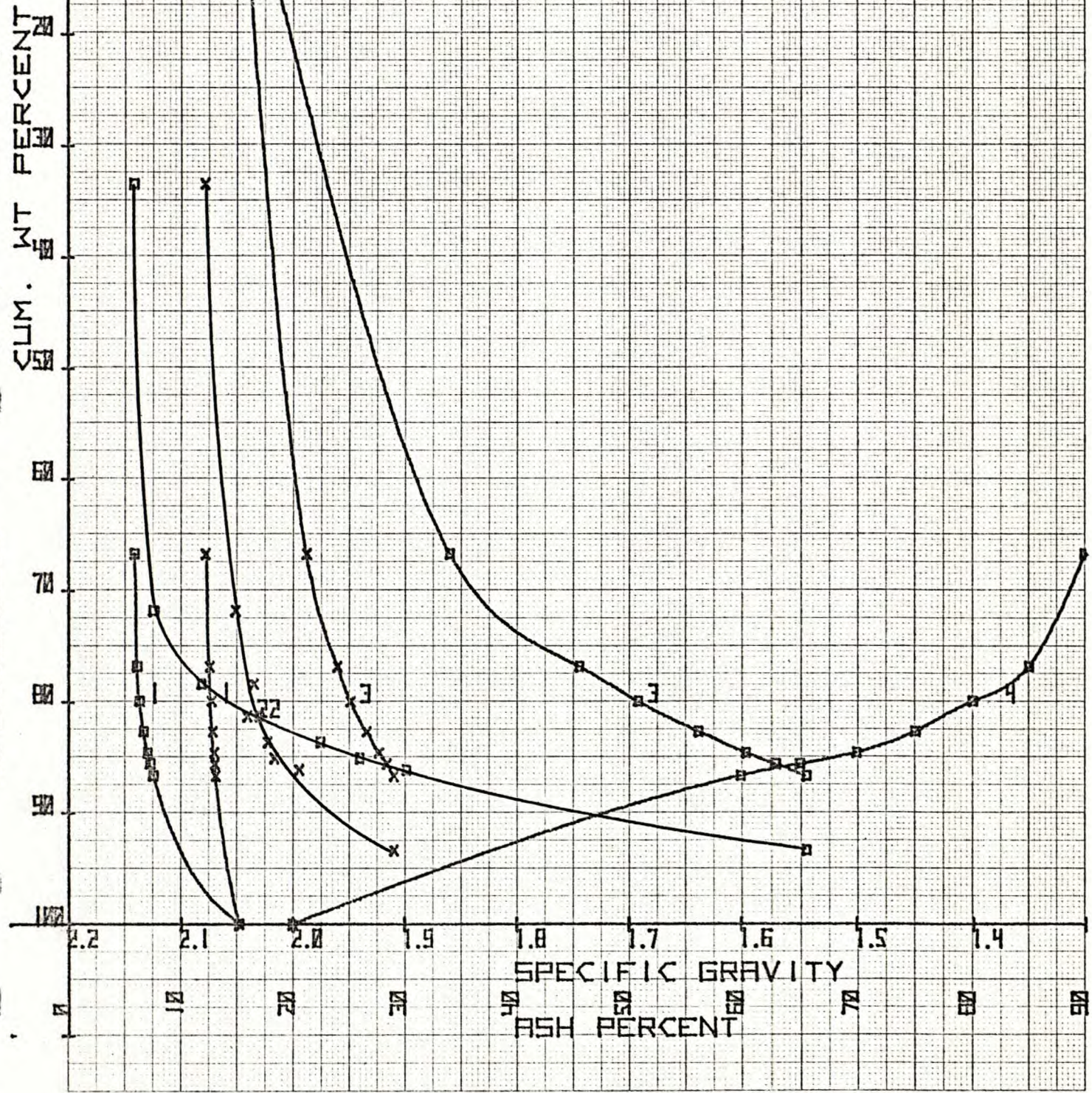


FIGURE 5A ITEM 5 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 10 X 25 CM
ALUFEL & ESSER CO. MADE IN U.S.A.

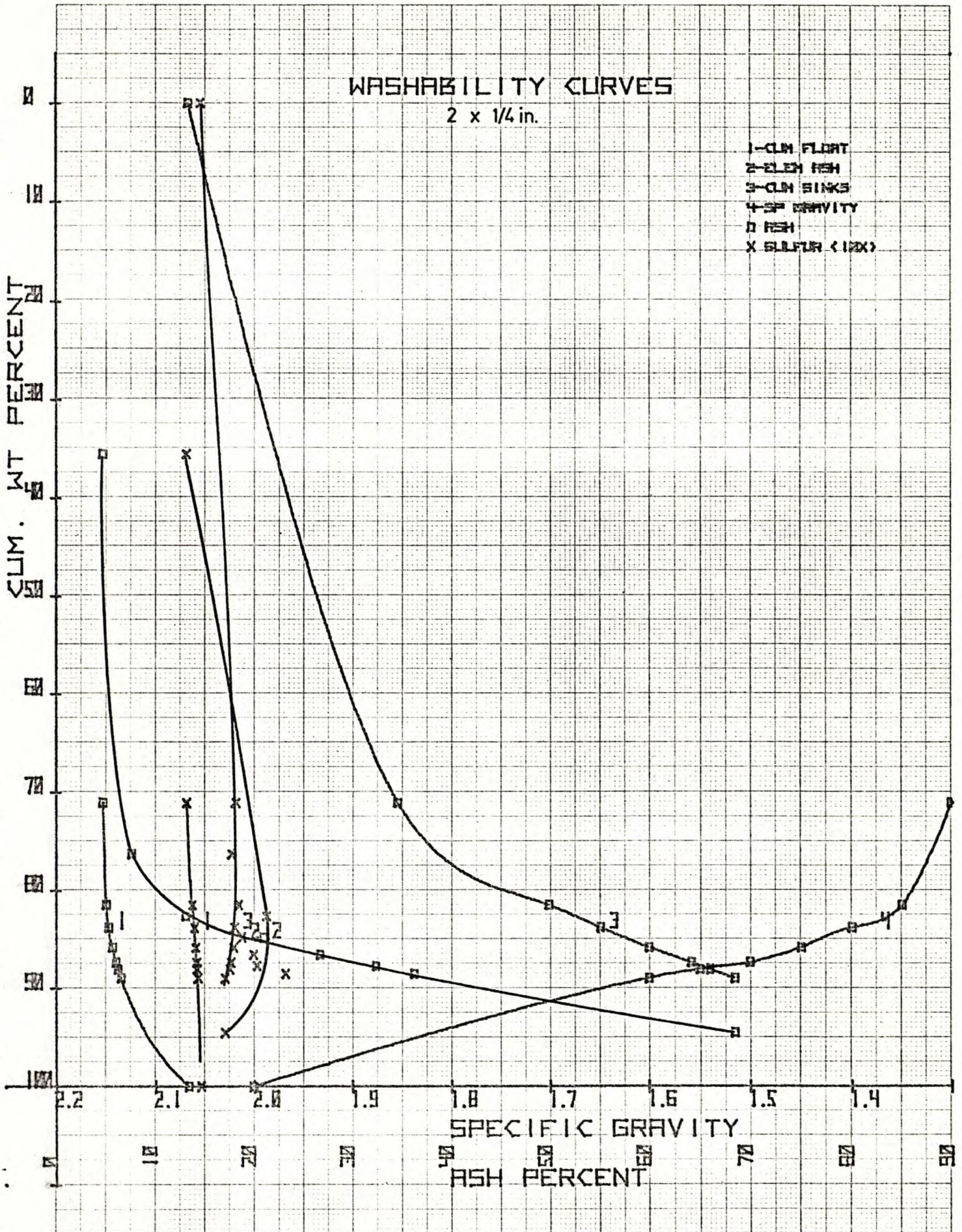


FIGURE 5B ITEM 5 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
KLEUFFEL & ESSER CO. MADE IN U.S.A.

WASHABILITY CURVES

2 in. x 28 mesh

- 1 - CUM. FLOAT
- 2 - CUM. ASH
- 3 - CUM. SINKS
- 4 - SPEC. GRAVITY
- ASH
- X SULFUR (10X)

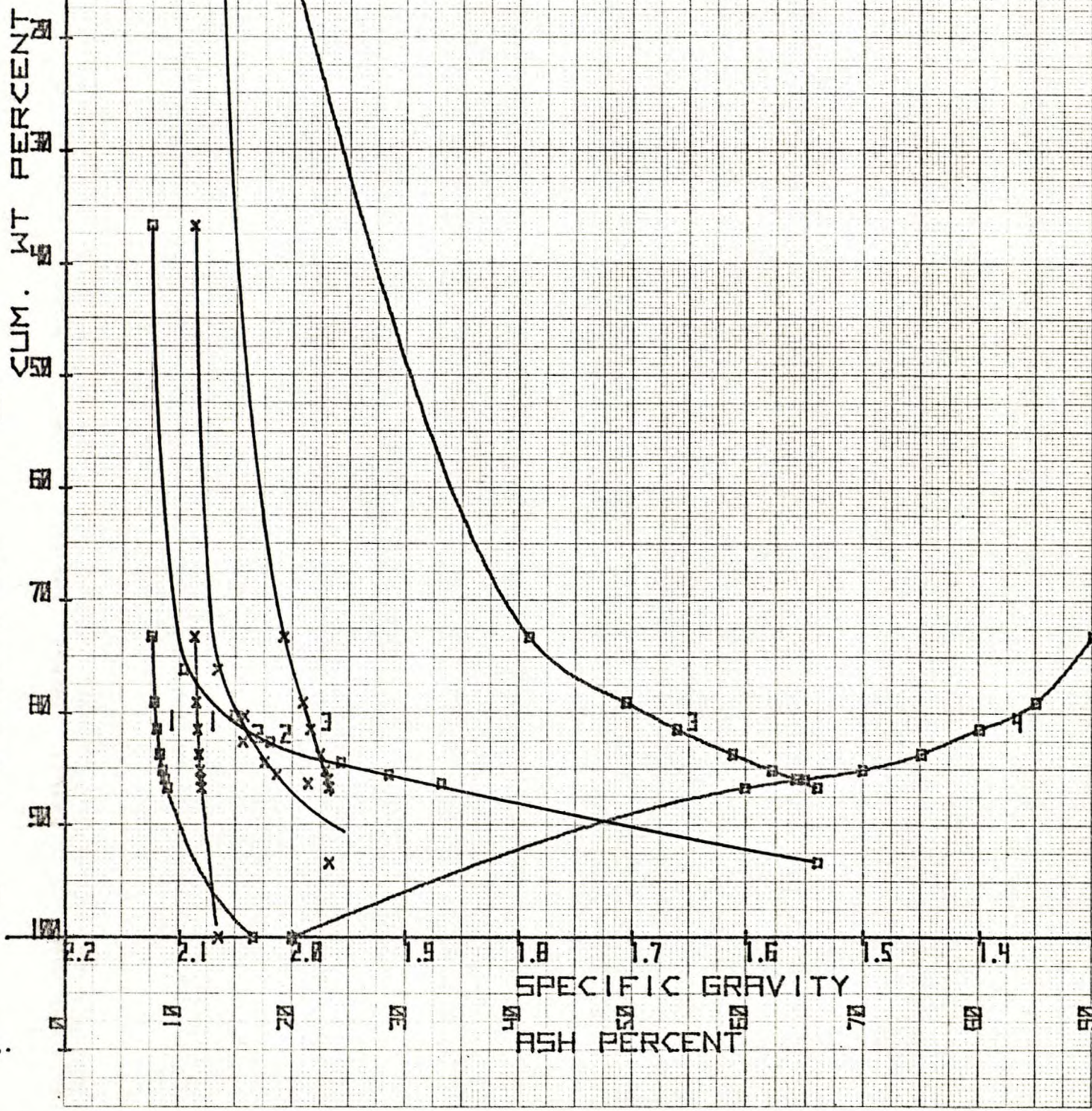


FIGURE 5C ITEM 5 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 10 X 25 CM. KEUFEL & ESSER CO. MADE IN U.S.A.

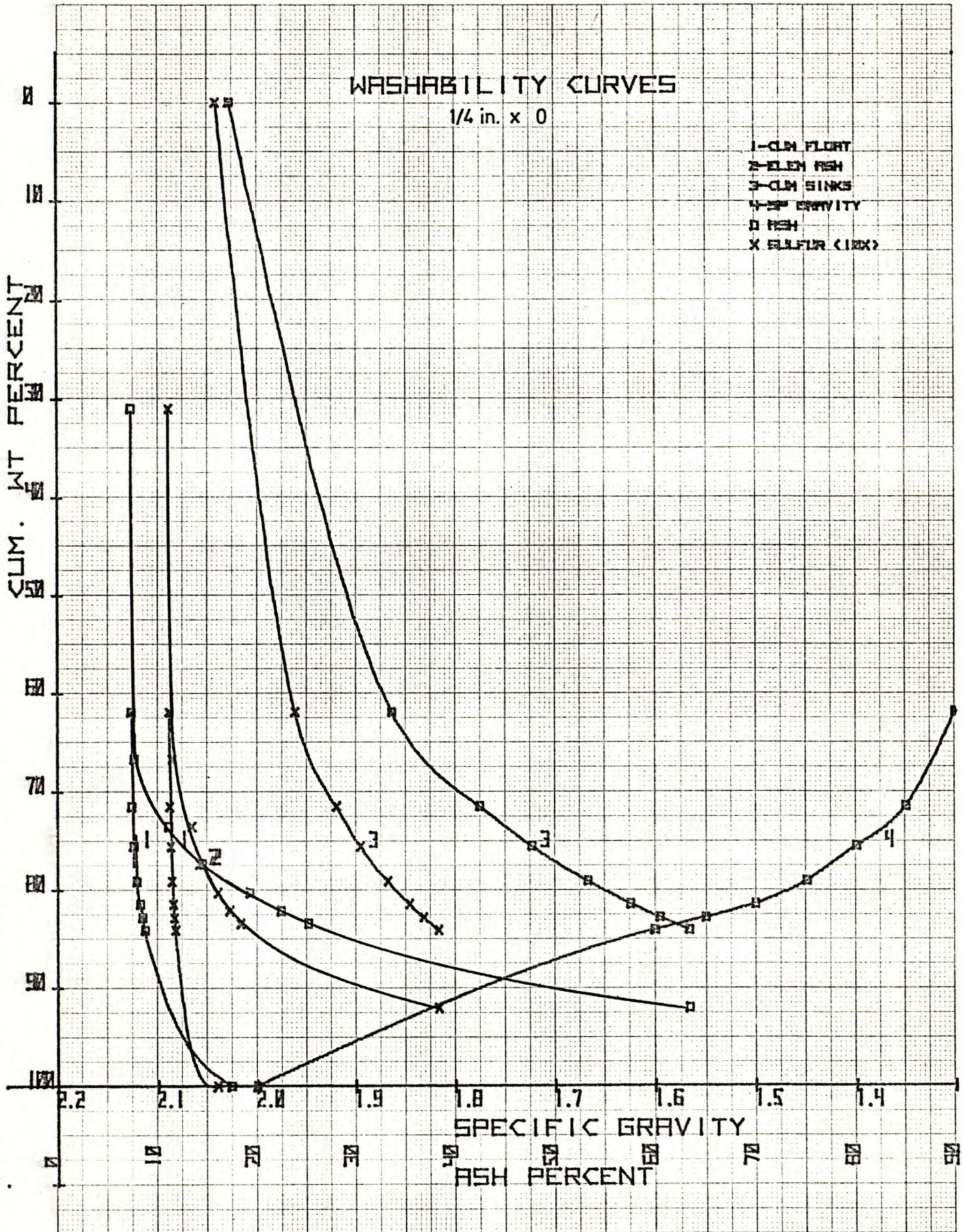


FIGURE 5D ITEM 5 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

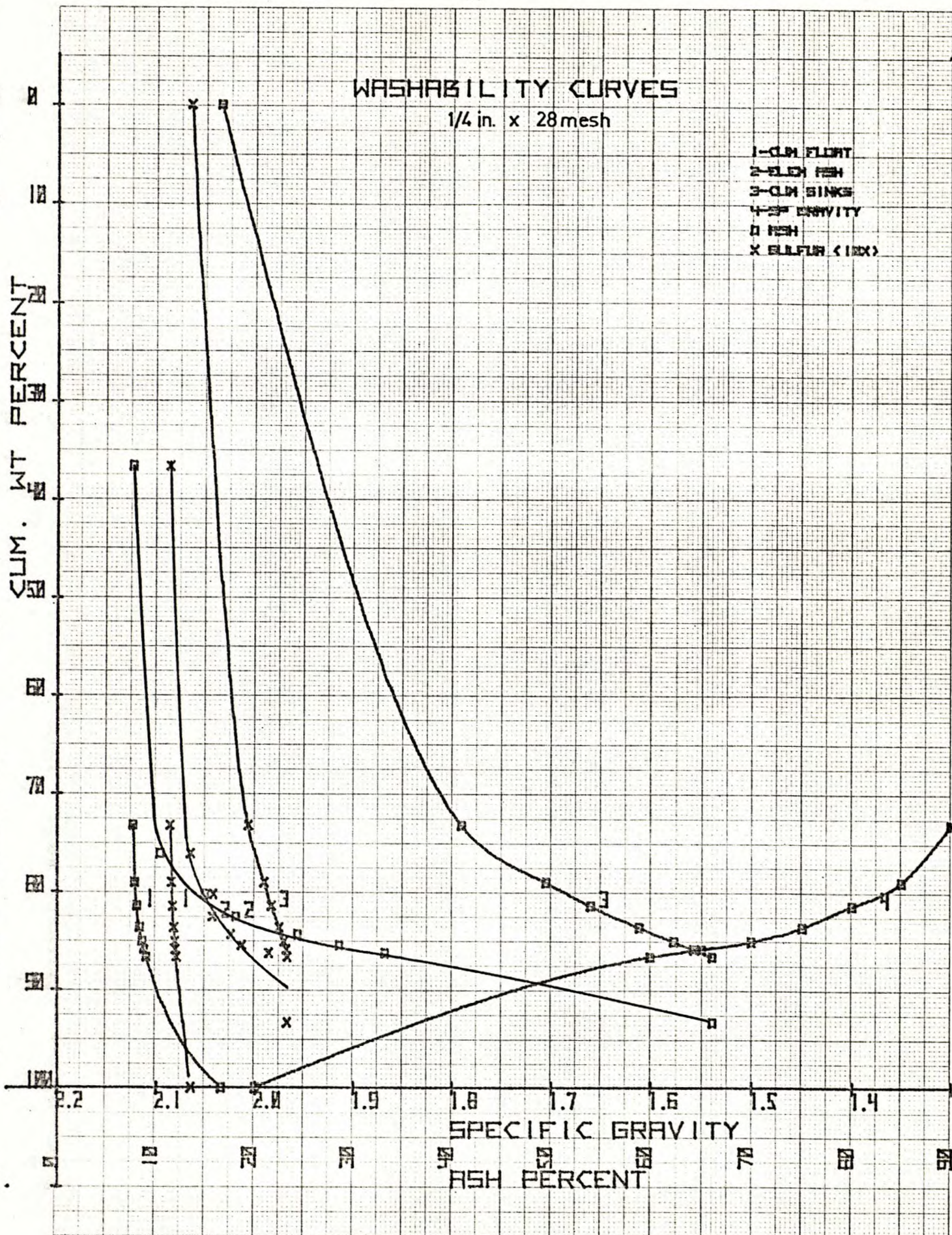


FIGURE 5E ITEM 5 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
NEUFEL & ESSER CO. MADE IN U.S.A.

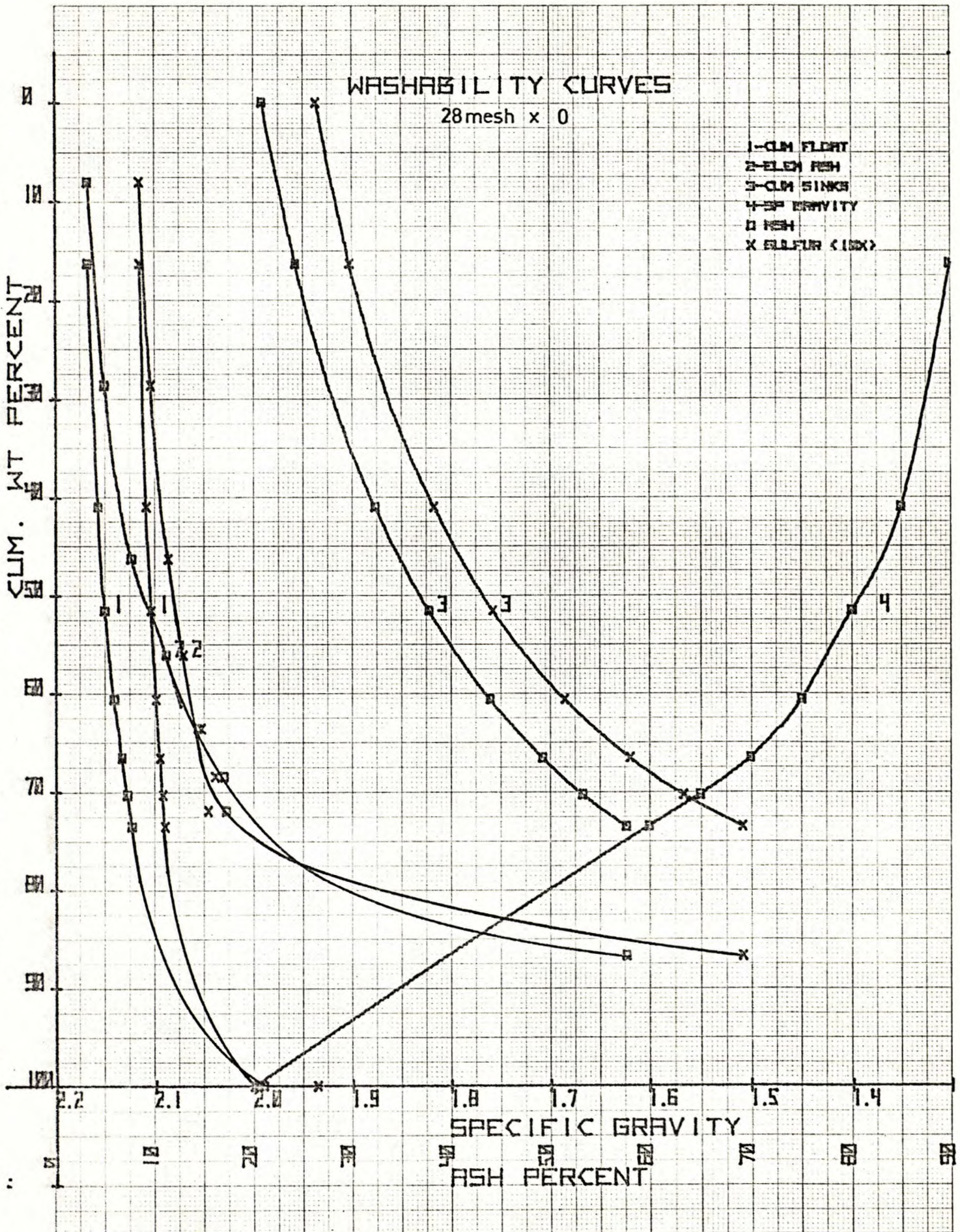


FIGURE 5F ITEM 5 - CHANNEL SAMPLE

46 1510

10 X 10 TO THE CENTIMETER 10 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

WASHABILITY CURVES

2 in. x 0

- 1-CLH FLOAT
- 2-CLH FSH
- 3-CLH SINKS
- 4-CLH GRAVITY
- FSH
- X SULFUR (10X)

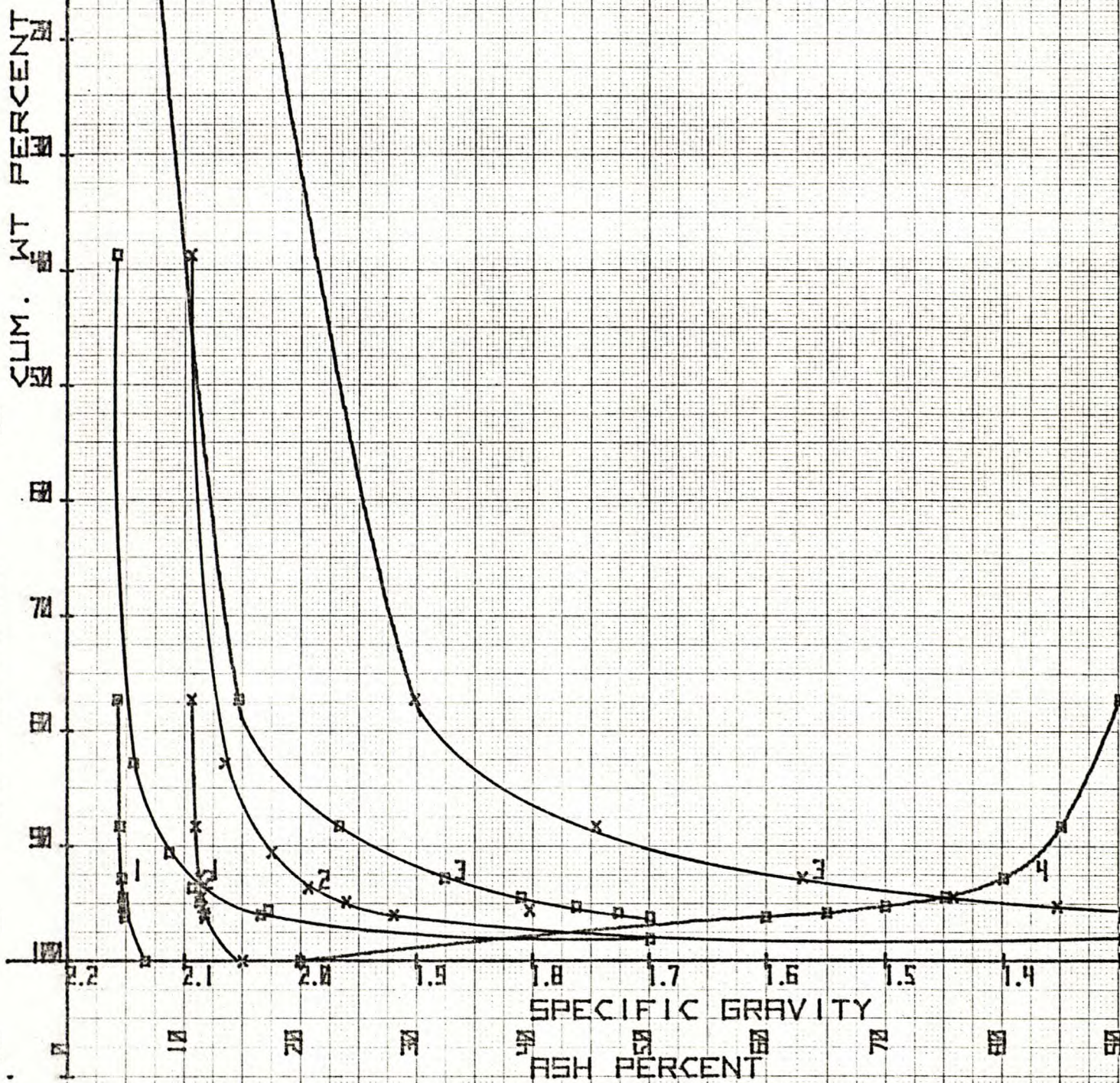


FIGURE 6A ITEM 6 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 10 X 25 CM.
KOPPEL & ESSER CO. MADE IN U.S.A.

WASHABILITY CURVES

2 x 1/4 in.

- 1-CL FLINT
- 2-CL SAND
- 3-CL GRAVEL
- 4-CL GRAVEL
- 5-CL GRAVEL
- 6-CL GRAVEL
- 7-CL GRAVEL
- 8-CL GRAVEL
- 9-CL GRAVEL
- 10-CL GRAVEL
- 11-CL GRAVEL
- 12-CL GRAVEL
- 13-CL GRAVEL
- 14-CL GRAVEL
- 15-CL GRAVEL
- 16-CL GRAVEL
- 17-CL GRAVEL
- 18-CL GRAVEL
- 19-CL GRAVEL
- 20-CL GRAVEL
- 21-CL GRAVEL
- 22-CL GRAVEL
- 23-CL GRAVEL
- 24-CL GRAVEL
- 25-CL GRAVEL
- 26-CL GRAVEL
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- 28-CL GRAVEL
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- 40-CL GRAVEL
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- 88-CL GRAVEL
- 89-CL GRAVEL
- 90-CL GRAVEL
- 91-CL GRAVEL
- 92-CL GRAVEL
- 93-CL GRAVEL
- 94-CL GRAVEL
- 95-CL GRAVEL
- 96-CL GRAVEL
- 97-CL GRAVEL
- 98-CL GRAVEL
- 99-CL GRAVEL
- 100-CL GRAVEL

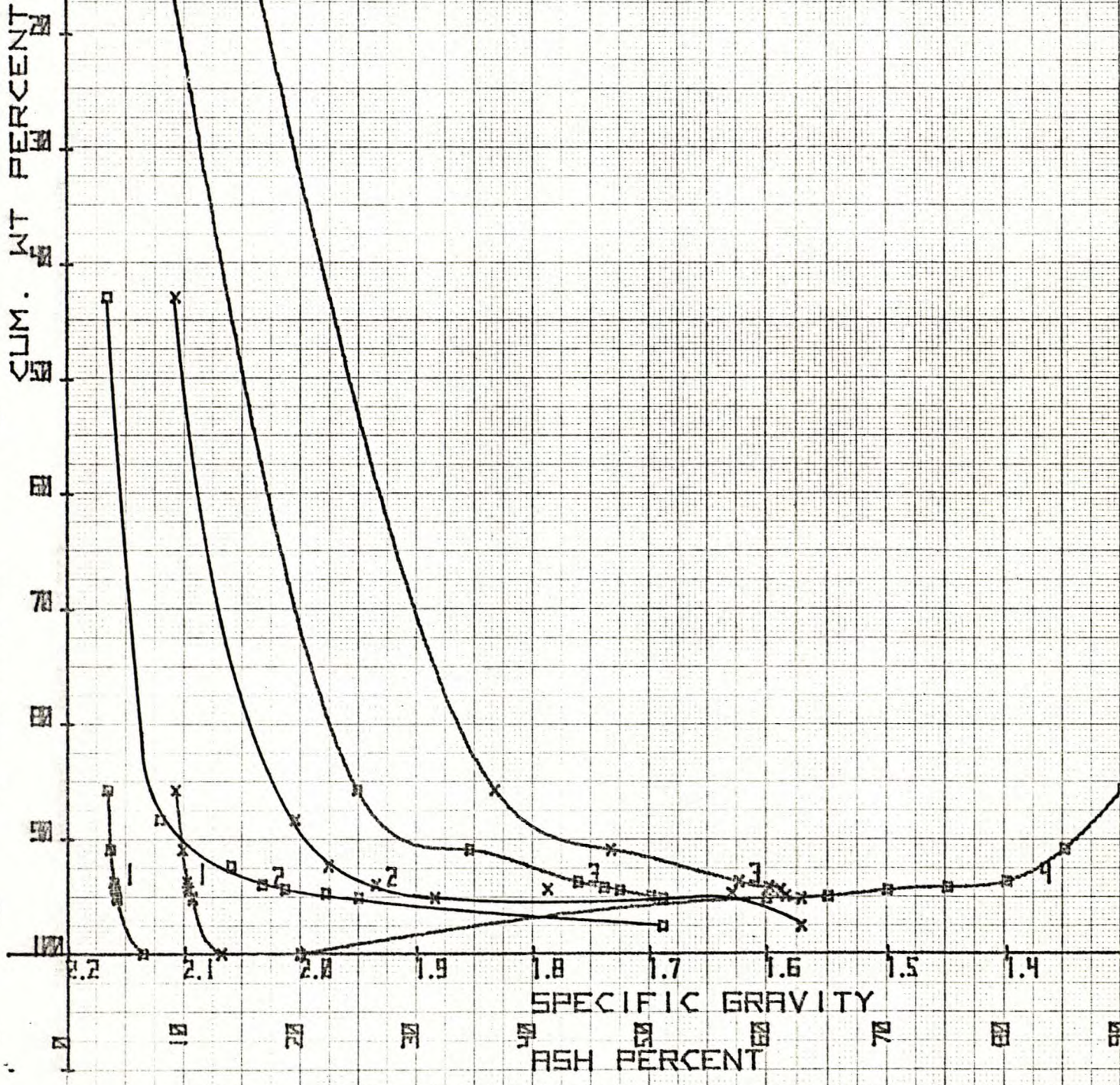


FIGURE 6B ITEM 6 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

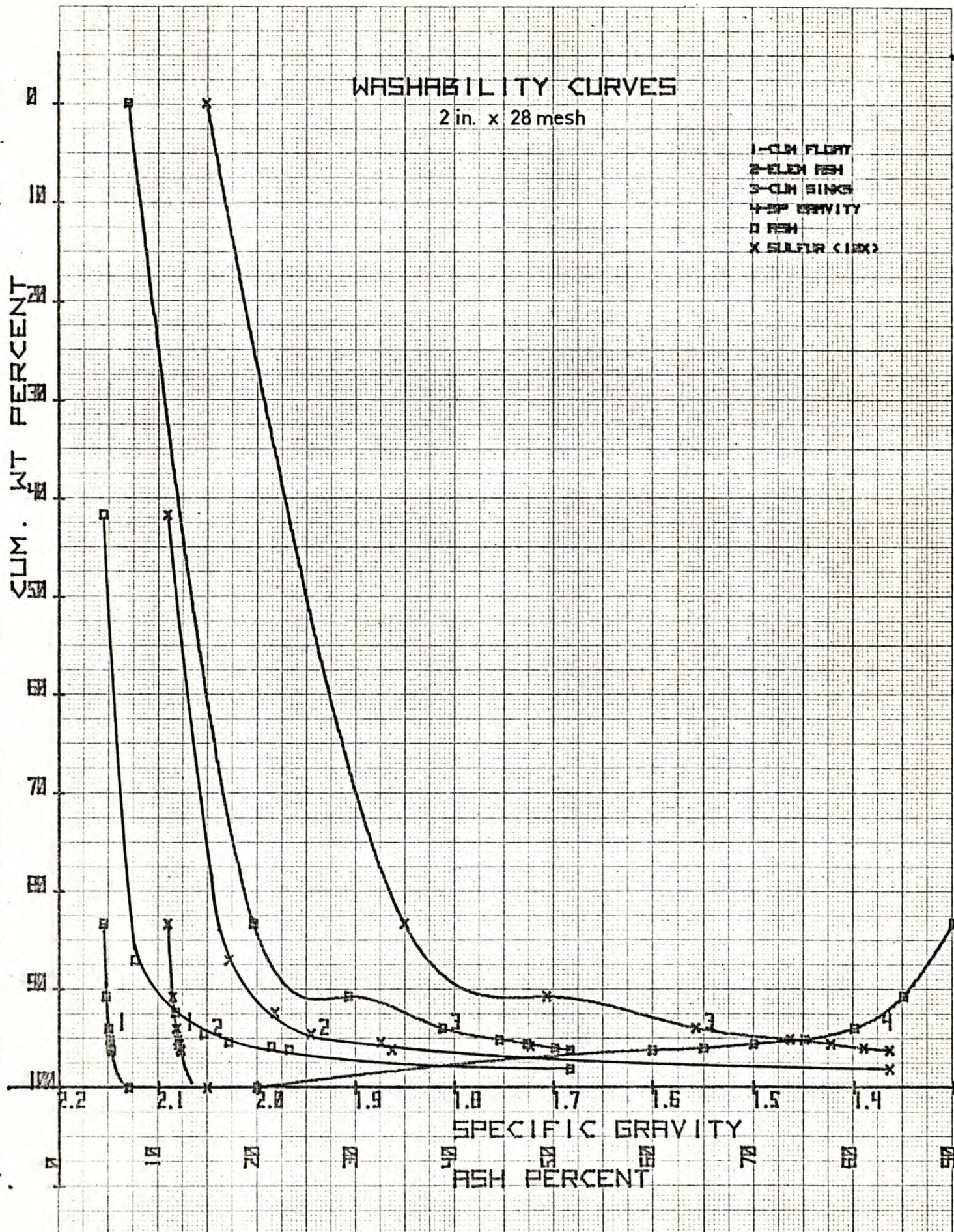


FIGURE 6C ITEM 6 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

WASHABILITY CURVES

1/4 in. x 0

- 1-CLM FLOAT
- 2-CLM FINE
- 3-CLM FINE
- 4-CLM FINE
- FINE
- X SULFUR (10X)

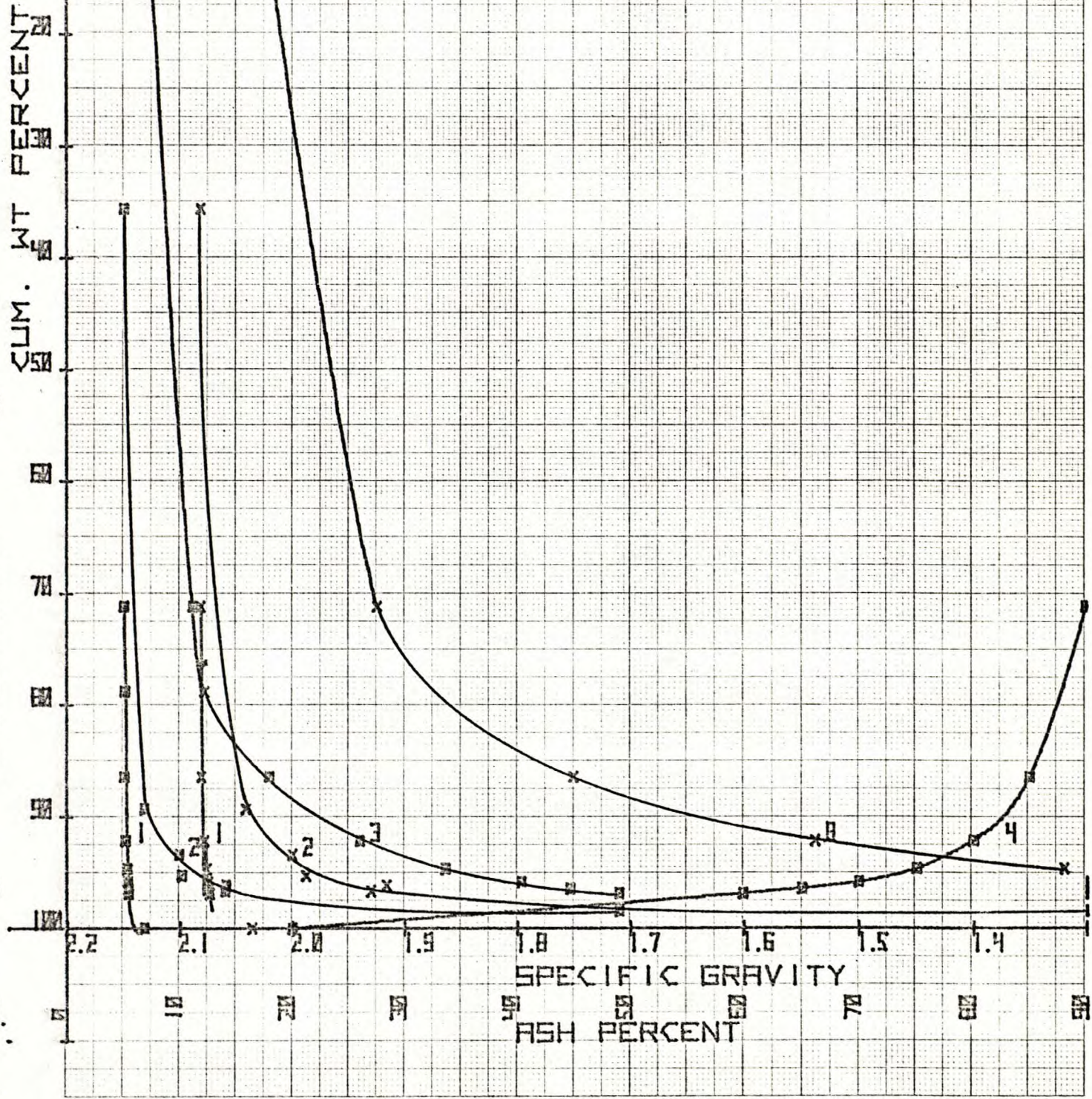


FIGURE 6D ITEM 6 - CHANNEL SAMPLE

46 1510

Model 10 X 10 TO THE CENTIMETER 10 X 25 CM
NEUFTEL & LESSER CO. MADE IN U.S.A.

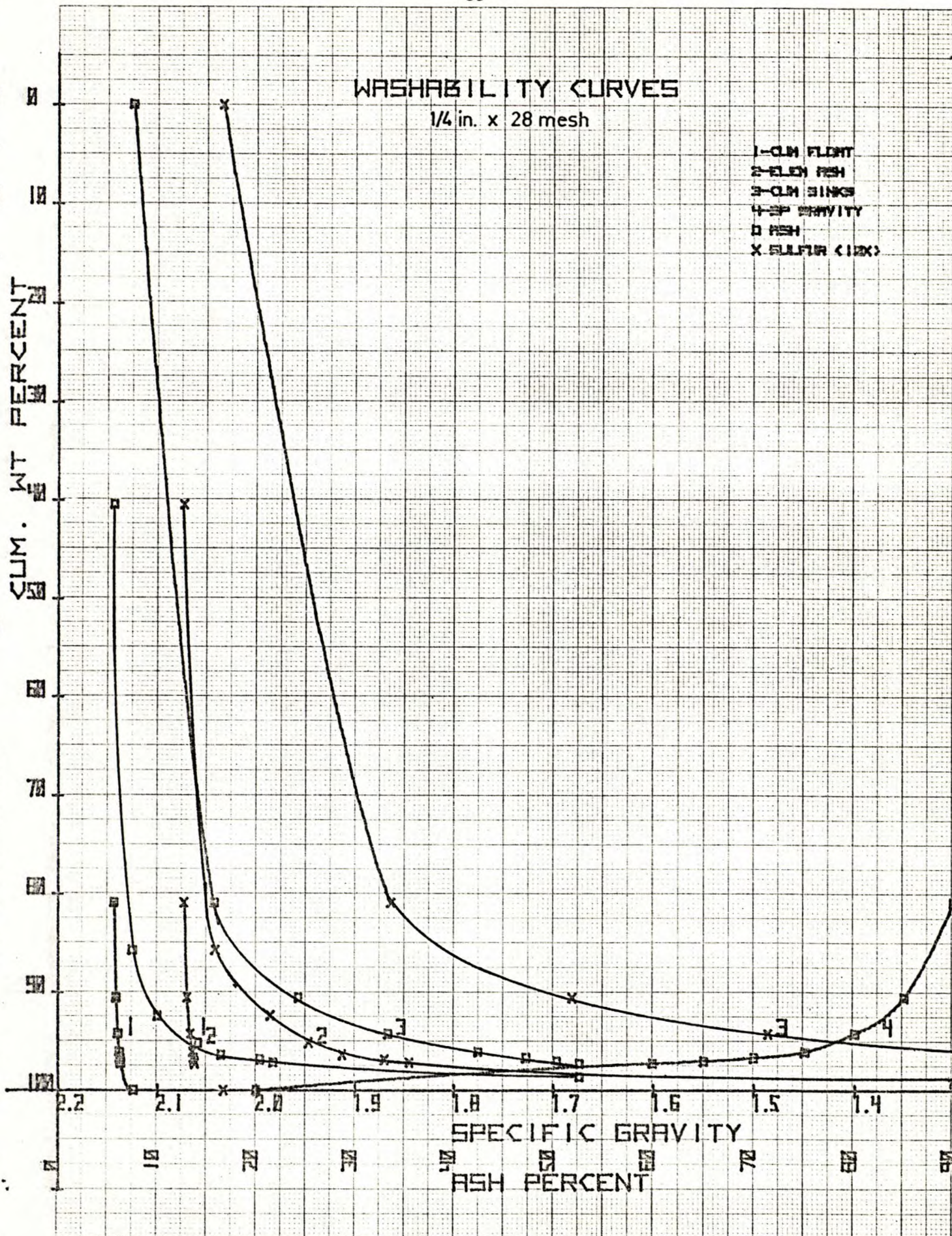


FIGURE 6E ITEM 6 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
NEWELL & FISHER CO. MADE IN U.S.A.

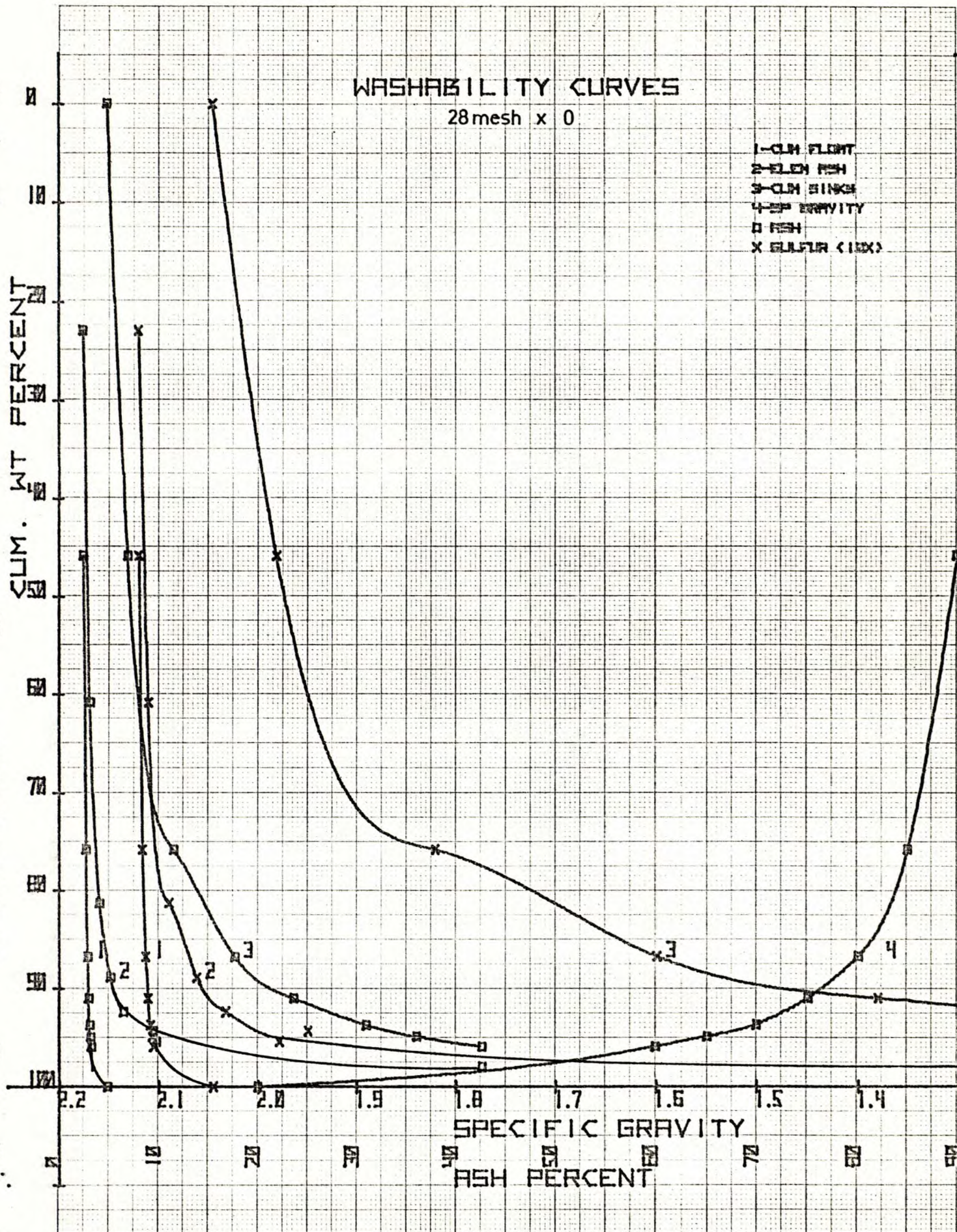


FIGURE 6F ITEM 6 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM
MURPHY & PERRY CO. MADE IN U.S.A.

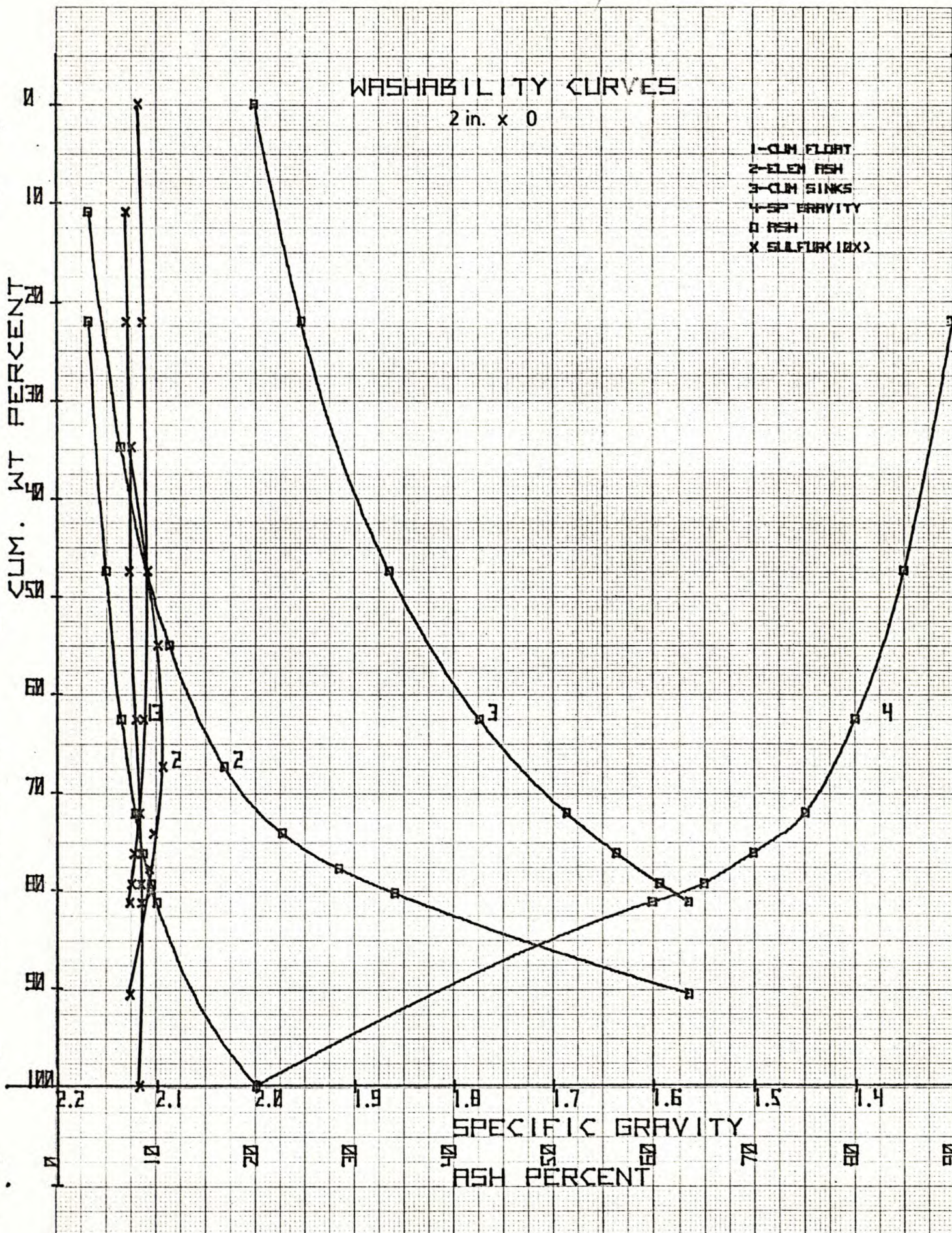


FIGURE 7.1A ITEM 7 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 15 X 25 CM
REUFFEL & FISHER CO. MADE IN U.S.A.

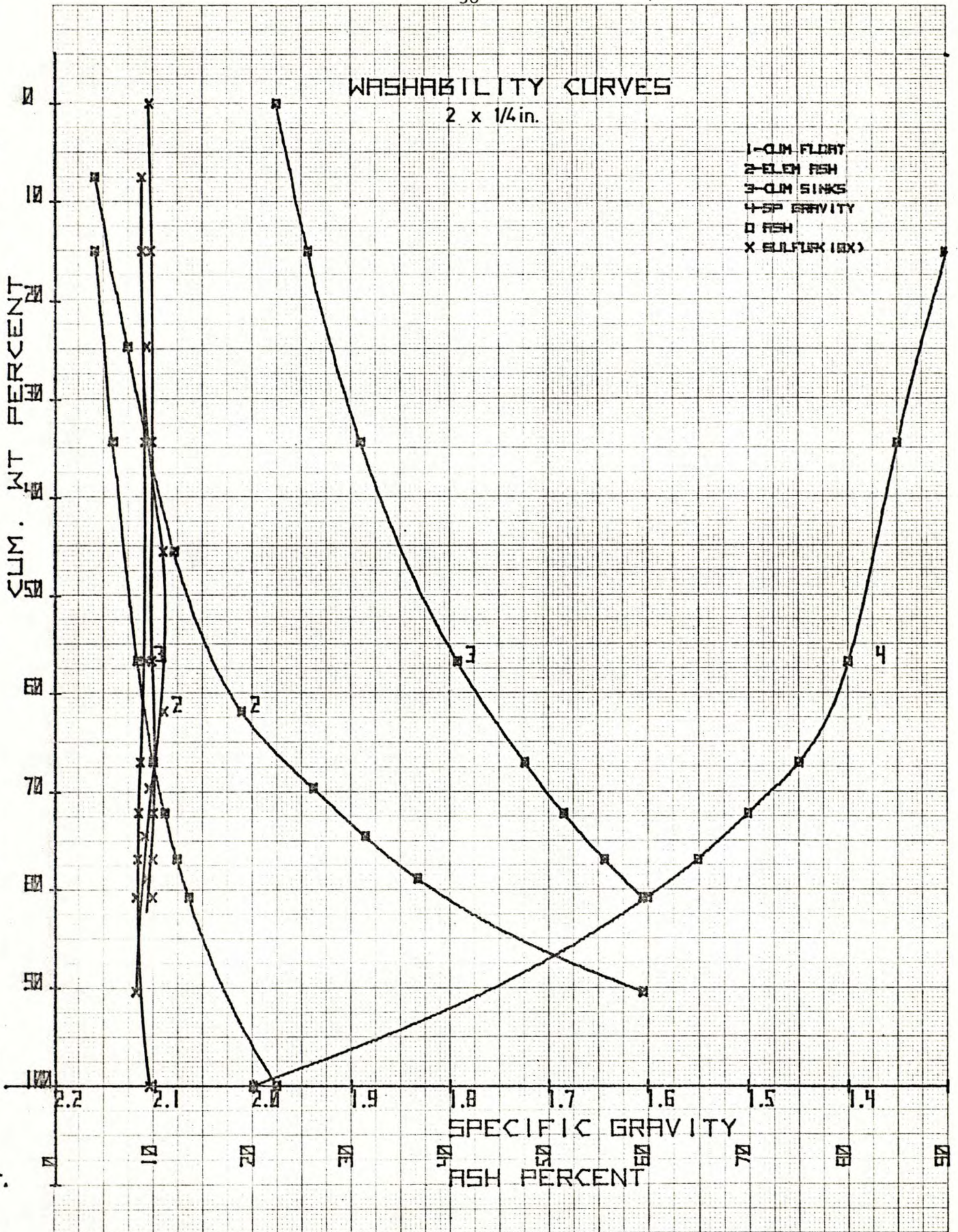


FIGURE 7.1B ITEM 7 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

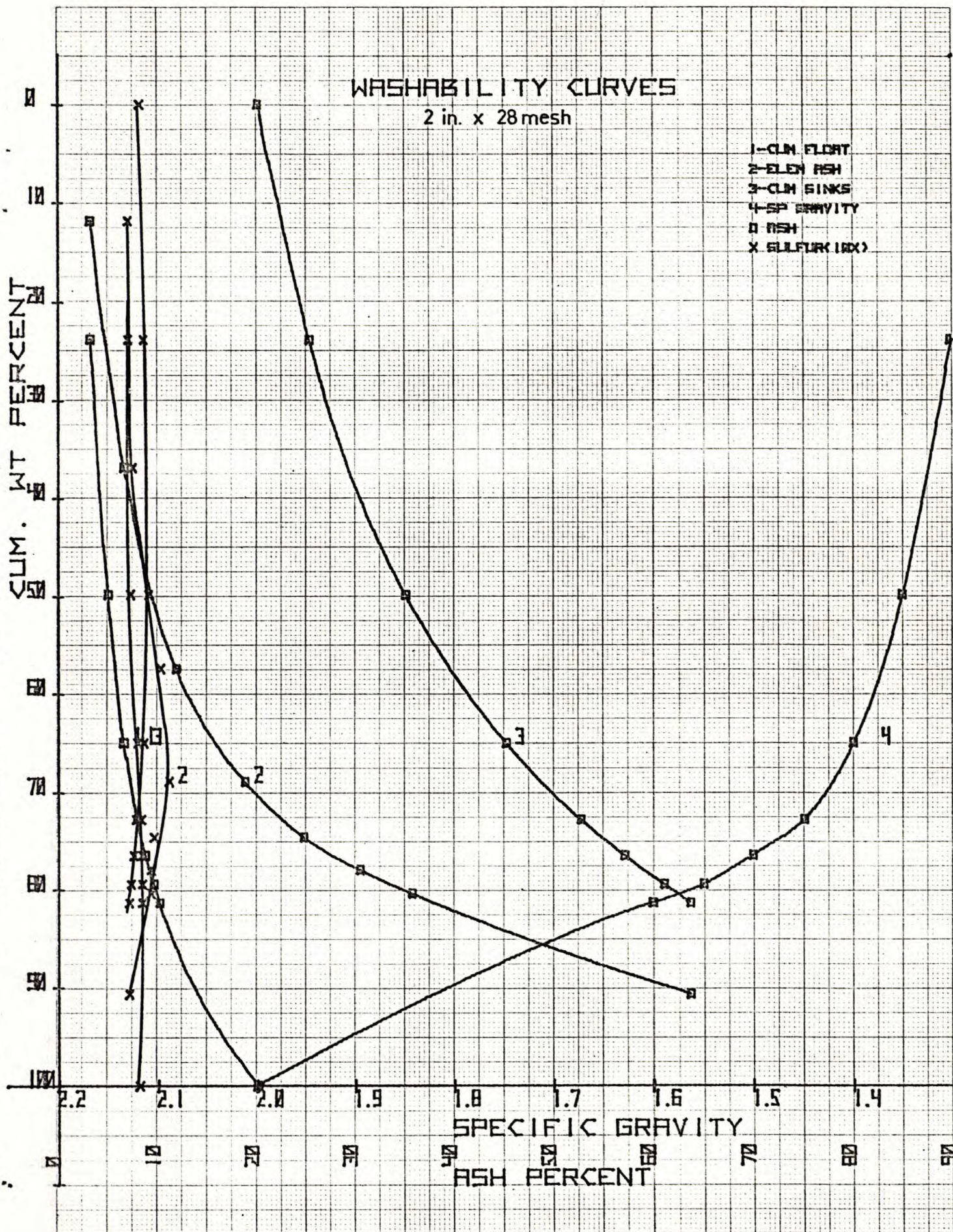


FIGURE 7.1C ITEM 7 - CHANNEL SAMPLE

461510

1/2 X 10 TO THE CENTIMETER 10 X 25 CM. KEUFFEL & ESSER CO. MADE IN U.S.A.

WASHABILITY CURVES

1/4 in. x 0

- 1-CUM FLOAT
- 2-ELEM ASH
- 3-CUM SINKS
- 4-SP GRAVITY
- ASH
- X SULFUR (10X)

CUM. WT PERCENT

SPECIFIC GRAVITY

ASH PERCENT

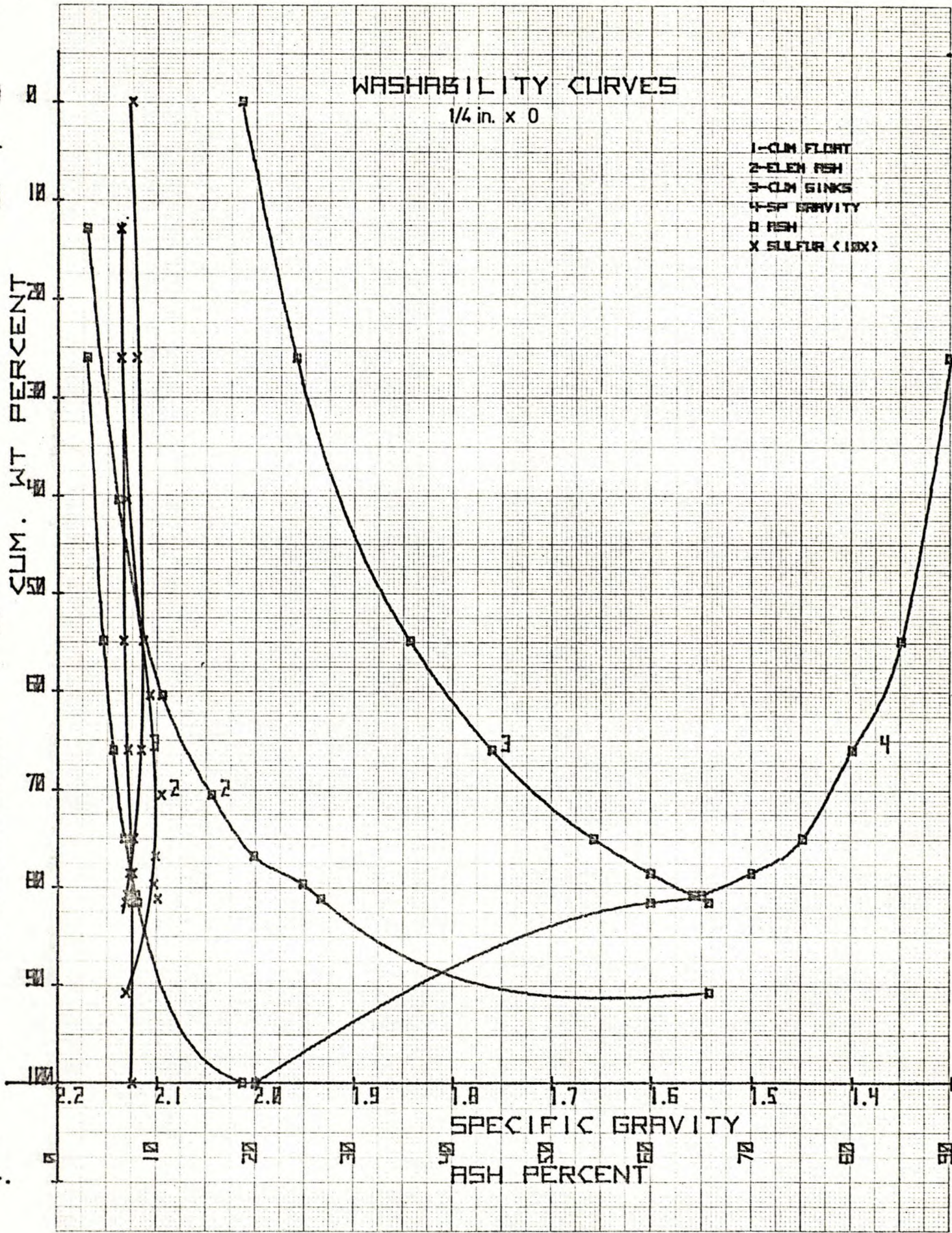


FIGURE 7.1D ITEM 7 - CHANNEL SAMPLE

46 1510

10 X 10 TO THE CENTIMETER 18 X 25 CM
NEEDLE PAPER CO. MADE IN U.S.A.

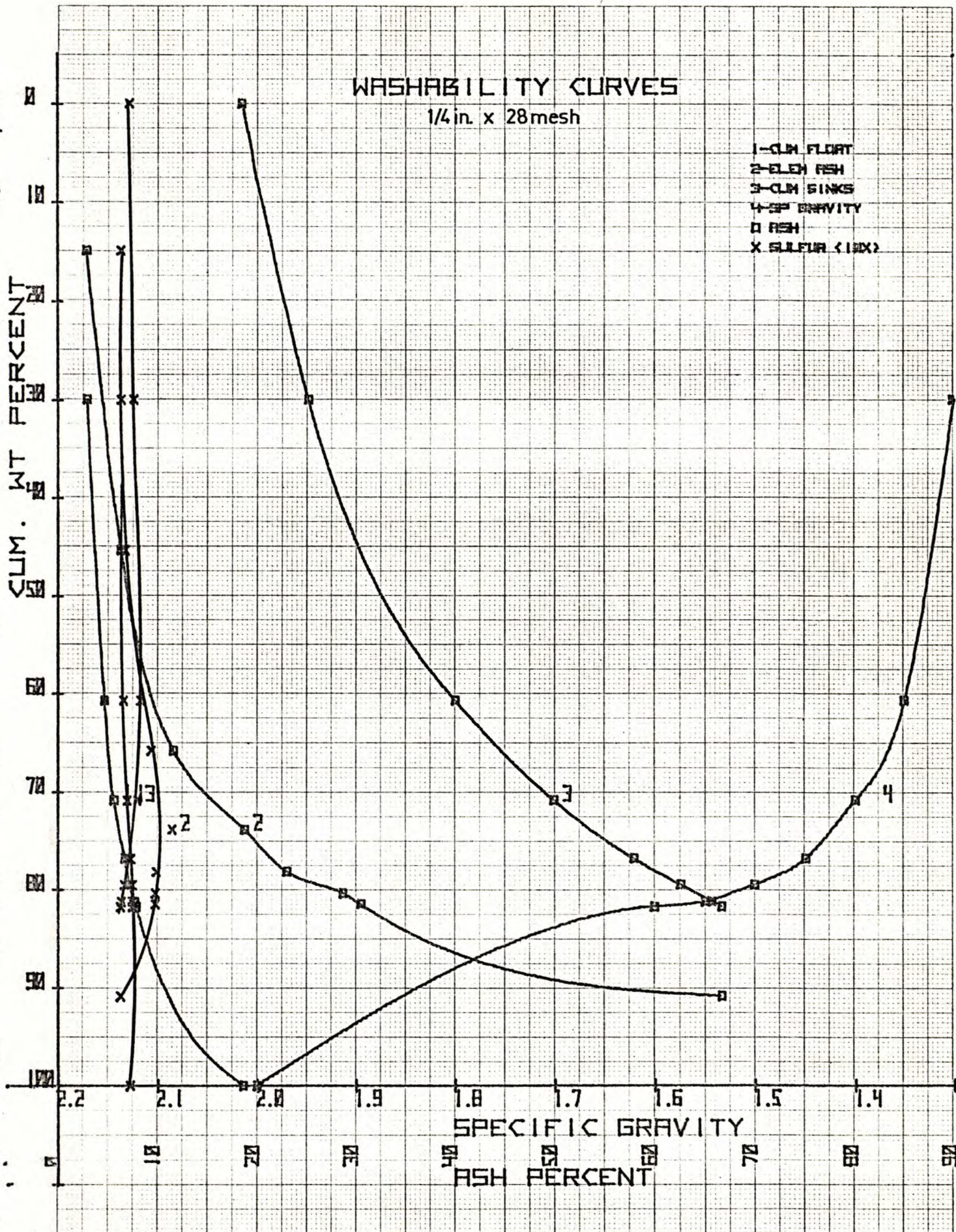


FIGURE 7.1E ITEM 7 - CHANNEL SAMPLE

461510

10 X 10 TO THE CENTIMETER OR X 25 CM.
KAYE REPP & LESSER CO. MADE IN U.S.A.

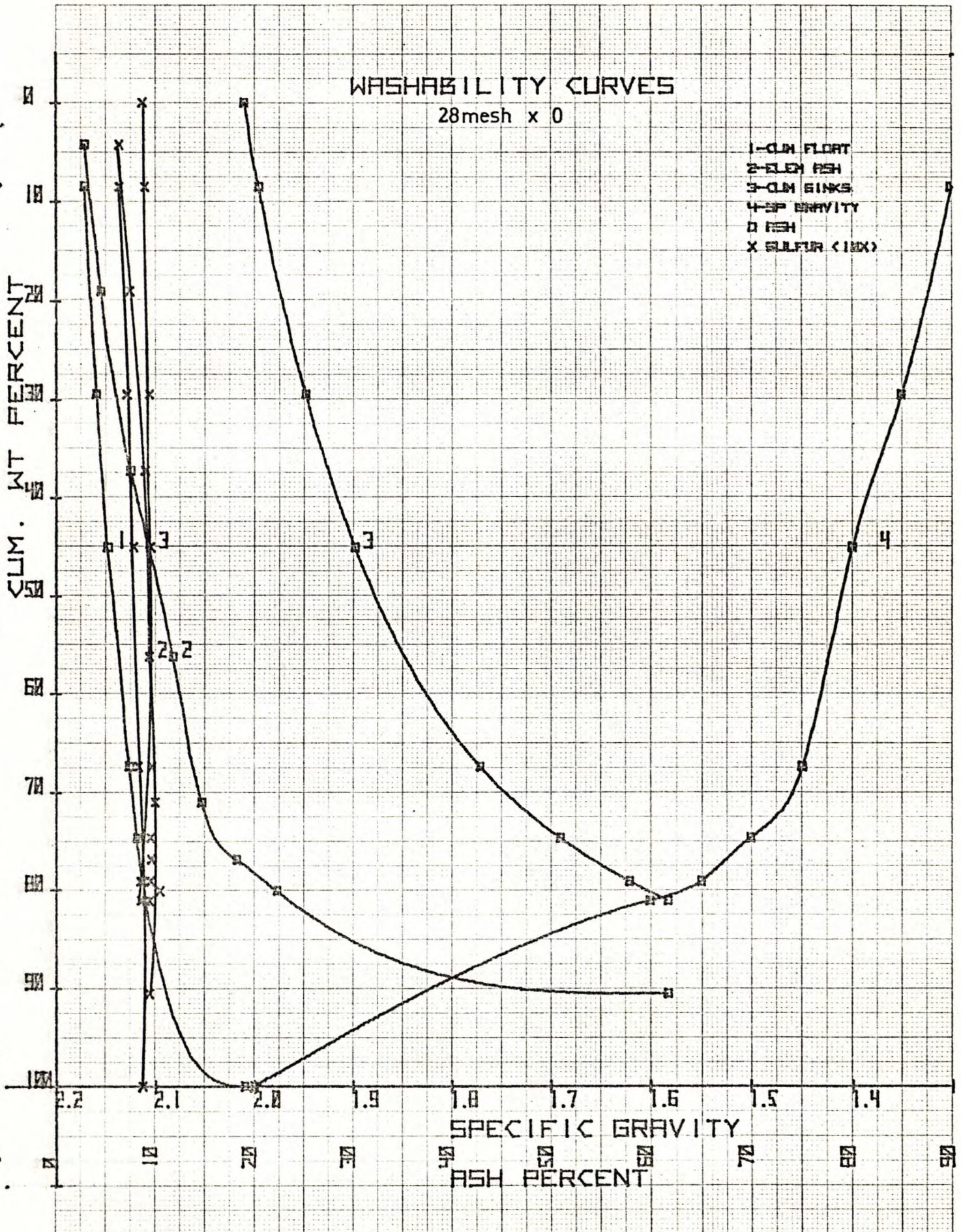


FIGURE 7.1F ITEM 7 - CHANNEL SAMPLE

APPENDIX B

Recleaning the Middlings

RECLEANING THE MIDDLEINGS

In view of the fact that no market for high-ash coal exists at this time nor can be foreseen in the near future, the recovery of coking coal from the middlings will be considered in this Appendix.

The middlings product obtained from the mixture (5+6+7) constituted 50.3% by weight of the raw feed to the plant, as shown in Table 3 in the main body of the report. Its ash content was 22.3% and the sulfur content 1.84% (dry basis). This product contained 87.32% of plus 28 mesh material (after dewatering on a sieve-bend followed by a vibrating screen with an aperture of 28 mesh). No rinsing was applied. Thus, the deslimed middlings represent 43.9% of the raw feed to the plant.

The washability data of this plus 28 mesh fraction have recently become available. They are presented in Table 5 and Figure B1. It is shown there that half of this material consisted of coal with 5.0% ash and 1.1% sulfur. In order to recover the maximum amount of coking coal from the middlings the use of a single dense-medium cyclone (24 in. diam) is needed.

The performance evaluation curves for this separator are shown in Figure B2. An example illustrates that at a yield of 50% the expected ash and sulfur contents for the clean coal are 5.5% and 1.2% respectively. It is noted that the 12.68% of minus 28 mesh material is not lost as it is sent to the slimes beneficiation circuit for recovery of coking coal.

The heavy-medium equipment required for recleaning the middlings comprises the following items.

- 1-Dual Mix Tank
- 1-10 x 8 in. Ni-hard pump
- 1-24 in. H.M. Cyclone
- 1-double set of desliming screens for coal and reject
- 1-medium recovery system(9 items incl., thickener, sump, 2 pumps, a small clarifier cyclone, specific gravity sensor, etc.).

TABLE : WASHING CHARACTERISTICS OF THE MIDDLEINGS PRODUCT (MIXTURE) 1/4 IN. x 28 M

SPECIFIC GRAVITY FRACTIONS	ELEMENTARY DATA PERCENT			CUMULATIVE DATA, PERCENT					
	WEIGHT	ASH	SULPHUR	FLOAT			SINK		
	WEIGHT	ASH	SULPHUR	WEIGHT	ASH	SULPHUR	WEIGHT	ASH	SULPHUR
FLOAT 1.30	48.22	4.87	1.12	48.22	4.87	1.12	100.00	22.03	1.84
1.30-1.35	9.40	7.77	1.58	57.62	5.34	1.20	51.78	38.01	2.50
1.35-1.40	7.96	11.66	2.46	65.58	6.11	1.35	42.38	44.72	2.71
1.40-1.45	4.42	12.29	1.80	70.00	6.50	1.38	34.42	52.36	2.77
1.45-1.50	2.33	28.83	2.91	72.33	7.22	1.43	30.00	58.27	2.91
1.50-1.60	4.17	29.00	2.50	76.50	8.41	1.48	27.67	60.75	2.91
1.60-SINK	23.50	66.38	2.98	100.00	22.03	1.84	23.50	66.38	2.98

Notes

- 1) 1/4 in. x 28 middlings constituted 87.3% by weight of the total middlings produced which, in turn, constituted 50.3% by weight of the raw feed to the plant

46 1510

10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

WASHABILITY CURVES

- 1 - CUM FLDT
- 2 - FLEN FSH
- 3 - CUM SINKS
- 4 - SP EMVITY
- FSH
- X FLS FUR (18 X)

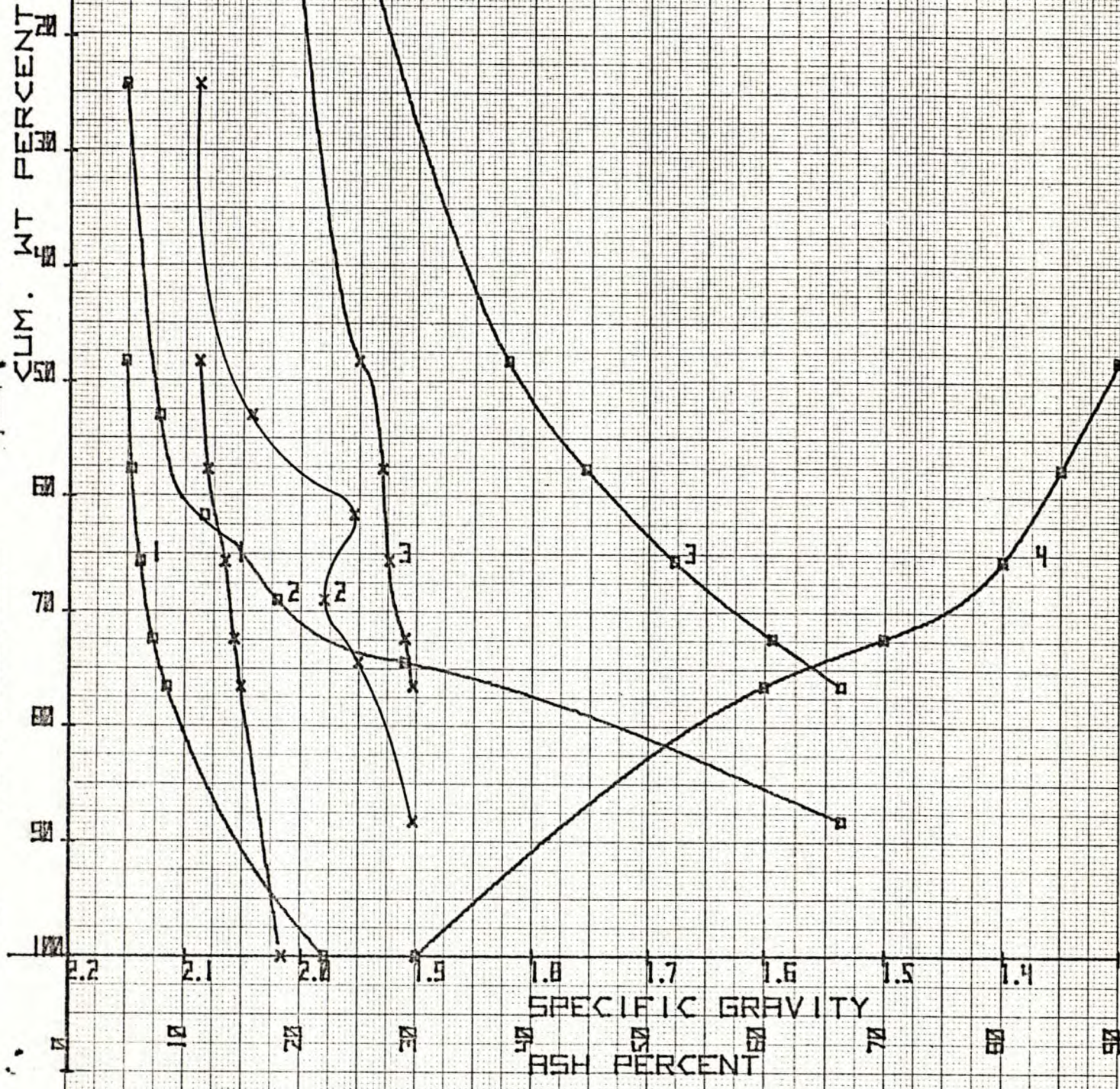


FIGURE B1 - MIDLINGS (MIXTURE) 1/4 IN. x 28 M FRACTION

461510

10 X 10 TO THE CENTIMETER 18 X 25 CM. KEUFFEL & ESSER CO. MADE IN U.S.A.

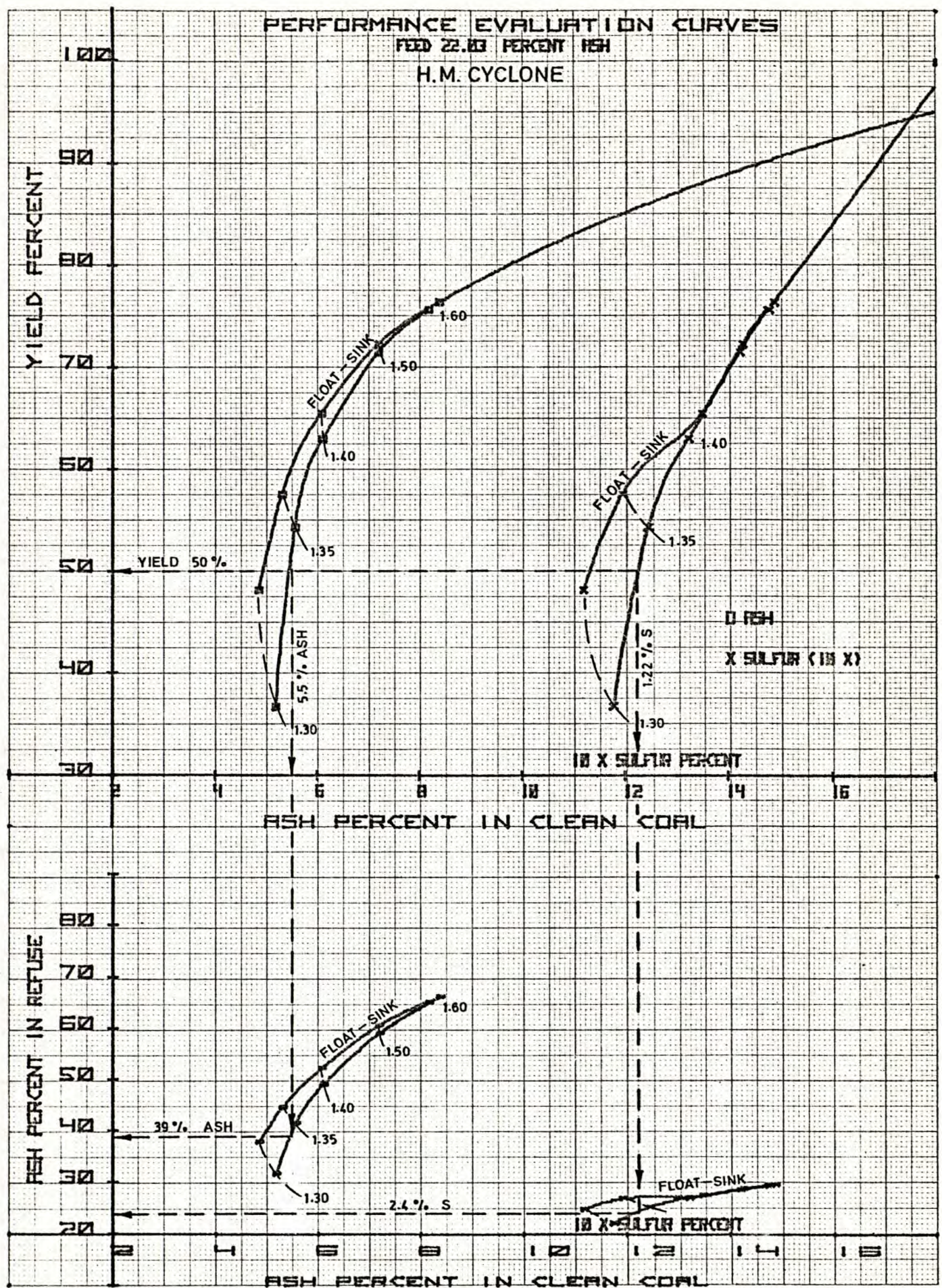


FIGURE B2 - HEAVY MEDIUM SEPARATION OF MIDDINGS (1/4 IN. x 28 M)