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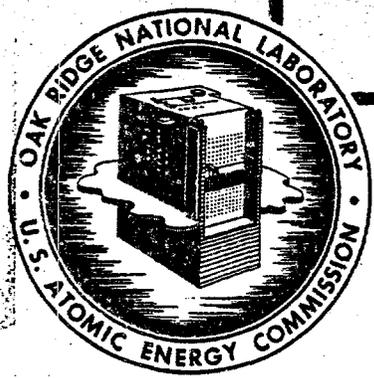
EVALUATION OF FILTERING EFFICIENCY
AND OPERATING LIFE OF FG MATERIAL
USED IN PILE COOLING AIR FILTER HOUSE

H. C. SAVAGE

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TECHNICAL DIVISION
Engineering Development Section

EVALUATION OF FILTERING EFFICIENCY AND
OPERATING LIFE OF FG MATERIAL USED IN
PILE COOLING AIR FILTER HOUSE

H. C. Savage

DATE ISSUED:
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1.0 ABSTRACT

This report covers an experimental investigation of the relative efficiencies and operating life of three combinations of American Air Filter Company's FG filter media as used in the pile cooling air filter house at Oak Ridge National Laboratory.

The combinations of FG material tested are as follows:

- (a) Two layers of 1/2 inch FG-50
- (b) Two layers of 1/2 inch FG-25
- (c) One layer of 1/2 inch FG-25 backed by one layer of 1/2 inch FG-50.

The above combinations were mounted in the frames presently in use and tested under operating conditions in the filter house.

The following conclusions and recommendations are drawn from test results.

- (1) Combination (b) has a filtering efficiency of only 42.5% as compared with combinations (a) and (c), (see Table IV). This is based on actual dust removal for equal air through put. Thus, two layers of 1/2 inch FG-25 is unsatisfactory from the standpoint of efficiency.

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1.0 ABSTRACT (Con't.)

- (2) The filtering efficiencies of combinations (a) and (c) are virtually equal for the period tested. The actual test period was 168 days which corresponds to normal periods of 194 days and 370 days respectively for the (a) and (c) combinations due to the proportionately larger flows through the test pockets.

- (3) With present discharge fan capacity and air stream dust burden, the operating life of combinations (a) and (c) are 1.67 years and 5.90 years respectively based on an allowable pressure drop across the FG filters of 4 inches H₂O. This gives the combination of FG-25 backed by FG-50 an advantage of 3.54 to 1 over two layers of FG-50.

- (4) From qualitative observations of the dust penetration through the test pockets it appears to be very probable that the efficiency of the FG-25 backed by FG-50 combination will decrease with a longer exposure period. This would undoubtedly increase the plugging rate of the #2 or CWS filters and the advantage gained by increased life due to lower pressure drop might well be reduced. It is suggested that the pressure drop across cell #4, filter #2 be checked for any increase in plugging rate (this cell contains filter pockets of the 25-50 combination).

2.0 TEST PROCEDURE

A total of twenty-two FG filter pockets were made up. The filter material used in the first and second layer of each pocket was weighed to the nearest 0.01 gm. After "loading" the pockets, the pressure drop across each was measured using air at 150 standard CFM. The 150 CFM corresponds approximately to the flow through each filter when in service in the pile filter house. A plot of ΔP vs. CFM was also made.

2.0 TEST PROCEDURE (Con't)

Three sets of filter pockets with six (6) pockets in each set were assembled using FG material picked at random from the stock maintained for filter house use. The combinations of FG material used are as follows:

Set #1 - two layers of 1/2" FG-50

Set #2 - two layers of 1/2" FG-25

Set #3 - one layer of 1/2" FG-25 backed by one layer of 1/2" FG-50

While in the process of making these sets, it was discovered that there was an appreciable difference in weight among the various pieces of FG-25 media, the panel weights showing a statistically significant distribution around two separate means. To test for any difference in filtering efficiency between the so-called "light" and "heavy" FG-25, two additional sets of pockets were assembled and tested. One of these sets consisted of two pockets containing "light" FG-25 material (weight of 2-1/2" pieces approximately 2 ft. x 3 ft. \cong 99 gms) while the other set of two pockets contained "heavy" FG-25 material (weight of 2-1/2" pieces approximately 2 ft. x 3 ft. \cong 115 gms.)

All of the test pockets were installed in cell #4 in the pile filter house on April 25, 1949. At this time all filters in this cell were replaced with pockets containing one layer of 1/2" FG-25 backed by one layer of 1/2" FG-50 plus the test pockets. This cell then contained a total of 150 pockets with a pressure drop across the cell of 1.00" H₂O.

2.0 TEST PROCEDURE (Con't)

At intervals of 2, 4, 6, 8, 14 and 24 weeks one pocket each from sets 1, 2 and 3 were removed from the filter house, the pressure drop at a standard flow across each pocket measured, and the filter material removed and weighed for dust burden. All pockets removed at one time had exposure position immediately adjacent to each other.

One each of the pockets containing "light" and "heavy" FG-25 material were removed after filtering periods of 8 weeks and 24 weeks and tested as above.

3.0 CALCULATIONS

A. Dust Burden - Pile Discharge Air

As a basis for all calculations the volume of air through the filter house was taken as 90,000 CFM.

The filter house dust burden was then calculated, independently for each test pocket as follows:

$$(1) \frac{\text{gms. dust/pocket}}{\text{exposure time (days)}} \times \frac{\text{filter house flow (90,000 cfm)}}{\text{pocket flow (cfm)}}$$

The gms. of dust per pocket was obtained by weighing. These weights are given in Table I.

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3.0 CALCULATIONS (Con't)

Using values of ΔP across cell 4, filter #1 (FG material) obtained from the Operations Division at each time of test pocket removal (see Table II), the flow through each test pocket was readily found from the plot of ΔP vs. flow at each removal (Figures 3, 4, and 5). These values are given in Table III.

A sample calculation of total filter house dust burden based on the combination of 1/2 inch FG-25 backed by 1/2 inch FG-50 after 42 days operating time is shown below:

Total grams of dust collected = 33.60 (Table I)
 Operating time = 42 days
 Total filter house flow = 90,000 CFM

The ΔP across cell #4, filter #1 at the time of removal (6-6-49) = 1.13" H₂O. From curve D, Figure #4, the instantaneous flow through the test pocket with a dust burden of 33.60 grams is 350 CFM. The average flow for the 42 day period is 400 cfm (Table III).

Substituting these values in equation (1) we get

$$\frac{33.60 \text{ gms}}{42 \text{ days}} \times \frac{90,000 \text{ cfm}}{400 \text{ cfm}} = 180 \text{ gms. dust/day}$$

The same calculation was made for each test pocket and the results are given in Table IV.

3.0 CALCULATIONS (Con't)

From Table IV the dust burden through the pile filter house, based on FG combinations of 25-50 and 50-50, is 190 gms./day - both these combinations giving approximately the same value. As compared with these two combinations the 25-25 combination shows a filtering efficiency of only 81/190 or 42.5% and can be dropped from further consideration on this basis.

B. Operating Life - FG Filter Material

The calculation of the operating life of the two FG combinations under consideration is based on the allowable pressure drop across the #1 or FG filters in the filter house and a plot of ΔP vs. dust burden (Figures 1 and 2) for the FG filter pockets.

The present maximum allowable ΔP across the filter house is \sim 8 inches H_2O of which about 7 inches H_2O drop is due to the FG and CWS filters, the remainder being line loss.

The initial ΔP across clean CWS filters is \sim 1 inch H_2O under operating conditions. This leaves a maximum ΔP , assuming no CWS increase, for the FG filters of \sim 6 inches H_2O . Allowing for a 2 inch H_2O increase in the pressure drop across the CWS filters (the increase has been \sim 1 inch H_2O after 11 months of operation) leaves a working ΔP across the FG material of 4 inches H_2O .

3.0 CALCULATIONS (Con't)

Total number FG filter pockets in filter house = 600.

Filter house dust burden (based on removal by FG-50 material) is 190 gms/day which is 190/600 or 0.316 gms. dust/day per pocket.

Filter Pocket Containing 1/2 inch FG-25 Backed by 1/2 inch FG-50

From Figure 1, extrapolating the straight line, a dust burden of 680 gms/pocket will produce a ΔP of 4 inches H₂O. This corresponds to an operating life of 680 gms./0.316 gms/day = 2150 days or 5.90 yrs.

Filter Pocket Containing Two Layers of 1/2 Inch FG-50

From Figure 2, extrapolating the straight line, a dust burden of 188 gms./pocket will produce a ΔP of 4 inches H₂O. This corresponds to an operating life of 188 gms./0.316 gms/day = 595 days or 1.67 yrs.

This gives an advantage of 3.54 to 1 in favor of the FG-25, FG-50 combination from a pressure drop consideration.

Values of operating life for several allowable pressure drops are tabulated below in case a change in fan capacity is considered any time in the future. (IMPORTANT: see Recommendations)

Working ΔP , FG Filters Inches H ₂ O	Operating Life, yrs.	
	25-50	50-50
3	4.43	1.15
*4	5.90	1.67
5	7.21	2.12
6	8.90	2.60

* Present Value

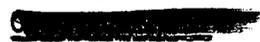


TABLE I

DUST BURDEN IN TEST POCKETS, GMS.

<u>Exposure Time</u>	<u>FG Filter Combination</u>		
<u>Days</u>	25-25	25-50	50-50
14	22.73	7.32	3.63
28	44.10	----	12.35
42	49.72	33.60	18.90
56	77.53	42.47	19.76
98	133.83	78.88	40.65
168	130.54	135.63	63.67

TABLE II

PRESSURE DROP ACROSS CELL #4, FILTER #1 (FG MATERIAL)

<u>Date</u>	<u>Operating Time, Days</u>	<u>ΔP, Inches H₂O</u>
4/26/49	0	1.00
5/9/49	14	1.00
5/23/49	28	1.12
6/6/49	42	1.13
6/20/49	56	1.10
8/1/49	98	1.35
10/10/49	168	1.70

TABLE III

FLOW THROUGH TEST POCKETS, CFM

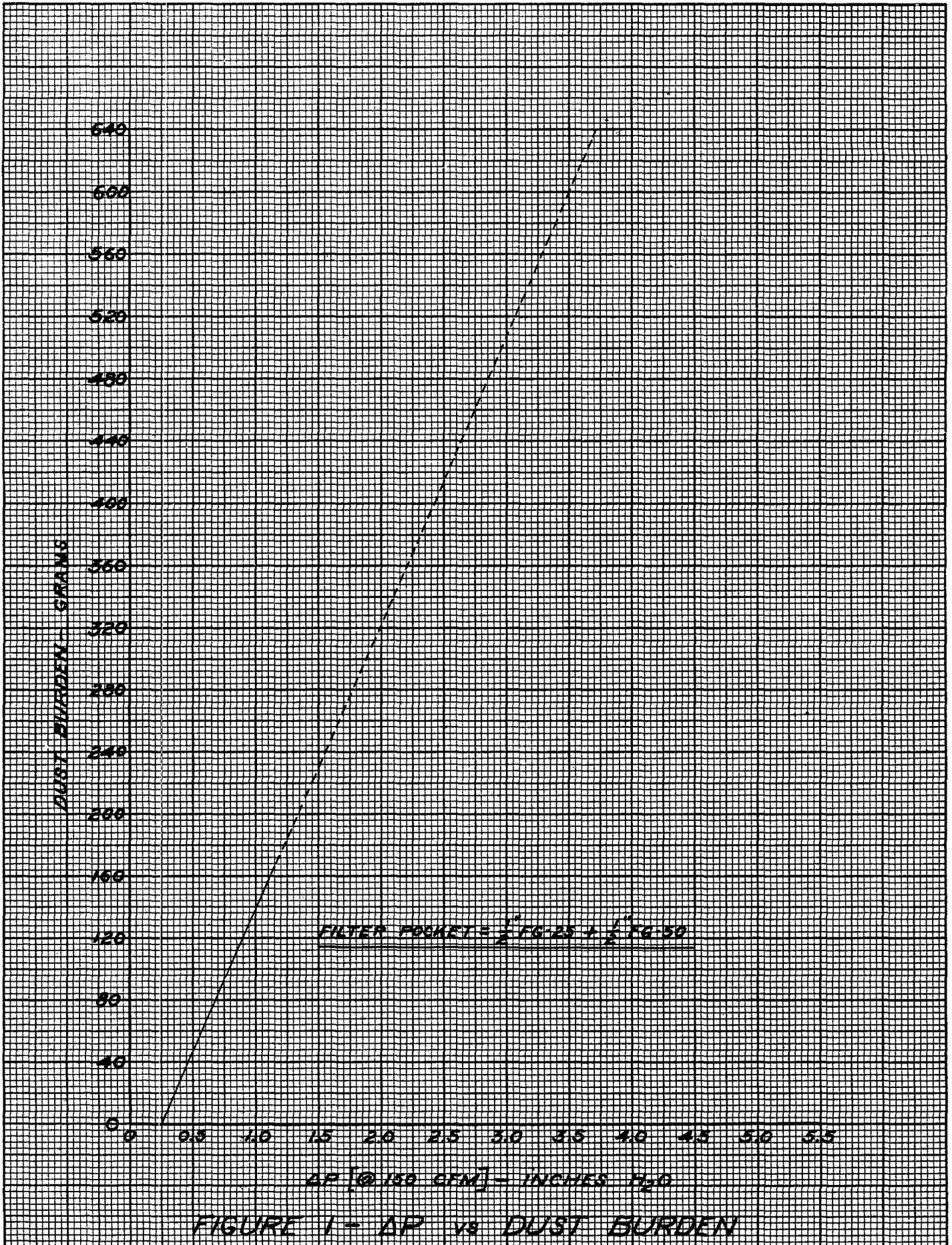
Operating Time Days	FG Filter Combination					
	Instantaneous Flow			Ave. Flow for Period		
	25-25	25-50	50-50	25-25	25-50	50-50
0	1850	470	255	---	---	---
14	1850	400	200	1850	435	227
28	1100	390	210	1660	415	216
42	1100	350	200	1475	400	212
56	540	350	170	1310	390	204
98	280	285	150	925	360	180
168	240	290	146	650	330	174

TABLE IV

CALCULATED FILTER HOUSE DUST BURDEN, GMS./DAY

Operating Time Days	FG Filter Combination		
	25-25	25-50	50-50
14	79	106	112
28	73	---	180
42	54	180	192
56	74	175	155
98	100	200	206
168	107	220	197
Average	81	194*	186*

* 14 day values not included in the average. The weight of dust involved was small so that a small loss in removing filter material from pockets is probably responsible for the low values.



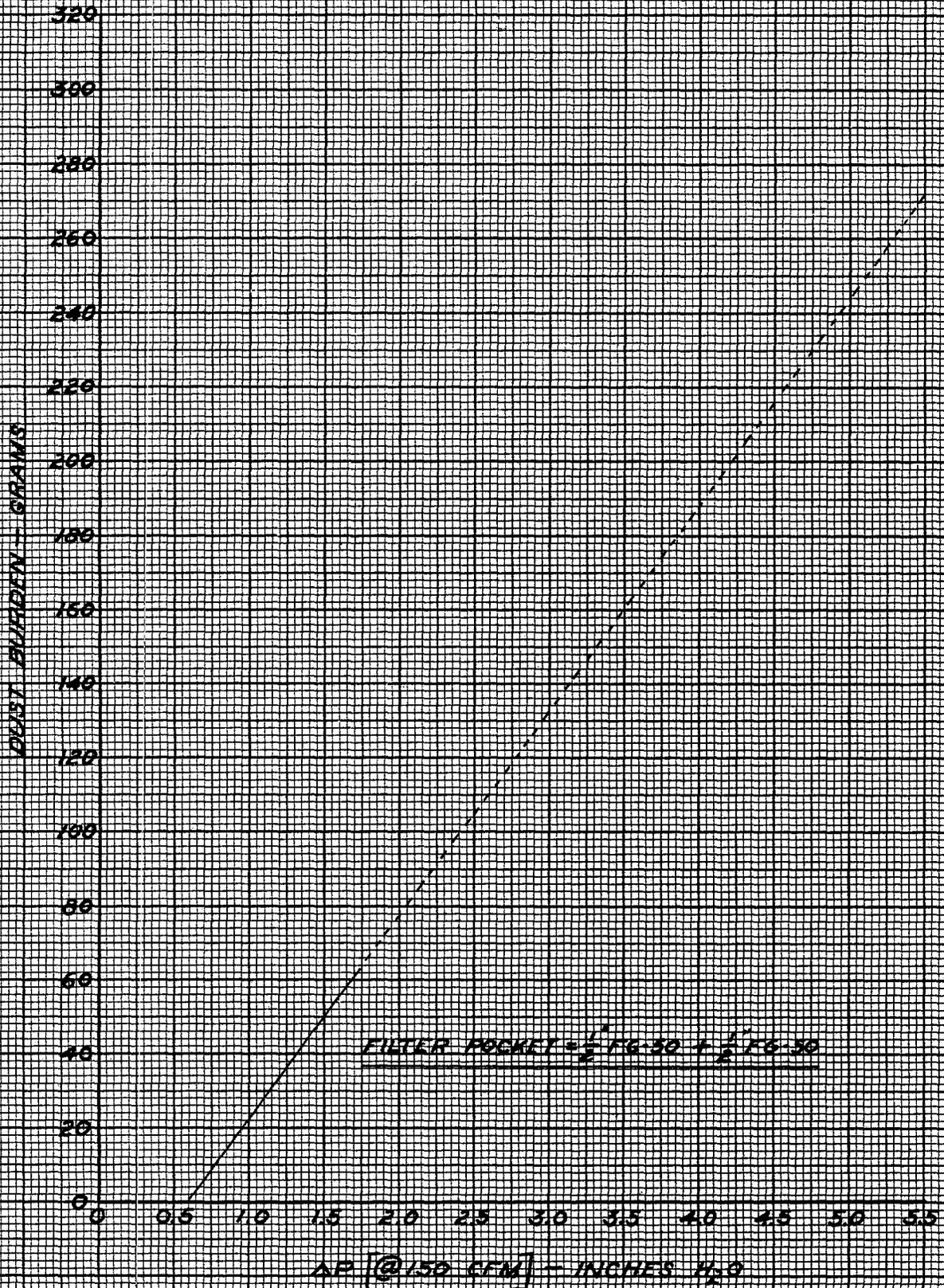


FIGURE 2 - ΔP vs DUST BURDEN

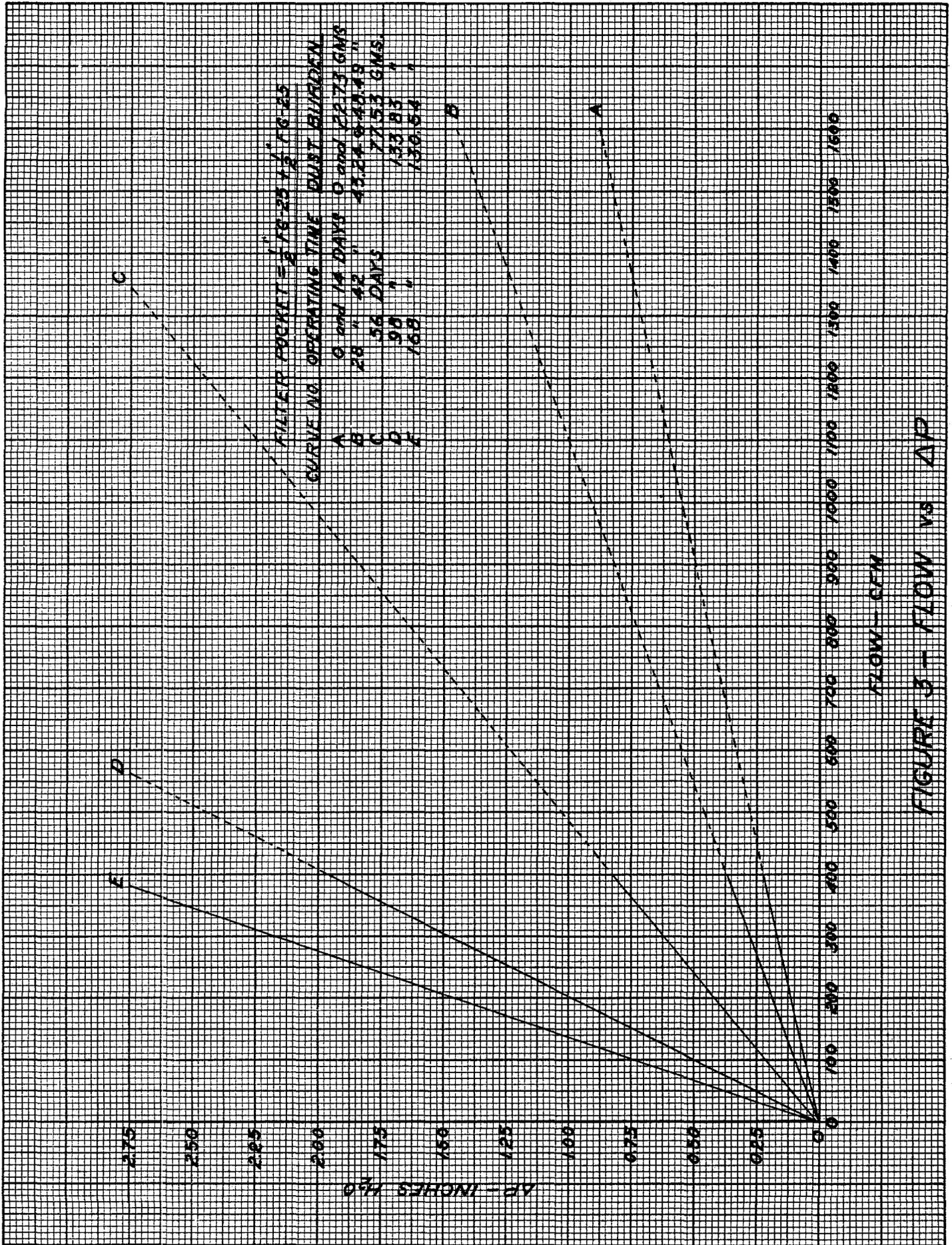


FIGURE 3 - FLOW VS ΔP

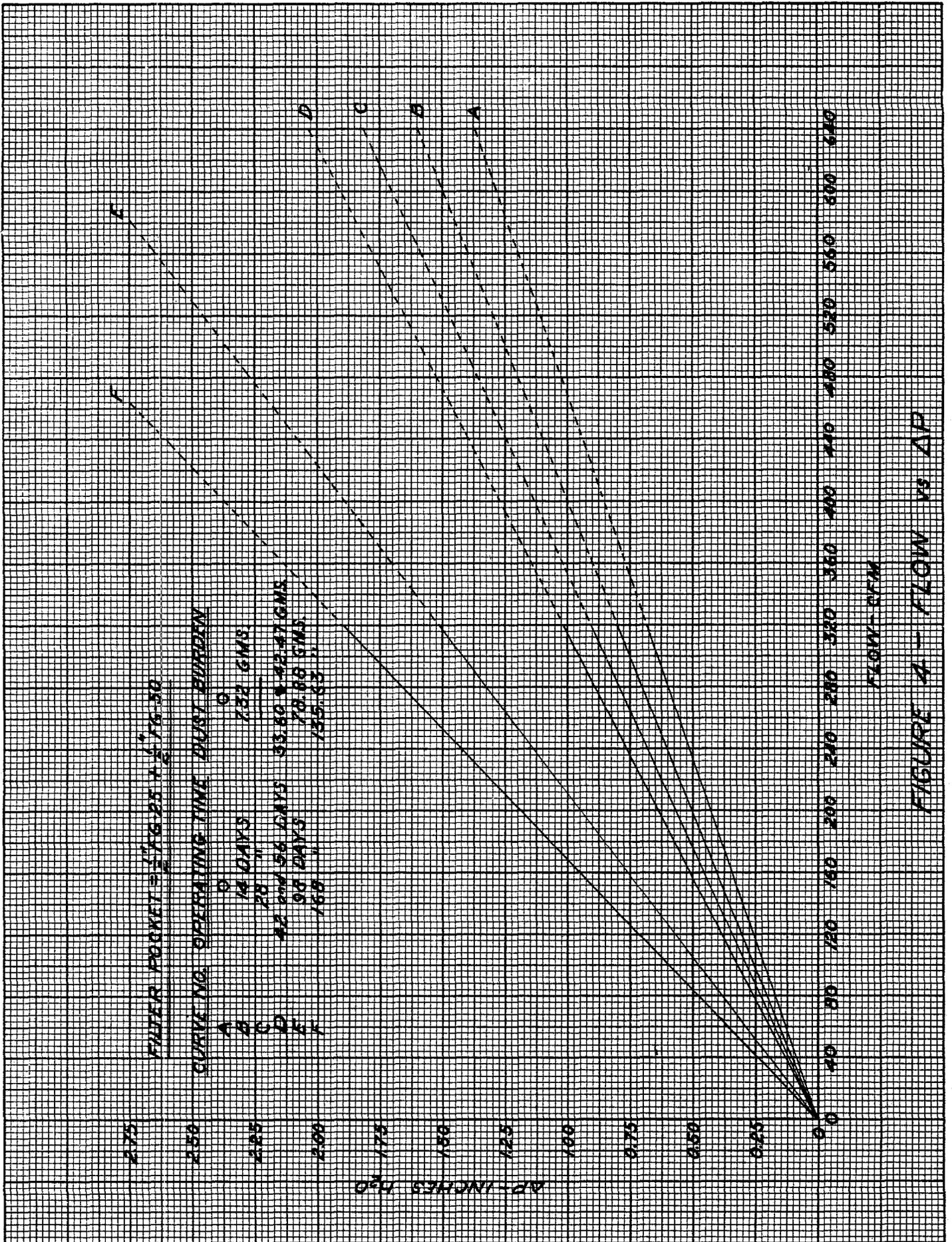
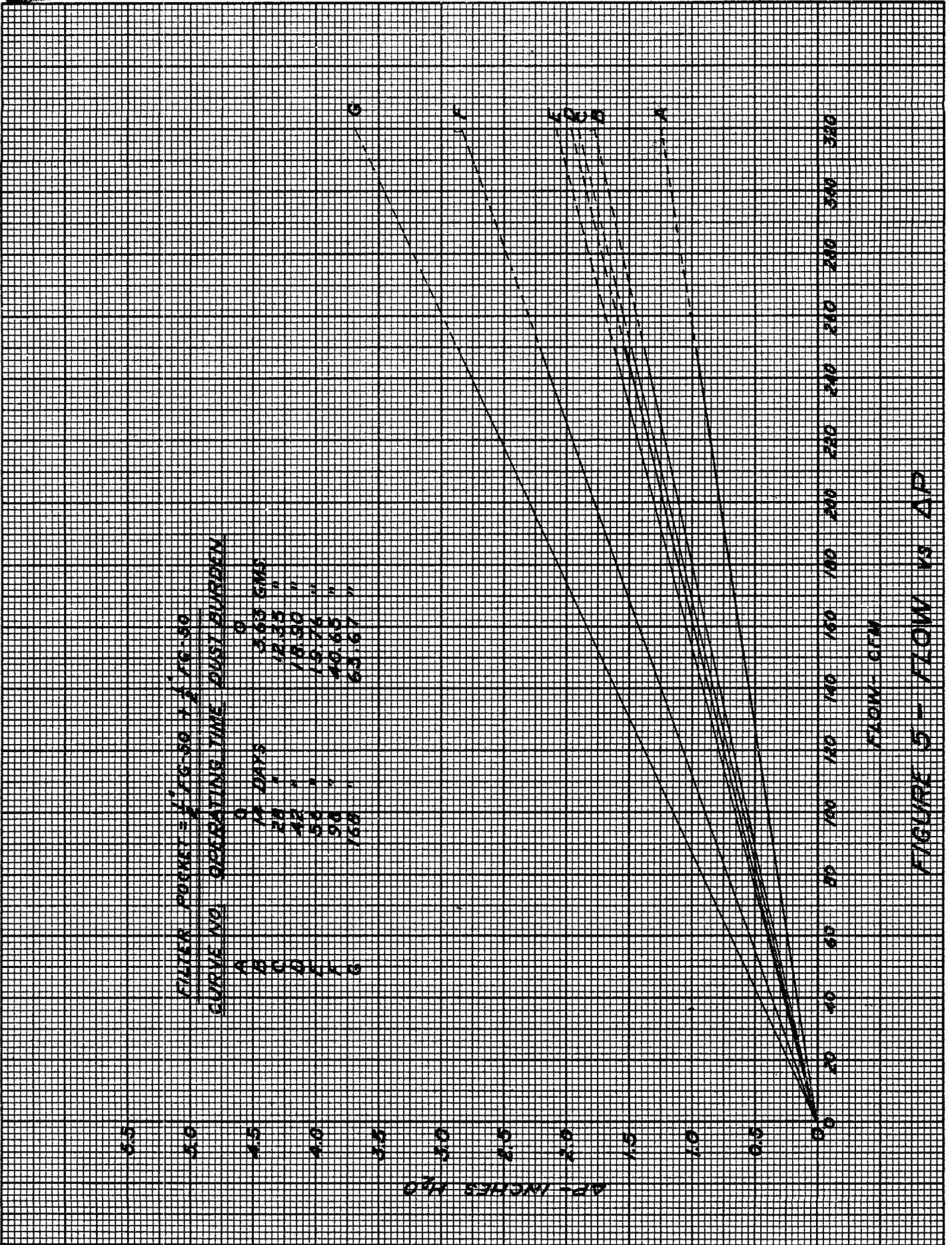


FIGURE 4 - FLOW VS. AP



FILTER POKET = 1' x 6" x 1' x 16" x 80
 CURVE NO. OPERATING TIME DUST BURDEN

FIGURE 5 - FLOW VS AP

FLOW - CFM

AP - INCHES H₂O

4.0 CONCLUSIONS

A filter pocket made up of 1/2 inch FG-25 backed by 1/2 inch FG-25 is unsatisfactory for use in pile filter house due to its low filtering efficiency as compared with pockets containing at least one layer of FG-50. This condition would lead to a fast plugging rate of the number 2 or CWS filters in the house.

The filter pocket made up of 1/2 inch FG-25 backed by 1/2 inch FG-50 appears to be just as efficient as the 50-50 combination for the period tested and has a useful life 3.54 times the latter based on a pressure drop consideration of 4 inches H₂O.

The test period on the 25-50 combination corresponded to a normal operating period of 370 days while the test period on the 50-50 combination corresponded to a normal operating period of 194 days. These increased times are due to the proportionately large flow through cell #4 which contained clean filters. During the test period cell #4 carried approximately 50% of the total filter house load (normal proportion = 25%).

The results obtained on the test pockets made up of "light" and "heavy" FG-25 material showed no difference in filtering efficiency and gave the same results as pockets made up of FG-25 material picked at random.

5.0 RECOMMENDATIONS

In comparing the 25-50 and the 50-50 combinations one point of uncertainty must be pointed out. At the last test pocket removal, the FG-50 material in the 25-50 combination showed 100% penetration indicating that its filtering efficiency might drop off with additional exposure time. This would increase the plugging rate on the #2 or CWS filters. This would sharply reduce the expected life of the #2 filter where replacement cost is approximately 3 times that of the FG-material. At present no increased rate has been noted in the #2 filter of Cell 4. However this pressure drop should be noted carefully over the next few months of operation and if an abnormal rate of pressure drop increase is noted, a re-evaluation of the relative results of the 25-50 over the 50-50 combinations should be made.

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