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LOW AIR RESISTANCE CANISTER, PARALLEL PLEATED HEPA FILTER.(U)
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Report N00014-81-C-2501 (CORRECTED COPY)

LOW AIR RESISTANCE CANISTER

Parallel Pleated HEPA Filter

Scott Aviation, A Figgie International Company
225 Erie Street
Lancaster, New York 14086

July 1, 1982

FINAL REPORT

Prepared for

Naval Research Laboratory
4555 Overlook Avenue, S.W.
Washington, D.C. 20375

MATERIAL INSPECTION AND RECEIVING REPORT

1. PROC. INSTRUMENT IDEN (CONTRACT) (ORDER) NO	6. INVOICE NO.	7. PAGE	OF
N00104-81-C-2501	25053-02	1	1
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2. SHIPMENT NO.	3. DATE SHIPPED	4. B/L	5. DISCOUNT TERMS
SAC0002		TCN	NET 30 DAYS

9. PRIME CONTRACTOR CODE 53655	10. ADMINISTERED BY CODE S3306A
SCOTT AVIATION DIV. A-T-O, INC. 225 ERIE STREET LANCASTER, NEW YORK 14086	BUFFALO RESIDENCY DCASMA-SYRACUSE 1103 FEDERAL BLDG. 111 W. HURON STREET BUFFALO, NEW YORK 14202
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15. ITEM NO.	16. STOCK/PART NO. DESCRIPTION (Indicate number of shipping containers-type of container-container number.)	17. QUANTITY SHIP'D/REC'D*	18. UNIT	19. UNIT PRICE	20. AMOUNT
0002	REPORTS AND DATA IN ACCORDANCE WITH EXHIBIT A (DD1423) FINAL REPORT	1	EA	NSP	

21. PROCUREMENT QUALITY ASSURANCE

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SUMMARY

A parallel pleated HEPA filter has been developed to reduce the pressure drop across the Navy ND-C-1 filter by increasing the surface area in a minimal amount of space. The pressure drop was reduced by 594 percent due to an increase in the effective surface area of 677 percent. Spacing of the pleats was accomplished by dispensing adhesive and thread simultaneously on the surface of the filter media. This produced a spacing of 4.07 pleats per cm with a height of 0.91 cm.

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ILLUSTRATIONS

INTRODUCTION

The canister presently used on the Navy Mark V gas mask is designated ND-C-1. This canister contains a flat disc of particulate filter media. One method to reduce the pressure drop across this filter is to increase the effective surface of the media area. This can be accomplished without increasing the diameter of the canister by pleating the filter media but it will increase the depth of the present canister equivalent to the height of the pleat. A method for cutting the circular configuration and encapsulation of the filter in the canister was developed at the Scott Aviation Plant #1 test laboratory.

MATERIALS

Filter media - Lydall Grade L-255 HEPA glass filter media, QPL-51079-1

July 30, 1981, qualified under MIL-F-51079.

Weight	90 g/M^2
Caliper	.43 mm
Tensile, MD	1.15 KN/M
Tensile, CD	.77 KN/M
Elongation	1.5%
Pressure Drop @ 32 LPM/100 cm^2	36 mm H_2O
DOP Penetration @ 32 LPM/100 cm^2	.015%
Water Repellency	760 mm
Ignition Loss	5.0%
Yield	11.1 M^2/kg

Thread - Neophil K-207 unbonded soft white nylon.

Adhesive (thread) - Borden Cascomelt HC-6286 heat sealable hot melt adhesive.
Type - thermoplastic solid
F & DA Status - none
Odor - mild at 176°C
Flamability - will char with overheating

Encapsulating media - Silicone Adhesive/Sealant
Corrosion properties - none
Temperature range - 65°C to 182°C for extended periods.
Color - white
Durometer Hardness - Shore A, 25 points
Elongation - 400%
Meets FDA Regulation No. 21 CFR177.2600
Meets NSF Criteria C2 for direct contact with food
UL approved for service to 180°C
Usage - 10 parts of #738 RTV to 3 parts of Trichloroethane 111 by weight.

EQUIPMENT

Pleating Machine

The experimental pleating was performed on a modified Rabo 68 Accordion Pleating Machine. This machine has top and bottom reciprocating blades which alternately fold the media in pleats against each other by retracting from the previous fold upward or downward, extending the folding edge outward, advancing upward or downward against the web of media and returning to a vertical position against the other blade. This folded material is then ejected out of the blade area in a continuous stream of pleats. The only adjustment provided on this machine is for pleat height.

String and Adhesive Applicator

The equipment used for this application was a Meltex model CR-05 Hot melt adhesive dispenser with 2 thermostatically controlled hoses and 2 each of eleven nozzle manifolds, one for the upper side and one for the lower side.

Encapsulating Machine

To seal the open ends of the circle of filter material and encapsulate it in the canister, a spinning machine was designed and built by Scott Aviation. The rotation was achieved by a Boston Ratiotrol Drive model VEL25D and a 1/4 HP DC motor with a range of 0-2200 RPM. The applicator disc is mounted on a vertical shaft with the liquid sealant reservoir in the up position. The canister and filter are inverted and clamped to the disc. The assembly is spun at 2100 rpm and the liquid sealent is dispersed up the inside wall of the canister and into the outer periphery of the pleats by centrifugal force.

Pleat Cutter

A circular saw was designed to cut discs of pleated material from a block of preformed and glued pleats. The saw consists of a metal disc with a spindle, a blade and a soft spring loaded, non rotating pressure foot. The scalloped blade is approximately 0. 5 millimeters thick, straight on the inside and beveled on the outer side to a sharp edge. The apex of the scallops are on approximately 13 millimeter centers. This blade was rotated at a speed of 1300 RPM with a one second feed.

Filter Construction - Figure 1

Diameter of the pleated media - 7.62 cm.

Total number of effective pleats - 31.

Number of pleats per centimeter - 4.07

Distance between pleats - 0.245 cm.

Pleat height - .91 cm.

Using the formula $L = 2\sqrt{R^2 - d^2}$ to determine the length of the pleats where

L = pleat length to be determined

2 L = total pleat length since each pleat has 2 faces

R = radius of the circle of the pleated material

d = distance from the center line or diameter of the filter to each pleat in acccumulative increments of 0.245 cm per pleat.

Pleats	d/cm	d/cm^2	L/cm	2 L/cm
1	0.245	0.06	7.60	15.20
2	0.490	0.24	7.56	15.11
3	0.735	0.54	7.48	14.95
4	0.980	0.96	7.36	14.72
5	1.225	1.50	7.21	14.43
6	1.470	2.16	7.03	14.06
7	1.715	2.94	6.80	13.61
8	1.960	3.84	6.53	13.07
9	2.205	4.86	6.21	12.43
10	2.450	6.00	5.83	11.67
11	2.695	7.26	5.39	10.77
12	2.940	8.64	4.85	9.69
13	3.185	10.14	4.18	8.36
14	3.430	11.76	3.32	6.63
15	3.675	13.51	2.00	4.00
				178.70 cm

total length of pleats.

Length of 15 pleats = 178.70 cm
surface = x 2
Surface Length of 30 pleats = 357.40 cm
2 x 7.62 cm = Length of Center pleat = 15.24 cm
Total pleat surface length 372.64 cm
372.64 cm long x 0.91 cm high = 339.1 cm^2 total area

Width of adhesive & string - 0.218 cm
Center string covers 31 pleats
Side strings cover 23 pleats each

Area of center string
31 pleats x 0.91 cm/pleat x 2 sides/pleat = 56.42 cm long
56.42 cm long x 0.218 cm wide = 12.3 cm^2 area

Area of side string
23 pleats x 0.91 cm/pleat x 2 sides/pleat x 2 str: ; =
83.72 cm long x 0.218 cm wide = 18.25 cm^2 area

Total ineffective area
Center string 12.3 cm^2
Side strings 18.25 cm^2
30.55 cm^2 total ineffective area

339.10 cm^2 total area of pleats
-30.55 cm^2 ineffective area
308.55 cm^2 total effective area of the pleats

Area of a flat filter similar to that used in the ND-C-1 canister but with a diameter the same as the parallel pleated filter.

$A = \pi R^2 = 3.14 (3.81 cm)^2 = 3.14 (14.52 cm^2) = 45.59 cm^2$

308.55 cm^2 total effective area of the parallel pleated filter = 6.77 or
45.59 cm^2 total effective area of the flat filter

677% increase in the area of the parallel pleated filter of the same diameter.

PRESSURE DROP TEST

For a diagram of the apparatus used see Figure 2.

Test of 10 samples of parallel pleated filters 0.91 cm high and 7.62 cm in diameter.

Q_s = Flow in liters per minute
V_F = Face velocity in cm/second
ΔP = Pressure drop in millimeters of water

Qs	V_F	1	2	3	4	5	6	7	8	9	10	AVERAGE P
12.76	4.7	5.92	6.27	6.65	6.63	6.17	6.50	6.30	6.55	6.68	6.55	6.42mm
24.03	8.8	10.46	11.05	11.76	11.61	10.77	11.38	11.00	11.81	11.81	11.56	11.32mm
35.28	12.9	14.99	15.98	16.89	16.54	16.56	16.46	15.67	17.02	17.02	16.71	16.38mm
46.00	16.8	19.81	21.13	22.61	22.07	20.35	21.72	20.80	22.35	22.53	22.10	21.55mm
56.72	20.8	24.89	26.97	28.45	27.79	25.91	27.48	26.16	28.45	28.58	28.19	27.29mm

Test of five (5) samples of a single flat disc of filter media 7.62 cm. in diameter. The flat disc represents a similar condition as found in the ND-C-1 canister

Qs	V_F	1	2	3	4	5	AVERAGE P
12.82	4.7	36.83	47.50	36.58	36.58	36.07	38.71 mm
24.14	8.8	64.26	82.55	65.02	63.25	62.48	67.51 mm
35.45	13.0	92.46	117.35	91.95	90.68	89.66	96.42 mm
46.22	16.9	121.16	154.94	121.67	120.14	118.62	127.31 mm
57.00	20.8	152.91	201.93	152.65	150.37	148.59	161.29 mm

For a graphic comparison see Figure 3.

$\frac{\text{P flat disc}}{\text{P Parallel pleat}}$ = Times reduced = % reduction using the parallel pleat

1. $\frac{38.71 \text{ mm}}{6.42 \text{ mm}} = 6.02 = 602\%$

2. $\frac{67.51 \text{ mm}}{11.32 \text{ mm}} = 5.96 = 596\%$

3. $\frac{96.42 \text{ mm}}{16.38 \text{ mm}} = 5.89 = 589\%$

4. $\frac{127.31 \text{ mm}}{21.55 \text{ mm}} = 5.91 = 591\%$

5. $\frac{161.29 \text{ mm}}{27.29 \text{ mm}} = 5.91 = 591\%$

602% + 596% +589% + 591% + 591% = 2969%

$\frac{2969\%}{5}$ = 594% average decrease in pressure drop using the parallel parallel pleated filter.

DOP PENETRATION

Test equipment - ATI Penetrometer model Q127, S/N 4064.

Parallel pleated filters tested at a flow rate of 32 SLPM.

	% Penetration		% Penetration
1.	.068	6.	.001
2.	.020	7.	.001
3.	.019	8.	.580
4.	.009	9.	.160
5.	.320	10.	.001

Flat filter at a flow of 32 SLPM

	% Penetration
1.	.015
2.	.019
3.	.010
4.	.007
5.	.009

CONCLUSION

1. The following datum was developed during the completion of this project:

    1. A parallel pleated filter can be manufactured to replace a flat filter with the same diameter and thereby reduce the pressure drop by a considerable amount. For a 0.91 cm high pleat this reduction averaged 594%.

    2. The depth of a canister with a flat filter must be increased an amount equal to the pleat height to utilize a parallel pleated filter.

    3. A pleating machine would have to be developed to provide the means of applying the string and adhesive to both sides of the filter media.

    4. The higher DOP penetration readings are probably due to the upsetting of the fiberglass fibers while attaching the adhesive and string to the bottom side of the block of pleated material. It was necessary to install the string and adhesive on the bottom side by hand since the pleating maching used did not lend itself to this operation.

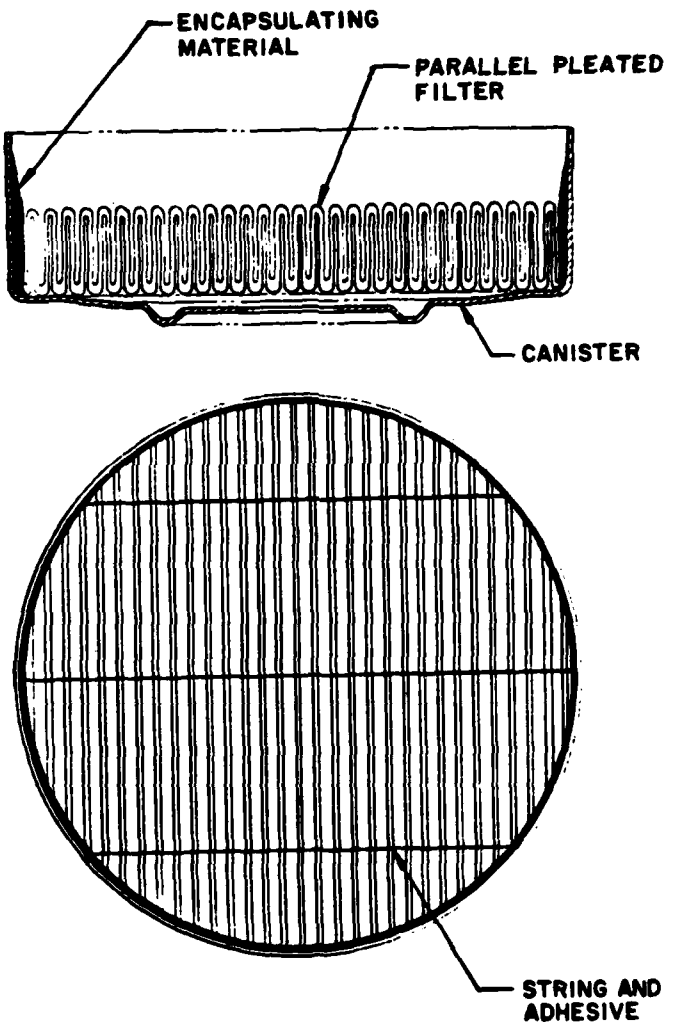


FIGURE 1 • FILTER ASSEMBLY

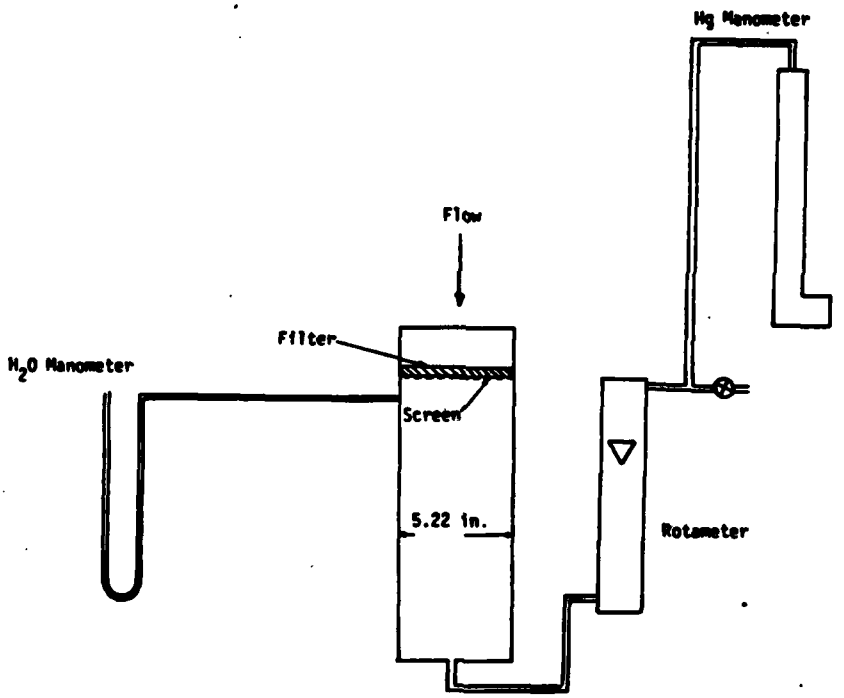
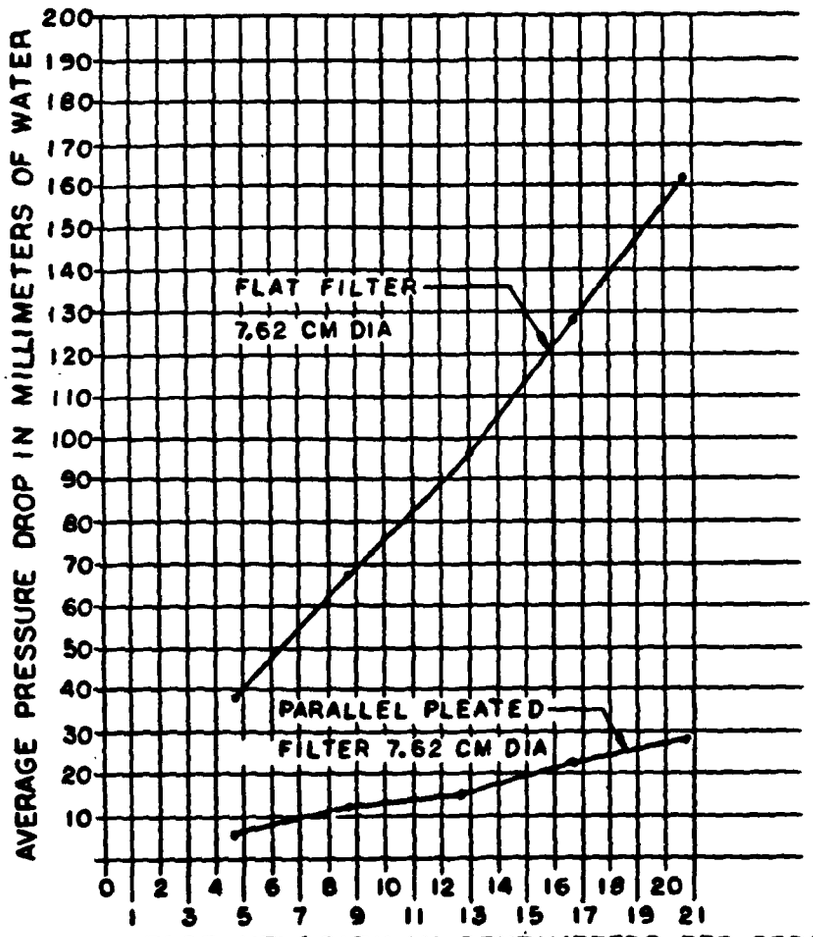


FIGURE 2=FILTER PRESSURE-DROP TESTING APPARATUS



PRESSURE DROP COMPARISON

FIGURE 3