Title
FIBERGLASS FILTER DESIGN

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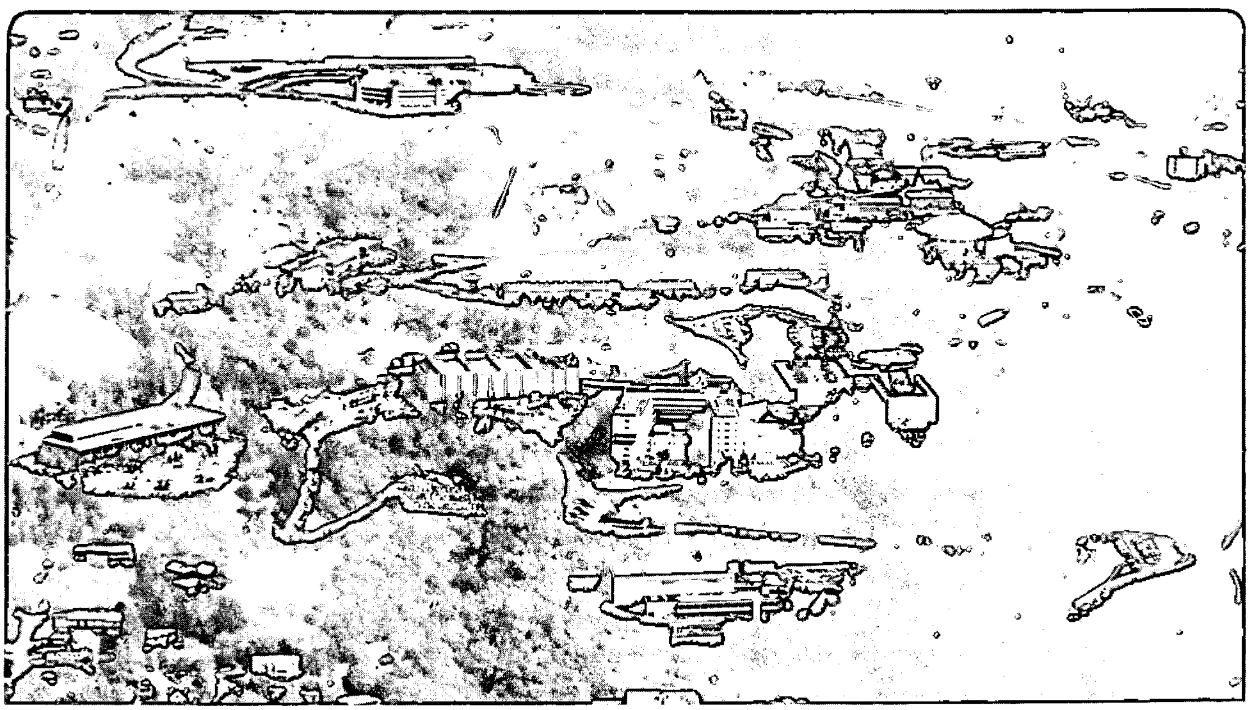

LAWRENCE BERKELEY LABORATORY - UNIVERSITY OF CALIFORNIA ENGINEERING NOTE		CODE ES0510	SERIAL M4903	PAGE 1 OF 8
AUTHOR S. Mitina	DEPARTMENT Mechanical Engineering	LOCATION Berkeley	DATE 5 February 1976	
PROGRAM — PROJECT — JOB ESCAR				
REFRIGERATION SYSTEM				
TITLE FIBERGLASS FILTER DESIGN				

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OBJECTIVE:

Design an oil mist separator to deliver less than 1.0 P.P.M. particles with a pressure drop less than 1.5 PSI (41" H_20), optimize cost, efficiency and pressure drop.

GIVEN:

3000 SCFM of dry helium gas at 18-20 ATM, assumed particles of size 0.01 - 1.0 μ (oil smoke). Pressure of particles above 10μ also considered.

DESIGN:

Based on gas density, superficial velocity and entrained particle size, data and recommendations obtained from:

1. "Filtration Of Radioactive Aerosols By GlassFibers," A. G. Blasewitz, et al. Hanford Works HW-20847 (1951).
2. "72" Bubble Chamber Vent~~ilation~~ System Aerosol Removal," R. Byrns LBL EN4313-03M51 - (1960).
3. "Oil-Water Removal System for 3000 SCFM - 300 PSI Helium Gas," LBL Spec M 484 - E. Hoyer (1976).

As seen from references 1 and 2; for particles in the range 0.1 to 1.0 micron fiberglass filters provide the most efficient separation.

Type AA and 115K of fiberglass have been selected.[1]

The problem is comprised of three parts:

1. Calculations of collection efficiency and pressure drop for various numbers, combinations, bed depths and packing density of fiberglass layers, for various diameters of pressure vessels and for various particles concentration in inlet flow.
2. Optimisation of obtained data.
3. Approximate estimation of life expectancy calculations have been done for 24", 30", 36", 42", 54" pressure vessel diameters and for 200, 500 and 1000 PPM concentration of particles in inlet flow.

Nomographs D-2, D-3, D-5, D-6 (ref. 1 and 2) have been used. D-2 and D-3 give ΔP for air flow at atmospheric pressure.

Pressure drop P correction factor for helium gas at 20 ATM was taken into account, thus:

$$\Delta P_{air} = \alpha \frac{\rho_{air} V^2}{2g} \Bigg| \Delta P_{he} = \alpha \frac{\rho_{he} V^2}{2g} \Bigg| \Delta P_{he} = \Delta P_{air} \frac{\rho_{he}}{\rho_{air}} ;$$

where: - FOR SAME V

$\rho_{air} = 0.0803 \frac{LBS}{SCF}$ at 1 ATM, 0° C; $\rho_{he} = 0.2085 \frac{LBS}{SCF}$ at 20 ATM, 0° C;

correction factor equals $\frac{0.2085}{0.0803} = 2.6$; collection efficiency n equals $\frac{1-10^{-DF}}{100}$

(reference 1), where DF - Decomtamination Factor, according to reference 1; "For each type of fiberglass investigated, the decontamination factor was empirically determined as a function of bed depth, packing density and superficial flow velocity" and is independent of gas flow density.

This statment is true for a collection efficiency. Nomograph D-3 and D-5 were used for helium flow.

Collection efficiency (ref. 1, 2 can be defined as $n\ (\%) = \left(1 - \frac{C_o}{C_{in}}\right) \cdot 100$, where C_o-outlet concentration, C_{in} - inlet concentration.

Results are summarized in tables below:

FOR $C_0 = 1$ PPM

ASSUMED CONCENTRATION OF PARTICLES IN INLET FLOW PPM	COL. EFFICIENCY OF FIBERGLAS FILTER REQUERED %
1000	99.9
500	99.8
200	99.5

TRIAL DISIGN I $\varnothing = 54''$, $V = 9.43$ FPM

LAYER	TYPE OF FIBERGLAS	PACKING DENSITY PSI	BED DEPTH L INCHES	COLLECTION EFFIC. %	ΔP_{AIR} PSI	ΔP_{HE} PSI
1	115K	1.5	10	47.0	.0013	.00338
2	115K	3.0	7	36.0	.0009	.00234
3	AA	1.2	3	99.999	.1119	.2909
TOTAL			20	99.999	.1141	.2967

1	115K	3	10	68.0	.0036	.00936
2	115K	6	5	66.0	.00976	.0253
3	AA	1.8	2	99.999	.1281	.3330
TOTAL			18	99.999	.1415	.3679

1	115K	1.5	5	28	.0006	.00156
2	115K	3	5	45	.0018	.00468
3	AA	0.6	2	99.929	.025	.065
TOTAL			12	99.96	.02767	.07194

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LAYER	TYPE OF FIBERGLAS	PACKING DENSITY PSI	BED DEPTH L INCHES	COLLECTION EFFIC. %	Δ PAIR PSI	Δ PHE PSI
1	115K	1.5	5	28.	.0006	.00156
2	115K	3.0	5	45	.0018	.00468
3	AA	1.2	2	99.999	.0758	.1971
TOTAL			12	99.996	.0782	.2033

1	115K	1.5	5	28	.0006	.00156
2	115K	1.5	5	28	.0006	.00156
3	AA	1.2	2	99.999	.0758	.1971
TOTAL			1.2	99.994	.0077	.2002

TRIAL DESIGN II $\phi = 42''$ $V = 15.53$ FPM

1	115K	1.5	5	24	.00108	.0028
2	115K	3.0	5	38	.00270	.00702
3	AA	1.2	2	99.999	.1191	.3097
TOTAL			12	99.999	.1229	.3195

1	115K	1.5	5	24	.00108	.0028
2	115K	1.5	5	24	.00108	.0028
3	AA	1.2	2	99.999	.1191	.3097
TOTAL			12	99.999	.1213	.3154

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LAYERS	TYPE OF FIBERGLAS	PACKING DENSITY PSI	BED DEPTH L INCHES	COLLECTION EF. %	ΔP AIR PSI	ΔP HELIUM PSI
1	115K	1.5	5	24	0.00108	0.0028
2	115K	1.5	5	24	0.00108	0.0028
3	AA	0.6	2	99.8	0.04332	0.1126
TOTAL			12	99.8	0.04548	0.1182

1	115K	1.5	5	24	0.00108	0.0028
2	115K	3.0	5	38	0.00270	0.00702
3	AA	0.6	2	99.8	0.04332	0.1126
TOTAL			12	99.9	0.0471	0.1225

1	115K	1.5	5	24	0.00108	0.0028
2	115K	3.0	3	30	0.00198	0.00515
3	AA	0.6	2	99.8	0.04332	0.1126
TOTAL			10	99.89	0.04638	0.1206

TRIAL DESIGN III $\phi = 36''$ $V = 21.22$ FPM

1	115K	1.5	5	21	0.001588	0.00413
2	115K	3.0	5	35	0.001768	0.00459
3	AA	1.2	2	99.999	0.16245	0.4224
TOTAL			12	99.999	0.1658	0.4311

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LAYERS	TYPE OF FIBERGLASS	PACKING DENSITY	BED DEPTH L INCHES	COLLECTION EFFICIENCY %	ΔP AIR PSI	ΔP HELIUM PSI
1	115K	1.5	5	21	0.001588	0.00413
2	115K	3.0	5	35	0.001768	0.00459
3	AA	0.6	2	99.65	0.05776	0.1502
TOTAL			12	99.85	0.06111	0.1589

1	115K	1.5	5	21	0.001588	0.00413
2	115K	1.5	5	21	0.001588	0.00413
3	AA	1.2	2	99.999	0.16245	0.4224
TOTAL			12	99.999	0.16563	0.4306

1	115K	1.5	3	14	0.00086	0.00223
2	115K	1.5	3	14	0.00086	0.00223
3	AA	1.2	2	99.999	0.16245	0.4224
TOTAL			8	99.992	0.1642	0.4269

1	115K	1.5	3	14	0.00086	0.00223
2	115K	1.5	3	14	0.00086	0.00223
3	AA	0.6	2	99.65	0.05776	0.1502
TOTAL			8	99.74	0.05948	0.1546

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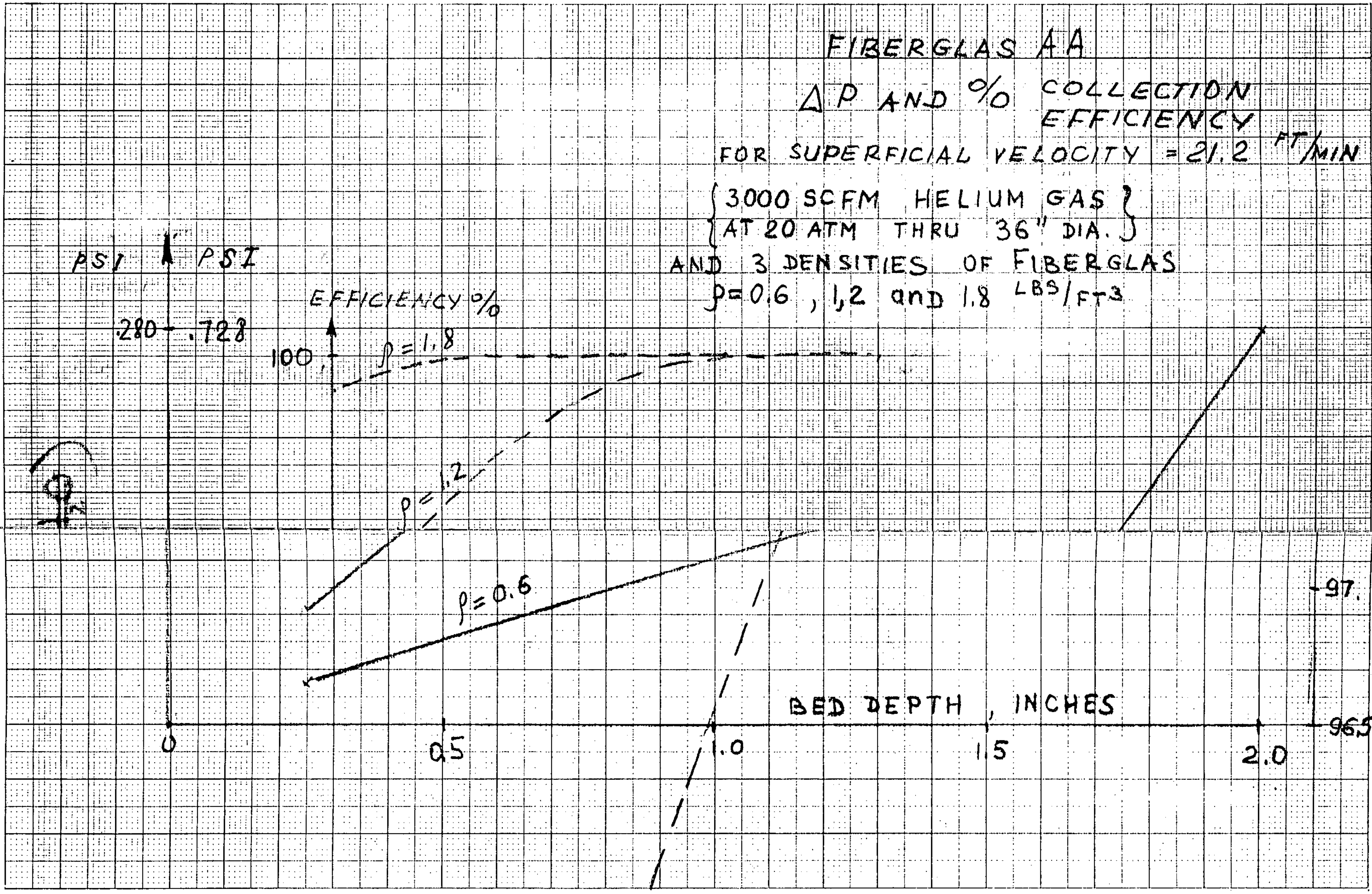
TRIAL DESIGN MARK IV ⌀24" V = 47.746 FPM

LAYERS	TYPE OF FIBERGLAS	PACKING DENSITY	BED DEPTH L INCHES	COLLECTION EFFICIENCY %	ΔP AIR PSI	ΔP HELIUM PSI
1	115K	1.5	5	16	0.00306	0.00795
2	115K	3.0	5	27	0.010469	0.0272
3	AA	1.2	2	99.995	0.3610	0.9386
TOTAL			12	99.996	0.3745	0.9737

1	115K	1.5	5	16	0.00306	0.00795
2	115K	3.0	5	27	0.010469	0.0272
3	AA	0.6	2	99.4	0.1300	0.338
TOTAL			12	99.63	0.1435	0.3731

1	115K	1.5	5	16	0.00306	0.00795
2	115K	3.0	3	18	0.005415	0.0141
3	AA	1.2	2	99.995	0.3610	0.9386
TOTAL			10	99.996	0.3694	0.96044

1	115K	3.0	5	27	0.010469	0.0272
2	115K	3.0	5	27	0.010469	0.0272
3	AA	0.6	2	99.4	0.1300	0.338
TOTAL			1.2	99.68	0.1509	0.3923


FIBERGLAS AA
ΔP AND % COLLECTION EFFICIENCY
FOR SUPERFICIAL VELOCITY = 21.2 FT/MIN
3000 SCFM HELIUM GAS AT 20 ATM THRU 36" DIA.
AND 3 DENSITIES OF FIBERGLAS
ρ = 0.6, 1.2 and 1.8 LBS/FT³
PSI
PSI
280
.728
EFFICIENCY %
100
ρ = 1.8
ρ = 1.2
ρ = 0.6
97.
96.5
BED DEPTH, INCHES
0
0.5
1.0
1.5
2.0

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