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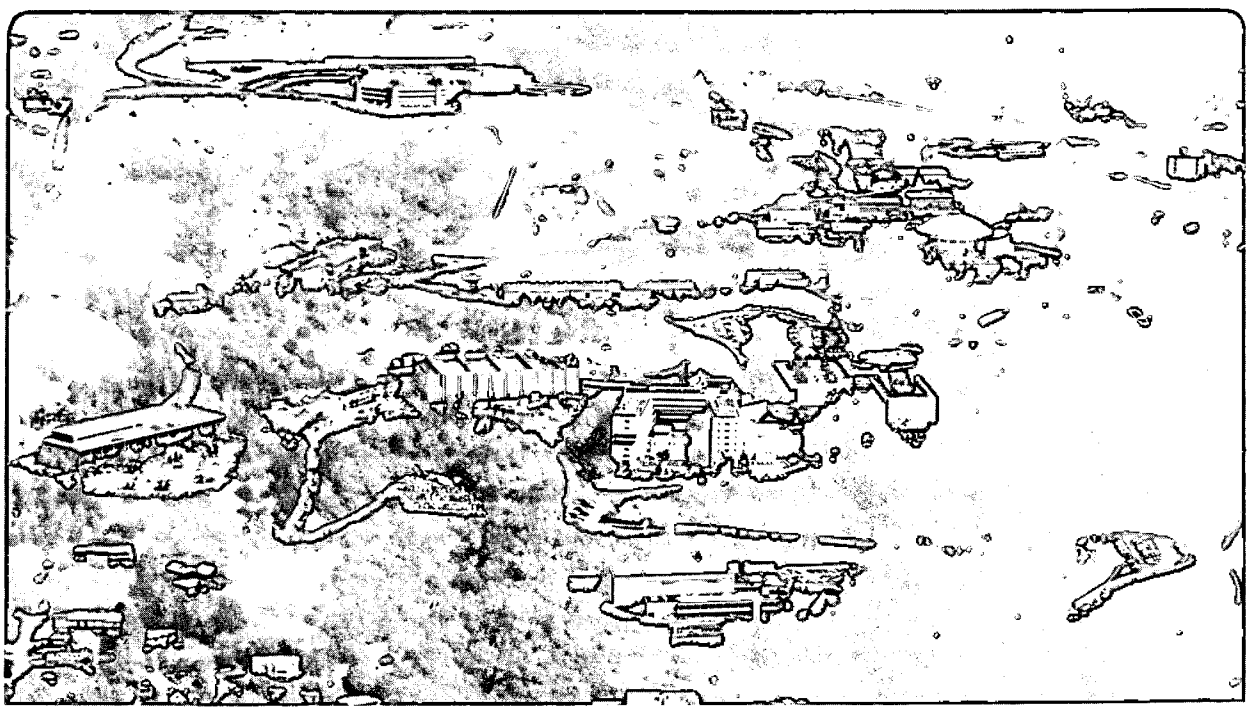

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ENGINEERING NOTE

CODE	SERIAL	PAGE
ES0510	M4903	1 of 8

AUTHOR	DEPARTMENT	LOCATION	DATE
S. Mitina	Mechanical Engineering	Berkeley	5 February 1976

PROGRAM — PROJECT — JOB
ESCAR

REFRIGERATION SYSTEM

TITLE
FIBERGLASS FILTER DESIGN

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_2O), 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 10 μ also considered.

DESIGN:

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

1. "Filtration Of Radioactive Aerosols By Glass Fibers," A. G. Blasewitz, et al. Hanford Wors 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 ϕ = 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

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	.2023

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			12	99.994	.0077	.2002

TRIAL DESIGN II Φ=42" V = 15.59 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

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

LAYERS	TYPE OF FIBER GLAS	PACKING DENSITY	BED DEPTH L INCHES	COLLECTION EFFICIENCY %	Δ P 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	0.4300

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

AUTHOR S. MITINA | DEPARTMENT | LOCATION | DATE

TRIAL DESIGN MARK IV Ø24" 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

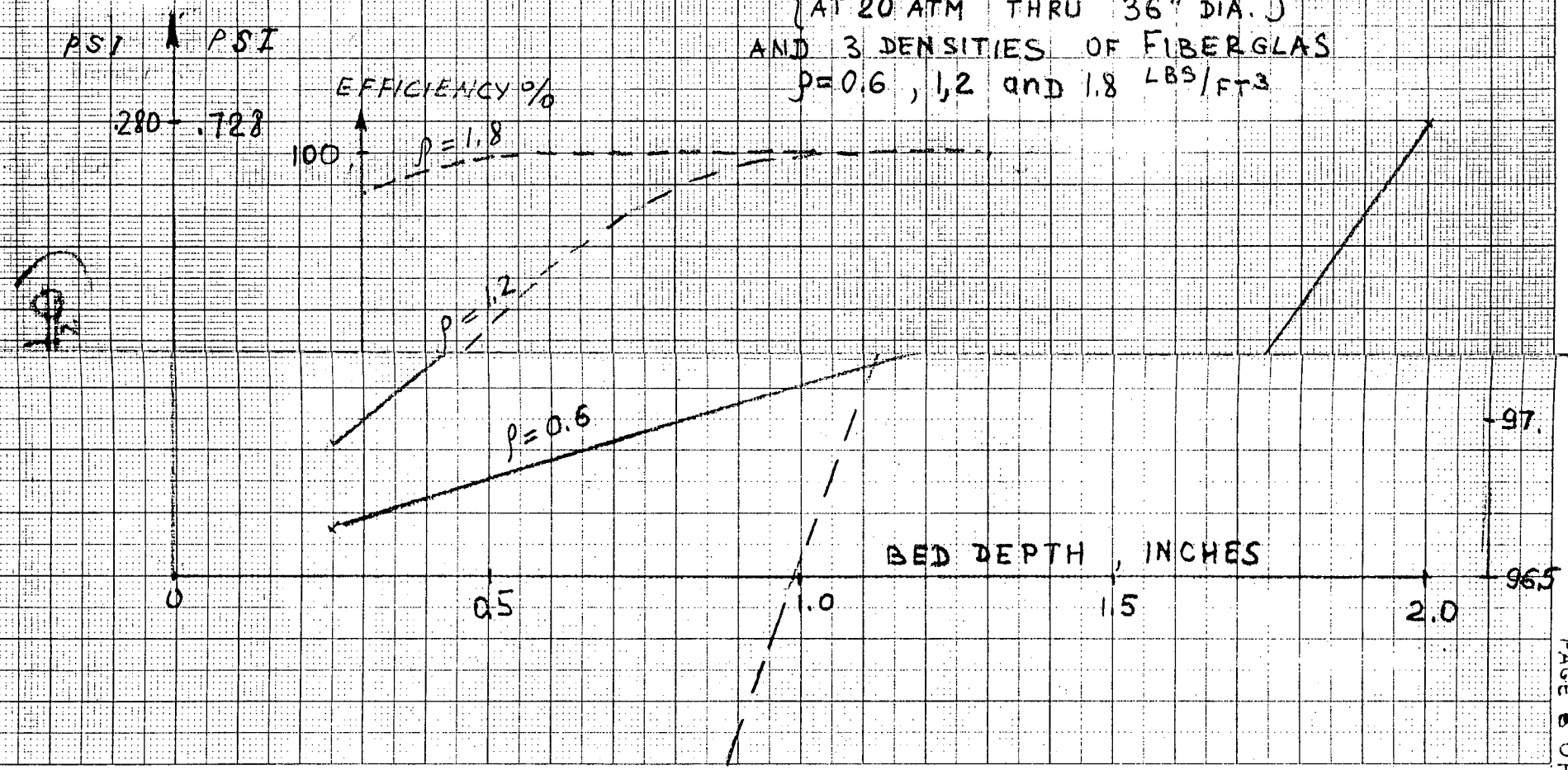
ΔP AND % COLLECTION EFFICIENCY

FOR SUPERFICIAL VELOCITY = 21.2 FT/MIN

{3000 SCFM HELIUM GAS AT 20 ATM THRU 36" DIA.}

AND 3 DENSITIES OF FIBERGLAS

$\rho = 0.6$, 1.2 and 1.8 LBS/FT^3



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