

PROGRAM DESCRIPTION I

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Program Title Cyclone Efficiency

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Program Description, Equations, Variables This program calculates the efficiency of gas cyclones, using the procedure described by Koch and Licht (see reference, below). The program has proven useful in estimating the effects of proposed changes in various dust collection systems. It has also proven useful in estimating the suitability of proposed cyclones for service in several applications. The symbols and equations used by the program are listed in the four continuation pages attached. When referring to the article, note the errors described on page 3.

Necessary Accessories Quad memory module (or 41-CV), printer

Operating Limits and Warnings The results obtained by this program are estimates only and are subject to variation, depending on many factors. The results obtained are not meant to take the place of physical tests of system efficiency.

Reference(s) Koch, W.H. and Licht, W., New Design Approach Boosts Cyclone Efficiency, Chemical Engineering, Nov. 7, 1977, p 80ff.

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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PROGRAM DESCRIPTION I
SYMBOLS USED

* = input variable

(CONTINUATION PAGE)

Symbol used in

Symbol	Description	Reference Article
* a	gas inlet height, ft.	a
* b	gas inlet width, ft.	b
* B	solids outlet diameter, ft.	B
* C	cylinder height, ft.	h
* d	gas outlet diameter, ft.	D_e
* D	overall diameter, ft.	D_c
* dp_i	incremental particle diameter, microns	d_p
G	configuration factor (see Eq. 8)	G
* H	overall height, ft.	H
K_a	(see Eq. 6)	K_a
K_b	(see Eq. 7)	K_b
K_c	(see Eq. 5)	K_c
* m_i	incremental particle weight fraction	m_i
n	vortex exponent (see Eq. 10)	n
N_H	inlet velocity heads (see Eq. 13)	N_H
* ρ_d	particle density, lbs/cu.ft.	ρ_p
* S	gas outlet insert length, ft.	S
* T	gas temperature, °F	T
* V	gas viscosity, lbm/ft-s	μ
V_H	volume below exit duct, (see Eq. 3B)	V_H
V_{nl}	volume at natural length (see Eq. 3A)	V_{nl}
V_s	annular volume (see Eq. 4)	V_s
δ	diameter of central core (see Eq. 2)	d
ΔP	gas pressure drop, in. WG	ΔP
L	"natural length" (see Eq. 1)	l
V_i	inlet velocity (see Eq. 15)	V_i
ρ_f	gas density, lb/cu.ft.	ρ_f
T_i	relaxation time (see Eq. 9)	T_i

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 η_i - incremental (grade) efficiency, %

 η_i
 η_r - overall efficiency, %

 η_r
 Q -

 Q

Erratum

In reference to the noted article, please note the following errors:

Table I: G should be defined as $8K_c/K_a^2 K_b^2$

Eq. (5) should be $\eta_r = \sum m_i \eta_i$

Nomenclature: ρ_f should be defined as lbm/ft^3

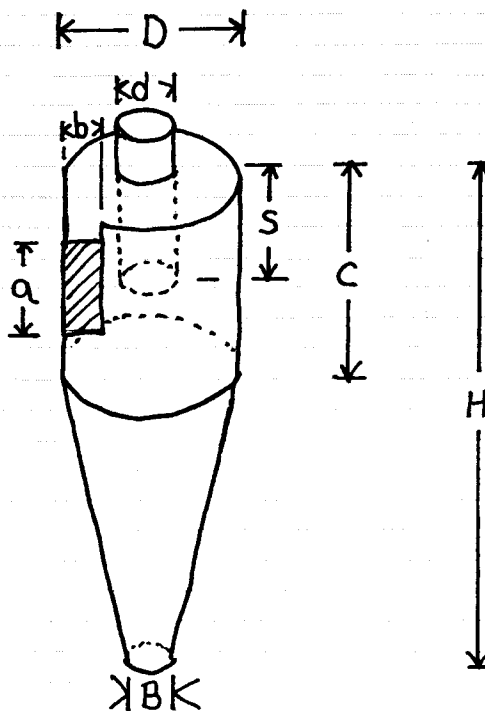
Eq. (9): numerator should be v_i^2

Eq. (11): numerator should be $(b/D_c)^{0.4}$

Eq. (12) righthand ratio should be $(v_i/v_s)_{\text{base}}$

Eq. (17) last term should be $\frac{\pi D_e^2}{4} (H-S)$

Variables input from cyclone geometry
(see printer listing)



$$L = 2.2 d \left(D^2 / a b \right)^{1/3} \quad (\text{EQ. 1})$$

$$\text{if } L < (H-S)$$

$$\delta = D - (D-B) \left[(S+L-C) / (H-C) \right] \quad (\text{EQ. 2})$$

$$V_{NL} = \frac{\pi D^2}{4} (C-S) + \left(\frac{\pi D^2}{4} \right) \left(\frac{L+S-C}{3} \right) \left(1 + \frac{\delta}{D} + \frac{\delta^2}{D^2} \right) - \frac{\pi d^2 L}{4} \quad (\text{EQ. 3A})$$

$$\text{if } L > (H-S)$$

$$V_H = \frac{\pi D^2}{4} (C-S) + \left(\frac{\pi D^2}{4} \right) \left(\frac{H-C}{3} \right) \left(1 + \frac{B}{D} + \frac{B^2}{D^2} \right) - \frac{\pi d^2}{4} (H-S) \quad (\text{EQ. 3B})$$

$$V_S = \left[\pi (S-a/2) (D^2 - d^2) \right] / 4 \quad (\text{EQ. 4})$$

$$K_C = (2V_S + V_{NL,H}) / 2D^3 \quad (\text{EQ. 5})$$

$$K_a = a / D \quad (\text{EQ. 6})$$

$$K_b = b / D \quad (\text{EQ. 7})$$

$$G = 8K_C / K_a^2 K_b^2 \quad (\text{EQ. 8})$$

$$\tau_i = P_d (d_{PL})^2 / (18V) \quad (\text{EQ. 9})$$

$$n = 1 - \left[1 - \frac{(12D)^{0.14}}{2.5} \right] \left[\frac{T+460}{530} \right]^{0.3} \quad (\text{EQ. 10})$$

(CONTINUATION PAGE)

$$\eta_i = 1 - e^{\left\{ -2 \left[\frac{G \tau_i Q}{D^3} (n+1) \right]^{0.5 / (n+1)} \right\}} \quad (\text{EQ. 11})$$

$$\eta_T = \sum m_i \eta_i \quad (\text{EQ. 12})$$

$$N_H = 16 a b / d^2 \quad (\text{EQ. 13})$$

$$\rho_f = 0.08 \left(\frac{530}{T+460} \right) \quad (\text{EQ. 14})$$

$$v_i = Q / a b \quad (\text{EQ. 15})$$

$$\Delta P = 0.003 \rho_f v_i^2 N_H \quad (\text{EQ. 16})$$

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Sample Problem (Sketch if Desired)

A cyclone with the following dimensions:

D-6 ft., d-2 ft., a-2.3 ft., b-1.8 ft., S-2.5 ft., C-5 ft.,
H-19.5 ft, and B-.9 ft.

Is to be used under the following conditions:

Q-150 cu.ft./sec, T-110 F, $V-1.28 \times 10^{-5}$ lbm/ft-s,
Pd-100 lbs/cu.ft.

- What are the grade efficiencies for a particle size range of 0.5 to 8.0 microns?
- How is the efficiency affected by a decrease in total gas flow to 100 cu.ft./sec. and what is the overall efficiency at these conditions if the particle distribution is as follows:

<u>Particle size</u>	<u>Weight %</u>
0.5	8.0
1.3	17.0

(see next page)

SOLUTION:

	Input	Function	Display	Comments
1.		USER		Set user mode.
		FIX n		Set display at desired n.
		XEQ ALPHA		
		CYC ALPHA	See next page.	All input/output prompting appears on the printer, see next page.
	6	R/S	6.00	In fix 2 format.
	2	R/S	2.00	
	1.8	R/S	1.80	
	2.3	R/S	2.30	
	2.5	R/S	2.50	
	5	R/S	5.00	
	19.5	R/S	19.50	
	.9	R/S	0.90	
	150	R/S	150.00	
	110	R/S	110.00	Printer displays "menu"
		A		Printer displays P, table of efficiencies, and plots.
		C		Choose change routine.
2.	9	R/S		Change Q.
	100	R/S		New Q.
		A		Printer prints new data.
		E		Choose overall efficiency routine.
	8	R/S		
	17	R/S		
	20	R/S		
	15	R/S		
	18	R/S		
	12	R/S		

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Particle
Size

Weight %

2.2	20.0
3.0	15.0
3.8	18.0
4.7	12.0
5.5	5.0
6.3	2.0
7.2	2.0
8.0	1.0

Continuation of Sample Problem
Description.

Continuation of Solution

Input

Function

Comments

5.0	R/S
2.0	R/S
2.0	R/S
1.0	R/S

Printer prompts for particle
size distribution. Input values
as prompted.

Printer displays overall efficiency
(see below).

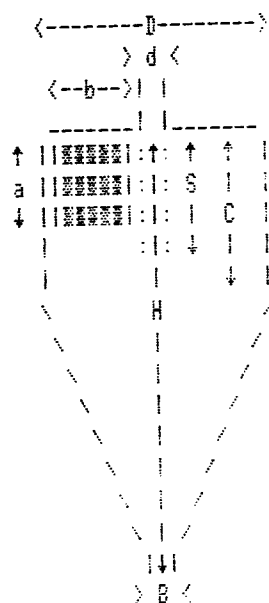
Printer input prompting and output:

Comments

CYCLONE

Program is started by XEQ ALPHA
CYC ALPHA

Printer prints sketch of cyclone
with dimensions marked for reference.



DIMENSIONS IN FEET

ENTER:

012940

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OVERALL DIAMETER <D>
6.00 ***
GAS OUTLET DIAMETER <d>
2.00 ***
GAS INLET WIDTH
1.80 ***
GAS INLET HEIGHT <a>
2.30 ***
INSERT LENGTH <S>
2.50 ***
CYLINDER HEIGHT <C>
5.00 ***
OVERALL HEIGHT <H>
19.50 ***
SOLIDS OUTLET DIAM.
0.90 ***
GAS FLOW, CF/S <Q>
150.00 ***
TEMPERATURE, DEG. F. <T>
150.00 ***
PARTICLE DIAMETERS,
MICRONS

SMALLEST <d1>
0.50 ***
LARGEST <d10>
8.00 ***
VISCOSITY, Lb/F-S <V>
1.28-05 ***
PARTICLE DENSITY,
Lb/CF <Pd>
100.00 ***

TO
CHANGE ENTER

D	1
d	2
b	3
a	4
S	5
C	6
H	7
B	8
Q	9
T	10
d1	11
d10	12
V	13
Pd	14

AND PRESS R/S.

OR PRESS A TO RUN.

TEMPERATURE, DEG. F. <T>
110.00 ***
ΔP=4.85 IN. W.G.

Printer prompts for input data.
Data is printed as input.

-----Whoops! Meant to enter 110.

After all data is input, printer
prints change routine "menu".

Enter 10 and press R/S.

Printer responds with prompt for
temperature input. Correct value
is entered. (repeat as desired). Press A.
ΔP is calculated and printed.

PARTICLE
SIZE
MICRONS

COLLECTION
EFFICIENCY
%

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0.5	55.8
1.3	76.4
2.2	85.2
3.0	90.1
3.8	93.0
4.7	94.9
5.5	96.3
6.3	97.2
7.2	97.8
8.0	98.3

Grade efficiencies are calculated and tabulated by printer.

PLOT OF %EFF
X <UNITS= 1. > +
Y <UNITS= 1. > +

0. 100.
0.

Efficiencies are plotted using PRPLOTP.

0.501	x
1.331	x
2.171	x
3.001	x
3.831	x
4.671	x
5.501	x
6.331	x
7.171	x
8.001	x

PRESS C OR E.
TO
CHANGE ENTER

D	1
d	2
b	3
a	4
s	5
C	6
H	7
B	8
Q	9
T	10
d1	11
d10	12
V	13
Pd	14

Press C to change input data, or E to calculate overall efficiency.

Operator presses C, printer prints change routine menu.

AND PRESS R/S.

OR PRESS A TO RUN.

GAS FLOW, CF/S <Q>
100.0000
ΔP=2.1561 IN. W.G.

Enter 9 press R/S, printer responds with prompt for Q.

Enter new Q, press A. New ΔP calculated and printed.

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PARTICLE SIZE MICRONS	COLLECTION EFFICIENCY %
=====	=====
0.5	51.6
1.3	72.3
2.2	81.7
3.0	87.2
3.8	90.6
4.7	93.0
5.5	94.6
6.3	95.8
7.2	96.7
8.0	97.3

New efficiency table is calculated and printed.

PLOT OF %EFF

X (UNITS= 1.) +

Y (UNITS= 1.) +

0. 100.

0.

0.501	x
1.331	x
2.171	x
3.001	x
3.831	x
4.671	x
5.501	x
6.331	x
7.171	x
8.001	x

New data plotted.

PRESS C OR E.
ENTER WT. % FOR

Press E.

0.5 MICRONS	8.0	***
1.3 MICRONS	17.0	***
2.2 MICRONS	20.0	***
3.0 MICRONS	15.0	***
3.8 MICRONS	18.0	***
4.7 MICRONS	12.0	***
5.5 MICRONS	5.0	***
6.3 MICRONS	2.0	***
7.2 MICRONS	2.0	***
8.0 MICRONS	1.0	***

Printer prompts for particle size distribution. Data is printed as input.

OVERALL EFF.=82.8%

Overall Efficiency printed.

USER INSTRUCTIONS

NOTE: All outputs of this program appear on the printer.

SIZE:
(HP-41C) 036

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1.	Set size 036, clear all key assignments and enter program.			
2.	Set USER mode.			
3.	Start program.		XEQ ALPHA CYC ALPHA	See printer output listing.
4.	Input data as prompted by printer. Example: Printer prints: Gas flow, cf/s (Q)	Q	R/S	Q
5.	When printer prints change menu, enter number of item to be changed and press R/S, repeat for as many items as desired.	change item #	R/S	Printer prompts for new input.
	OR			
5.	Press A to run		A	Output values are calculated printed and plotted.
6.	Press C to change data and return to step 5.		C	
	OR			
6.	Press E and enter size distribution as prompted by printer.		E	Printer prompts for size dist.
7.	Repeat step 6 as desired.			

PROGRAM LISTING

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STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS	STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
01	*LBL	"CYC		43	ACCHR		
"			Program lines	44	PRBUF		
02	"		01-213 print	45	"↑ "		
CYCLONE"			and elevation	46	ACA		
03	PRA		view of a	47	124		
04	ADV		cyclone with	48	ACCHR		
05	ADV		appropriate	49	ACCHR		
06	" <----		dimensions.	50	31		
-----D-----"			(see printer	51	ACCHR		
07	"↑----->		output listing,	52	ACCHR		
"			page 7)	53	ACCHR		
08	PRA			54	ACCHR		
09	"			55	ACCHR		
> d <"				56	124		
10	PRA			57	ACCHR		
11	" <--b			58	" :↑: ↑		
-->"				↑ "			
12	ACA			59	ACA		
13	124			60	124		
14	ACCHR			61	ACCHR		
15	1			62	PRBUF		
16	SKPCHR			63	"a "		
17	X<>Y			64	ACA		
18	ACCHR			65	124		
19	PRBUF			66	ACCHR		
20	" "			67	ACCHR		
21	ACA			68	31		
22	95			69	ACCHR		
23	ACCHR			70	ACCHR		
24	ACCHR			71	ACCHR		
25	ACCHR			72	ACCHR		
26	ACCHR			73	ACCHR		
27	ACCHR			74	124		
28	ACCHR			75	ACCHR		
29	ACCHR			76	58		
30	124			77	ACCHR		
31	ACCHR			78	124		
32	1			79	ACCHR		
33	SKPCHR			80	58		
34	X<>Y			81	ACCHR		
35	ACCHR			82	" S "		
36	95			83	ACA		
37	ACCHR			84	124		
38	ACCHR			85	ACCHR		
39	ACCHR			86	2		
40	ACCHR			87	SKPCHR		
41	ACCHR			88	X<>Y		
42	ACCHR			89	ACCHR		

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STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS	STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
90	PRBUF			137	ACCHR		
91	7			138	2		
92	ACCHR			139	SKPCHR		
93	1			140	124		
94	SKPCHR			141	ACCHR		
95	124			142	2		
96	ACCHR			143	SKPCHR		
97	ACCHR			144	X<>Y		
98	31			145	ACCHR		
99	ACCHR			146	PRBUF		
100	ACCHR			147	2		
101	ACCHR			148	SKPCHR		
102	ACCHR			149	X<>Y		
103	ACCHR			150	ACCHR		
104	124			151	8		
105	ACCHR			152	SKPCHR		
106	58			153	X<>Y		
107	ACCHR			154	ACCHR		
108	124			155	5		
109	ACCHR			156	SKPCHR		
110	X<>Y			157	7		
111	ACCHR			158	ACCHR		
112	1			159	2		
113	SKPCHR			160	SKPCHR		
114	124			161	124		
115	ACCHR			162	ACCHR		
116	2			163	PRBUF		
117	SKPCHR			164	2		
118	67			165	SKPCHR		
119	ACCHR			166	92		
120	X<>Y			167	ACCHR		
121	SKPCHR			168	"		
122	124			H	"		
123	ACCHR			169	"H /"		
124	PRBUF			170	ACA		
125	2			171	PRBUF		
126	SKPCHR			172	1.007		
127	124			173	STO 00		
128	ACCHR			174	*LBL 00		
129	"			175	RCL 00		
:	"			176	INT		
130	ACA			177	2		
131	ACCHR			178	+		
132	58			179	SKPCHR		
133	ACCHR			180	92		
134	1			181	ACCHR		
135	SKPCHR			182	8		
136	7			183	RCL 00		

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STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS	STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
184	INT			228	X<>Y		
185	-			229	STO IND		
186	SKPCHR				Y		
187	124			230	ISG 00		
188	ACCHR			231	GTO 15		
189	X<>Y			232	*LBL C		
190	SKPCHR			233	" TO"		Print
191	47			234	PRA		change
192	ACCHR			235	"CHANGE		routine
193	PRBUF				ENTER"		"menu".
194	ISG 00			236	PRA		
195	GTO 00			237	ADV		
196	10			238	" D		
197	SKPCHR				1"		
198	124			239	PRA		
199	ACCHR			240	" d		
200	7				2"		
201	ACCHR			241	PRA		
202	X<>Y			242	" b		
203	ACCHR				3"		
204	PRBUF			243	PRA		
205	"			244	" a		
	> B <"				4"		
206	PRA			245	PRA		
207	ADV			246	" S		
208	" DIME				5"		
	NSIONS I"			247	PRA		
209	"-IN FEET			248	" C		
	"				6"		
210	PRA			249	PRA		
211	ADV			250	" H		
212	ADV				7"		
213	ADV			251	PRA		
214	"ENTER:"		Prepare for	252	" B		
215	PRA		data input		8"		
216	ADV		loop.	253	PRA		
217	ADV			254	" Q		
218	1.014				9"		
219	STO 00			255	PRA		
220	*LBL 15		Prompt for and	256	" T		
221	XEQ IND		accept inputs.		10"		
	00			257	PRA		
222	PRA			258	" d1		
223	STOP				11"		
224	PRX			259	PRA		
225	RCL 00			260	" d10		
226	11				12"		
227	+			261	PRA		

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STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS	STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
262	" V			301	RTN		
	13"			302	*LBL 05		
263	PRA			303	"INSERT		
264	" Pd				LENGTH <"		
	14"			304	"FS>"		
265	PRA			305	RTN		
266	ADV			306	*LBL 06		
267	ADV			307	"CYLINDE		
268	"AND PRE				R HEIGHT"		
	SS R/S."			308	"F <C>"		
269	PRA			309	RTN		
270	ADV			310	*LBL 07		
271	"OR PRES			311	"OVERALL		
	S A TO R"				HEIGHT "		
272	"FUN."			312	"F<H>"		
273	PRA			313	RTN		
274	ADV			314	*LBL 08		
275	ADV			315	"SOLIDS		
276	*LBL 16				OUTLET D"		
277	STOP		Accept	316	"FIAM. <		
278	XEQ IND		changes to		B>"		
	X		input data.	317	RTN		
279	PRA			318	*LBL 09		
280	11			319	"GAS FLO		
281	+				W, CF/S "		
282	STOP			320	"F<Q>"		
283	PRX			321	RTN		
284	STO IND			322	*LBL 10		
	Y			323	"TEMPERA		
285	GTO 16				TURE, DE"		
286	*LBL 01		LBL 01-	324	"FG. F.		
287	"OVERALL		LBL 14		<T>"		
	DIAMETE"		Data input	325	RTN		
288	"FR <D>"		headings.	326	*LBL 11		
289	RTN			327	"PARTICL		
290	*LBL 02				E DIAMET"		
291	"GAS OUT			328	"FERS."		
	LET DIAM"			329	PRA		
292	"ETER <			330	"MICRONS		
	d>"				"		
293	RTN			331	PRA		
294	*LBL 03			332	ADV		
295	"GAS INL			333	"SMALLES		
	ET WIDTH"				T <d1>"		
296	"F "			334	RTN		
297	RTN			335	*LBL 12		
298	*LBL 04			336	"LARGEST		
299	"GAS INL				<d10>"		
	ET HEIGH"						
300	"FT <a>"						

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STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS	STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
337	RTN			381	RCL 18		
338	*LBL 13			382	RCL 17		Calculate δ
339	"VISCOSI			383	-		and store
TY, Lb/F"				384	/		in R03
340	"H-S <V>			385	RCL 12		
"				386	RCL 19		
341	RTN			387	-		
342	*LBL 14			388	*		
343	"PARTICL			389	RCL 12		
E DENSIT"				390	X<>Y		
344	"FY, "			391	-		
345	PRA			392	STO 03		
346	"Lb/CF <			393	RCL 03		
Pd>"				394	RCL 12		
347	RTN			395	/		
348	STOP			396	ENTER↑		
349	*LBL A		Start run.	397	X↑2		
350	PI		Store $\frac{\pi D^2}{4}$	398	+		
351	RCL 12			399	1		Calculate
352	X↑2			400	+		V_{n1} and
353	*		in R02	401	RCL 01		store in
354	4			402	RCL 16		
355	/			403	+		
356	STO 02			404	RCL 17		R04
357	RCL 12			405	-		
358	X↑2		Calculate	406	3		
359	RCL 14		natural length,	407	/		
360	RCL 15		(and store in	408	*		
361	*		R01.	409	RCL 02		
362	/			410	*		
363	3			411	RCL 13		
364	1/X			412	X↑2		
365	Y↑X			413	PI		
366	2.2			414	*		
367	*			415	RCL 01		
368	RCL 13			416	*		
369	*			417	4		
370	STO 01			418	/		
371	RCL 18			419	-		
372	RCL 16			420	RCL 17		
373	-			421	RCL 16		
374	X<Y?		if $L > (H-S)$	422	-		
375	GTO 17		calculate V_H	423	RCL 02		
376	RCL 16			424	*		
377	RCL 01		otherwise	425	+		
378	+			426	STO 04		
379	RCL 17			427	GTO 18		Jump V_H
380	-			428	*LBL 17		

PROGRAM LISTING

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STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS	STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
429	RCL	02		477	/		
430	RCL	18	calculate V_H	478	2		and store K_c
431	RCL	17		479	*		
432	-		and store in	480	RCL	04	in R09
433	3			481	+		
434	/		R04	482	2		
435	*			483	/		
436	RCL	19		484	RCL	12	calculate
437	RCL	12		485	3		(n+1)
438	ENTER↑			486	Y↑X		
439	X↑2			487	/		
440	+			488	STO	09	
441	1			489	RCL	12	
442	+			490	12		
443	*			491	*		
444	RCL	18		492	.14		
445	RCL	16		493	Y↑X		
446	-			494	2.5		
447	RCL	13		495	/		
448	X↑2			496	1		
449	PI			497	X<>Y		
450	*			498	-		
451	4			499	RCL	21	
452	/			500	460		
453	*			501	+		
454	-			502	530		
455	RCL	17		503	/		
456	RCL	16		504	.3		
457	-			505	Y↑X		
458	RCL	02		506	*		
459	*			507	1		
460	+			508	X<>Y		
461	STO	04		509	-		
462	*LBL	18	Calculate	510	1		and store
463	RCL	16	V_s	511	+		in R05.
464	RCL	15		512	STO	05	
465	2		and	513	.5		0.5/(n+1)
466	/			514	X<>Y		store in R06
467	-			515	/		
468	PI		K_c	516	STO	06	
469	*			517	RCL	25	calculate
470	RCL	12		518	18		Pd/18V
471	X↑2			519	/		
472	RCL	13		520	RCL	24	and store in
473	X↑2			521	/		R07
474	-			522	STO	07	
475	*			523	RCL	09	
476	4			524	8		

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STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS	STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
525	*			573	X<>Y		
526	RCL	15		574	/		
527	RCL	12		575	*		
528	/			576	8		
529	X↑2		calculate G	577	ACCHR		
530	/		and store in	578	"P="		
531	RCL	14	R08	579	RDN		
532	RCL	12		580	ARCL X		
533	/			581	"F IN. W		
534	X↑2				.G."		
535	/			582	ACA		
536	RCL	20		583	PRBUF		
537	*			584	0.009		
538	RCL	12		585	STO 00		set for
539	3			586	ADV		calculation
540	Y↑X			587	" PARTIC		of grade
541	/				LE C"		efficiencies
542	RCL	05		588	"COLLECT		
543	*				ION"		Print
544	STO	08		589	PRA		table
545	RCL	23	store	590	" SIZE		headers
546	RCL	22	d10-d1		E"		
547	-		9	591	"EFFICIE		
548	9				NCY"		
549	/		in r10	592	PRA		
550	STO	10		593	" MICRO		
551	RCL	15	calculate		NS		
552	RCL	14	inlet area	594	"F %"		
553	*			595	PRA		
554	STO	11		596	" =====		
555	RCL	13	calculate		==		
556	X↑2		NH	597	"F =====		
557	/				===="		
558	16			598	PRA		
559	*			599	FIX 1		
560	.003		calculate and	600	*LBL 19		calculate
561	*		print	601	RCL 00		%Efficiencies
562	.08		pressure	602	INT		for particle
563	*		drop	603	RCL 10		sizes in range
564	RCL	20		604	*		
565	RCL	11		605	RCL 22		
566	/			606	+		
567	X↑2			607	" "		
568	*			608	10		
569	RCL	21		609	X>Y?		
570	460			610	"F "		
571	+			611	RDN		
572	530			612	ARCL X		

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STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS	STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
613	3.28 E-5			659	STO 03		
614	*			660	RCL 22		
615	X↑2			661	STO 08		
616	RCL 07			662	RCL 23		
617	*			663	STO 09		
618	RCL 08			664	"%EFF"		
619	*			665	ASTO 11		
620	RCL 06			666	ADV		
621	Y↑X			667	ADV		
622	-2			668	XROM "PR		plot
623	*			PLOTP"			efficiencies
624	E↑X			669	ADV		
625	1			670	ADV		
626	X<>Y			671	ADV		
627	-			672	"PRESS C		
628	RCL 00			OR E."			prompt for
629	26			673	PRA		routine choices
630	+			674	STOP		
631	X<>Y			675	LBL E		
632	STO IND			676	0		
Y				677	STO 01		accept
633	100			678	0.009		particle
634	*			679	STO 00		size
635	RND			680	"ENTER W		distribution
636	"F			T. % FOR"			
"				681	PRA		
637	100			682	ADV		
638	X<>Y			683	FIX 1		
639	X<Y?			684	LBL 20		calculate
640	"F "			685	CLA		and print
641	10			686	RCL 00		overall
642	X>Y?			687	INT		efficiency
643	"F "			688	RCL 10		
644	RDN			689	*		
645	ARCL X			690	RCL 08		
646	PRA			691	+		
647	ISG 00			692	10		
648	GTO 19			693	X>Y?		
649	0			694	"F "		
650	STO 00		clear	695	X<>Y		
651	STO 02		plotting	696	ARCL X		
652	STO 04		registers	697	"F MICRO		
653	STO 05			NS"			
654	STO 06			698	PRA		
655	STO 07			699	STOP		
656	100			700	PRX		
657	STO 01			701	100		
658	1			702	/		

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STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS	STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
703	RCL	00		51			
704	26						
705	+						
706	RCL	IND					
X							
707	RCL	Z					
708	*						
709	ST+	01					
710	ISG	00					
711	GTO	20		60			
712	ADV						
713	RCL	01					
714	100						
715	*						
716	"OVERALL						
EFF."							
717	ARCL	X					
718	"F%"						
719	PRA			70			
720	ADV						
721	ADV						
722	ADV						
723	STOP						
724	LBL	"%EF					
F"			Global label				
725	RCL	08	necessary				
726	-		for proper				
727	RCL	10	labeling of				
728	/		plotting				
729	26		function.	80			
730	+						
731	RCL	IND					
X							
732	100						
733	*						
734	.END.			90			

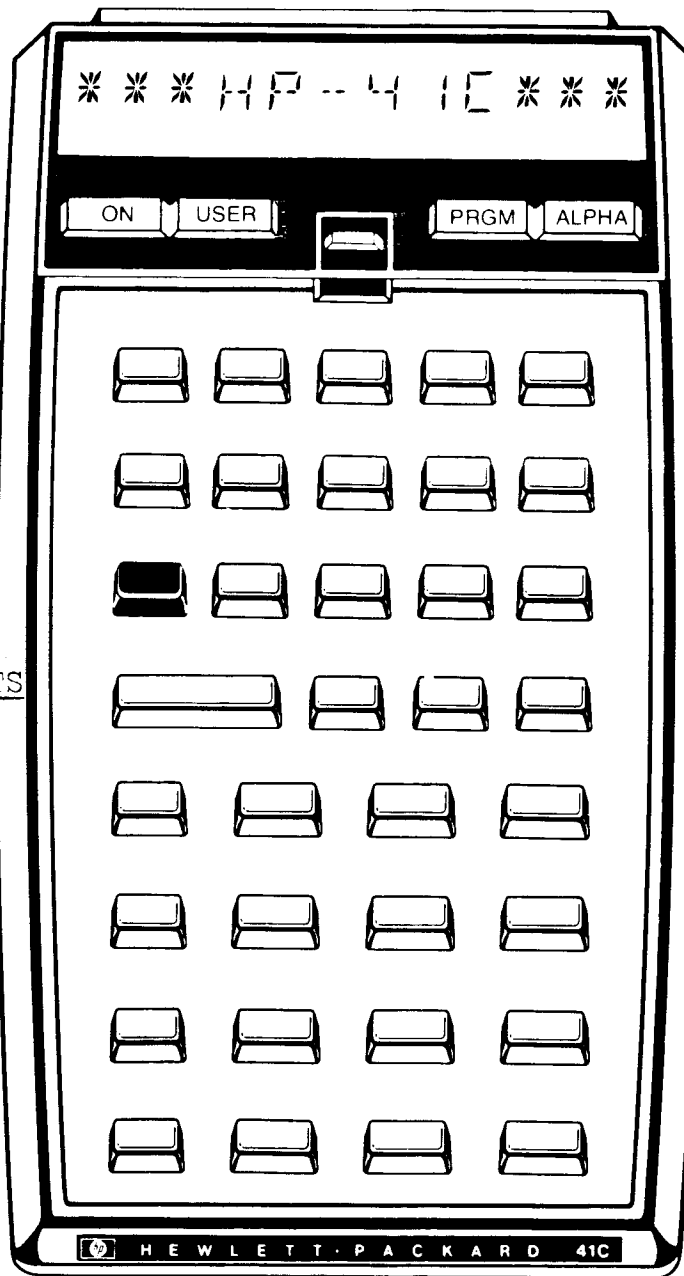
REGISTERS, STATUS, FLAGS, ASSIGNMENTS

DATA REGISTERS			STATUS			
00	Loop Control	Registers	SIZE 036	TOT. REG. 318	USER MODE	
01	registers	00	ENG	FIX 2	SCI	ON X OFF
02	01 through	through	DEG	RAD	GRAD	
03	11 are used	11	FLAGS			
04	by the	are also used	#	INIT S/C	SET INDICATES	CLEAR INDICATES
05	program to	by the PRPLOTP	NONE			
06	store	function at				
07	intermediate	program line				
08	answers.	668				
09						
10						
11						
12	D					
13	d					
14	b					
15	a					
16	S					
17	C					
18	H					
19	B					
20	Q					
21	T					
22	d1					
23	d10					
24	V					
25	Pd		ASSIGNMENTS			
26	Efficiency 1		FUNCTION	KEY	FUNCTION	KEY
27	Efficiency 2		NONE			
28	Efficiency 3					
29	Efficiency 4					
30	Efficiency 5					
31	Efficiency 6					
32	Efficiency 7					
33	Efficiency 8					
34	Efficiency 9					
35	Efficiency 10					

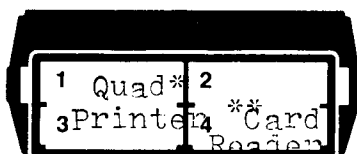
KEYBOARD CARD LABELING

KEYBOARD

NO KEY ASSIGNMENTS



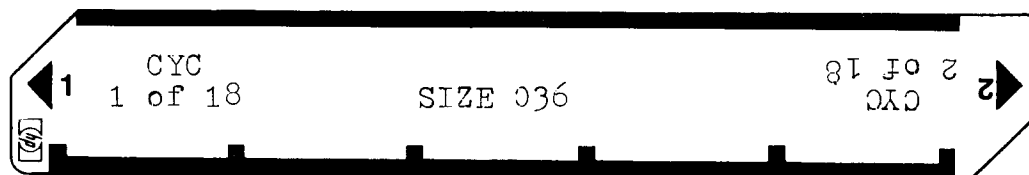
SYSTEM CONFIGURATION



*or 41-CV

**Highly recommended
because of program size.

CARD



PROGRAM REGISTERS NEEDED: 283

ROW 1 (1 : 2)



ROW 2 (2 : 4)



ROW 3 (5 : 6)



ROW 4 (6 : 8)



ROW 5 (8 : 9)



ROW 6 (9 : 11)



ROW 7 (11 : 16)



ROW 8 (17 : 22)



ROW 9 (23 : 29)



ROW 10 (29 : 36)



ROW 11 (36 : 42)



ROW 12 (43 : 48)



ROW 13 (48 : 54)



ROW 14 (55 : 58)



ROW 15 (58 : 62)



ROW 16 (62 : 67)



ROW 17 (68 : 74)



ROW 18 (74 : 79)



ROW 19 (80 : 84)



ROW 20 (84 : 92)



ROW 21 (92 : 98)



ROW 22 (99 : 104)



ROW 23 (105 : 111)



ROW 24 (111 : 118)



ROW 25 (118 : 124)



ROW 26 (125 : 129)



ROW 27 (129 : 134)



ROW 28 (135 : 141)



ROW 29 (142 : 150)



ROW 30 (150 : 158)



ROW 31 (159 : 165)



ROW 32 (166 : 168)



ROW 33 (168 : 170)



ROW 34 (170 : 177)



ROW 35 (178 : 186)



ROW 36 (187 : 193)



ROW 37 (193 : 199)



ROW 38 (199 : 205)



ROW 39 (205 : 206)



ROW 40 (207 : 208)



ROW 41 (208 : 210)



ROW 42 (210 : 215)



ROW 43 (216 : 222)



ROW 44 (222 : 230)



ROW 45 (231 : 235)



ROW 46 (235 : 235)



ROW 47 (235 : 238)



ROW 48 (238 : 240)



ROW 49 (240 : 242)



ROW 50 (242 : 243)



ROW 51 (243 : 244)



ROW 52 (244 : 246)



ROW 53 (246 : 248)



ROW 54 (248 : 250)



ROW 55 (250 : 251)



ROW 56 (252 : 252)



ROW 57 (252 : 254)



ROW 58 (254 : 256)



ROW 59 (256 : 258)



ROW 60 (258 : 260)



ROW 61 (260 : 260)



ROW 62 (261 : 262)



ROW 63 (262 : 264)



ROW 64 (264 : 268)



ROW 65 (268 : 269)



ROW 66 (269 : 271)



ROW 67 (271 : 274)



ROW 68 (275 : 283)



ROW 69 (283 : 287)



ROW 70 (287 : 288)



ROW 71 (288 : 291)



ROW 72 (291 : 292)



ROW 73 (292 : 295)



ROW 74 (295 : 296)



ROW 75 (296 : 299)



ROW 76 (299 : 300)



ROW 77 (300 : 303)



ROW 78 (303 : 305)



ROW 79 (306 : 307)



ROW 80 (307 : 311)



ROW 81 (311 : 311)



ROW 82 (311 : 315)



ROW 83 (315 : 316)



ROW 84 (316 : 319)



ROW 85 (319 : 319)



ROW 86 (319 : 323)



ROW 87 (323 : 324)



ROW 88 (324 : 327)



ROW 89 (327 : 327)



ROW 90 (327 : 330)



ROW 91 (330 : 333)



ROW 92 (333 : 336)



ROW 93 (336 : 338)



ROW 94 (339 : 339)



ROW 95 (339 : 342)



ROW 96 (343 : 343)



ROW 97 (343 : 346)



ROW 98 (346 : 351)



ROW 99 (352 : 364)



ROW 100 (365 : 373)



ROW 101 (374 : 381)



ROW 102 (382 : 392)



ROW 103 (393 : 404)



ROW 104 (404 : 416)



ROW 105 (417 : 427)



ROW 106 (427 : 435)



ROW 107 (436 : 445)



ROW 108 (446 : 456)



ROW 109 (457 : 467)



ROW 110 (468 : 480)



ROW 111 (481 : 492)



ROW 112 (492 : 500)



ROW 113 (500 : 508)



ROW 114 (509 : 518)



ROW 115 (519 : 530)



ROW 116 (531 : 542)



ROW 117 (543 : 553)



ROW 118 (554 : 562)



ROW 119 (562 : 570)



ROW 120 (570 : 578)



ROW 121 (578 : 581)



ROW 122 (581 : 586)



ROW 123 (587 : 587)



ROW 124 (587 : 588)



ROW 125 (588 : 590)



ROW 126 (590 : 591)



ROW 127 (591 : 593)



ROW 128 (593 : 594)



ROW 129 (594 : 596)



ROW 130 (596 : 597)



ROW 131 (597 : 602)



ROW 132 (603 : 610)



ROW 133 (610 : 614)



ROW 134 (615 : 626)



ROW 135 (627 : 635)



ROW 136 (636 : 637)



ROW 137 (638 : 645)



ROW 138 (645 : 653)



ROW 139 (654 : 662)



ROW 140 (663 : 669)



ROW 141 (670 : 672)



ROW 142 (672 : 678)



ROW 143 (678 : 680)



ROW 144 (680 : 684)



ROW 145 (685 : 694)



ROW 146 (695 : 697)



ROW 147 (698 : 705)



ROW 148 (706 : 712)



ROW 149 (713 : 716)



ROW 150 (716 : 719)



ROW 151 (720 : 725)



ROW 152 (726 : 734)



ROW 153 (734 : 734)

