Programmable TI 58/59 Specialty Pakettes
Fluid Dynamics

TEXAS INSTRUMENTS
INCORPORATED

THE TI-59 PAKETTE STORY

Since the early days of handheld programmable calculators, Texas Instruments (TI) has been deeply involved in supplying not only calculators with exceptional power but also programs (software) to match. Many experts were put to work within their special fields of endeavor to design quality Software Libraries for TI calculator users. Among the Libraries produced by TI for the TI-59 are:

- Statistics
- Real Estate and Investment
- Surveying
- Navigation
- Aviation
- Leisure
- Business Decisions
- Securities Analysis

Fully recognizing TI-59 users may require programs other than those included in TI-59 Libraries, a second program source was developed. This source, the Professional Program Exchange, gathers, compiles and redistributes programs **written by TI-59 users** who defined their own specific program needs and filled these needs by writing programs. These programs, now in Pakettes, add a new dimension to the software made available to TI-59 user. Combining some of the best TI originated programs with the most popular programs found in the Professional Program Exchange, Program Pakettes offer a true software value. Current TI Pakette offerings include:

- Securities
- Statistical Testing
- Civil Engineering
- Electronic Engineering
- Blackbody
- Oil/Gas/Energy
- Printer Utility
- Astrology
- Programming Aids
- 59 Fun
- 3-D Graphics
- Fluid Dynamics
- Mathematics
- Lab Chemistry

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Calculator Products Division

Submission Abstract

Program Title
SOLUTION TO PIPE PROBLEMS

Rev.

Abstract of Program Solves for either Head loss, length, diameter, or flow when given any of the other three. Solution is accomplished by the Newton-Raphson iterative method using the Colebrook and Darcy-Weisbach equations. Provisions are made to include the Head loss coefficients of fittings.

Original TI-59 Program by Allan Tremblay of Quebec, Canada.

User Benefits: Eliminates need for the Moody diagram.

Category Number 61

Required Progs.

Prog. Steps 707

PC-100A Needed ☐
Library Module ID ☐

Submittal Agreement

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Submission Checklist

- ☑ Recorded Magnetic Cards
- ☑ Submission Abstract
- ☑ Program Description
- ☑ User Instructions
- ☑ Sample Problem
- ☑ Listing
- ☐
- ☐

Program Title: SOLUTION TO PIPE PROBLEMS

Rev.

Method, Equations, Sketches, Limitations, References, Error Recovery:

d – pipe diameter
L – pipe length
V – velocity of liquid
ν – kinematic viscosity
Q – flow of liquid
f – flow resistance
ε – pipe roughness

Re – Reynolds number
Hf – head loss
Gc – gravitational constant (either 32.174 for English units or 9.806 for metric units)
μ – absolute viscosity
ρ – density of liquid

I. The equations used to compute head loss or length (depending on which is given) are:

$$RE = dV/\nu \qquad \text{where } \nu = \mu/\rho$$

$$Q = \pi d^2\ V/4$$

$$\Delta x = \frac{x + 0.86\ \ln\ (Ax + B)}{1 + 0.86\ (A/(Ax+B))} \qquad \text{where } x = 1/\sqrt{f}$$

$$A = 2.51/Re$$

$$B = (\varepsilon/d)/3.7$$

(The equation for Δx is the Newton-Raphson rearrangement of the Colebrook equation)

$$Hf = (f\ L\ V^2)/(2\ Gc\ d)$$

$$L = (Hf\ 2\ Gc\ d)/(fV^2)$$

(The equations for Hf and L are forms of the Darcy-Weisbach equation)

II. The equations used to compute Q, V, Re, and/or f (given Hf, L, D, ε, and $\nu = \mu/\rho$) are:

$$V = (1/\sqrt{f})\ \sqrt{(Hf \cdot 2\ Gc\ d)/L}$$

$$Q = (\pi\ d^2\ V)/4$$

$$Re = (d\ V\ \rho)/\mu$$

$$1/\sqrt{f} = -0.86\ \ln \left[\ (\varepsilon/d)/3.7 + 2.51/(Re\ \sqrt{f})\ \right]$$

$$\text{where } Re\ \sqrt{f} = ((d\rho)/\mu)\sqrt{(Hf\ 2\ Gc\ d)/L}$$

(The equation for $1/\sqrt{f}$ is the Colebrook equation)

III. The equations used to compute d, f, and/or Re (given Hf, Q, L, $\nu = \mu/\rho$, and ε) are:

☒ See Continuation Sheet

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Continuation Sheet

Continued From: ☒ Program Description ☐ User Instructions ☒ Stmt. of Example

Program Title: SOLUTION TO PIPE PROBLEMS	Rev.

$$d = \left[(f\ 8\ L\ Q^2)/(\pi^2\ Gc\ Hf) \right]^{0.2}$$

$$Re = \left[(4\ Q\rho)/(\pi\mu) \right](1/d)$$

$$1/\sqrt{f} = \sqrt{Re}/8 \text{ and the Colebrook equation}$$

$$\mu = (1/\sqrt{f})\ \sqrt{(Hf\ 2\ Gc\ d)/L}$$

In section I, iteration stops when $| \Delta x | < .001$

In sections II and III, iteration stops when $| 1/\sqrt{f_2} - 1/\sqrt{f_1} | < .001$, where $1/\sqrt{f_2}$ is the value obtained in the previous iteration.

In all three sections, the border line between laminar and turbulent flow is set at Re = 2100 ($Re\ \sqrt{f} = 367$). Also, if applicable, the equivalent length due to fittings, denoted Le, is computed by the equation Le = (Kd)/f, where k is the head loss coefficient of fittings.

Continuation of Statement of Example

5.) Same as example 1, except that somewhere along the 1500 ft. pipe there is a fully opened globe valve for which k = 10. Determine the Head loss.

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User Instructions

Program Title
SOLUTION FOR PIPE PROBLEMS

Gc	ν	ε		
k	Hf	L	d	V^+, Q^-

Partition (OP 17) 719 , 29
Parentheses Levels 3
t Register ☒
Angular Mode (if applicable)
SBR Levels 1
Absolute Addresses ☐
Library Module ID
Disturbs Pending Operations ☒

LABELS (Op 08)

INV		lnx	√	CE	√	CLR		x⇌t	√	x²	√
√x	√	1/x	√	STO	√	RCL	√	SUM		yˣ	√
EE	√	(	√	)	√	÷	√	GTO	√	×	√
SBR	√	−	√	RST	√	+	√	R/S		•	
+/−	√	=		CLR		INV		log		CP	
tan	√	Pgm		P→R		sin	√	cos	√	CMs	
Exc		Prd		|x|		Eng		Fix		Int	
Deg		Pause		x=t		Nop		Op		Rad	
Lbl		x≥t		Σ+		x̄		Grad		St flg	
If flg		D.MS		π		List		Write		Dsz	
Adv		Prt									

USER DEFINED KEYS

- A Head loss coeff.
- B Head loss
- C Length
- D Diameter
- E Vel.+, Flow−
- A' Gravitational Constant
- B' Kinematic Visc.
- C' Roughness
- D'
- E'

FLAGS 0	K? 1	Set if Q 2	Hf? 3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS		OUTPUT/MODE (see legend below)
1	Enter program				
2	Enter constants				
	Gc	Gc		A'	Gc
	ν	ν		B'	ν
	ε	ε		C'	ε
3	Enter known variables + (enter 3 of the 4)				
	Q} or V}	Q} or V}	+/− or	E} E}	Q} or V}
	d	d		D	d
	L	L		C	L
	Hf	Hf		B	Hf
4	Compute unknown variable				
	clear display			CLR	0
	To find Q			E	−Q (negative sign indicates Q)
	To find V			E	−Q (required to find V)
				R/S	V
	To find d			D	d
	To find L			C	L
	To find Hf			B	Hf

+Reset all flags before entering variables (Press RST)

Modes: n' — Printed only (n) — Displayed Briefly (Pause)

DATA REGISTERS (INV List)

- 0
- 1 k
- 2 Hf
- 3 L
- 4 d
- 5 V
- 6 Q
- 7 Gc
- 8 ν
- 9 ε
- 10 $1/\sqrt{f}$
- 11 f
- 12 Re
- 13 A
- 14 B
- 15 $k = fV^2/2\ Gc\ d$
- 16 Re $\sqrt{f}$
- 17 $1/\sqrt{f'}$
- 18 Le
- 9

Sample Problem

Statement of Example

1.) Determine the Head loss due to the flow of 2500 gal./min. (5.57 ft^3/sec) of oil, ν = 0.0001 ft^2/sec, through 1500 ft. of 10" diameter (0.833 ft) cast-iron pipe (ε = 0.00085 ft).

2.) Water at 15^oC ($\nu = 1.13 \times 10^{-6}$ m^2/sec) flows through a 25 cm.-diameter riveted steel pipe (ε = 0.003M) with a Head loss of 5 Meters in 400 Meters. Determine the flow.

3.) Water at 70^oF ($\nu = 1.1 \times 10^{-5} ft^2/sec$) flows through an 8"-diameter (0.667 ft) steel pipe (ε = 0.00015 ft). What length would be required to produce a Head loss of 8 ft. Lbf/Lbm? Velocity is 4 ft/sec.

4.) Determine the size of clean wrought-iron (ε = 0.00015 ft) pipe required to convey 2000 GPM (4.456 ft^3/sec) of oil (ν = 0.0001 ft^2/sec) 5000 ft with a Head loss of 60 ft. Lbf/Lbm.

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
1.)	RST		reset flags
.00085	C'	0.00085	ε
32.174	A'	32.174	Gc
.0001	B'	0.0001	ν
1500	C	1500	L
.833	D	0.833	d
5.57	+/- E	5.57	Q
	CLR	0	clear display
	B	(1.5856229306)	Δx calculated
		(0.0046372945)	in each
		(0.0000000345)	iteration
		67.31449243	Hf
2.)	RST		
9.806	A'	9.806	Gc
1.13 EE 6 +/-	B'	1.13 - 06	ν
	INV EE	0.00000113	
.003	C'	0.003	ε
5	B	5	Hf
400	C	400	L
.25	D	0.25	d
	CLR	0	clear display

Modes: n* — Printed only (n) — Displayed Briefly (Pause)
(n)* — Printed and displayed

☒ Over

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Sample Problem (cont'd)

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
	E	-.0597494491	negative indicates Q
	R/S	1.217105782	V
3.)	RST		
32.174	A'	32.174	Gc
1.1 EE 5 +/-	B'	1.1 -05	ν
	INV EE	0.000011	
.00015	C'	0.00015	ε
8	B	8	Hf
.667	D	0.667	d
4	E	4	V
	CLR	0	clear display
	C	(2.612770094)	iterations of
		(.0201668154)	Δx
		(.0000009031)	
		1250.300312	L
4.)	RST		Gc already in memory
.0001	B'	0.0001	ν
.00015	C'	0.00015	ε
60	B	60	Hf
5000	C	5000	L
4.456	+/- E	4.456	Q
	CLR	0	clear display
	D	(.1358517446)	iterations of
		(.0096988827)	Δx
		(.0006987223)	
		.9752566324	d (in ft.)
5.)	RST		Gc and ν already store
.00085	C'	0.00085	ε
1500	C	1500	L
.833	D	0.833	d
5.57	+/- E	5.57	Q
10	A	10	K
	CLR	0	clear display
	B	(1.585229306)	iterations of
		(.0046372945)	Δx
		(.0000000345)	
		83.54811965	Hf

Modes: n* — Printed only (n) — Displayed Briefly (Pause)
(n)* — Printed and displayed

LOC	CODE	KEY	COMMENTS
000	76	LBL	
001	11	A	
002	42	STO	
003	01	01	
004	86	STF	
005	01	01	
006	91	R/S	
007	76	LBL	
008	12	B	
009	42	STO	
010	02	02	
011	43	RCL	
012	02	02	
013	29	CP	
014	67	EQ	
015	38	SIN	
016	86	STF	
017	03	03	
018	91	R/S	
019	76	LBL	
020	13	C	
021	42	STO	
022	03	03	
023	43	RCL	
024	03	03	
025	29	CP	
026	67	EQ	
027	38	SIN	
028	91	R/S	
029	76	LBL	
030	14	D	
031	29	CP	
032	67	EQ	
033	24	CE	
034	42	STO	
035	04	04	
036	91	R/S	
037	76	LBL	
038	24	CE	
039	61	GTO	
040	30	TAN	
041	76	LBL	
042	16	A'	
043	42	STO	
044	07	07	
045	91	R/S	
046	76	LBL	
047	17	B'	
048	42	STO	
049	08	08	
050	91	R/S	
051	76	LBL	
052	18	C'	
053	42	STO	
054	09	09	
055	91	R/S	
056	76	LBL	
057	15	E	
058	29	CP	
059	67	EQ	
060	39	COS	
061	22	INV	
062	77	GE	
063	23	LNX	
064	42	STO	
065	05	05	
066	91	R/S	
067	76	LBL	
068	23	LNX	
069	94	+/-	
070	42	STO	
071	06	06	
072	86	STF	
073	02	02	
074	91	R/S	
075	76	LBL	
076	30	TAN	
077	07	7	
078	42	STO	
079	10	10	
080	76	LBL	
081	35	1/X	
082	53	(	
083	53	(	
084	43	RCL	
085	10	10	
086	35	1/X	
087	33	X²	
088	65	×	
089	08	8	
090	65	×	
091	43	RCL	
092	03	03	
093	65	×	
094	43	RCL	
095	06	06	
096	33	X²	
097	55	÷	
098	89	π	
099	33	X²	
100	55	÷	
101	43	RCL	
102	07	07	
103	55	÷	
104	43	RCL	
105	02	02	
106	54	)	
107	45	Y^X	
108	93	.	
109	02	2	
110	54	)	
111	42	STO	
112	04	04	
113	22	INV	
114	87	IFF	
115	01	01	
116	32	X:T	
117	53	(	
118	43	RCL	
119	01	01	
120	65	×	
121	43	RCL	
122	04	04	
123	55	÷	
124	43	RCL	
125	11	11	
126	54	)	
127	44	SUM	
128	03	03	
129	76	LBL	
130	32	X:T	
131	02	2	
132	01	1	
133	00	0	
134	00	0	
135	32	X:T	
136	53	(	
137	04	4	
138	65	×	
139	43	RCL	
140	06	06	
141	55	÷	
142	43	RCL	
143	08	08	
144	55	÷	
145	89	π	
146	55	÷	
147	43	RCL	
148	04	04	
149	54	)	
150	42	STO	
151	12	12	
152	22	INV	
153	77	GE	
154	33	X²	
155	53	(	
156	53	(	
157	53	(	
158	43	RCL	
159	09	09	
160	55	÷	

MERGED CODES

62	Pgm	Ind	72	STO	Ind	83	GTO	Ind
63	Exc	Ind	73	RCL	Ind	84	Op	Ind
64	Prd	Ind	74	SUM	Ind	92	INV	SBR

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LOC	CODE	KEY	COMMENTS
161	43	RCL	
162	04	04	
163	54	)	
164	55	÷	
165	03	3	
166	93	.	
167	07	7	
168	85	+	
169	02	2	
170	93	.	
171	05	5	
172	01	1	
173	55	÷	
174	43	RCL	
175	12	12	
176	65	×	
177	43	RCL	
178	10	10	
179	54	)	
180	23	LNX	
181	65	×	
182	93	.	
183	08	8	
184	06	6	
185	94	+/-	
186	54	)	
187	61	GTO	
188	34	√X	
189	76	LBL	
190	33	X^2	
191	53	(	
192	24	CE	
193	34	√X	
194	55	÷	
195	08	8	
196	54	)	
197	76	LBL	
198	34	√X	
199	53	(	
200	24	CE	
201	75	-	
202	32	X⇌T	
203	43	RCL	
204	10	10	
205	54	)	
206	50	I×I	
207	66	PAU	
208	66	PAU	
209	32	X⇌T	
210	42	STO	
211	10	10	
212	93	.	
213	00	0	
214	00	0	
215	01	1	
216	32	X⇌T	
217	22	INV	
218	77	GE	
219	42	STO	
220	61	GTO	
221	35	1/X	
222	76	LBL	
223	42	STO	
224	53	(	
225	53	(	
226	43	RCL	
227	02	02	
228	65	×	
229	02	2	
230	65	×	
231	43	RCL	
232	07	07	
233	65	×	
234	43	RCL	
235	04	04	
236	55	÷	
237	43	RCL	
238	03	03	
239	54	)	
240	34	√X	
241	65	×	
242	43	RCL	
243	10	10	
244	54	)	
245	42	STO	
246	05	05	
247	43	RCL	
248	10	10	
249	35	1/X	
250	33	X^2	
251	42	STO	
252	11	11	
253	43	RCL	
254	04	04	
255	91	R/S	
256	43	RCL	
257	05	05	
258	91	R/S	
259	76	LBL	
260	38	SIN	
261	87	IFF	
262	02	02	
263	43	RCL	
264	53	(	
265	89	π	
266	65	×	
267	43	RCL	
268	04	04	
269	33	X^2	
270	65	×	
271	43	RCL	
272	05	05	
273	55	÷	
274	04	4	
275	54	)	
276	42	STO	
277	06	06	
278	61	GTO	
279	65	×	
280	76	LBL	
281	43	RCL	
282	53	(	
283	04	4	
284	65	×	
285	43	RCL	
286	06	06	
287	55	÷	
288	89	π	
289	55	÷	
290	43	RCL	
291	04	04	
292	33	X^2	
293	54	)	
294	42	STO	
295	05	05	
296	76	LBL	
297	65	×	
298	53	(	
299	43	RCL	
300	04	04	
301	65	×	
302	43	RCL	
303	05	05	
304	55	÷	
305	43	RCL	
306	08	08	
307	54	)	
308	42	STO	
309	12	12	
310	32	X⇌T	
311	02	2	
312	01	1	
313	00	0	
314	00	0	
315	32	X⇌T	
316	22	INV	
317	77	GE	
318	45	Y^X	
319	53	(	
320	53	(	
321	43	RCL	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

LOC	CODE	KEY	COMMENTS
322	09	09	
323	55	÷	
324	43	RCL	
325	04	04	
326	54	)	
327	55	÷	
328	03	3	
329	93	.	
330	07	7	
331	54	)	
332	42	STO	
333	14	14	
334	53	(	
335	02	2	
336	93	.	
337	05	5	
338	01	1	
339	55	÷	
340	43	RCL	
341	12	12	
342	54	)	
343	42	STO	
344	13	13	
345	05	5	
346	42	STO	
347	10	10	
348	76	LBL	
349	53	(	
350	53	(	
351	53	(	
352	43	RCL	
353	10	10	
354	85	+	
355	93	.	
356	08	8	
357	06	6	
358	65	×	
359	53	(	
360	43	RCL	
361	13	13	
362	65	×	
363	43	RCL	
364	10	10	
365	85	+	
366	43	RCL	
367	14	14	
368	54	)	
369	23	LNX	
370	54	)	
371	55	÷	
372	53	(	
373	01	1	
374	85	+	
375	93	.	
376	08	8	
377	06	6	
378	65	×	
379	43	RCL	
380	13	13	
381	55	÷	
382	53	(	
383	43	RCL	
384	13	13	
385	65	×	
386	43	RCL	
387	10	10	
388	85	+	
389	43	RCL	
390	14	14	
391	54	)	
392	54	)	
393	54	)	
394	94	+/-	
395	44	SUM	
396	10	10	
397	66	PAU	
398	66	PAU	
399	50	I×I	
400	32	X:T	
401	93	.	
402	00	0	
403	00	0	
404	01	1	
405	32	X:T	
406	22	INV	
407	77	GE	
408	52	EE	
409	61	GTO	
410	53	(	
411	76	LBL	
412	52	EE	
413	43	RCL	
414	10	10	
415	35	1/X	
416	33	X^2	
417	42	STO	
418	11	11	
419	61	GTO	
420	54	)	
421	76	LBL	
422	45	Y^X	
423	53	(	
424	06	6	
425	04	4	
426	55	÷	
427	43	RCL	
428	12	12	
429	54	)	
430	42	STO	
431	11	11	
432	76	LBL	
433	54	)	
434	22	INV	
435	87	IFF	
436	01	01	
437	55	÷	
438	53	(	
439	43	RCL	
440	01	01	
441	65	×	
442	43	RCL	
443	04	04	
444	55	÷	
445	43	RCL	
446	11	11	
447	54	)	
448	44	SUM	
449	03	03	
450	76	LBL	
451	55	÷	
452	53	(	
453	43	RCL	
454	11	11	
455	65	×	
456	43	RCL	
457	05	05	
458	33	X^2	
459	55	÷	
460	02	2	
461	55	÷	
462	43	RCL	
463	07	07	
464	55	÷	
465	43	RCL	
466	04	04	
467	54	)	
468	42	STO	
469	15	15	
470	87	IFF	
471	03	03	
472	61	GTO	
473	53	(	
474	43	RCL	
475	03	03	
476	65	×	
477	43	RCL	
478	15	15	
479	54	)	
480	42	STO	
481	02	02	
482	91	R/S	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

PPX-59 Professional Program Exchange

6 1 8 0 0
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LOC	CODE	KEY	COMMENTS
483	76	LBL	
484	61	GTO	
485	53	(	
486	43	RCL	
487	02	02	
488	55	÷	
489	43	RCL	
490	15	15	
491	54	)	
492	44	SUM	
493	03	03	
494	43	RCL	
495	03	03	
496	91	R/S	
497	76	LBL	
498	39	COS	
499	00	0	
500	42	STO	
501	18	18	
502	22	INV	
503	87	IFF	
504	01	01	
505	71	SBR	
506	05	5	
507	42	STO	
508	10	10	
509	76	LBL	
510	94	+/-	
511	53	(	
512	43	RCL	
513	01	01	
514	65	×	
515	43	RCL	
516	04	04	
517	55	÷	
518	43	RCL	
519	10	10	
520	35	1/X	
521	33	X^2	
522	54	)	
523	42	STO	
524	18	18	
525	76	LBL	
526	71	SBR	
527	53	(	
528	43	RCL	
529	04	04	
530	55	÷	
531	43	RCL	
532	08	08	
533	65	×	
534	53	(	
535	43	RCL	
536	02	02	
537	65	×	
538	02	2	
539	65	×	
540	43	RCL	
541	07	07	
542	65	×	
543	43	RCL	
544	04	04	
545	55	÷	
546	53	(	
547	43	RCL	
548	03	03	
549	85	+	
550	43	RCL	
551	18	18	
552	54	)	
553	54	)	
554	34	√X	
555	54	)	
556	42	STO	
557	16	16	
558	32	X↕T	
559	03	3	
560	06	6	
561	07	7	
562	32	X↕T	
563	22	INV	
564	77	GE	
565	75	-	
566	53	(	
567	53	(	
568	53	(	
569	43	RCL	
570	09	09	
571	55	÷	
572	43	RCL	
573	04	04	
574	54	)	
575	55	÷	
576	03	3	
577	93	.	
578	07	7	
579	85	+	
580	02	2	
581	93	.	
582	05	5	
583	01	1	
584	55	÷	
585	43	RCL	
586	16	16	
587	54	)	
588	23	LNX	
589	65	×	
590	93	.	
591	08	8	
592	06	6	
593	54	)	
594	94	+/-	
595	61	GTO	
596	81	RST	
597	76	LBL	
598	75	-	
599	53	(	
600	43	RCL	
601	16	16	
602	55	÷	
603	06	6	
604	04	4	
605	54	)	
606	76	LBL	
607	81	RST	
608	42	STO	
609	17	17	
610	22	INV	
611	87	IFF	
612	01	01	
613	85	+	
614	53	(	
615	43	RCL	
616	17	17	
617	75	-	
618	32	X↕T	
619	43	RCL	
620	10	10	
621	54	)	
622	50	I×I	
623	66	PAU	
624	66	PAU	
625	32	X↕T	
626	42	STO	
627	10	10	
628	93	.	
629	00	0	
630	00	0	
631	01	1	
632	32	X↕T	
633	22	INV	
634	77	GE	
635	85	+	
636	61	GTO	
637	94	+/-	
638	76	LBL	
639	85	+	
640	43	RCL	
641	17	17	
642	42	STO	
643	10	10	

MERGED CODES

62	Pgm	Ind	72	STO	Ind	83	GTO	Ind
63	Exc	Ind	73	RCL	Ind	84	Op	Ind
64	Prd	Ind	74	SUM	Ind	92	INV	SBR

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LOC	CODE	KEY	COMMENTS
644	35	1/X	
645	33	X²	
646	42	STO	
647	11	11	
648	53	(	
649	43	RCL	
650	10	10	
651	65	×	
652	53	(	
653	43	RCL	
654	02	02	
655	65	×	
656	02	2	
657	65	×	
658	43	RCL	
659	07	07	
660	65	×	
661	43	RCL	
662	04	04	
663	55	÷	
664	53	(	
665	43	RCL	
666	03	03	
667	85	+	
668	43	RCL	
669	18	18	
670	54	)	
671	54	)	
672	34	√X	
673	54	)	
674	42	STO	
675	05	05	
676	53	(	
677	43	RCL	
678	04	04	
679	65	×	
680	43	RCL	
681	05	05	
682	55	÷	
683	43	RCL	
684	08	08	
685	54	)	
686	42	STO	
687	12	12	
688	53	(	
689	43	RCL	
690	05	05	
691	65	×	
692	89	π	
693	65	×	
694	43	RCL	
695	04	04	
696	33	X²	
697	55	÷	
698	04	4	
699	54	)	
700	42	STO	
701	06	06	
702	94	+/-	
703	91	R/S	
704	43	RCL	
705	05	05	
706	91	R/S	

MERGED CODES

62 Pgm Ind
63 Exc Ind
64 Prd Ind
72 STO Ind
73 RCL Ind
74 SUM Ind
83 GTO Ind
84 Op Ind
92 INV SBR

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professional
program exchange

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6,1 8,0,1,2
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TEXAS INSTRUMENTS
Calculator Products Division

Submission Abstract

Program Title HEAT TRANSFER COEFFICIENT/PRESSURE DROP

Rev.

Abstract of Program This program calculates heat transfer coefficient and incompressible pressure drop in a closed conduit given fluid properties and geometric parameters. The selection laminar or turbulent correlations for heat transfer coefficient and friction factor is automatically selected based on Reynolds Number. Separate keyboard functions are programmed for flow area, heat transfer area, Prandtl Number, Reynolds Number and friction factor.

Original SR-52 Program by David Black of Pittsburgh, Pa.

User Benefits:

Provides keyboard functions for commonly used thermal/hydraulic design calculations.

Category Number 61

Required Progs.

Prog. Steps 319

PC-100A Needed ☐

Library Module ID ☐

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Submission Checklist

- ☑ Recorded Magnetic Cards
- ☑ Submission Abstract
- ☑ Program Description
- ☑ User Instructions
- ☑ Sample Problem
- ☑ Listing
- ☐
- ☐

Program Title: HEAT TRANSFER COEFFICIENT/PRESSURE DROP

Rev.

Method, Equations, Sketches, Limitations, References, Error Recovery:

Reynolds Number = $Re = D_h W/A_p \mu$

Prandtl Number = $Pr = C_p \mu/k$

$$h = 0.023 \frac{k}{D_h} Re^{0.8} Pr^{0.4}, \quad Re \geq 2300$$

$$h = 1.62 \frac{k}{D_h} \left[\frac{N_h \; Re \; Pr}{(L/D_h)} \right]^{1/3}, \quad Re < 2300$$

$$\Delta P = \left(\frac{FL}{D} + C_o \right) \left(W/A_f \right)^2 /773\rho$$

$$f = 0.0056 + 0.5 \; Re^{-0.32}, \quad Re \geq 2300$$

$$f = 64/Re, \quad Re < 2300$$

$$A_f = N_h \frac{\pi}{4} D_h^2$$

$$A_{ht} = N_h \pi D_h L$$

Number of hydraulic channels for non-circular conduits = $N_h = \dfrac{\text{actual flow area}}{\frac{\pi}{4} D_h^2}$

Program uses consistent set of units, Btu, sec, in, °F, lb

☐ See Continuation Sheet

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6	1	8	0	1	2

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User Instructions

Program Title
HEAT TRANSFER COEFFICIENT/PRESSURE DROP

Used	Pr	Used	Used	Aht
h	ΔP	Re	f	Af

Partition (OP 17) 479.59*

Parentheses Levels

t Register ☒

Angular Mode (if applicable)

SBR Levels 3

Absolute Addresses ☐

Library Module ID

*319.19 for TI-58

Disturbs Pending Operations ☐

LABELS (Op 08)

INV		lnx		CE		CLR		x⇌t		x²	
√x		1/x		STO	✓	RCL	✓	SUM	✓	yˣ	
EE	✓	(		)		÷		GTO	✓	X	
SBR		−		RST		+		R/S		•	
+/−		=		CLR		INV		log		CP	
tan		Pgm		P→R		sin		cos		CMs	
Exc		Prd		|x|		Eng		Fix		Int	
Deg		Pause		x=t		Nop	✓	Op		Rad	
Lbl		x≥t		Σ+		x̄		Grad		St flg	
If flg	✓	D.MS	✓	π		List		Write		Dsz	
Adv		Prt									

USER DEFINED KEYS

- A Calculate h
- B Calculate ΔP
- C Calculate Re
- D Calculate f
- E Calculate Af
- A' Turbulent h
- B' Calculate Pr
- C' Re comparison
- D' Turbulent f
- E' Calculate Aht

FLAGS Used 0	Print Test 1	Print Test 2	3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS			OUTPUT/MODE (see legend below)
1	Enter program (and alphanumeric codes)					
2	Store fluid properties and geometric parameters		SBR	STO		10
		W (lb/sec)		R/S		11
		D_h(in)		R/S		12
		N_h		R/S		13
		L (in)		R/S		14
		C_o		R/S		15
		0		R/S		16
		k (Btu/sec-in-^oF)		R/S		17
		C_p(Btu/lb-^oF)		R/S		18
		μ (lb/in-sec)		R/S		19
		(lb/in^3)		R/S		20
	In any order except ΔP					
3	Calculate h		A			h
4	Calculate ΔP		D			f
5			B			ΔP

Modes: n* — Printed only (n) — Displayed Briefly (Pause)
(n)* — Printed and displayed

DATA REGISTERS (INV List)

0
1
2
3
4
5
6
7
8
9
10 W – flow rate
11 D_h – hydraulic dia.
12 N_h–No. of hydraulic channels
13 L – length
14 C_o – press. loss coeff.
15 used
16 k – thermal cond.
17 C_p – specific heat
18 μ – viscosity
19 ρ – density

☒ See Continuation Sheet

Continuation Shee

Continued From: ☐ Program Description ☒ User Instructions ☐ Stmt. of Example

Program Title:
HEAT TRANSFER COEFFICIENT/PRESSURE DROP

Rev.

Step	Procedure	Enter	Press	Output
6	Calculate Re		C	Re
7	Calculate Pr		2nd B'	Pr
8	Calculate f (stores f in R_{16} for ΔP)		D	f
9	Calculate A_f		E	A_f
10	Calculate A_{ht}		2nd E'	A_{ht}

Sample Problem

Statement of Example

Determine heat transfer coefficient and pressure drop for 100 lb/sec of water flowing in 50 - 1/2 diameter tubes 20 ft long at 100°F.

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
Enter program and alphanumerics			
	SBR STO	10	
100	R/S	11	W in Reg. 10
.5	R/S	12	Dh in Reg. 11
50	R/S	13	Nh in Reg. 12
240	R/S	14	L in Reg. 13
1.5	R/S	15	Co in Reg. 14
0	R/S	16	O in Reg. 15
8.84EE 6 +/-	R/S	17	k in Reg. 16
2.41 EE 5 +/-	R/S	18	μ in Reg. 17
1.0	R/S	19	Cp in Reg. 18
.0354	R/S	20	ρ in Reg. 19
	A	(.0110509207)* H*	
	D	(.01548519)* F*	} F required to find ΔP
	B	(33.86955578)* ΔP*	
	B'	(2.726244344)* PR*	
	C	(211326.0655)* Re*	

Modes: n* — Printed only (n) — Displayed Briefly (Pause)
(n)* — Printed and displayed

☒ Over

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Sample Problem (cont'd)

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6	1	8	0	1	2

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ENTER	PRESS	OUTPUT/MODE (see legend below)		COMMENT
	E	(9.817477042)*	AF*	
	E'	(18849.55592)*	AHT*	

Modes: n* — Printed only (n) — Displayed Briefly (Pause)
(n)* — Printed and displayed

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6 1 8 0 1 2
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LOC	CODE	KEY	COMMENTS
000	76	LBL	
001	11	A	
002	18	C'	
003	87	IFF	
004	00	00	
005	16	A'	
006	71	SBR	
007	52	EE	
008	65	×	
009	71	SBR	
010	44	SUM	
011	65	×	
012	43	RCL	
013	12	12	
014	55	÷	
015	71	SBR	
016	88	DMS	
017	54	)	
018	22	INV	
019	45	Y^x	
020	03	3	
021	65	×	
022	43	RCL	
023	16	16	
024	65	×	
025	01	1	
026	93	.	
027	06	6	
028	02	2	
029	55	÷	
030	43	RCL	
031	11	11	
032	54	)	
033	92	RTN	
034	76	LBL	
035	16	A'	
036	71	SBR	
037	52	EE	
038	45	Y^x	
039	93	.	
040	08	8	
041	65	×	
042	71	SBR	
043	44	SUM	
044	45	Y^x	
045	93	.	
046	04	4	
047	65	×	
048	43	RCL	
049	16	16	
050	55	÷	
051	43	RCL	
052	11	11	
053	65	×	
054	93	.	
055	00	0	
056	02	2	
057	03	3	
058	54	)	
059	42	STD	
060	00	00	
061	02	2	
062	03	3	
063	19	D'	
064	43	RCL	
065	00	00	
066	22	INV	
067	86	STF	
068	01	01	
069	92	RTN	
070	76	LBL	
071	12	B	
072	71	SBR	
073	88	DMS	
074	65	×	
075	43	RCL	
076	15	15	
077	85	+	
078	43	RCL	
079	14	14	
080	54	)	
081	65	×	
082	53	(	
083	43	RCL	
084	10	10	
085	55	÷	
086	71	SBR	
087	43	RCL	
088	54	)	
089	33	X^2	
090	55	÷	
091	43	RCL	
092	19	19	
093	55	÷	
094	07	7	
095	07	7	
096	03	3	
097	54	)	
098	42	STD	
099	00	00	
100	43	RCL	
101	01	01	
102	19	D'	
103	43	RCL	
104	00	00	
105	92	RTN	
106	76	LBL	
107	17	B'	
108	22	INV	
109	86	STF	
110	01	01	
111	76	LBL	
112	44	SUM	
113	53	(	
114	43	RCL	
115	18	18	
116	65	×	
117	43	RCL	
118	17	17	
119	55	÷	
120	43	RCL	
121	16	16	
122	54	)	
123	42	STD	
124	00	00	
125	43	RCL	
126	02	02	
127	22	INV	
128	87	IFF	
129	01	01	
130	19	D'	
131	43	RCL	
132	00	00	
133	92	RTN	
134	76	LBL	
135	13	C	
136	22	INV	
137	76	LBL	
138	52	EE	
139	86	STF	
140	02	02	
141	53	(	
142	43	RCL	
143	11	11	
144	65	×	
145	43	RCL	
146	10	10	
147	55	÷	
148	43	RCL	
149	17	17	
150	55	÷	
151	71	SBR	
152	43	RCL	
153	54	)	
154	42	STD	
155	00	00	
156	43	RCL	
157	03	03	
158	22	INV	
159	87	IFF	
160	02	02	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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LOC	CODE	KEY	COMMENTS
161	19	D'	
162	43	RCL	
163	00	00	
164	92	RTN	
165	76	LBL	
166	18	C'	
167	22	INV	
168	86	STF	
169	00	00	
170	71	SBR	
171	52	EE	
172	75	-	
173	02	2	
174	03	3	
175	00	0	
176	00	0	
177	54	)	
178	29	CP	
179	77	GE	
180	87	IFF	
181	92	RTN	
182	76	LBL	
183	14	D	
184	53	(	
185	18	C'	
186	87	IFF	
187	00	00	
188	68	NOP	
189	06	6	
190	04	4	
191	55	÷	
192	71	SBR	
193	52	EE	
194	54	)	
195	42	STO	
196	15	15	
197	92	RTN	
198	76	LBL	
199	68	NOP	
200	53	(	
201	93	.	
202	05	5	
203	55	÷	
204	71	SBR	
205	52	EE	
206	45	Yˣ	
207	93	.	
208	03	3	
209	02	2	
210	85	+	
211	93	.	
212	00	0	
213	00	0	
214	05	5	
215	06	6	
216	54	)	
217	42	STO	
218	15	15	
219	42	STO	
220	00	00	
221	02	2	
222	01	1	
223	19	D'	
224	43	RCL	
225	00	00	
226	92	RTN	
227	76	LBL	
228	15	E	
229	22	INV	
230	76	LBL	
231	43	RCL	
232	86	STF	
233	01	01	
234	53	(	
235	43	RCL	
236	11	11	
237	33	X²	
238	65	×	
239	89	π	
240	55	÷	
241	04	4	
242	65	×	
243	43	RCL	
244	12	12	
245	54	)	
246	42	STO	
247	00	00	
248	43	RCL	
249	04	04	
250	22	INV	
251	87	IFF	
252	01	01	
253	19	D'	
254	43	RCL	
255	00	00	
256	92	RTN	
257	76	LBL	
258	10	E'	
259	53	(	
260	71	SBR	
261	88	DMS	
262	65	×	
263	04	4	
264	65	×	
265	71	SBR	
266	43	RCL	
267	54	)	
268	42	STO	
269	00	00	
270	43	RCL	
271	05	05	
272	19	D'	
273	43	RCL	
274	00	00	
275	92	RTN	
276	76	LBL	
277	87	IFF	
278	86	STF	
279	00	00	
280	92	RTN	
281	76	LBL	
282	88	DMS	
283	53	(	
284	43	RCL	
285	13	13	
286	55	÷	
287	43	RCL	
288	11	11	
289	54	)	
290	92	RTN	
291	76	LBL	
292	19	D'	
293	69	OP	
294	04	04	
295	43	RCL	
296	00	00	
297	69	OP	
298	06	06	
299	92	RTN	
300	76	LBL	
301	42	STO	
302	01	1	
303	00	0	
304	42	STO	
305	00	00	
306	76	LBL	
307	61	GTO	
308	43	RCL	
309	00	00	
310	91	R/S	
311	72	ST*	
312	00	00	
313	69	OP	
314	20	20	
315	22	INV	
316	52	EE	
317	61	GTO	Exit Lea
318	61	GTO	mode and

store these alphanumeric co
in the appropriate register

7533.	0
3335.	0
3554.	0
1321.	0
132337.	0

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6	1	8	0	1	3

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TEXAS INSTRUMENTS
Calculator Products Division

Submission Abstract

Program Title	Rev.
INCOMPRESSIBLE FLUID PIPELINE PRESSURE DROP	

Abstract of Program Program calculates the pressure drop for an incompressible fluid in either laminar or turbulent flow. Friction factor calculations are selected automatically from the Reynolds number. The friction coefficient determined for turbulent flow is based on the trial and error solution of the Colebrook equation (Moody chart basis). A table of various roughness coefficients, required by the Colebrook equation, is included.

Note: Program will handle metal, concrete, and wood stave pipes only.

Original SR-52 Program by Elliot Weisman of Wilmington, Del.

User Benefits: Rapid solution of a large variety of pipe flow problems involving trial and error.

Category Number 61	Required Progs.	Prog. Steps 292	PC-100A Needed ☐ Library Module ID ☐

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Submission Checklist

- ☒ Recorded Magnetic Cards
- ☒ Submission Abstract
- ☒ Program Description
- ☒ User Instructions
- ☒ Sample Problem
- ☒ Listing
- ☐
- ☐

Program Title:
INCOMPRESSIBLE FLUID PIPELINE PRESSURE DROP

Rev.

Method, Equations, Sketches, Limitations, References, Error Recovery:

PIPELINE PRESSURE DROP EQUATIONS

Laminar Flow $Re \leq 2100$

$$Re = 64/f \qquad (1)$$

$$f = d\,\mu/\,(49.3\ Q\ Sp.G.) \qquad (2)$$

$$\Delta P = .01347\ L\ Sp.G.\ Q^2\ f/\ d^5 \qquad (3)$$

Turbulent Flow $Re > 2100$

friction factor ,f, based on Colebrook equation to include effects of pipe roughness coefficients

$$\frac{1}{\sqrt{f}} = -2 \log \left[\frac{2.51}{Re\sqrt{f}} + \frac{k}{3.7d}\right] \qquad (4)$$

Turbulent flow calculations proceed on the basis of assuming values of f or $1/\sqrt{f}$ and solve

$$X = \frac{1}{\sqrt{f}} + 2 \log \left[\frac{2.51}{Re\sqrt{f}} + \frac{k}{3.7d}\right] \qquad (5)$$

until $|X| < .001$ then use this value of f that satisfies (5) in (3) to calculate ΔP

Reference: Chem. Eng., Feb 18 1974 p. 154-156
Chem. Eng., Jun 10 1974 p. 110

☐ See Continuation Sheet

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6 1 | 8 0 1 3
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PPX-59
professional program exchange

User Instructions

Program Title
INCOMPRESSIBLE FLUID PIPELINE PRESSURE DROP

K	Re/ΔP			Init.
Q	L	I.D.	Sp.G.	Visc.

Partition (OP 17) 479 . 59*
Parentheses Levels
t Register ☒
Angular Mode (if applicable)
SBR Levels 1
Absolute Addresses ☒
Library Module ID
*319.19 for TI-58
Disturbs Pending Operations ☐

LABELS (Op 08)

INV __	lnx __	CE __	CLR __	x⇌t __	x² __
√x __	1/x __	STO __	RCL __	SUM __	yˣ __
EE __	(__	) __	÷ __	GTO __	X __
SBR __	− __	RST __	+ __	R/S __	. __
+/− __	= __	CLR __	INV __	log __	CP __
tan __	Pgm __	P→R __	sin __	cos __	CMs __
Exc __	Prd __	|x| __	Eng __	Fix __	Int __
Deg __	Pause __	x=t __	Nop __	Op __	Rad __
Lbl __	x≥t __	Σ+ __	x̄ __	Grad __	St flg __
If flg __	D.MS __	π __	List __	Write __	Dsz __
Adv __	Prt __				

USER DEFINED KEYS

A Q = Flow rate
B L = Length
C Pipe I.D.
D Sp. Gravity
E Viscosity
A' K = Roughness
B' Re/ΔP
C' used
D' used
E' Initialize

FLAGS 0	K 1	Sp.G. 2	Visc. 3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS	OUTPUT/MODE (see legend below) PRINTED		DISPLAYED
1	Enter program					
2	Initialize		*E'			0
3	Enter Flow Parameters (any order)					
a	flow rate, Q, gpm	Q	A	rate	FLOW	rate
b	pipe length, L, ft	L	B	length	L	length
c	pipe diameter, d, inches	d	C	diameter	I.D.	diameter
*d	specific gravity, Sp. G.	Sp. G.	D	sp. gravity	SP. G.	sp. gravity
**e	viscosity, μ, centipoise	μ	E	viscosity	VISC	viscosity
***f	roughness coefficient, k, inches	k	*A'	rough.coef.	K	rough. coef.
4	Calculate Reynolds number		*B'	number	Re	number
5	Calculate pressure, drop, psi		RUN	pres. drop	ΔP	pres. drop
6	New case then go to step 3 and enter new values of 3a-f as desired.		*E'			

NOTES ********************************

* if 3d not entered program will default to Sp.G. = 1.0
** if 3e not entered program will default to μ = 1.0 cp
*** if 3f not entered program will default to k = .0018 inches
(See Continuation Sheet for pipe other than commercial wrought iron or steel)

Modes: n* — Printed only (n) — Displayed Briefly (Pause)
n — Printed and Displayed

DATA REGISTERS (INV List)

0	
1	Sp. Gravity
2	Pipe length
3	Pipe I.D.
4	Flow
5	Viscosity
6	K
7	used
8	used
9	Reynolds number
10	ΔP
1	
2	
3	
4	
5	
6	
7	
8	
9	

☐ See Continuation Sheet

Continued From: ☐ Program Description ☐ User Instructions ☐ Stmt. of Example

Program Title: INCOMPRESSIBLE FLUID PIPELINE PRESSURE DROP

Rev.

Surface Roughness Coefficients for various pipes

Type of Pipe	k inches
Drawn tubing (brass,lead,copper)	.00006
Commercial steel or wrought iron	.0018
Asphalted cast iron	.0048
Galvanized iron	.006
Cast iron	.0102
Wood stave	.0072 - .036
Concrete	.012 - .12
Riveted steel	.036 - .36

Source: Chem. Eng. Handbook 3rd ed., p. 5-19.

Sample Problem

Statement of Example

Calculate the pressure drop in psi for water at 70°F flowing through a .5 inch i.d. steel pipe 100 ft. long at 5 gpm.

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)			COMMENT
		PRINTED		DISPLAYED	
Initialize	*E'			0.	clears memories and resets flags
5.	A	5.	FLOW	5.	flow rate, gpm
100	B	100.	L	100.	pipe length, ft.
.5	C	0.5	I.D.	0.5	pipe diameter, in.
1	D	1.	SP.G.	1.	specific gravity
1	E	1.	VISC	1.	viscosity, cp
.0018	*A'	0.0018	K	0.0018	roughness coeff. for steel
	*B'	31616	Re	31616	Reynolds No. (~5 sec)
	R/S	33.254...	ΔP	33.25459743	Pressure drop, psi (~15 sec)

NOTE: the values for specific gravity, viscosity, roughness coefficient above are the default values in the program for these properties. It was not necessary to enter these values. Could have gone to *B' directly. See users instruction sheet for more detail.

Modes: n* — Printed only (n) — Displayed Briefly (Pause)
(n)* — Printed and displayed

☐ Over

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LOC	CODE	KEY	COMMENTS
000	76	LBL	
001	19	D'	
002	43	RCL	
003	07	07	
004	92	RTN	
005	76	LBL	
006	11	A	
007	42	STO	
008	04	04	
009	02	2	
010	01	1	
011	02	2	
012	07	7	
013	03	3	
014	02	2	
015	04	4	
016	03	3	
017	18	C'	
018	43	RCL	
019	04	04	
020	69	OP	
021	06	06	
022	91	R/S	
023	76	LBL	
024	12	B	
025	42	STO	
026	02	02	
027	02	2	
028	07	7	
029	18	C'	
030	43	RCL	
031	02	02	
032	69	OP	
033	06	06	
034	91	R/S	
035	76	LBL	
036	13	C	
037	42	STO	
038	03	03	
039	02	2	
040	04	4	
041	04	4	
042	00	0	
043	01	1	
044	06	6	
045	04	4	
046	00	0	
047	18	C'	
048	43	RCL	
049	03	03	
050	69	OP	
051	06	06	
052	91	R/S	
053	76	LBL	
054	14	D	
055	42	STO	
056	01	01	
057	86	STF	
058	02	02	
059	03	3	
060	06	6	
061	03	3	
062	03	3	
063	04	4	
064	00	0	
065	02	2	
066	02	2	
067	18	C'	
068	43	RCL	
069	01	01	
070	69	OP	
071	06	06	
072	92	RTN	
073	76	LBL	
074	15	E	
075	42	STO	
076	05	05	
077	86	STF	
078	03	03	
079	04	4	
080	02	2	
081	02	2	
082	04	4	
083	03	3	
084	06	6	
085	01	1	
086	05	5	
087	18	C'	
088	43	RCL	
089	05	05	
090	69	OP	
091	06	06	
092	92	RTN	
093	76	LBL	
094	16	A'	
095	42	STO	
096	06	06	
097	86	STF	
098	01	01	
099	02	2	
100	06	6	
101	18	C'	
102	43	RCL	
103	06	06	
104	69	OP	
105	06	06	
106	92	RTN	
107	76	LBL	
108	17	B'	
109	87	IFF	
110	02	02	
111	01	01	
112	19	19	
113	01	1	
114	42	STO	
115	01	01	
116	71	SBR	
117	00	00	
118	59	59	
119	87	IFF	
120	03	03	
121	01	01	
122	29	29	
123	01	1	
124	42	STO	
125	05	05	
126	71	SBR	
127	00	00	
128	79	79	
129	87	IFF	
130	01	01	
131	01	01	
132	43	43	
133	93	.	
134	00	0	
135	00	0	
136	01	1	
137	08	8	
138	42	STO	
139	06	06	
140	71	SBR	
141	00	00	
142	99	99	
143	43	RCL	
144	03	03	
145	65	×	
146	43	RCL	
147	05	05	
148	55	÷	
149	04	4	
150	09	9	
151	93	.	
152	04	4	
153	55	÷	
154	43	RCL	
155	04	04	
156	55	÷	
157	43	RCL	
158	01	01	
159	95	=	
160	34	√X	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

LOC	CODE	KEY	COMMENTS
161	35	1/X	
162	42	STO	
163	07	07	
164	06	6	
165	04	4	
166	65	×	
167	19	D'	
168	33	X^2	
169	95	=	
170	42	STO	
171	09	09	
172	03	3	
173	05	5	
174	05	5	
175	04	4	
176	18	C'	
177	43	RCL	
178	09	09	
179	69	OP	
180	06	06	
181	91	R/S	
182	75	-	
183	02	2	
184	01	1	
185	00	0	
186	00	0	
187	95	=	
188	22	INV	
189	77	GE	
190	02	02	
191	30	30	
192	19	D'	
193	55	÷	
194	43	RCL	
195	09	09	
196	65	×	
197	02	2	
198	93	.	
199	05	5	
200	01	1	
201	85	+	
202	43	RCL	
203	06	06	
204	55	÷	
205	03	3	
206	93	.	
207	07	7	
208	55	÷	
209	43	RCL	
210	03	03	
211	95	=	
212	28	LOG	
213	65	×	
214	02	2	
215	85	+	
216	19	D'	
217	95	=	
218	42	STO	
219	08	08	
220	50	I×I	
221	75	-	
222	93	.	
223	00	0	
224	00	0	
225	01	1	
226	95	=	
227	77	GE	
228	02	02	
229	69	69	
230	19	D'	
231	35	1/X	
232	33	X^2	
233	65	×	
234	93	.	
235	00	0	
236	01	1	
237	03	3	
238	04	4	
239	07	7	
240	65	×	
241	43	RCL	
242	02	02	
243	65	×	
244	43	RCL	
245	01	01	
246	65	×	
247	43	RCL	
248	04	04	
249	33	X^2	
250	55	÷	
251	43	RCL	
252	03	03	
253	45	Y^X	
254	05	5	
255	95	=	
256	42	STO	
257	10	10	
258	07	7	
259	05	5	
260	03	3	
261	03	3	
262	18	C'	
263	43	RCL	
264	10	10	
265	69	OP	
266	06	06	
267	98	ADV	
268	91	R/S	
269	19	D'	
270	75	-	
271	43	RCL	
272	08	08	
273	95	=	
274	50	I×I	
275	42	STO	
276	07	07	
277	61	GTO	
278	01	01	
279	92	92	
280	76	LBL	
281	18	C'	
282	69	OP	
283	00	00	
284	69	OP	
285	04	04	
286	92	RTN	
287	76	LBL	
288	10	E'	
289	47	CMS	
290	25	CLR	
291	81	RST	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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TEXAS INSTRUMENTS
Calculator Products Division

Submission Abstract

Program Title HAZEN-WILLIAMS FORMULA (Pipes)	Rev.

Abstract of Program

Computes flow, slope, diameter or C-value given any three of the four. Converts flow units and solves for velocity. English units are used.

Original TI-59 Program by William Wheeler of Demarest, N. J.

User Benefits:

Saves time.

Category Number 62	Required Progs.	Prog. Steps 240	PC-100A Needed ☐ Library Module ID ☐

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Name Texas Instruments Tel. No. ______

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City ______ State ______ Zip ______

Submission Checklist

- ☒ Recorded Magnetic Cards
- ☒ Submission Abstract
- ☒ Program Description
- ☒ User Instructions
- ☒ Sample Problem
- ☒ Listing
- ☐ ______
- ☐ ______

Program Description

Program Title:
HAZEN-WILLIAMS FORMULA (Pipes)

Rev.

Method, Equations, Sketches, Limitations, References, Error Recovery:

Method

"Solve" key both initializes program and sets flag to give keys A, B, C & D a double function, both storing entry and solving for same.

If C is not entered (is zero) a default value of 100 will be used.

Equations

$$Q = \frac{D^{2.63}\ S^{0.54}\ C}{102804} \qquad (1)$$

$$Q = \frac{D^2 V}{284} \qquad (2)$$

where Q = flow, mgd, million gallons per day
D = diameter, inches
S = slope of hydraulic gradient, feet per thousand feet
C = C-value
V = velocity, feet per second

Conversions

1.546 (mgd) = cfs (cubic feet per second)
694.4 (mgd) = gpm (gallons per minute)

Limitations

If Q, D or S is not entered, a zero or an error may flash.

Default Values

If Q, D, C or S not entered the program will use last value entered <u>or</u> computed, whichever is most recent. If C = 0, 100 will be used.

☐ See Continuation Sheet

6 2 8 0 2 2
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User Instructions

Program Title
HAZEN-WILLIAMS FORMULA

cfs → mgd	mgd → gpm	gpm → cfs	mgd → fps	fps → mgd
D	Q	C	S	Solve

Partition (OP 17) 479, 59*
Parentheses Levels
t Register ☐
Angular Mode (if applicable)
SBR Levels
Absolute Addresses ☐
Library Module ID
*239.29 for TI-58
Disturbs Pending Operations ☐

LABELS (Op 08)

INV	√	lnx	√	CE	√	CLR	√	x⇌t	√	x^2	√
√x	√	1/x	√	STO	√	RCL	√	SUM	√	y^x	
EE		(		)		÷		GTO		×	
SBR		−		RST		+		R/S		•	
+/−		=		CLR		INV		log		CP	
tan		Pgm		P→R		sin		cos		CMs	
Exc		Prd		|x|		Eng		Fix		Int	
Deg		Pause		x=t		Nop		Op		Rad	
Lbl		x≥t		Σ+		x̄		Grad		St flg	
If flg		D.MS		π		List		Write		Dsz	
Adv		Prt									

USER DEFINED KEYS
- A Stores Diameter
- B Stores Q
- C Stores C-value
- D Stores Slope
- E Solves – (A,B,C or D)
- A' Converts cfs to mgd
- B' Converts mgd to gpm
- C' Converts gpm to mgd
- D' Converts mgd to fps
- E' Converts fps to mgd

FLAGS	0	1	2	3	4	5	6	7	8	9
	X									

STEP	PROCEDURE	ENTER	PRESS		OUTPUT/MODE (see legend below)
1	Enter and Store Diameter	D	A		Diameter
2	Enter and Store Q	Q	B		Q
3	Enter and Store C-value	C	C		C-value
4	Enter and Store Slope	S	D		Slope
5	Solve for D and store		E	A	D
6	Solve for Q and store		E	B	Q
7	Solve for C and store		E	C	C
8	Solve for S and store		E	D	S
9	Convert cfs to mgd	cfs	2nd	A	mgd
10	Convert mgd to gpm	mgd	2nd	B	gpm
11	Convert gpm to cfs	gpm	2nd	C	cfs
12	Convert mgd to fps *	mgd	2nd	D	fps
13	Convert fps to mgd *	fps	2nd	E	mgd

* For velocity calculations D must be stored

Modes: n* — Printed only (n) — Displayed Briefly (Pause)
(n)* — Printed and displayed

DATA REGISTERS (INV List)

00	D
01	Q
02	C
03	S
4	
5	
6	
7	
8	
9	
20	0.54
21	2.63
22	102804
3	
4	
5	
6	
7	
8	
9	

☐ See Continuation Sheet

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6 2 | 8 0 2 2
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TEXAS INSTRUMENTS
Calculator Products Division

Sample Problem

Statement of Example

A 12-inch pipe between two reservoirs is 2000 feet long.
The difference in elevation of the reservoirs is 10 feet.
S = 10/2 = 5 ft. per 1000. (Slope of hydraulic gradient)
Part 1 What is the flow if C = 100?

Part 2 Flow is measured to be 1165 gpm
a. What is C-value?
b. What is the velocity?

Part 3 Parallel pipe with new pipe. What size pipe will flow an additional 400 gpm of C = 105?

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
12	A	12	Store Diam.
5	D	5	Store Slope
	E, B	1.598381582 mgd	Solve Q *
		Answer Part 1	
1165	2nd, C	2.593735599 cfs	Convert gpm to cfs
2.5937	2nd, A	1.677684347 mgd	Convert cfs to mgd
1.6777	B	1.6777	Store mgd
	E, C	104.9624207	Solve C-value
		Answer Part 2a	
	E, B	1.6777	Solve Q
1.6777	2nd, D	3.308797222 fps	Convert to fps
		Answer Part 2b	
400	2nd, C	.8905529954 cfs	Convert gpm to cfs
0.89055	2nd, A	.5760349288 mgd	Convert cfs to mgd
0.57604	B	0.57604	Store mgd
	E, A	7.992007798 in	Solve Diameter
		Answer Part 3	
		* 100 is entered for C as default value	

Modes: n* — Printed only (n) — Displayed Briefly (Pause)
(n)* — Printed and displayed

☐ Over

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LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
000	76	LBL		055	91	R/S		110	21	21	
001	15	E		056	76	LBL		111	55	÷	
002	93	.		057	13	C		112	43	RCL	
003	05	5		058	87	IFF		113	02	02	
004	04	4		059	00	00		114	95	=	
005	42	STO		060	34	√X		115	45	Y^X	
006	20	20		061	42	STO		116	43	RCL	
007	02	2		062	02	02		117	20	20	
008	93	.		063	91	R/S		118	35	1/X	
009	06	6		064	76	LBL		119	95	=	
010	03	3		065	14	D		120	42	STO	
011	42	STO		066	87	IFF		121	03	03	
012	21	21		067	00	00		122	22	INV	
013	01	1		068	35	1/X		123	86	STF	
014	00	0		069	42	STO		124	00	00	
015	02	2		070	03	03		125	91	R/S	
016	08	8		071	91	R/S		126	76	LBL	
017	00	0		072	76	LBL		127	34	√X	
018	04	4		073	33	X^2		128	43	RCL	
019	42	STO		074	43	RCL		129	01	01	
020	22	22		075	00	00		130	65	×	
021	68	NOP		076	45	Y^X		131	43	RCL	
022	25	CLR		077	43	RCL		132	22	22	
023	32	X⇌T		078	21	21		133	55	÷	
024	43	RCL		079	65	×		134	43	RCL	
025	02	02		080	43	RCL		135	00	00	
026	22	INV		081	03	03		136	45	Y^X	
027	67	EQ		082	45	Y^X		137	43	RCL	
028	44	SUM		083	43	RCL		138	21	21	
029	01	1		084	20	20		139	55	÷	
030	00	0		085	65	×		140	43	RCL	
031	00	0		086	43	RCL		141	03	03	
032	42	STO		087	02	02		142	45	Y^X	
033	02	02		088	55	÷		143	43	RCL	
034	76	LBL		089	43	RCL		144	20	20	
035	44	SUM		090	22	22		145	95	=	
036	25	CLR		091	95	=		146	42	STO	
037	86	STF		092	42	STO		147	02	02	
038	00	00		093	01	01		148	22	INV	
039	91	R/S		094	22	INV		149	86	STF	
040	76	LBL		095	86	STF		150	00	00	
041	11	A		096	00	00		151	91	R/S	
042	87	IFF		097	91	R/S		152	76	LBL	
043	00	00		098	76	LBL		153	32	X⇌T	
044	32	X⇌T		099	35	1/X		154	43	RCL	
045	42	STO		100	43	RCL		155	01	01	
046	00	00		101	01	01		156	65	×	
047	91	R/S		102	65	×		157	43	RCL	
048	76	LBL		103	43	RCL		158	22	22	
049	12	B		104	22	22		159	55	÷	
050	87	IFF		105	55	÷		160	43	RCL	
051	00	00		106	43	RCL					
052	33	X^2		107	00	00					
053	42	STO		108	45	Y^X					
054	01	01		109	43	RCL					

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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LOC	CODE	KEY	COMMENTS
161	03	03	
162	45	Y^x	
163	43	RCL	
164	20	20	
165	55	÷	
166	43	RCL	
167	02	02	
168	95	=	
169	45	Y^x	
170	43	RCL	
171	21	21	
172	35	1/X	
173	95	=	
174	42	STO	
175	00	00	
176	22	INV	
177	86	STF	
178	00	00	
179	91	R/S	
180	76	LBL	
181	19	D'	
182	65	×	
183	02	2	
184	08	8	
185	04	4	
186	55	÷	
187	43	RCL	
188	00	00	
189	33	X^2	
190	95	=	
191	91	R/S	
192	76	LBL	
193	10	E'	
194	65	×	
195	43	RCL	
196	00	00	
197	33	X^2	
198	55	÷	
199	02	2	
200	08	8	
201	04	4	
202	95	=	
203	91	R/S	
204	76	LBL	
205	17	B'	
206	65	×	
207	06	6	
208	09	9	
209	04	4	
210	93	.	
211	04	4	
212	95	=	
213	91	R/S	
214	76	LBL	
215	18	C'	
216	65	×	
217	01	1	
218	93	.	
219	05	5	
220	04	4	
221	06	6	
222	55	÷	
223	06	6	
224	09	9	
225	04	4	
226	93	.	
227	04	4	
228	95	=	
229	91	R/S	
230	76	LBL	
231	16	A'	
232	55	÷	
233	01	1	
234	93	.	
235	05	5	
236	04	4	
237	06	6	
238	95	=	
239	91	R/S	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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TEXAS INSTRUMENTS
Calculator Products Division

Submission Abstract

Program Title
EQUIVALENT PIPE METHOD

Rev.

Abstract of Program

Reduces piping systems to a single equivalent pipe. First computes equivalent length for each pipe for a standard diameter and C-value. Then, adds any number of mixed combinations of series and parallel pipes.

Original TI-59 Program by William Wheeler of Demarest, N. J.

User Benefits:

Fast and simplified

Category Number 62

Required Progs.

Prog. Steps 216

PC-100A Needed ☐
Library Module ID ☐

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City ____ State ____ Zip ____

Submission Checklist

☒ Recorded Magnetic Cards
☒ Submission Abstract
☒ Program Description
☒ User Instructions
☒ Sample Problem
☒ Listing
☐
☐

IMPORTANT

Program Description

Program Title:
EQUIVALENT PIPE METHOD

Rev.

Method, Equations, Sketches, Limitations, References, Error Recovery:

Method

Complex piping systems are reduced to an equivalent pipe for flow and headloss calculations. Each pipe is made into an equivalent length of the same common (standard) diameter and C-value and added, series or parallel.

Equations

$$\text{Equivalent length} = EL = \left(\frac{D}{\text{Std } D}\right)^{-\frac{2.63}{0.54}} \left(\frac{C}{\text{Std } C}\right)^{-\frac{1}{0.54}} L \qquad (1)$$

$$\text{For Series Pipes, } EL\ (\text{Total}) = EL_1 + EL_2 \qquad (2)$$

$$\text{For Parallel Pipes, } EL\ (\text{Total}) = (EL_1^{-0.54} + EL_2^{-0.54})^{-\frac{1}{0.54}} \qquad (3)$$

where, D = Pipe diam. (any units), Std D = User selected standard diam.
C = C-value, Std C = User selected standard C-value
L = Length (any units)

Default Values

If L, D, C, Std D or Std C not entered, last value entered is used.
If D or Std D = 0, 10 is used
If C or Std C = 0, 100 is used

Limitations

For systems of circular pipes flowing full. Equiv. Pipe Method is not valid where cross pipes cannot be ignored or considered a junction. C-values are overall C-values and include miscellaneous losses from fittings etc.

Time Saving Tips

Use default values. Ignore C-values for approx. calculations.
Do not re-enter pipe data when not necessary.
EG: To find EL of 5 parallel pipes same L, D and C, Key in L, Press A, press E 5 times, read answer.

References (For methodology and additional examples)

Wheeler, W., "Solve Equivalent Pipe Problems with A Small Calculator," Water & Sewage Works, November, 1976.

☐ See Continuation Sheet

Page 3 of 7 | 6 | 2 | 8 | 0 | 2 | 4 |
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User Instructions

Program Title
EQUIVALENT PIPE METHOD

CL Sum	Std D	Std C	STO & CLR	RCL & ENT
Length	Diam	C	+ Series	+ Para

Partition (OP 17) 479, 59*

Parentheses Levels

t Register ☒

Angular Mode (if applicable)

SBR Levels

Absolute Addresses ☐

Library Module ID *239.29 for TI-58

Disturbs Pending Operations ☐

LABELS (Op 08)

INV ✓	lnx ✓	CE ✓	CLR ✓	x:t ✓	x² ✓
√x ✓	1/x ✓	STO	RCL	SUM	yˣ
EE	(	)	÷	GTO	×
SBR	−	RST	+	R/S	.
+/−	=	CLR	INV	log	CP
tan	Pgm	P→R	sin	cos	CMs
Exc	Prd	|x|	Eng	Fix	Int
Deg	Pause	x=t	Nop	Op	Rad
Lbl	x≥t	Σ+	x̄	Grad	St flg
If flg	D.MS	π	List	Write	Dsz
Adv	Prt				

USER DEFINED KEYS

A Length
B Diameter
C C-value
D Adds EL Series
E Adds EL Parallel
A' Clears Sum & Counter
B' Std. Diameter
C' Std C-value
D' STO EL & clrs Sum
E' Rcls EL & loads LDC

FLAGS used 0	1	2	3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS			OUTPUT/MODE (see legend below)
1	Enter & store Std D	Std D	2nd	B		Std D
2	Enter & store Std C	Std C	2nd	C		Std C
3	Enter & store length	Length	A			Length
4	Enter & store Diameter	Diameter	B			Diameter
5	Enter & store C-value	C	C			C
6	Compute EL		D			(Pipe Number) EL
7	Add to series EL, repeat 3, 4, 5.		D			(Pipe Number) EL
8	Add to para EL, repeat 3, 4, 5.		E			(Pipe Number) EL
9	Clear counter and sum only		2nd	A		0
10	Clear all for new problem		2nd	CMs		0
11	Store EL, clear counter and sum only		2nd	D		0
12	Recall EL and load L, D and C		2nd	E		EL
13	For Individ. Pipe EL after 7 or 8		x≷t			EL
	For EL of new Std D or Std C					
	Repeat steps 11, 12, 1, 2 and 6					

DATA REGISTERS (INV List)

00	Counter
01	Diameter
02	C-value
03	Total EL
04	Current EL
05	Length
06	Std Diameter
07	Std C-value
08	EL opt. storage
9	
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

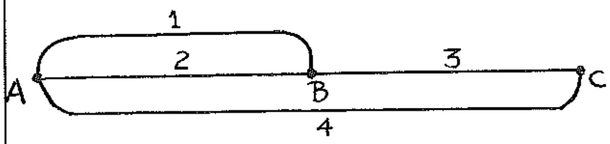
Modes: n* — Printed only (n) — Displayed Briefly (Pause)
(n)* — Printed and displayed

☐ See Continuation Sheet

Sample Problem

Statement of Example (Use FIX* 0)

Part 1 - Compute EL as 10-inch C=100 pipe from A to C



Pipe No.	L	D	C
1	789	8	100
2	666	8	123
3	666	12	88
4	999	10	88

Part 2 - Convert computed EL to EL of 8-inch, C = 130 pipe

Part 3 - Run same problem backwards, C to A using 8-inch, C = 130 as a check of parts 1 and 2.

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)		COMMENT
789	A	789	{Note 1}	Ent & Sto L
8	B	8		Ent & Sto D
	D	(1) 2339		Computes EL
666	A	666	{Note 2}	Ent & Sto L
123	C	123		Ent & Sto C
	E	(2) 482		Computes Total EL
12	B	12	{Note 3}	Ent & Sto D
88	C	88		Ent & Sto C
	D	(3) 829		Computes Total EL
999	A	999	{Note 4}	Ent & Sto L
10	B	10		Ent & Sto D
	E	(4) 280	Answer Part 1	Computes Total EL
	2nd D	0		Sto EL, Clrs total
	2nd E	280		Rcls EL, loads LDC
8	2nd B	8		Ent & Stos Std D
130	2nd C	130		Ent & Stos Std C
	D	(1) 154		Computes EL
			Answer Part 2	

Modes: n* — Printed only (n) — Displayed Briefly (Pause)
(n)* — Printed and displayed

☒ Over

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Sample Problem (cont'd)

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6 2 | 8 0 2 4
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ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
	CLR, 2nd CMS	0	Clear for New Problems
8	2nd B	8	Stores Std D
130	2nd C	130	Stores Std C
666	A	666	
12	B	12	
88	C	88	
	D	(1) 190	Computes EL
	2nd D	0	Stores EL
8	B	8	
123	C	123 {Note 5}	
	D	(1) 738	Computes EL
789	A	789	
100	C	100 {Note 6}	
	E	(2) 264	Computes EL
	2nd E	190	Rcls EL (Pipe 3)
	D	(3) 454	Computes EL
999	A	999	
10	B	10	
88	C	88	
	E	(4) 154	Computes EL
		Answer Part 3	
	Note 1	Uses default value of 100 in program for C	
	Note 2	Uses default value of 8 from previous pipe D	
	Note 3	Uses default value of 666 from previous pipe for L	
	Note 4	Uses default value of 88 for C from previous pipe	
	Note 5	Uses default value of 666 from previous pipe for L	
	Note 6	Uses default value of 8 for D from previous pipe	

Modes: n* — Printed only (n) — Displayed Briefly (Pause)
(n)* — Printed and displayed

PPX-59 Professional Program Exchange

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6 2 8 0 2 4
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LOC	CODE	KEY	COMMENTS
000	76	LBL	
001	11	A	
002	29	CP	
003	67	EQ	
004	22	INV	
005	42	STO	
006	05	05	
007	91	R/S	
008	76	LBL	
009	22	INV	
010	43	RCL	
011	00	00	
012	66	PAU	
013	43	RCL	
014	03	03	
015	76	LBL	
016	12	B	
017	42	STO	
018	01	01	
019	91	R/S	
020	76	LBL	
021	13	C	
022	42	STO	
023	02	02	
024	91	R/S	
025	76	LBL	
026	14	D	
027	43	RCL	
028	01	01	
029	29	CP	
030	22	INV	
031	67	EQ	
032	23	LNX	
033	01	1	
034	00	0	
035	76	LBL	
036	23	LNX	
037	55	÷	
038	43	RCL	
039	06	06	
040	22	INV	
041	67	EQ	
042	24	CE	
043	01	1	
044	00	0	
045	76	LBL	
046	24	CE	
047	95	=	
048	45	Y^X	
049	53	(	
050	02	2	
051	93	.	
052	06	6	
053	03	3	
054	94	+/-	
055	55	÷	
056	93	.	
057	05	5	
058	04	4	
059	54	)	
060	65	×	
061	53	(	
062	53	(	
063	43	RCL	
064	02	02	
065	22	INV	
066	67	EQ	
067	25	CLR	
068	01	1	
069	00	0	
070	00	0	
071	76	LBL	
072	25	CLR	
073	55	÷	
074	43	RCL	
075	07	07	
076	22	INV	
077	67	EQ	
078	32	X:T	
079	01	1	
080	00	0	
081	00	0	
082	76	LBL	
083	32	X:T	
084	54	)	
085	45	Y^X	
086	93	.	
087	05	5	
088	04	4	
089	35	1/X	
090	94	+/-	
091	54	)	
092	65	×	
093	43	RCL	
094	05	05	
095	95	=	
096	42	STO	
097	04	04	
098	87	IFF	
099	00	00	
100	33	X^2	
101	76	LBL	
102	34	√X	
103	44	SUM	
104	03	03	
105	69	OP	
106	20	20	
107	43	RCL	
108	00	00	
109	66	PAU	
110	43	RCL	
111	04	04	
112	32	X:T	
113	43	RCL	
114	03	03	
115	91	R/S	
116	76	LBL	
117	15	E	
118	86	STF	
119	00	00	
120	61	GTO	
121	14	D	
122	76	LBL	
123	33	X^2	
124	43	RCL	
125	03	03	
126	67	EQ	
127	35	1/X	
128	53	(	
129	43	RCL	
130	03	03	
131	45	Y^X	
132	93	.	
133	05	5	
134	04	4	
135	94	+/-	
136	85	+	
137	43	RCL	
138	04	04	
139	45	Y^X	
140	93	.	
141	05	5	
142	04	4	
143	94	+/-	
144	54	)	
145	45	Y^X	
146	93	.	
147	05	5	
148	04	4	
149	94	+/-	
150	35	1/X	
151	95	=	
152	42	STO	
153	03	03	
154	43	RCL	
155	04	04	
156	32	X:T	
157	69	OP	
158	20	20	
159	43	RCL	
160	00	00	

MERGED CODES

62	Pgm Ind	72	STO Ind	83	GTO Ind
63	Exc Ind	73	RCL Ind	84	Op Ind
64	Prd Ind	74	SUM Ind	92	INV SBR

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6 2	8 0 2 4

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LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
161	66	PAU									
162	43	RCL									
163	03	03									
164	22	INV									
165	86	STF									
166	00	00									
167	91	R/S									
168	76	LBL									
169	16	A'									
170	25	CLR									
171	42	STO									
172	00	00									
173	42	STO									
174	03	03									
175	91	R/S									
176	76	LBL									
177	17	B'									
178	42	STO									
179	06	06									
180	91	R/S									
181	76	LBL									
182	18	C'									
183	42	STO									
184	07	07									
185	91	R/S									
186	76	LBL									
187	35	1/X									
188	43	RCL									
189	04	04									
190	61	GTO									
191	34	ΓX									
192	76	LBL									
193	10	E'									
194	43	RCL									
195	06	06									
196	42	STO									
197	01	01									
198	43	RCL									
199	07	07									
200	42	STO									
201	02	02									
202	25	CLR									
203	43	RCL									
204	08	08									
205	42	STO									
206	05	05									
207	91	R/S									
208	76	LBL									
209	19	D'									
210	43	RCL									
211	03	03									
212	42	STO									
213	08	08									
214	61	GTO									
215	16	A'									

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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TEXAS INSTRUMENTS
Calculator Products Division

Submission Abstract

Program Title
WEYMOUTH GAS PIPELINE PRESSURE DROP

Rev.

Abstract of Program

Uses the widely accepted Weymouth formula to calculate pipeline pressure drop in PSI as a function of flow rate, supply pressure, gas molecular weight or specific gravity, supply temperature, and pipeline inside diameter.

Output includes pressure drop for pipelines between 1 and 100 miles long. Iterating in one mile sections, it also computes total pressure drop.

Original SR-52 Program by K. Rogers of Orangeburg, S. C.

User Benefits:

Speeds calculation of a complicated formula.

Category Number 66	**Required Progs.**	**Prog. Steps** 321	PC-100A Needed ☐ Library Module ID ☐

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Submission Checklist

- ☒ Recorded Magnetic Cards
- ☒ Submission Abstract
- ☒ Program Description
- ☒ User Instructions
- ☒ Sample Problem
- ☒ Listing
- ☐ ______
- ☐ ______

IMPORTANT

Program Description

Program Title: WEYMOUTH GAS PIPELINE PRESSURE DROP	Rev.

Method, Equations, Sketches, Limitations, References, Error Recovery:

From Gas Processors Suppliers Assn "Eng'g Data Book"

Page 10-1 EQ (a) $Qs = 433.45 \frac{Ts}{P_s} \times d^{2.667} \times \left(\frac{P_1^2 - P_2^2}{LST} \right)^{1/2}$

Weymouth Formula

This formula uses an 'effective' average flowing pressure and is known to become more inaccurate as total pressure drop approaches 10% of the supply pressure.

Rearranging for 1 mile: $P_2 = \left[P_1^2 - T(MW) \left(\frac{Q}{82570 d^{2.667}} \right)^2 \right]^{1/2}$

P_1 = Upstream Pressure, PSIA

P_2 = Downstream Pressure, PSIA

Qs = Gas Flow Rate, Std. Ft^3/Day

d = Pipeline I.D., inches

L = Length, miles

S = Specific Gravity of GAS = $\frac{MW}{29}$

T = Flowing Temp. in "Rankine" = $^{\circ}F + 460$

T_s = Std. Temp = $60^{\circ}F$

P_s = Std. Pr. = 14.65 PSIA

Velocity In Pipeline = $\frac{Q}{A} = \frac{QT}{P_1 d^2 (16690)}$ ft/sec

Gas Density = $\frac{P(MW)}{10.73\ T}$ LBS/FT^3 Assuming Compressibility = 1

Where pipeline exceeds 1 mile, program reinitializes last P_2 to new P_1 and calculates new P_2.

☐ See Continuation Sheet

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User Instructions

Program Title
WEYMOUTH GAS PIPELINE PRESSURE DROP

ΔP/Mile	Vel.	ΔP/n mi.		Density
Flow	Pres.	M. Wt.	Temp.	I.D.

Partition (OP 17) 479 ▪ 59

Parentheses Levels ______

t Register ☐

Angular Mode (if applicable) ______

SBR Levels 1

Absolute Addresses ☒

Library Module ID ______

Disturbs Pending Operations ☐

LABELS (Op 08)

INV	lnx	CE	CLR	x⇄t	x²
√x	1/x	STO	RCL	SUM	y^x
EE	(	)	÷	GTO	×
SBR	−	RST	+	R/S	.
+/−	=	CLR	INV	log	CP
tan ✓	Pgm	P→R	sin ✓	cos ✓	CMs
Exc	Prd	|x|	Eng	Fix	Int
Deg	Pause	x=t	Nop	Op	Rad
Lbl	x≥t	Σ+	x̄	Grad	St flg
If flg	D.MS	π	List	Write	Dsz
Adv	Prt				

USER DEFINED KEYS

- A Flow
- B Supply Pressure
- C Molecular Wt.
- D Supply Temp.
- E Pipeline I.D.
- A' ΔP/Mile
- B' Velocity
- C' ΔP/n miles
- D'
- E' Ideal Density

FLAGS 0	1	2	3	4	5	6	7	8	9
	SBR Test								

STEP	PROCEDURE	ENTER	PRESS	OUTPUT/MODE (see legend below)		
				PRINTED		DISPLAYED
1.	Enter Program and alphanumerics					
2.	Enter Flow Rate in SCFD	Flow	A	rate	FLOW	last PSIA
3.	Enter Supply Pressure in PSIG	Pres.	B	pres + 14.7	PRES	last M. WT.
4.	Enter Gas Molecular Wt = SP.GR. x 29	M.Wt.	C	m. wt.	M.WT.	last TEMP
5.	Enter Supply Temperature in Deg.	Temp	D	temp+460°	TEMP	last I.D.
6.	Enter Pipeline Inside Diameter	I.D.	E	i.d.	I.D.	disregard
7.	Find ΔP over 1 mile		A'	ΔP over 1 pressure drop	 MI.	 pressure drop
8.	Find Velocity		B'	velocity	VEL	velocity
9.	Find ΔP over n miles	n	C'	ΔP over n pressure drop	 MI.	 pressure drop
10.	Find Ideal Density		E'	density	DENS	density

Modes: n* — Printed only (n) — Displayed Briefly (Pause)
(n)* — Printed and displayed

DATA REGISTERS (INV List)

00	
01	Flow
02	Pressure + 14.7
03	M. Wt.
04	Temp. + 460
05	I.D.
06	Used
07	Used
08	Used
09	Pressure + 14.7
10	Alphanumerics
11	
12	See end of listing
13	
14	
15	
16	
17	
18	
19	

☐ See Continuation Sheet

Sample Problem

Statement of Example

Find the pressure drop through a 29" I.D. pipeline when 100,000,000 SCFD of a gas with a molecular weight of 18 (Specific Gravity = .621) is flowing at 50°F at a 125 PSIG supply pressure. (a) Find total pressure drop for a length of 4 miles (b) Find gas velocity (first mile) (c) Find gas density.

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)			COMMENT
		PRINTED		DISPLAYED	
1 EE 8	A	100000000.	FLOW	0	
125	B	139.7	PRES	0	
18	C	18.	M.WT	-460	
50	D	510.	TEMP	0	Temp. in Rankine
29	E	29.	I.D.	0	
	A'	ΔP OVER			
		1.	MI.		
		0.765123808		.765123808	
	B'	26.00886722	VEL	26.00886722	
4	C'	ΔP OVER			
		4.	MI.		
		3.086203882		3.086203882	
	E'	0.459514281	DENS	0.459514281	

Modes: n* — Printed only (n) — Displayed Briefly (Pause)
(n)* — Printed and displayed

☐ Over

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LOC	CODE	KEY	COMMENTS
000	76	LBL	
001	11	A	
002	42	STO	
003	01	01	
004	22	INV	
005	52	EE	
006	43	RCL	
007	10	10	
008	69	OP	
009	00	00	
010	69	OP	
011	04	04	
012	43	RCL	
013	01	01	
014	69	OP	
015	06	06	
016	43	RCL	
017	02	02	
018	91	R/S	
019	76	LBL	
020	12	B	
021	85	+	
022	01	1	
023	04	4	
024	93	.	
025	07	7	
026	95	=	
027	42	STO	
028	09	09	
029	42	STO	
030	02	02	
031	43	RCL	
032	11	11	
033	69	OP	
034	04	04	
035	43	RCL	
036	02	02	
037	69	OP	
038	06	06	
039	43	RCL	
040	03	03	
041	91	R/S	
042	76	LBL	
043	13	C	
044	42	STO	
045	03	03	
046	43	RCL	
047	12	12	
048	69	OP	
049	04	04	
050	43	RCL	
051	03	03	
052	69	OP	
053	06	06	
054	43	RCL	
055	04	04	
056	75	-	
057	04	4	
058	06	6	
059	00	0	
060	95	=	
061	91	R/S	
062	76	LBL	
063	14	D	
064	85	+	
065	04	4	
066	06	6	
067	00	0	
068	95	=	
069	42	STO	
070	04	04	
071	43	RCL	
072	13	13	
073	69	OP	
074	04	04	
075	43	RCL	
076	04	04	
077	69	OP	
078	06	06	
079	43	RCL	
080	05	05	
081	91	R/S	
082	76	LBL	
083	15	E	
084	42	STO	
085	05	05	
086	43	RCL	
087	14	14	
088	69	OP	
089	04	04	
090	43	RCL	
091	05	05	
092	69	OP	
093	06	06	
094	43	RCL	
095	06	06	
096	91	R/S	
097	76	LBL	
098	16	A'	
099	22	INV	
100	76	LBL	
101	38	SIN	
102	86	STF	
103	01	01	
104	43	RCL	
105	05	05	
106	45	Y^X	
107	02	2	
108	93	.	
109	06	6	
110	06	6	
111	07	7	
112	95	=	
113	65	×	
114	08	8	
115	02	2	
116	05	5	
117	07	7	
118	00	0	
119	95	=	
120	42	STO	
121	06	06	
122	43	RCL	
123	01	01	
124	55	÷	
125	43	RCL	
126	06	06	
127	95	=	
128	33	X^2	
129	65	×	
130	43	RCL	
131	04	04	
132	65	×	
133	43	RCL	
134	03	03	
135	95	=	
136	94	+/-	
137	85	+	
138	43	RCL	
139	02	02	
140	33	X^2	
141	95	=	
142	34	$\sqrt{X}$	
143	94	+/-	
144	85	+	
145	43	RCL	
146	02	02	
147	95	=	
148	42	STO	
149	08	08	
150	22	INV	
151	87	IFF	
152	01	01	
153	01	01	
154	56	56	
155	92	RTN	
156	98	ADV	
157	69	OP	
158	00	00	
159	43	RCL	
160	15	15	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
161	69	OP		216	04	04		271	05	05	
162	02	02		217	43	RCL		272	69	OP	
163	43	RCL		218	20	20		273	00	00	
164	16	16		219	69	OP		274	43	RCL	
165	69	OP		220	06	06		275	17	17	
166	03	03		221	98	ADV		276	69	OP	
167	69	OP		222	91	R/S		277	04	04	
168	05	05		223	76	LBL		278	43	RCL	
169	43	RCL		224	18	C'		279	21	21	
170	17	17		225	85	+		280	75	-	
171	69	OP		226	01	1		281	01	1	
172	00	00		227	95	=		282	95	=	
173	69	OP		228	42	STO		283	69	OP	
174	04	04		229	00	00		284	06	06	
175	01	1		230	42	STO		285	43	RCL	
176	69	OP		231	21	21		286	20	20	
177	06	06		232	76	LBL		287	99	PRT	
178	43	RCL		233	30	TAN		288	98	ADV	
179	08	08		234	43	RCL		289	91	R/S	
180	99	PRT		235	08	08		290	76	LBL	
181	98	ADV		236	94	+/-		291	10	E'	
182	91	R/S		237	44	SUM		292	53	(	
183	76	LBL		238	02	02		293	43	RCL	
184	17	B'		239	22	INV		294	09	09	
185	43	RCL		240	97	DSZ		295	65	×	
186	01	01		241	00	00		296	43	RCL	
187	65	×		242	39	COS		297	03	03	
188	43	RCL		243	71	SBR		298	54	)	
189	04	04		244	38	SIN		299	55	÷	
190	95	=		245	61	GTO		300	53	(	
191	42	STO		246	30	TAN		301	01	1	
192	07	07		247	76	LBL		302	00	0	
193	43	RCL		248	39	COS		303	93	.	
194	05	05		249	43	RCL		304	07	7	
195	33	X²		250	09	09		305	03	3	
196	65	×		251	75	-		306	65	×	
197	01	1		252	43	RCL		307	43	RCL	
198	06	6		253	02	02		308	04	04	
199	06	6		254	75	-		309	95	=	Exit learn code and store these alphanumeric codes in the appropriate registers.
200	09	9		255	43	RCL		310	42	STO	
201	00	0		256	08	08		311	20	20	
202	65	×		257	95	=		312	43	RCL	
203	43	RCL		258	42	STO		313	19	19	
204	02	02		259	20	20		314	69	OP	
205	95	=		260	69	OP		315	04	04	
206	35	1/X		261	00	00		316	43	RCL	
207	65	×		262	43	RCL		317	20	20	21273243.
208	43	RCL		263	15	15		318	69	OP	33351736.
209	07	07		264	69	OP		319	06	06	30404337.
210	95	=		265	02	02		320	91	R/S	37173033.
211	42	STO		266	43	RCL					24401640.
212	20	20		267	16	16					7533.
213	43	RCL		268	69	OP					32421735.
214	18	18		269	03	03					302440.
215	69	OP		270	69	OP					421727.

16173136.

MERGED COD

62	Pgm Ind	72	STO Ind
63	Exc Ind	73	RCL Ind
64	Prd Ind	74	SUM Ind

FLUID DYNAMICS

- **SOLUTION TO PIPE PROBLEMS**
  Solves for either head loss, length, diameter, or flow when given any of the other three. Provisions are made to include the head loss coefficients of fittings.
  TI-59 only.

- **HEAT TRANSFER COEFFICIENT/PRESSURE DROP**
  This program calculates heat transfer coefficient and incompressible pressure drop in a closed conduit given fluid properties and geometric parameters.
  TI-58 or TI-59.

- **INCOMPRESSIBLE FLUID PIPELINE PRESSURE DROP**
  Determines the pressure drop for an incompressible fluid in either laminar or turbulent flow.
  TI-58 or TI-59.

- **HAZEN-WILLIAMS FORMULA (Pipes)**
  Computes flow, slope, diameter, or C-value given any three of the four. The program also solves for velocity.
  TI-58 or TI-59.

- **EQUIVALENT PIPE METHOD**
  Reduces piping systems to a single equivalent pipe by computing the equivalent length for each pipe for a standard diameter and C-value, then adding in any number of series and parallel pipes.
  TI-58 or TI-59.

- **WEYMOUTH GAS PIPELINE PRESSURE DROP**
  Uses Weymouth formula to calculate pressure drop given flow rate, supply pressure, gas molecular weight or specific gravity, supply temperature, and pipeline inside diameter.
  TI-59 only.

PREPROGRAMMED MAGNETIC CARDS ARE NOT INCLUDED.
(The program Code Lists must be keyed into blank magnetic cards.)

TEXAS INSTRUMENTS
INCORPORATED
DALLAS, TEXAS

Printed in U.S.A.