Programmable TI 58/59 Specialty Pakettes

Oil/Gas/Energy

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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
- Farming
- Math/Utilities
- Aviation
- Leisure
- Business Decisions
- Securities Analysis
- Electrical Engineering
- RPN Simulator

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
- Production Planning
- Marketing/Sales

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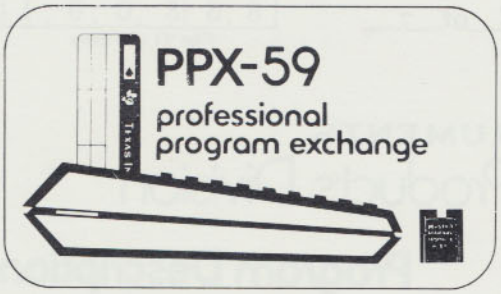

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TEXAS INSTRUMENTS
Calculator Products Division

Submission Abstract

Program Title	Rev.
WELL LOG INTERPRETATION	

Abstract of Program

Calculates formation water resistivity, ppm, porosity, and water saturation for a formation using the SP and induction log and a sonic or density porosity log.

Original SR-52 Program written by Noel D. Rietman of Amarillo, Texas

User Benefits:

Significant user time savings - also reduces the likelihood of error.

Category Name 0/G/E	Required Progs.	Prog. Steps 189	Card Sides 1	PC-100A Needed ☐ Library Module ID ☐

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Signature _____ Date _____

Name Texas Instruments Tel. No. _____

Address _____

City _____ State _____ Zip _____

Submission Checklist

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

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TEXAS INSTRUMENTS
Calculator Products Division

Program Description

Program Title:
Well Log Interpretation

Rev.

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

A constant K is calculated from:

$$K=10^{\left[\left(\log\left[\frac{5537}{\frac{Ts+7}{57}\,Rmfs\ -\ .016}\right]^{1.04}\right)\ (.413)\ -\ .973\right]}$$

Rmfs = mud filtrate resistivity (ohms M^2/M) at
Ts = sample temperature (^oF).

Then:

$$Rmf = \left(\frac{K+Ts}{K+T_f}\right) Rmfs$$

Rmf = mud filtrate resistivity (ohms M^2/M) at
Tf = formation temperature (^oF).

$$Rw = \frac{Rmf}{10^{\left(\frac{-SP}{.14\,T_f+46.5}\right)}}$$

Rw = formation water resistivity at T_f (ohms M^2/M)
SP = spontaneous potential (millivolts)

$$ppm = \left[\frac{5537}{\left(\frac{K+T_f}{K+50}\right) Rw-.016}\right]^{1.04}$$

ppm = NaCl concentration (parts per million)

Fractional porosity (Ø) is calculated as follows:

Density log: $$\emptyset = \frac{P_B - Pg}{Pl-Pg}$$

P_B = bulk density (gm/cc)
Pg = grain density (gm/cc)
Pl = liquid density (gm/cc)

☐ See Continuation Sheet

Program Title: WELL LOG INTERPRETATION	Rev.

sonic log: $\emptyset = \frac{t - \Delta tm}{t_f - \Delta tm}$

Δt = transit time (microseconds)
Δtm = matrix transit time (Microseconds)
Δt_f = fluid transit time (microseconds)

Fractional water saturation (Sw) is calculated from:

$$Sw = \left(\frac{A \quad Rw}{\emptyset^m \quad R_t} \right)^{1/n}$$

A = formation volume factor constant
m = cementation factor
N = saturation exponent
R_t = formation resistivity

8 16 8 0 0 1

PPX-59
professional program exchange

User Instructions

Program Title WELL LOG INTERPRETATION

Humble	Rmf	Rw	Porosity	

Partition (OP 17): 479 . 59 *
Parenthesis Levels: 1
Angular Mode (if applicable):
SBR Levels: 1
Library Module ID:
* for TI-58 239.29

t Register ☐
Absolute Addresses ☐
Disturbs Pending Operations ☑

LABELS (Op 08)

INV	ln x	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	Ix I	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	Set up Humble form
B	Calc. Rmf
C	Calc. Rw
D	Calc. Porosity & SW
E	
A'	
B'	
C'	
D'	
E'	

FLAGS	0	1	2	3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS	OUTPUT/MODE (see legend below)
1	Stored Δt_f, Δtm or Pf, Pg in	10 and 11, respectively.		
2	Store A in 15, m in 14, and n in 16 for SW = $(A\ RW/\phi^m\ R_t)^{1/n}$			
	Or, to use the Humble formula (A=.62, m=2.15, n=2) press A.			
3	If A was not pressed, press B			7.000
4	Enter temperature (°F) for Rmfs	Ts	R/S	
5	Enter Rmfs	Rmfs	R/S	
6	Enter formation temperature (°F)	T_f	R/S	Rmf @ T_f
7	Set up Rw calculation procedure		R/S	10.000
8	Enter negative of SP (mv)	-SP	R/S	Rw @ T_f
9			R/S	ppm
10	Enter Δt (μsec) or P_B (gm/cc)	Δt or P_B	R/S	Porosity (Fractional)
11	Enter formation resistivity	R_t	R/S	SW (Fractional)
	After 11, repeat from 10 for another interval in the same zone.			
	After 11, press C and repeat from 8 for another formation in the same well.			
	After 11, press B and repeat from 4 for another well.			
	Data stored in 10 and 11 must be changed for lithology changes.			

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

☐ See Continuation Sheet

DATA REGISTERS (INV Dsz)

0	
1	Ts
2	
3	
4	Rmfs
5	K
6	BHT
7	Rmf
8	Interim
9	Rw
10	Δt_f or Pf
11	Δtm or Pg
12	Porosity
13	
14	m
15	A
16	n
17	R_t
18	
19	

TEXAS INSTRUMENTS
Calculator Products Division

Sample Problem

Statement of Example

Calculate the formation water resistivity at formation temperature, ppm, the porosity (Ø) and the water saturation (SW) for a well log which has the following characteristics: Mud filtrate resistivity 1.2 ohms M^2/M at 75°F, 200°F formation temperature, -40 millivolts spontaneous potential, 67 and 72 microseconds per/foot transit time (Δt), 40 and 30 ohms M^2/M measured formation resistivity (R_t), 188.7 Msec/ft. fluid transit time and 55.56 Msec/ft. matrix transit time (5,300 ft./sec. Velocity in fluid and 18,000 ft/sec. matrix velocity.)

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
188.7	STO 10		Stores Δt_f
55.56	STO 11		Stores Δtm
	A	7.000	Sets up $Sw = (A/\emptyset^m)^n$
with A = .62, m = 2.15, n = 2. To use other values, store A in 15, m in 14 and n in 16, then press B, displaying 7.000.			
75	R/S	1.439	Enter temp. T_s
1.2	R/S	3.425	Enter Rmfs at T_s
200	R/S	.463	Enter formation temperature T_f Read Rmf @ T_f.
	R/S	10.000	
40	R/S	.134	Enter negative of SP. Read formation water resistivity Rw.
	R/S	16218.786	Read ppm.
67	R/S	.086	Enter Δt. Read Ø.
40	R/S	.638	Enter R_t. Read SW
72	R/S	.123	Enter Δt. Read Ø.
30	R/S	.499	Enter R_t. Read SW.

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	58	FIX	
003	03	03	
004	02	2	
005	93	.	
006	01	1	
007	05	5	
008	42	STO	
009	14	14	
010	93	.	
011	06	6	
012	02	2	
013	42	STO	
014	15	15	
015	02	2	
016	42	STO	
017	16	16	
018	76	LBL	
019	12	B	
020	25	CLR	
021	07	7	
022	85	+	
023	91	R/S	
024	42	STO	
025	01	01	
026	95	=	
027	55	÷	
028	05	5	
029	07	7	
030	65	×	
031	91	R/S	
032	42	STO	
033	04	04	
034	19	D'	
035	28	LOG	
036	65	×	
037	93	.	
038	04	4	
039	01	1	
040	03	3	
041	75	-	
042	93	.	
043	09	9	
044	07	7	
045	03	3	
046	95	=	
047	22	INV	
048	28	LOG	
049	42	STO	
050	05	05	
051	85	+	
052	43	RCL	
053	01	01	
054	95	=	
055	55	÷	
056	53	(	
057	43	RCL	
058	05	05	
059	85	+	
060	91	R/S	
061	42	STO	
062	06	06	
063	54	)	
064	65	×	
065	43	RCL	
066	04	04	
067	95	=	
068	42	STO	
069	07	07	
070	91	R/S	
071	43	RCL	
072	06	06	
073	65	×	
074	93	.	
075	01	1	
076	04	4	
077	85	+	
078	04	4	
079	06	6	
080	93	.	
081	05	5	
082	95	=	
083	42	STO	
084	08	08	
085	76	LBL	
086	13	C	
087	01	1	
088	00	0	
089	45	Y×	
090	53	(	
091	91	R/S	
092	55	÷	
093	43	RCL	
094	08	08	
095	54	)	
096	95	=	
097	35	1/X	
098	65	×	
099	43	RCL	
100	07	07	
101	95	=	
102	42	STO	
103	09	09	
104	91	R/S	
105	65	×	
106	53	(	
107	43	RCL	
108	05	05	
109	85	+	
110	43	RCL	
111	06	06	
112	54	)	
113	55	÷	
114	53	(	
115	43	RCL	
116	05	05	
117	85	+	
118	05	5	
119	00	0	
120	54	)	
121	95	=	
122	19	D'	
123	76	LBL	
124	14	D	
125	91	R/S	
126	75	-	
127	43	RCL	
128	11	11	
129	95	=	
130	55	÷	
131	53	(	
132	43	RCL	
133	10	10	
134	75	-	
135	43	RCL	
136	11	11	
137	54	)	
138	95	=	
139	42	STO	
140	12	12	
141	91	R/S	
142	42	STO	
143	17	17	
144	43	RCL	
145	12	12	
146	45	Y×	
147	43	RCL	
148	14	14	
149	94	+/-	
150	65	×	
151	43	RCL	
152	15	15	
153	65	×	
154	43	RCL	
155	09	09	
156	55	÷	
157	43	RCL	
158	17	17	
159	95	=	
160	45	Y×	

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

8,6 | 8,0,0,1
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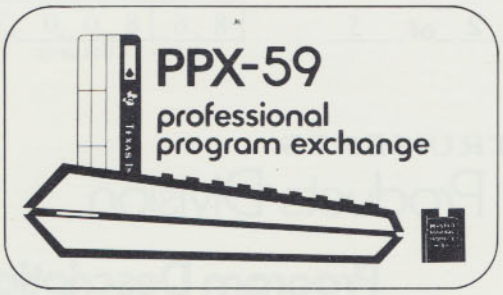
LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
161	43	RCL									
162	16	16									
163	35	1/X									
164	95	=									
165	61	GTO									
166	14	D									
167	76	LBL									
168	19	D'									
169	75	-									
170	93	.									
171	00	0									
172	01	1									
173	06	6									
174	95	=									
175	35	1/X									
176	65	×									
177	05	5									
178	05	5									
179	03	3									
180	07	7									
181	95	=									
182	45	Y×									
183	01	1									
184	93	.									
185	00	0									
186	04	4									
187	95	=									
188	92	RTN									

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	Rev.
RAPID GAS RESERVE ESTIMATE	

Abstract of Program

Calculate recoverable reserves of natural gas per acre foot of bulk reservoir volume. Useful for reconnaisance estimates where only depth, average rock porosity and connate water content are known. If actual reservoir pressure and/or deviation (Z) factor are known, any or all of these values may be entered to improve the accuracy of the estimate.

Original SR-52 Program by Joe M. Coffield of Shreveport, La.

User Benefits:

Provides a rapid approximation of potential natural gas reserves for drilling prospect evaluation, particularly in areas of limited reservoir information.

Category Name O/G/E	Required Progs.	Prog. Steps 140	Card Sides 1	PC-100A Needed ☐ Library Module ID ☐

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Signature _____ Date _____

Name Texas Instruments Tel. No. _____

Address _____

City _____ State _____ Zip _____

Submission Checklist

- ☒ Recorded Magnetic Cards
- ☒ Submission Abstract
- ☒ Program Description
- ☒ User Instructions
- ☒ Sample Problem
- ☒ Listing
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TEXAS INSTRUMENTS
Calculator Products Division

Program Description

Program Title: RAPID GAS RESERVE ESTIMATE	Rev.

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

Calculates recoverable natural gas reserves on a unit basis, millions of cubic feet (MMCF), at 15.025 psia and 60°F. base, per acre foot (A') of bulk reservoir volume, using the following relationship:

$$Q = \frac{43{,}560 \times POR\%/100 \times (1\text{-}WTR\%/100) \times 520 \times (BHP + 14.7) \times .8}{1{,}000{,}000 \times (BHT + 460) \times 15.025 \times Z}$$

Q = MMCF/A'

POR% = Rock porosity, % of bulk volume

WTR% = Connate water, % of pore space

BHP = Average bottom hole pressure (psia)

BHT = Average bottom hole temperature (°F)

Z = Deviation factor

Program requires entry only of depth, porosity %/100 and Wtr %/100, estimating BHP from a gradient of 0.433 psi/foot and BHT from 1.5°F. gradient per 100' with assumed surface temperature of 60°F. Z factor is calculated as unity unless specified. BHP, BHT and Z factor may be entered if known, in which case actual values wiill be employed in the calculation.

Recovery factor is programmed at 80%, roughly equivalent to assuming an abandonment BHP of 20% of the original BHP. Answer may be adjusted to other recovery factors as follows:

$$Q\ (90\%\ \text{recovery}) = \frac{Q \times .90}{.80}\ , \text{etc.}$$

☐ See Continuation Sheet

8 1 6 | 8 1 0 1 0 1 2

PPX-59
professional program exchange

User Instructions

Program Title RAPID GAS RESERVE ESTIMATE

BHP (psig)	BHT (°F)	Z		
POR%/100	WTR%/100	Depth (ft)	Calc.	

Partition (OP 17): 479.59*

Parenthesis Levels: 1

Angular Mode (if applicable):

SBR Levels: 1

Library Module ID:

*for TI-58 239.29

t Register ☐

Absolute Addresses ☐

Disturbs Pending Operations ☑

LABELS (Op 08)

INV	ln x	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	Lrst	Write	Dsz
Adv	Prt				

USER DEFINED KEYS

A	BHP (psig)
B	BHT (°F)
C	Deviation factor (Z)
D	Used as Return LBL
E	Used as Return LBL
A'	Porosity % ÷ 100
B'	Connate wtr. % ÷ 100
C'	Depth (ft)
D'	Calculate Q
E'	Used as Return LBL

FLAGS	0	1	2	3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS	OUTPUT/MODE (see legend below)
1	Enter program			0
2	Clear memories		CMs	0
3	Enter porosity %/100	POR/100	A	POR/100
4	Enter connate wtr%/100	WTR/100	B	WTR/100
5*	Enter avg. reservoir pressure (psig) if known	BHP (psig)	A'	BHP (psig)
6*	Enter avg. reservoir temperature (°F), if known	BHT(°F)	B'	BHT(°F)
7*	Enter deviation factor, if known	Z	C'	Z
8	Calculate recoverable gas reserve MMCF/A'		D	Q(MMCF/A')

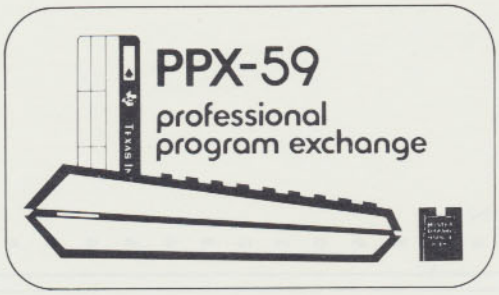
*Note: Any or all of these parameters may be entered if known, otherwise BHP and BHT will be approximated proportional to depth and Z will be calculated as unity.

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

DATA REGISTERS (INV List)

0	
1	POR% ÷ 100
2	WTR% ÷ 100
3	DEPTH (Ft)
4	BHP (psig)
5	BHT (°F)
6	Z
7	
8	
9	
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

☐ See Continuation Sheet



8,6 8,0,0,2
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Calculator Products Division

Sample Problem

Statement of Example

PART A: Depth of reservoir = 10,000'; Porosity = 25%, Connate water = 30%,
Calculate recoverable gas reserves (80% recovery factor)

PART B: Depth of reservoir - 10,000', Porosity = 25%, Connate water = 30%
Average reservoir pressure = 4575 psig, Deviation factor = 1.02
Calculate recoverable gas reserves (80% recovery factor)

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
PART A:	CMs*		Clear memories
.25	A	.25*	POR%/100
.30	B	.30*	WTR%/100
10,000	C	10,000*	Depth (ft)
	D	(1.3686)*	MMCF/A'
		1.36863724	
PAFT B:	CMs*		Clear memories
.25	A	.25*	POR%/100
.30	B	.30*	WTR%/100
10,000	C	10,000*	Depth (Ft)
4575	A'	4575*	BHP (psig)
1.02	C'	1.02*	Z
	D	(1.4175)*	MMCF/A'
		1.417466118	
		*Printed and Displayed	

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

☐ Over

PPX-59 Professional Program Exchange

8,6 8,0,0,2
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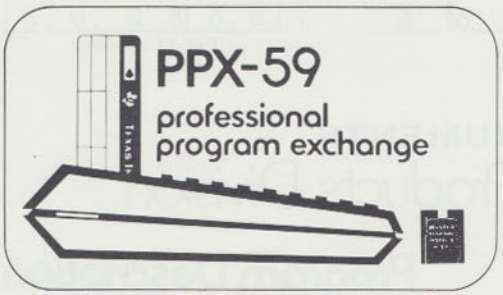
LOC	CODE	KEY	COMMENTS
000	76	LBL	
001	11	A	
002	98	ADV	
003	42	STO	
004	01	01	
005	76	LBL	
006	12	B	
007	42	STO	
008	02	02	
009	99	PRT	
010	91	R/S	
011	76	LBL	
012	13	C	
013	42	STO	
014	03	03	
015	99	PRT	
016	91	R/S	
017	76	LBL	
018	16	A'	
019	42	STO	
020	04	04	
021	99	PRT	
022	86	STF	
023	00	00	
024	91	R/S	
025	76	LBL	
026	17	B'	
027	42	STO	
028	05	05	
029	99	PRT	
030	86	STF	
031	01	01	
032	91	R/S	
033	76	LBL	
034	18	C'	
035	86	STF	
036	02	02	
037	42	STO	
038	06	06	
039	99	PRT	
040	91	R/S	
041	76	LBL	
042	14	D	
043	87	IFF	
044	00	00	
045	10	E'	
046	43	RCL	
047	03	03	
048	65	×	
049	93	.	
050	04	4	
051	03	3	
052	03	3	
053	76	LBL	
054	19	D'	
055	85	+	
056	01	1	
057	04	4	
058	93	.	
059	07	7	
060	95	=	
061	65	×	
062	01	1	
063	93	.	
064	02	2	
065	00	0	
066	06	6	
067	00	0	
068	05	5	
069	65	×	
070	53	(	
071	01	1	
072	75	-	
073	43	RCL	
074	02	02	
075	54	)	
076	55	÷	
077	53	(	
078	87	IFF	
079	01	01	
080	77	GE	
081	43	RCL	
082	03	03	
083	65	×	
084	93	.	
085	00	0	
086	01	1	
087	05	5	
088	85	+	
089	06	6	
090	00	0	
091	76	LBL	
092	15	E	
093	85	+	
094	04	4	
095	06	6	
096	00	0	
097	54	)	
098	65	×	
099	43	RCL	
100	01	01	
101	87	IFF	
102	02	02	
103	87	IFF	
104	76	LBL	
105	88	DMS	
106	95	=	
107	58	FIX	
108	04	04	
109	22	INV	
110	86	STF	
111	00	00	
112	22	INV	
113	86	STF	
114	01	01	
115	22	INV	
116	86	STF	
117	02	02	
118	99	PRT	
119	22	INV	
120	58	FIX	
121	91	R/S	
122	76	LBL	
123	10	E'	
124	43	RCL	
125	04	04	
126	19	D'	
127	76	LBL	
128	77	GE	
129	43	RCL	
130	05	05	
131	15	E	
132	76	LBL	
133	87	IFF	
134	65	×	
135	43	RCL	
136	06	06	
137	35	1/X	
138	61	GTO	
139	88	DMS	

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	Rev.
COMPRESSIBILITY FACTORS FOR SWEET NATURAL GASES	

Abstract of Program

Calculates the compressibility factor (Z) for sweet natural gases to account for deviations, from the ideal gas law, in the behavior of real gases. It is based upon a simplified version of a correlation by Dranchuk, Purvis & Robinson (1974). Input required is gas specific gravity, temperature and pressure. Output includes pseudo-critical temperature and pressure, pseudo-reduced temperature and pressure and the gas compressibility factor.

Original Program written by J. J. Doubek of Denver, Colorado.

User Benefits:

Provides a quick method of es timating compressibility factors without the need of tables, graphs or detailed analysis of natural gas (sweet) composition.

Category Name O/G/E	Required Progs.	Prog. Steps 252	Card Sides 1	PC-100A Needed ☐ Library Module ID ☐

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Address _____

City _____ State _____ Zip _____

Submission Checklist

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

TEXAS INSTRUMENTS
Calculator Products Division

Program Description

Program Title:
COMPRESSIBILITY FACTORS FOR SWEET NATURAL GASES

Rev.

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

This program calculates compressibility factors (Z) for sweet natural gases to account for deviations from the ideal gas law. In cases where the gas composition is unknown, the pseudo-critical properties are determined from a graph based upon the specific gravity of the gas. Thomas, Hankinson & Phillips (1) took data from such a graph and developed the following correlations:

$$T_c = 170.491 + 307.344\ G$$
$$P_c = 709.604 - 58.718\ G$$

Standing & Katz (2) developed a graphical Z factor chart in 1942 which uses pseudo-reduced pressure and temperatures as parameters. This graph may be represented by the BWR equation of state fitted by Dranchuk, et al (3) in 1974:

$$Z = 1 + (A_1 + A_2/T_r + A_3/T_r^3)\rho_r + (A_4 + A_5/T_r)\rho_r^2 + A_7\rho_r^2/T_r^3$$

where

$$\rho_r = 0.27 P_r/(Z T_r) \qquad T_r = T/T_c \qquad P_r = P/P_c$$

$A_1 = 0.31506$ $A_2 = -1.0467$ $A_3 = -0.5783$
$A4 = 0.5353$ $A_5 = -0.6123$
$A_7 = 0.6815$

The program assumes $Z = 1.0$ for the first calculation and then iterates five times. Should more accuracy be desired, a larger value may be stored in register 00 in program step 008. Each iteration requires approximately 4.4 seconds to calculate.

(1) Thomas, L. K., R. W. Hankinson and K. A. Phillips (1970). Determination of Acoustic Velocities for Natural Gas, J. Pet. Tech., 22, 889-895.

(2) Standing, M. B. and D. L. Katz (1942). Density of Natural Gases, Trans. AIME, 146, 140.

(3) Dranchuk, P. M., R. A. Purvis and D. B. Robinson (1974). Computer Calculation of Natural Gas Compressibility Factors Using the Standing and Katz Correlations, Inst. of Pet. Tech., IP-74-008.

☐ See Continuation Sheet

8,6|8,0,0,3

PPX-59
professional program exchange

User Instructions

Program Title GAS COMPRESSIBILITY FACTOR

S.G.	T	P	Z	

Partition (OP 17): 479,59 *
Parenthesis Levels: 2
Angular Mode (if applicable):
SBR Levels:
Library Module ID:
t Register ☐
Absolute Addresses ☐
Disturbs Pending Operations ☑

* for TI-58 319.19

LABELS (Op 08)

INV	ln x	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=1	Σ+	x̄	Grad	St flg
If flg	D.MS	π	List	Write	Dsz
Adv	Prt				

USER DEFINED KEYS

A	Specific Gravity
B	Temperature °F
C	Pressure PSIA
D	Calculate Z
E	
A'	
B'	
C'	
D'	
E'	

FLAGS	0	1	2	3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS	OUTPUT/MODE (see legend below)
1	Start		R/S	1.
2	Input Specific Gravity	Decimal	A	T_c
3			R/S	P_c
4	Input Temperature	°F	B	T_r
5	Input Pressure	PSIA	C	P_r
6	Calculate Z		D	Z

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

DATA REGISTERS (INV Dsz)

0	5 Iterations
1	Specific Gravity
2	Critical Temp.
3	Critical Pressure
4	Gas Temperature
5	Reduced Temp.
6	Gas Pressure
7	Reduced Pressure
8	Reduced Density
9	Used
0	
1	
2	
3	
4	
5	
6	
7	
8	
19	Compressibility Z

☐ See Continuation Sheet

TEXAS INSTRUMENTS
Calculator Products Division

Sample Problem

Statement of Example

A natural gas reservoir has a temperature of 200° F, and a pressure of 2500 PSIA. What is the gas compressibility factor if the gas has a specific gravity of .65?

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
	RSET R/S	1.*	
.65	A	370.2636* TC*	T_c
	R/S	671.432* PC*	P_c
200	B	1.779813085* TR*	T_r
2500	C	3.723385242* PR*	P_r
	D	.8872903496* Z*	Z

*Printed and Displayed

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

☐ Over

PPX-59 Professional Program Exchange

8,6 8 0 0 3
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LOC	CODE	KEY	COMMENTS
000	47	CMS	
001	22	INV	
002	58	FIX	
003	04	4	
004	05	5	
005	09	9	
006	42	STO□	
007	04	04	
008	05	5	
009	42	STO□	
010	00	00	
011	01	1	
012	42	STO□	
013	19	19	
014	99	PRT	
015	91	R/S	
016	76	LBL	
017	11	A	
018	42	STO□	
019	01	01	
020	53	(	
021	43	RCL	
022	01	01	
023	65	×	
024	03	3	
025	00	0	
026	07	7	
027	93	.	
028	03	3	
029	04	4	
030	04	4	
031	54	)	
032	85	+	
033	01	1	
034	07	7	
035	00	0	
036	93	.	
037	04	4	
038	09	9	
039	95	=	
040	42	STO□	
041	09	09	
042	03	3	
043	07	7	
044	00	0	
045	00	0	
046	01	1	
047	05	5	
048	69	□P	
049	04	04	
050	43	RCL	
051	09	09	
052	69	□P	
053	06	06	
054	91	R/S	
055	42	STO□	
056	02	02	
057	07	7	
058	00	0	
059	09	9	
060	93	.	
061	06	6	
062	75	-	
063	53	(	
064	43	RCL	
065	01	01	
066	65	×	
067	05	5	
068	08	8	
069	93	.	
070	07	7	
071	02	2	
072	54	)	
073	95	=	
074	42	STO□	
075	03	03	
076	03	3	
077	03	3	
078	00	0	
079	00	0	
080	01	1	
081	05	5	
082	69	□P	
083	04	04	
084	43	RCL	
085	03	03	
086	69	□P	
087	06	06	
088	91	R/S	
089	76	LBL	
090	12	B	
091	44	SUM	
092	04	04	
093	43	RCL	
094	04	04	
095	55	÷	
096	43	RCL	
097	02	02	
098	95	=	
099	42	STO□	
100	05	05	
101	03	3	
102	07	7	
103	00	0	
104	00	0	
105	03	3	
106	05	5	
107	69	□P	
108	04	04	
109	43	RCL	
110	05	05	
111	69	□P	
112	06	06	
113	91	R/S	
114	76	LBL	
115	13	C	
116	42	STO□	
117	06	06	
118	43	RCL	
119	06	06	
120	55	÷	
121	43	RCL	
122	03	03	
123	95	=	
124	42	STO□	
125	07	07	
126	03	3	
127	03	3	
128	00	0	
129	00	0	
130	03	3	
131	05	5	
132	69	□P	
133	04	04	
134	43	RCL	
135	07	07	
136	69	□P	
137	06	06	
138	91	R/S	
139	76	LBL	
140	14	D	
141	53	(	
142	43	RCL	
143	07	07	
144	65	×	
145	93	.	
146	02	2	
147	07	7	
148	54	)	
149	55	÷	
150	53	(	
151	43	RCL	
152	05	05	
153	65	×	
154	43	RCL	
155	19	19	
156	54	)	
157	95	=	
158	42	STO□	
159	08	08	
160	53	(	

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

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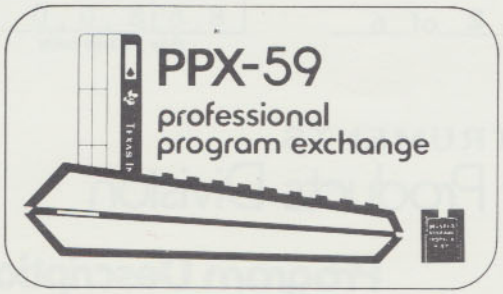
LOC	CODE	KEY	COMMENTS
161	01	1	
162	85	+	
163	53	(	
164	53	(	
165	93	.	
166	03	3	
167	01	1	
168	05	5	
169	00	0	
170	06	6	
171	75	-	
172	01	1	
173	93	.	
174	00	0	
175	04	4	
176	07	7	
177	55	÷	
178	43	RCL	
179	05	05	
180	75	-	
181	93	.	
182	05	5	
183	07	7	
184	08	8	
185	03	3	
186	55	÷	
187	43	RCL	
188	05	05	
189	45	Y^x	
190	03	3	
191	54	)	
192	65	×	
193	43	RCL	
194	08	08	
195	54	)	
196	85	+	
197	53	(	
198	53	(	
199	93	.	
200	05	5	
201	03	3	
202	05	5	
203	03	3	
204	75	-	
205	93	.	
206	06	6	
207	01	1	
208	02	2	
209	03	3	
210	55	÷	
211	43	RCL	
212	05	05	
213	54	)	
214	65	×	
215	43	RCL	

LOC	CODE	KEY	COMMENTS
216	08	08	
217	45	Y^x	
218	02	2	
219	54	)	
220	85	+	
221	53	(	
222	93	.	
223	06	6	
224	08	8	
225	01	1	
226	06	6	
227	65	×	
228	43	RCL	
229	08	08	
230	45	Y^x	
231	02	2	
232	55	÷	
233	43	RCL	
234	05	05	
235	45	Y^x	
236	03	3	
237	95	=	
238	42	STO	
239	19	19	
240	97	DSZ	
241	00	00	
242	14	D	
243	04	4	
244	06	6	
245	69	OP	
246	04	04	
247	43	RCL	
248	19	19	
249	69	OP	
250	06	06	
251	91	R/S	

LOC	CODE	KEY	COMMENTS

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	Rev.
Production Sch. for Exponentially Declining Wells	

Abstract of Program

For wells exhibiting exponential decline, this program calculates: (A) Decline rate and economic life in reserves, initial potential and economic limit are input., or (B) Reserves and economic life if initial potential, economic limit and decline rates are input.

Following (A) or (B), the program calculates yearly production, cumulative and year end production on a yearly basis.

Original SR-52 Program written by R. J. Doubek of Denver, Colorado.

User Benefits:

Saves time over manual calculation of reserves and production schedule forecasts and is less costly than computer-generated forecasts used for economic analysis of wells with exponentially declining production characteristics.

Category Name O/G/E	Required Progs.	Prog. Steps 195	Card Sides 1	PC-100A Needed ☐ Library Module ID ☐

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Signature _____ Date _____

Name Texas Instruments Tel. No. _____

Address _____

City _____ State _____ Zip _____

Submission Checklist

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

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TEXAS INSTRUMENTS
Calculator Products Division

Program Description

Program Title: Production Schedule for Exponentially Declining Wells	Rev.

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

Production rate decline curves are widely used to forecast future production rates and to estimate remaining reserves. Many wells exhibit exponential decline in that a graph of the natural logarithm of production vs. time is a straight line with a slope of $^{-b}$. This type of decline is known as constant rate, or percentage decline in that if q is the rate:

$$\frac{q_1}{q_o} = \frac{q_2}{q_1} = \frac{q_3}{q_2} = \ldots\ldots = \exp(^{-b})$$

or $\exp(^{-b}) = 1 - d$ d = percent decline

also $q = q_o e^{-bt}$ t = time

and $Q\text{-}Q_o = \frac{q_o - q}{b}$ Q = cumulative production

If reserves, initial rate and economic limit rate are input, the program will calculate decline and economic life. If reserves are input as zero, the program makes a conditional transfer and calculates reserves and economic life.

Following determination of economic life - yearly production, cumulative production and year end rate may be determined by inputting year (1, 2, etc.), Run, Run, etc., on a sequential basis.

☐ See Continuation Sheet

8 6 8 0 0 4

PPX-59
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program exchange

User Instructions

Program Title Prod. Sch. for Exponential Decline

Q or O	I.P.	Ec. Limit	d or o	Year

Partition (OP 17): 479 .59*
Parenthesis Levels: 3
Angular Mode (if applicable):
SBR Levels: 1
Library Module ID:
t Register ☐
Absolute Addresses ☐
Disturbs Pending Operations ☑

* for TI-58 239.29

LABELS (Op 08)

INV	ln x	CE	CLR	x:t	x²	
√x	1/x	STO	RCL	SUM	y^x	
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	Reserves (Bbl)
B	Initial Poten.- (B/D)
C	Ec. Limit (B/D)
D	Decline (%/year)
E	Year
A'	
B'	
C'	
D'	
E'	

FLAGS	0	1	2	3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS	OUTPUT/MODE (see legend below)
1	Start		RUN	0.
2	Input Q or O		A	Q or O
3	Input Initial Potential	I.P. (B/D)	B	I.P.
4	Input Economic Limit	E.L. (B/D)	C	E.L.
5	Input d or o	d or o	D	d or Q*
6			R/S	Life (years)
7	Input first year	1	E	Production
8				cumulative
9			R/S	ending production
10	Repeat steps #7, 8, 9 as required 2 etc.		R/S	

*If Q is input in step #5, display is decline (d). If di is input in step #5, display is reserves (Q).

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

☐ See Continuation Sheet

DATA REGISTERS (INV Ost)

0	
1	Reserves (Q)
2	Int. Potential (B/D)
3	Ec. Limit (B/D)
4	Decline (%/year)
5	b
6	Life (years)
7	Year (N)
8	
9	Cumulative (Bbl)
10	
11	Year end rate (B/D)
12	Reserves (Q)
13	
14	
15	Yr. end rate (B/D)
6	
7	
8	
9	

8 6 8 0 0 4
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program exchange

TEXAS INSTRUMENTS
Calculator Products Division

Sample Problem

Statement of Example

A. Determine the reserves and life for a well that has an initial potential of 75 B/D oil, an economic limit of 5 B/D, and a decline rate of 23% per year. Prepare a three year production forecast for the well.

B. Check the decline rate using reserves determined in part (A).

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
(A)	RSET R/S	0.	
0	A	0.*	
75	B	75.*	Int. Initial potential
5	C	5.*	In. Economic Limit
.23	D	97,756.09993*	Reserves (Bbl).
	R/S	10.36119084*	Life (years)
1	E	24,089.89605*	1st year production
	R/S	24,089.89605*	1st year cumulative
	R/S	57.75*	Year end rate
2	E	18,549.21996*	2nd yr. production
	R/S	42,639.11601*	2nd yr. cumulative
	R/S	44.4675*	Year end rate
3	E	14,282.89937*	3rd yr. production
	R/S	56,922.01538*	3rd yr. cumulative
	R/S	34.239975*	Year end rate
(B)	CLR RESET		
	R/S	0.	
97 756	A	97756.*	In. Reserves
75	B	75.*	In. initial potential
5	C	5.*	In. Ec. Limit
0	D	.2300002057*	Decline Rate (check)
	R/S	10.36118025*	Life

*Printed and Displayed

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

☐ Over

PPX-59 Professional Program Exchange

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LOC	CODE	KEY	COMMENTS
000	29	CP	
001	47	CMS	
002	91	R/S	
003	76	LBL	
004	11	A	
005	42	STO	
006	01	01	
007	99	PRT	
008	91	R/S	
009	76	LBL	
010	12	B	
011	42	STO	
012	02	02	
013	42	STO	
014	15	15	
015	99	PRT	
016	91	R/S	
017	76	LBL	
018	13	C	
019	42	STO	
020	03	03	
021	99	PRT	
022	91	R/S	
023	76	LBL	
024	14	D	
025	42	STO	
026	04	04	
027	71	SBR	
028	38	SIN	
029	76	LBL	
030	39	COS	
031	99	PRT	
032	91	R/S	
033	76	LBL	
034	15	E	
035	42	STO	
036	07	07	
037	98	ADV	
038	76	LBL	
039	85	+	
040	53	(	
041	43	RCL	
042	07	07	
043	65	×	
044	43	RCL	
045	05	05	
046	54	)	
047	22	INV	
048	23	LNX	
049	35	1/X	
050	65	×	
051	43	RCL	
052	02	02	
053	95	=	
054	42	STO	
055	11	11	
056	53	(	
057	43	RCL	
058	15	15	
059	75	-	
060	43	RCL	
061	11	11	
062	54	)	
063	65	×	
064	03	3	
065	06	6	
066	05	5	
067	55	÷	
068	43	RCL	
069	05	05	
070	95	=	
071	42	STO	
072	09	09	
073	99	PRT	
074	91	R/S	
075	44	SUM	
076	12	12	
077	43	RCL	
078	12	12	
079	99	PRT	
080	91	R/S	
081	43	RCL	
082	11	11	
083	42	STO	
084	15	15	
085	43	RCL	
086	15	15	
087	99	PRT	
088	91	R/S	
089	61	GTO	
090	39	COS	
091	76	LBL	
092	38	SIN	
093	53	(	
094	43	RCL	
095	01	01	
096	75	-	
097	43	RCL	
098	04	04	
099	54	)	
100	22	INV	
101	77	GE	
102	37	P/R	
103	53	(	
104	53	(	
105	43	RCL	
106	02	02	
107	75	-	
108	43	RCL	
109	03	03	
110	54	)	
111	65	×	
112	03	3	
113	06	6	
114	05	5	
115	55	÷	
116	43	RCL	
117	01	01	
118	54	)	
119	42	STO	
120	05	05	
121	53	(	
122	01	1	
123	75	-	
124	01	1	
125	55	÷	
126	43	RCL	
127	05	05	
128	22	INV	
129	23	LNX	
130	54	)	
131	42	STO	
132	04	04	
133	99	PRT	
134	91	R/S	
135	76	LBL	
136	30	TAN	
137	53	(	
138	53	(	
139	43	RCL	
140	02	02	
141	55	÷	
142	43	RCL	
143	03	03	
144	54	)	
145	23	LNX	
146	55	÷	
147	43	RCL	
148	05	05	
149	54	)	
150	42	STO	
151	06	06	
152	99	PRT	
153	91	R/S	
154	92	RTN	
155	76	LBL	
156	37	P/R	
157	53	(	
158	53	(	
159	01	1	
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

PPX-59 Professional Program Exchange

8 6 8 0 0 4
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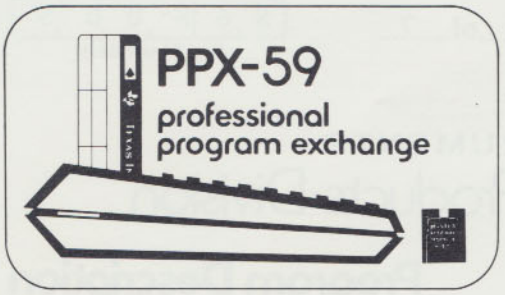
LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
161	53	(									
162	01	1									
163	75	-									
164	43	RCL									
165	04	04									
166	54	)									
167	54	)									
168	23	LNX									
169	54	)									
170	42	STO									
171	05	05									
172	53	(									
173	53	(									
174	43	RCL									
175	02	02									
176	75	-									
177	43	RCL									
178	03	03									
179	54	)									
180	65	×									
181	03	3									
182	06	6									
183	05	5									
184	55	÷									
185	43	RCL									
186	05	05									
187	54	)									
188	42	STO									
189	01	01									
190	99	PRT									
191	91	R/S									
192	61	GTO									
193	30	TAN									
194	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	Rev.
GAS WELL DELIVERABILITY	

Abstract of Program

Shut in pressure, pipeline pressure, gas in place, slope from back pressure curve and producing characteristics of a gas well are the input items. Future annual production volumes are calculated from these data for a well in a depletion drive reservoir.

Original SR-52 Program by Noel D. Rietman of Amarillo, Texas

User Benefits:

Significant user time savings - also reduces likelihood of error.

Category Name 0/G/E	Required Progs.	Prog. Steps 148	Card Sides 1	PC-100A Needed ☐ Library Module ID ☐

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Signature _____ Date _____

Name Texas Instruments Tel. No. _____

Address _____

City _____ State _____ Zip _____

Submission Checklist

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

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TEXAS INSTRUMENTS
Calculator Products Division

Program Description

Program Title: GAS WELL DELIVERABILITY	Rev.

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

If current shut-in wellhead pressure is unknown, it may be calculated from:

$$P = \left(\frac{Go - Gc}{Go} \right) Po$$

P = Current shut-in wellhead pressure (psia)
Go = Original gas in place (MMcf)
Gc = Cumulative gas production (MMcf)
Po = Original shut-in wellhead pressure (psia)

Likewise, if the well producing coefficient C is not know, it can be calculated from:

$$C = \frac{365\,(q)}{(P^2 - L^2)^n}$$

q = A known producing rate (Mcf/day)
P = The corresponding shut-in wellhead pressure (psia)
L = The corresponding flowing wellhead pressure (psia)
n = Slope from back pressure curve on the well
C = Well producing coefficient (Mcf/yr/psia^2)

The number of time steps per year for the calculation is then chosen.

The method then consists of an iteration procedure as follows:

For time step 1, the production Q_1 is:

$$Q_1 = C\,(P_1^2 - L^2)^n$$

Q_1 = Production (MMcf) during time step 1
P_1 = Shut-in wellhead pressure at beginning of step 1 (psia)

A beginning pressure for time step 2 is then calculated from:

$$P_2 = \left(\frac{G_1 - Q_1}{G_1} \right) P_1$$

P_2 = Shut in wellhead pressure at beginning of step 2 (psia)
G_1 = Gas in place at beginning of step 1 (MMcf)

The production Q_2 is then calculated from:

$$Q_2 = C\,(P_2^2 - L^2)^r$$

Q_2 = Production (MMcf) during time step 2

☒ See Continuation Sheet

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PPX-59
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User Instructions

Program Title
GAS WELL DELIVERABILITY

Cale P	Cale C	Production	Restart	Changer LP

Partition (OP 17): 479 . 59*
Parenthesis Levels: 0
t Register ☐
Angular Mode (if applicable):
SBR Levels: 0
Absolute Addresses ☐
Library Module ID:
Disturbs Pending Operations ☐
* for TI-58 239.29

LABELS (Op 08)

INV	ln x	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	Ixl	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	Calculates pressure
B	Calculates coeff.
C	Calc. annual product.
D	Restart w/new line pres.
E	Enter new line pressure
A'	
B'	
C'	
D'	
E'	

FLAGS	0	1	2	3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS	OUTPUT/MODE (see legend below)
1	Enter program (fix 1, store time steps/year in 12)			
2	Initialize calc. of rem. pressure		A	1.0
3	Enter data	orig. gas in place	R/S	2.0
4	Enter data	cuml. prod.	R/S	3.0
5	Enter data. Read rem. pressure	orig. press.	R/S	Rem. press.
6	Initialize calc. of flow coeff.		B	1.0
7	Enter current shut-in pressure	SIP	R/S	2.0
8	Enter test flowing pressure	FP	R/S	3.0
9	Enter slope	Slope	R/S	4.0
10	Enter test flow rate	Flow rate	R/S	Flow coeff.
11	Initialize calc. of annual prod.		C	5.0
12	Enter slope	Slope	R/S	6.0
13	Enter rem. pressure	Rem. press.	R/S	7.0
14	Enter rem. gas in place	Rem. gas in place	R/S	8.0
15	Enter flow coefficient	coeff.	R/S	9.0
16	Enter pipeline pressure	P.L. press.	R/S	1st year prod.*
			R/S	2nd year prod.*
		(repeat pressing R/S for Additional years production)		

*Printed and Displayed

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

☐ See Continuation Sheet

DATA REGISTERS (INV)

0	*dsz
1	orig. gas in place
2	
3	
4	slope
5	remaining press.
6	rem. gas in place
7	05/06
8	
9	coefficient
10	(line pressure)^2
11	cuml. production
12	time steps/year
13	stored rem. press.
4	
5	
6	
7	
8	
9	

Program Title: GAS WELL DELIVERABILITY	Rev.

A new pressure P_3 is calculated from:

$$P_3 = \left\{ \frac{G_1-Q_1-Q_2}{G_1} \right\} P_1$$

Then $Q_3 = C\,(P_3^{\,2}-L^2)^n$

and $P_4 = \left\{ \frac{G_1-Q_1-Q_2-Q_3}{G_1} \right\} P_1$

etc.

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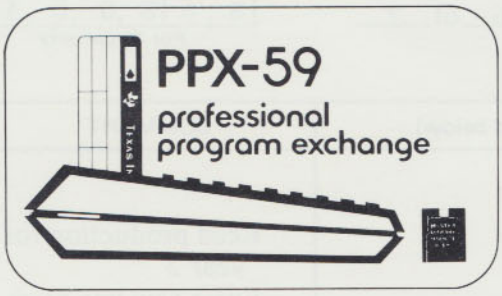

TEXAS INSTRUMENTS
Calculator Products Division

Sample Problem

Statement of Example

Calculate the future annual production for a gas well with the following characteristics: Original gas in place 1061 MMcf, cuml. prod. 605 MMcf, original wellhead shut-in pressure 850 psia, n value from back pressure curve .9. The well will now flow 410 Mcf per day against a pressure of 140 psia. Use a line pressure of 200 psia for the first 2 years, then 50 psia thereafter. Use 4 time steps per year.

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
fix decimal point at 1. Store 4 in 12 (time steps/year).			
	A	1.0	Initialize calc. of pressure.
1061	R/S	2.0	Enter orig. gas in place
605	R/S	3.0	Enter cuml. prod.
850	R/S	365.3	Enter orig. shut-in W.H. press. Display remaining pressure
	B	1.0	Initialize calc. of C.
365.3	R/S	2.0	Enter remaining W.H. pressure
140	R/S	3.0	Enter current test pressure
.9	R/S	4.0	Enter slope
410	R/S	4.2	Enter current test rate. Display C
	C	5.0	Initialize calc. of annual prod.
.9	R/S	6.0	Enter Slope
365.3	R/S	7.0	Enter rem. WH.Pres.
456	R/S	8.0	Enter rem. gas in place
4.2	R/S	9.0	Enter C
200	R/S	97.0*	Enter line pressure
*Displayed & Printed		Modes: (n)*—Printed only (n)—Displayed Briefly (Pause) n*—Printed and displayed	Read production for year 1

☐ Over

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Sample Problem (cont'd)

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ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
	R/S	49.5*	Read production for year 2
	E	1.0*	Enter new line press.
50	R/S	69.1*	Read production for year 3
	R/S	44.1*	Read production for year 4.
	R/S	30.2*	Read production for year 5.
	R/S	21.8*	Read production for year 6.
	R/S	16.3*	Read production for year 7.
	R/S	12.5*	Read production for year 8.
	etc.		
		(Flash indicates well is depleted)	

*Printed and Displayed.

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

PPX-59 Professional Program Exchange

8,6 8,0 0,5
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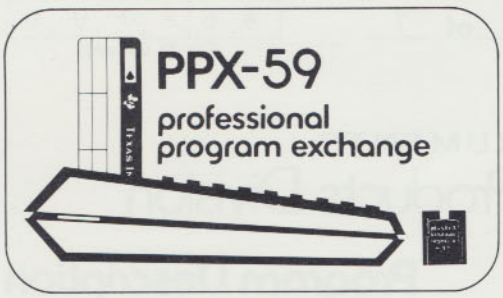
LOC	CODE	KEY	COMMENTS
000	76	LBL	
001	11	A	
002	01	1	
003	92	RTN	
004	42	STO	
005	01	01	
006	75	-	
007	02	2	
008	92	RTN	
009	95	=	
010	55	÷	
011	43	RCL	
012	01	01	
013	65	×	
014	03	3	
015	92	RTN	
016	95	=	
017	92	RTN	
018	61	GTO	
019	11	A	
020	76	LBL	
021	12	B	
022	01	1	
023	92	RTN	
024	33	X²	
025	75	-	
026	02	2	
027	92	RTN	
028	33	X²	
029	95	=	
030	45	Y^X	
031	03	3	
032	92	RTN	
033	95	=	
034	35	1/X	
035	65	×	
036	04	4	
037	92	RTN	
038	65	×	
039	03	3	
040	06	6	
041	05	5	
042	95	=	
043	92	RTN	
044	61	GTO	
045	12	B	
046	76	LBL	
047	13	C	
048	43	RCL	
049	12	12	
050	42	STO	
051	00	00	
052	05	5	
053	92	RTN	
054	42	STO	
055	04	04	
056	06	6	
057	92	RTN	
058	42	STO	
059	05	05	
060	42	STO	
061	13	13	
062	07	7	
063	92	RTN	
064	42	STO	
065	06	06	
066	35	1/X	
067	65	×	
068	43	RCL	
069	05	05	
070	95	=	
071	42	STO	
072	07	07	
073	08	8	
074	92	RTN	
075	65	×	
076	93	.	
077	00	0	
078	00	0	
079	01	1	
080	55	÷	
081	43	RCL	
082	12	12	
083	95	=	
084	42	STO	
085	09	09	
086	09	9	
087	92	RTN	
088	33	X²	
089	42	STO	
090	10	10	
091	00	0	
092	42	STO	
093	11	11	
094	76	LBL	
095	38	SIN	
096	43	RCL	
097	05	05	
098	33	X²	
099	75	-	
100	43	RCL	
101	10	10	
102	95	=	
103	45	Y^X	
104	43	RCL	
105	04	04	
106	65	×	
107	43	RCL	
108	09	09	
109	95	=	
110	44	SUM	
111	11	11	
112	65	×	
113	43	RCL	
114	07	07	
115	95	=	
116	94	+/-	
117	44	SUM	
118	05	05	
119	97	DSZ	
120	00	00	
121	38	SIN	
122	43	RCL	
123	12	12	
124	42	STO	
125	00	00	
126	00	0	
127	48	EXC	
128	11	11	
129	99	PRT	
130	92	RTN	
131	61	GTO	
132	38	SIN	
133	76	LBL	
134	14	D	
135	43	RCL	
136	13	13	
137	42	STO	
138	05	05	
139	76	LBL	
140	15	E	
141	01	1	
142	92	RTN	
143	33	X²	
144	42	STO	
145	10	10	
146	61	GTO	
147	38	SIN	

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	Rev.
OIL RESERVE ESTIMATE CONSTANT PERCENTAGE DECLINE (Exponential Decline)	

Abstract of Program

Given the initial rate of production, the estimated annual percentage decline, and the economic limit, the program can be used to compute the future rate of production and cumulative production as a function of time. It also calculates the remaining reserves.

When the economic limit is reached, the program assumes production will be halted and will indicate when (months and fraction thereof) this limit is reached and give the outputs for that fractional part of an interval.

Display will flash when the economic limit is reached.

User Benefits:

Predicts the future performance of an oil well or oil lease and computes the remaining reserves.

Category Name	Required Progs.	Prog. Steps	Card Sides	PC-100A Needed / Library Module ID
O/G/E		159	1	☐ / ☐

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Name Texas Instruments Tel. No. _____

Address _____

City _____ State _____ Zip _____

Submission Checklist

- ☒ Recorded Magnetic Cards
- ☒ Submission Abstract
- ☒ Program Description
- ☒ User Instructions
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- ☐ _____
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TEXAS INSTRUMENTS
Calculator Products Division

Program Description

Program Title: OIL RESERVE ESTIMATE CONSTANT PERCENTAGE DECLINE (Exponential Decline)	Rev.

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

Equations Used:

Symbol	Description	Units
P_I	Initial Production Rate	Barrels/Mo.
P_t	Production at Time t	Barrels/Mo.
t	Time Interval	Months
E_L	Economic Limit	Barrels/Mo.
N_P	Cumulative Production for t	Barrels
ΣN_P	Total Cumulative Production	Barrels
APD	Annual Percentage Decline	%
R_D	Decline Rate	%/Mo. (As Dec.)

(1) $$P_t = P_I \times e^{-R_D t}$$

(2) $$N_P = \frac{P_I - P_t}{R_D}$$

(3) $$t = \frac{\ln (\frac{P_I}{P_t})}{R_D}$$

(4) $$R_D = \frac{1}{12} \ln (\frac{1}{1 - .01\ APD})$$

☐ See Continuation Sheet

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

Program Title:	OIL RESERVE ESTIMATE CONSTANT PERCENTAGE DECLINE (Exponential Decline)	Rev.

FLOW DIAGRAM

INPUTS & OUTPUTS

LBL E'
INITIALIZE
CLR
CMs

LBL A' (INPUT)
STORE P_I

LBL B' (INPUT APD
CALCULATE & STORE
R_D

LBL C' (INPUT)
STORE E_L

LBL D' (INPUT)
STORE t

LBL A
RCL P_F (09)

LBL B
RCL N_P (07)

LBL C
RCL ΣN_P (08)

LBL D
RCL Σt (05)

CALCULATIONS

LBL E (CALCULATE

$P_F = P_I \times e^{-R_D t}$ *
STO P_F (06)(09)

$- E_L =$

INV
if pos

<0

≥0

$N_P = \frac{P_I - P_F}{R_D}$ **
STO N_P (07)
SUM N_P (08)

RCL t (04)
SUM t (05)

RCL P_F (06)
STO P_F (01) AS P_I

RCL Σt (05)

rtn

RCL E_L (03)
STO E_L (06) AS P_F

$t = \frac{\left(\ln \frac{P_I}{E_L}\right)}{R_D}$

STO t (04)
SUM t (05)

$P_F = P_I \times e^{-R_D t}$ *
STO P_F (06)(09)

$N_P = \frac{P_I - E_L}{R_D}$ **
STO N_P (07)
SUM N_P (08)

ERROR INDICATION TO
SHOW E_L WAS
REACHED

rtn

* SUBROUTINE IFFG
** SUBROUTINE D.MS

8 6 8 0 0 6

PPX-59
professional program exchange

User Instructions

Program Title OIL RESERVE ESTIMATE
CONSTANT PERCENTAGE DECLINE

P_I	APD	E_L	t	Initialize
P_F	N_P	ΣN_P	Σt	Calculate

Partition (OP 17): 479 . 59 *
Parenthesis Levels: 1
Angular Mode (if applicable):
SBR Levels: 1
Library Module ID:
t Register ☐
Absolute Addresses ☑
Disturbs Pending Operations ☑

* for TI-58 239.29

LABELS (Op 08)

INV	ln x	CE	CLR	x:t	x^2
$\sqrt{x}$	1/x	STO	RCL	SUM	y^x
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+	$\bar{x}$	Grad	St flg
If flg	D.MS	π	List	Write	Dsz
Adv	Prt				

USER DEFINED KEYS

A	(P_F) End of interval production rate
B	(N_P) Interval Produc.
C	(ΣN_P) Cum. Produc.
D	(Σt) Months from Initial Produc.
E	Press to Calculate
A'	(P_I) Initial Prod. Rte
B'	(APD) Anl. Deci. %
C'	(E_L) Economic Limit
D'	(t) Time Interval to be evaluated
E'	Press to Initialize

FLAGS	0	1	2	3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS	OUTPUT/MODE (see legend below)
1	Read Magnetic Card (Sides A & B)			
2	Initialize		2nd E'	0.
3	Enter Initial Production Rate	P_I (Brl/Mo.)	2nd A'	P_I (Brl/Mo.)
4	Enter Annual Decline Rate %	APD (%)	2nd B'	R_D (Dec./Mo.)
5	Enter Economic Limit	E_L (Brl/Mo.)	2nd C'	E_L (Brl/Mo.)
6	Enter time interval each calculation	t (Mo.)	2nd D'	t (Mo.)
	Steps 3, 4, 5, & 6 may be entered in any order			
7	Calculate		E	Σ t (Mo.)
8	Determine production rate at end of interval		A	P_F (Brl/Mo.)
9	Determine production during interval		B	N_P (Brl)
10	Determine Cum. Production		C	ΣN_P (Brl)
11	Redisplay Cum. Time		D	Σt (Mo.)
	Steps 8, 9, 10 & 11 may be pressed in any order after Step 7 is performed			
12	Repeat Steps 7 thru 11 for each additional interval desired. Flashing display indicates economic limit reached. Press CE to stop flashing.			

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

DATA REGISTERS (INV List)

0		
1	P_I	(Barrels/Mo.)
2	R_D	(Dec./Mo)
3	E_L	(Barrels/Mo.)
4	t	(mo.)
5	Σt	(mo.)
6	P_F	(Barrels/Mo.)
7	N_P	(Barrels)
8	ΣN_P	(Barrels)
9	P_F	(Barrels/Mo.)
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		

☐ See Continuation Sheet

TEXAS INSTRUMENTS
Calculator Products Division

Sample Problem

Statement of Example

An oil lease has an initial production rate (P_I) of 1000 B/Mo. Annual Production decline is estimated to be 30% and the economic limit to be 120 B/Mo. Compute the production rate at the end of each 12 month period until the economic limit is reached. Find: (1) the production rate at the end of each interval (P_t), (2) the cumulative production during the interval (N_P), (3) the total cumulative production up to the end of the interval (ΣN_P), and (4) when the economic limit is reached.

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
	2nd E'	0.	Initialize
1000	2nd A'	1000.	Input P_I
30	2nd B'	.029722912	Input APD & Display R_D (as decimal)
120	2nd C'	120.	Input E_L
12	2nd D'	12.	Input t
	E	12.	Σt
	A	700.	P_t
	B	10093.	N_P — 1st Interval
	C	10093.	ΣN_P
	E	24.	Σt
	A	490.	P_t
	B	7065.	N_P — 2nd Interval
	C	17158.	ΣN_P
	E	36.	Σt
	A	343.	P_t
	B	4946.	N_P — 3rd Interval
	C	22104.	ΣN_P

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

☒ Over

PPX-59 Professional Program Exchange
Sample Problem (cont'd)

8,6|8,0,0,6
For TI use only

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
	E	48.	Σt
	A	240.	P_t
	B	3462.	N_P
	C	25566.	ΣN_P
	E	60.	Σt
	A	168.	P_t
	B	2423.	N_P
	C	27990.	ΣN_P
	E	71. (Flashing)	Economic Limit is Reached
	CE	7.	Stablize Display
	A	120.	P_t
	B	1617.	N_P
	C	29607	ΣN_P

4th Interval

5th Interval

NOTE: D can be pressed to redisplay Σt during any of above intervals.

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

PPX-59 Professional Program Exchange

8,6,8,0,0,6
For TI use only

LOC	CODE	KEY	COMMENTS
000	76	LBL	
001	10	E'	
002	58	FIX	
003	09	09	
004	25	CLR	
005	47	CMS	
006	92	RTN	
007	76	LBL	
008	16	A'	
009	42	STO	
010	01	01	
011	92	RTN	
012	76	LBL	
013	17	B'	
014	65	×	
015	93	.	
016	00	0	
017	01	1	
018	75	-	
019	01	1	
020	95	=	
021	35	1/X	
022	94	+/-	
023	23	LNX	
024	55	÷	
025	01	1	
026	02	2	
027	95	=	
028	42	STO	
029	02	02	
030	92	RTN	
031	76	LBL	
032	18	C'	
033	42	STO	
034	03	03	
035	92	RTN	
036	76	LBL	
037	19	D'	
038	42	STO	
039	04	04	
040	92	RTN	
041	76	LBL	
042	15	E	
043	58	FIX	
044	00	00	
045	71	SBR	
046	87	IFF	
047	75	-	
048	43	RCL	
049	03	03	
050	95	=	
051	29	CP	
052	22	INV	
053	77	GE	
054	00	00	
055	71	71	
056	43	RCL	
057	06	06	
058	71	SBR	
059	88	DMS	
060	43	RCL	
061	04	04	
062	44	SUM	
063	05	05	
064	43	RCL	
065	06	06	
066	42	STO	
067	01	01	
068	43	RCL	
069	05	05	
070	92	RTN	
071	43	RCL	
072	03	03	
073	42	STO	
074	06	06	
075	53	(	
076	43	RCL	
077	01	01	
078	55	÷	
079	43	RCL	
080	06	06	
081	54	)	
082	23	LNX	
083	55	÷	
084	43	RCL	
085	02	02	
086	95	=	
087	42	STO	
088	04	04	
089	44	SUM	
090	05	05	
091	71	SBR	
092	87	IFF	
093	71	SBR	
094	88	DMS	
095	43	RCL	
096	05	05	
097	33	X^2	
098	94	+/-	
099	34	$\sqrt{X}$	
100	92	RTN	
101	76	LBL	
102	87	IFF	
103	43	RCL	
104	01	01	
105	65	×	
106	53	(	
107	43	RCL	
108	02	02	
109	94	+/-	
110	65	×	
111	43	RCL	
112	04	04	
113	54	)	
114	22	INV	
115	23	LNX	
116	95	=	
117	42	STO	
118	06	06	
119	42	STO	
120	09	09	
121	92	RTN	
122	76	LBL	
123	88	DMS	
124	53	(	
125	94	+/-	
126	85	+	
127	43	RCL	
128	01	01	
129	54	)	
130	55	÷	
131	43	RCL	
132	02	02	
133	95	=	
134	42	STO	
135	07	07	
136	44	SUM	
137	08	08	
138	92	RTN	
139	76	LBL	
140	11	A	
141	43	RCL	
142	09	09	
143	92	RTN	
144	76	LBL	
145	12	B	
146	43	RCL	
147	07	07	
148	92	RTN	
149	76	LBL	
150	13	C	
151	43	RCL	
152	08	08	
153	92	RTN	
154	76	LBL	
155	14	D	
156	43	RCL	
157	05	05	
158	92	RTN	

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

OIL/GAS/ENERGY

- **WELL LOG INTERPRETATION**
  Calculates formation water resistivity, ppm, porosity, and water saturation for a formation using the SP and induction log and a sonic or density porosity log.
  TI-58 or TI-59.

- **RAPID GAS RESERVE ESTIMATE**
  Recoverable reserves of natural gas per acre foot of bulk reservoir volume are calculated.
  TI-58 or TI-59.

- **COMPRESSIBILITY FACTORS FOR SWEET NATURAL GASES**
  Given gas specific gravity, temperature, and pressure, the compressibility factor is calculated.
  TI-58 or TI-59.

- **PRODUCTION SCHEDULE FOR EXPONENTIALLY DECLINING OIL WELLS**
  Calculates decline rate and economic life of reserves.
  TI-58 or TI-59.

- **GAS WELL DELIVERABILITY**
  Given shut in pressure, gas in place, slope from back pressure curve and producing characteristics of a gas well, future annual production values are calculated.
  TI-58 or TI-59.

- **OIL RESERVE ESTIMATE CONSTANT PERCENTAGE DECLINE**
  Given the initial rate of production, the estimated annual percentage decline, and the economic limit, this program calculates the future rate of production and cumulative production as a function of time.
  TI-58 or TI-59.

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

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