

APPENDIX F
CALCULATOR PROGRAMS

calculator programs in Appendix F may be used to rate collectors which first order thermal performance equations are available. Appropriate monthly pool temperatures, (T_i), ambient temperatures (T_a) and insolation rates for specific months and locations may be entered in programs as indicated and non-standard day ratings similar to FSEC standard day ratings calculated. If wind speed corrections are called for the slope term may be multiplied by the following factors before being entered

<u>Wind Speed Over Collector Surface</u> (mph)	<u>2nd Term Multiplier</u>
10	1.18
15	1.61
	2.04

Program "A" for the HP 15 C is basically identical to that which FSEC uses to rate collectors for standard Florida day conditions except that it makes use of first order rather than second order thermal performance equations. The shorter "looped" programs yield results which are within one percent or so of the longer version. They require slightly longer running time on the calculators but are far easier to enter and de-bug.

The following entries and outputs will allow de-bugging of the programs

INPUTS		<u>OUTPUTS (Btu/ft²·day)</u>	
	<u>TI</u>		
R ₁ = 66*	LBL A 66	HP 15 C Program "A"	502.86
80	LBL B 80		
1112	LBL C 1112	HP 15 C Program "B"	501.63
= 3.6*	LBL D 3.6		
= .81	LBL E .81	HP 11 C Program	501.63
R ₆ = 6			
R ₇ = .01**		HP 55 Program	501.63
R ₈ = 0		TI 59 Program	501.63
R ₉ = 0			Δ = .2%
R ₀ = 0			
R ₁ = 0			

* (-66) For HP 55 program
 ** (1) For HP 55 program

SOLAR POOL HEATER SIZING PROGRAM "A"

FOR HP 15 C

BY

Doug Root, FSEC Educational Consultant

TO LOAD PROGRAM A (IN PROGRAM MODE) 228 STEPS

000	g P/R	031-33	.03	064	RCL R ₈
001	F LBL A	034	x	065	x
002	RCL R ₁	035	STO R ₈	066	g Test 1
003	CHS	036	÷	067	STO + R ₉
004	6	037	RCL R ₄	068	RCL R ₁
005	+	038	x	069	CHS
006	RCL R ₂	039	CHS	070	2
007	+	040	RCL R ₅	071	+
008	RCL R ₃	041	+	072	RCL R ₂
009-11	.01	042	RCL R ₈	073	+
012	x	043	x	074	RCL R ₃
013	STO R ₈	044	g Test 1	075-77	.07
014	÷	045	STO + R ₉	078	x
015	RCL R ₄	046	RCL R ₁	079	STO R ₈
016	x	047	CHS	080	÷
017	CHS	048	4	081	RCL R ₄
018	RCL R ₅	049	+	082	x
019	+	050	RCL R ₂	083	CHS
020	RCL R ₈	051	+	084	RCL R ₅
021	x	052	RCL R ₃	085	+
022	g Test 1	053-55	.05	086	RCL R ₈
023	STO R ₉	056	x	087	x
024	RCL R ₁	057	STO R ₈	088	g Test 1
025	CHS	058	÷	089	STO + R ₉
026	4	059	RCL R ₄	090	RCL R ₁
027	+	060	x	091	CHS
028	RCL R ₂	061	CHS	092	RCL R ₂
029	+	062	RCL R ₅	093	+
030	RCL R ₃	063	+	094	RCL R ₃

.095-97	09	135.	+	175.	CHS
.098	x	136.	RCL R ₃	176.	3
.099	STC R ₈	137-39.	.13	177.	
100.	÷	140.	x	178.	RCL R ₂
101.	RCI R ₄	141.	STO R ₈	179.	+
102.	x	142.	÷	180.	RCL R ₃
103.	CHS	143.	RCL R ₄	181-183.	.17
104.	RCI R ₅	144.	x	184.	x
105.	+	145.	CHS	185.	STO R ₈
106.	RCI R ₈	146.	RCL R ₅	186.	÷
107.	x	147.	+	187.	RCL R ₄
108.	g Test 1	148.	RCL R ₈	188.	x
109.	STO + R ₉	149.	x	189.	CHS
110.	RCL R ₁	150.	g Test 1	190.	RCL R ₅
111.	CHS	151.	STO + R ₉	191.	+
112.	RCI R ₂	152.	RCL R ₁	192.	RCL R ₈
113.	+	153.	CHS	193.	x
114.	RCI R ₃	154.	3	194.	g Test 1
115-17.	.11	155.		195.	STO + R ₉
118.	x	156.	RCL R ₂	196.	RCL R ₁
119.	STC R ₈	157.	+	197.	CHS
120.	÷	158.	RCL R ₃	198.	5
121.	RCI R ₄	159-61.	.15	199.	
122.	x	162.	x	200.	RCL R ₂
123.	CHS	163.	STO R ₈	201.	+
124.	RCI R ₅	164.	÷	202.	RCL R ₃
125.	+	165.	RCL R ₄	203-205.	.19
126.	RCI R ₈	166.	x	206.	x
127.	x	167.	CHS	207.	STOR ₈
128.	g Test 1	168.	RCL R ₅	208.	÷
129.	STO + R ₉	169.	+	209.	RCL R ₄
130.	RCL R ₁	170.	RCL R ₈	210.	x
131.	CHS	171.	x	211.	CHS
132.	1	172.	g Test 1	212.	RCL R ₅
133.		173.	STO + R ₉	213.	
134.	RCL R ₂	174.	RCL R ₁	214.	RCL R ₈

215. x
 216. g Test 1
 217. STO + R₉
 218. 6
 219. STO R₆
 220-22 .01
 223 STO R₇
 224 RCL R₉
 225 0
 226 STO R₉
 227 R
 228 g RTN

TO RUN PROGRAM "A" (20 sec.)

<u>REGISTER</u>	<u>KEY IN</u>
1	Ambient Temp. (°F)
2	Pool Temp. (°F)
3	Solar Intensity (Btu/ft ² day)
4	1st order slope term (positive value)
5	1st order intercept term
9	0
f A	Runs Program

NOTE: After the first run, the registers do not need to be rekeyed except for desired changes. Program "A" automatically clears the accumulating memory (register 9) and the contents of registers 1-5 are not altered by the running of the program.

SOLAR POOL HEATER SIZING PROGRAM "B"

FOR HP 15 C

BY

Doug Root, FSEC Educational Consultant

TO LOAD PROGRAM B (IN PROGRAM MODE) 46 Steps

001	f LBL B	032-3	.2
002	RCL R ₁	034	g TEST 7
003	CHS	035	GTO f B
004	RCL R ₆	036	6
005	+	037	STO R ₆
006	RCL R ₂	038-40	.01
007	+	041	STO R ₇
008	RCL R ₃	042	RCL R ₀
009	RCL R ₇	043	0
010	x	044	STO R ₀
011	STO R ₈	045	R+
012	÷	046	g RTN

TO RUN PROGRAM "B" (35 Sec.)

	<u>REGISTER</u>	KEY IN
015	CHS	1 Ambient Temp. (°F)
016	RCL R ₅	2 Pool Temp. (°F)
017	+	3 Solar Intensity
018	RCL R ₈	(Btu/Ft ² ·day)
019	x	4 1 st order slope term
020	g TEST :	(Positive value)
021	STO + R ₆	5 1 st order intercept term
022-5	1.23	6 6
026	STO - R ₆	7 .01
027-9	.02	8 0
030	STO + R ₇	0 0
031	RCL R ₇	f B Runs Program

NOTE: After the first run it is not necessary to rekey the registers unless changes are desired in weather data or collector performance data. The program automatically resets the register inputs. If registers are manually cleared, reinput data.

SOLAR POOL HEATER SIZING PROGRAM

FOR HP 11 C

BY

Doug Root and Jim Huggins, FSEC

TO LOAD PROGRAM (IN PROGRAM MODE) 47 Steps

001	f LBL A	032-33	.2
002	RCL R	034	X Y (X ↔ Y)
003	CHS	035	X ≤ Y
00	4RCL I ₆	036	GTO f A
005	+	037	6
006	RCL R ₆	038	STO R ₆
007	+	039-41	
008	RCL R	042	STO R ₇
009	RCL R	043	RCL R ₉
010	x	044	0
011	STO R	045	STO R ₉
012	÷	046	R+
013	RCL R	047	g RTN
014	x		TO RUN PROGRAM (36 sec.)
015	CHS		<u>REGISTER</u> <u>ENTER</u>
016	RCL R	R ₁	Ambient Temp. (°F)
017	+	R ₂	Pool Temp. (°F)
018	RCL R	R ₃	Insolation Rate
019	x	R ₄	Slope Term (Positive Value)
020	X > 0	R ₅	Intercept Term
021	STO + R ₉	R ₆	6
022-25	1.23	R ₇	.01
026	STO - R ₆	R ₈	0
027-29	.02	R ₉	0
030	STO + R ₇		
031	RCL R		

NOTE: After the first run it is not necessary to rekey the registers unless changes are desired in weather data or collector performance data. The program automatically resets the register inputs. If the registers are manually cleared, reinput data.

SOLAR POOL HEATER SIZING PROGRAM

FOR HP 55

Doug Root, FSEC Educational Consultant

TO LOAD PROGRAM (IN PROGRAM MODE) 49 STEPS

001	RCL	031	RCL
002	R ₁	032	R ₉
003	RCL	033	STO
004	R ₆	034	
005	+	035	R ₆
006	RCL	036	2
007	R ₂	037	STO
008	+	038	+
009	RCL	039	R ₇
010	R ₃	040	RCL
011	RCL	041	R ₇
012	R ₇	042	2
013	x	043	0
014	STO	044	X ↔ Y
015	R ₈	045	f
16	÷	046	X ≤ Y
017	RCL	047	RCL
018	R ₄	048	.
019	x	049	1
020	RCL		
021	R ₅		
022	+		
023	RCL		
024	R ₈		
025	x		
026	0		
027	X ↔ Y		
028	f		
029	X ≤ 1 31		
030	Σ +		

<u>REGISTER</u>	<u>KEY IN</u>
1	(-) Ambient Temp. (°F)
2	Pool Temp. (°F)
3	Solar Intensity ÷ 100 (Btu/ft ² · day)
4	(-) 1st order slope term
5	1st order intercept term
6	6
7	1
8	0
9	1.23
.1	0

R/S RUNS PROGRAM

NOTE: After each run values for registers 6-9 and R₁ must be reentered.

SOLAR POOL HEATER SIZING PROGRAM

FOR TI-59

Doug Root and Mukesh Khattar, FSEC

TO LOAD PROGRAM (IN PROGRAM MODE) 107 STEPS

000	76 LBL	031	00 0	062	65 X
001	11 A	032	01 1	063	43 RCL
002	42 STO	033	42 STO	064	04 04
003	01 01	034	07 07	065	95 =
004	91 R/S	035	00 0	066	94 +/-
005	76 LBL	036	42 STO	067	85 +
006	12 B	037	08 08	068	43 RCL
007	42 STO	038	42 STO	069	08 08
008	02 02	039	09 09	070	95 =
009	91 R/S	040	76 LBL	071	29 CP
010	76 LBL	041	17 B'	072	32 X ↔ T
011	13 C	042	43 RCL	073	77 GE
012	42 STO	043	07 07	074	18 C'
013	03 03	044	65 X	075	32 X ↔ T
014	91 R/S	045	43 RCL	076	44 SUM
015	76 LBL	046	03 03	077	09 09
016	14 D	047	65 X	078	76 LBL
017	42 STO	048	43 RCL	079	18 C'
018	04 04	049	05 05	080	43 RCL
019	91 R/S	050	95 =	081	06 06
020	76 LBL	051	42 STO	082	75 -
021	15 E	052	08 08	083	01 1
022	42 STO	053	43 RCL	084	93 .
023	05 05	054	02 02	085	02 2
024	91 R/S	055	85 +	086	03 3
025	76 LBL	056	43 RCL	087	95 =
026	16 A'	057	06 06	088	42 STO
027	06 6	058	75 -	089	06 06
028	42 STO	059	43 RCL	090	43 RCL
029	06 06	060	01 01	091	07 07
030	93 .	061	95 =	092	85 +

093	93 .	101	93 .
094	00 0	102	02 2
095	02 2	103	77 GE
096	95 =	104	17 B'
097	42 STO	105	43 RCL
098	07 07	106	09 09
099	29 CP	107	91 R/S
100	32 X ↔ T		

LABELS

KEY IN

Label A	Ambient Air Temperature, T_a (°F)
Label B	Pool WaterTemp., T_p (°F)
Label C	Insolation Rate H (Btu/ft ² · day)
Label D	Slope, $F_R U_L$ (Btu/ft ² · °F)
Label E	Intercept, $F_R(\tau\alpha)_n$

Press Label A' to run the program. To rerun the program with new values you need to input only those values which change and press Label A'

MATHEMATICAL EQUATION

$$\text{OUTPUT} = \sum_{n=1}^9 [H(.01 + n*.02) F_R(\tau\alpha)_n - F_R U_L (T_p + 6 - 1.23*n - T_a)]^+$$

The superscript + indicates that only positive values are included in the summation.

COMPUTER PROGRAMING DATA

The meth
set out in Fortran by Dr. Magdy Girgis and is available upon request to solar designers, installation contractors and other interested parties who have purchased "Designing and Installing Commercial Solar Pool Heating Systems." Please send your requests along with a photocopy of the title page of this document to:

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