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**TASK COMPLETION REPORT
FOR UPDATE ZERORGH**

by

Robert G. Steinke

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TASK COMPLETION REPORT FOR UPDATE ZERORGH

Robert G. Steinke

ABSTRACT

Update ZERORGH programs the Namelist-variable multiplier FRGH to the $\rho \cdot g \cdot h$ gravity-head term in all motion equations of TRAC-P Version 5.4.28.

1.0. INTRODUCTION

The one-dimensional (1D) hydraulic and three-dimensional (3D) VESSEL components in TRAC-P have in their motion (momentum) equations a $\rho \cdot g \cdot h$ gravity-head term where ρ is the fluid phasic density, g is the acceleration-of-gravity constant (9.80665 m s^{-2} , $32.17405 \text{ ft s}^{-2}$), and h is the vertical elevation. Knolls Atomic Power Laboratory requested the capability to apply a Namelist-variable multiplier to the $\rho \cdot g \cdot h$ gravity-head term in all motion equations of TRAC-P. The default value of this multiplier would be unity. Inputting zero would eliminate the effect of the $\rho \cdot g \cdot h$ gravity-head term in the motion equations.

2.0. UPDATE ZERORGH

Update ZERORGH and LABPRG input-data file LABRGH, a listing of which is shown in Appendix A, programs the FRGH multiplier to the $\rho \cdot g \cdot h$ gravity-head term in all motion equations of TRAC-P. This is done for the 1D hydraulic components in subroutines FEMOM and TF1DS1 and for the 3D VESSEL component in subroutines FEMOMX, FEMOMY, FEMOMZ, and TF3DS1. Namelist variable FRGH is defined to Namelist data group INOPTS for input in subroutine INPUT, saved in common block CONTRL, initialized to 1.0 in subroutine BLKDAT, and checked that its input value lies in the range of -1000.0 to 1000.0 in subroutine NAMLST.

3.0. TESTING

Update ZERORGH, with other pending updates in TRAC-P Version 5.4.28, was tested with six modified cases of the ZIONPWR standard test problem. ZIONPWR is a vertically oriented flow channel modeled by single FILL, PUMP, 1D VESSEL, VALVE, and BREAK components in series with ROD and SLAB HTSTR components providing heat-transfer coupling to the 1D VESSEL component. Results of that testing are shown in Appendix B. Cases 1 and 2 define FRGH = 1.0 by its internal default value and by Namelist input, respectively. The solution results of both calculations were identical, as expected. Case 3 defines FRGH = 0.0 by

Namelist input, and Case 4 defined the PUMP- and VALVE-component $GRAV = 0.0$ and VESSEL-component $GZC = 0.0$. Both of these cases effectively zero out the $\rho \cdot g \cdot h$ gravity-head term in all motion equations. This orients the flow channel horizontally. Comparing their TRCOUT files showed only differences caused by the output echo of their different input-variable values. The solution results of cases 3 and 4 were identical, as expected. Cases 5 and 6 are similar in form to cases 3 and 4, respectively, except that in case 5, $FRGH = 0.6$; and in case 6, $GRAV = 0.6$ and $GZC = -0.6$. This corresponds to the flow channel being oriented 36.87° from horizontal. Again, TRCOUT-file differences were caused by the output echo of their different input-variable values, and the solution results were identical except for one slight difference. Control blocks -12 and -312 had values that differed by 1 in the seventh significant digit of the seventh large edit (of 9 large edits). Different arithmetic operations evaluating the $\rho \cdot g \cdot h$ gravity-head term and computer-storage format round-off are felt to be the cause of this isolated difference in solution output values.

These six cases evaluate the use of Namelist variable $FRGH$ or the $GRAV$ and GZC variables to orient the ZIONPWR flow channel vertical, horizontal, or 36.87° from horizontal. Both the $FRGH$ value as a multiplier (and $FRGH = 1.0$ and its multiplier value incorporated directly into the $GRAV$ and GZC factors of the $\rho \cdot g \cdot h$ gravity-head term of the motion equations) were shown to give the expected identical solutions for three different orientations of the ZIONPWR flow channel.

4.0. CONCLUSIONS

Update ZERORGH and its LABPRG input-data file LABRGH program TRAC-P Version 5.4.28 to apply the new Namelist-variable multiplier $FRGH$ to the $\rho \cdot g \cdot h$ gravity-head term in all motion (momentum) equations. Vertical, horizontal, and 36.87° from horizontal orientations of the ZIONPWR standard test problem were tested. Defining these orientations to $FRGH$ or directly to $GRAV$ or GZC gave identical solutions in each of the three cases.

ACKNOWLEDGMENT

The author wishes to thank Richard J. Smith for valuable discussions during the development and testing of this TRAC-P update.

Appendix A

Listing of LABPRG Input-Data File LABRGH and Update ZERORGH

File LABRGH

```

1  0  0  1  labnew data required by update zerorgh
2  frgh      lunounit
3  0  0  0  labnew data end

```

File ZERORGH

```

1  *ident zerorgh
2  */ -----Update Header Rev. 02-01-96-----
3  */
4  */   File & Update Ident name (must be the same): zerorgh
5  */   TSHOOTER identifier:
6  */
7  */   Code developer: Bob Steinke           Date developed: 7/28/97
8  */   Acknowledgements: KAPL requested a multiplier for the RGH term
9  */   Update reviewer: Rich Smith           Date reviewed: 8/xx/97
10 */
11 */   Update to be applied to MOD2 _X_ or other :
12 */
13 */   CFS file path: /073417
14 */
15 */   Purpose of update: Update zerorgh (ZERO the RGH term) defines
16 */                        a new Namelist variable FRGH that is
17 */                        applied as a multiplier to the gravity-head
18 */                        RGH term in all motion equations evaluated
19 */                        by TRAC-P. The FRGH default value is 1.0.
20 */                        |FRGH|.LE.1000.0 constrains its user-
21 */                        defined input value.
22 */
23 */   Basis for update: Allows the TRAC-P user to apply a FRGH
24 */                        multiplier to the gravity-head term in all
25 */                        the motion equations evaluated by TRAC-P.
26 */                        FRGH=0.0 eliminates the gravity-head term
27 */                        from the motions equations.
28 */
29 */   Dependencies on other updates: none
30 */
31 */   Justification of non-ANSI coding: N.A.
32 */
33 */   Is this a NULL update? YES _X_ NO ____
34 */
35 */   Does this update generate new unit labels? YES_X_ NO ____
36 */   If yes, path and /name of LABNEW file: /073417/labrgH
37 */
38 */   Does the TRAC I/O change because of this update? YES _X_ NO ____
39 */   TRAC I/O includes input, dump, output, and graphics files. If
40 */   yes, then submit the necessary manual changes.
41 */
42 */   New Namelist variable FRGH needs the following format description
43 */   defined on page 6-8 in Chapter 6 of the TRAC User's Guide:
44 */
45 */   FRGH      -1000.0      Multiplier applied to the gravity-      1.0
46 */                        to 1000.0      head term in all motion equations
47 */
48 */   Does this change require that any of the TRAC support codes, e.g.

```

```

49 */      EXTRACT, GOCNVRT, or EXCON, be changed?  YES ___ NO _X_
50 */      If yes, then include a description of the necessary changes.
51 */      This description will be passed onto the custodian of the TRAC
52 */      support codes.
53 */
54 */      Does the TRAC User's Guide, Theory Manual, or Programmer's Guide
55 */      change because of this update?  YES _X_ NO ___
56 */      If yes, then submit the necessary manual changes.
57 */
58 */      See FRGH format description above for the TRAC User's Guide.
59 */
60 */      NAME OF
61 */      SUBROUTINE
62 */      OR COMDECK
63 */      CHANGED      DESCRIPTION OF CHANGE
64 */
65 */      CONTRLLR      Stores Namelist variable FRGH in common block CONTRL.
66 */      BLKDAT        Initializes Namelist variable FRGH=1.0.
67 */      FEMOM         Applies the Namelist variable multiplier FRGH to the
68 */                   gravity-head term in the motion equation of 1D
69 */                   hydraulic components during the prep stage.
70 */      FEMOMX        Applies the Namelist variable multiplier FRGH to the
71 */                   gravity-head term in the xr-direction motion
72 */                   equation of the VESSEL component during the prep
73 */                   stage.
74 */      FEMOMY        Applies the Namelist variable multiplier FRGH to the
75 */                   gravity-head term in the yt-direction motion
76 */                   equation of the VESSEL component during the prep
77 */                   stage.
78 */      FEMOMZ        Applies the Namelist variable multiplier FRGH to the
79 */                   gravity-head term in the z-direction motion
80 */                   equation of the VESSEL component during the prep
81 */                   stage.
82 */      INPUT         Defines and echoes to output Namelist variable FRGH.
83 */      NAMLST        Tests that Namelist variable FRGH lies in the value
84 */                   range from -1000.0 to 1000.0.
85 */      TF1DS1        Applies the Namelist variable multiplier FRGH to the
86 */                   gravity-head term in the motion equation of 1D
87 */                   hydraulic components during the outer stage.
88 */      TF3DS1        Applies the Namelist variable multiplier FRGH to the
89 */                   gravity-head term in all three direction motion
90 */                   equations of the VESSEL component during the
91 */                   outer stage.
92 */
93 */      -----
94 */
95 */      comdeck contrllr changes
96 */      *delete upencyl.4                                contrllr
97 */          * ercemx,epss ,etime ,frgh ,htlosi,htloso,
98 */
99 */      subroutine blkdat changes
100 */      *delete fixfr.1                                blkdat
101 */          data alp2,alpcut,alpctr,alp3/1.,0.98,0.995,0.9999/
102 */          data fdfhl,frgh/1.0,1.0/
103 */
104 */      subroutine femom changes
105 */      *delete femom.723,femom.724                    femom
106 */          rxrv=vvj+(x1*(ssmom-dp/(alpl*rv+(1.0-alpl)*rl))

```

```

107      1      -delt*frgh*gc*grav(j))/(1.0-x1*dvjp)
108 *delete femom.898
109      dhldz=dhltt*rdx*delt*frgh*gc*gravr
110 *delete femom.904
111      dhlt=frgh*0.5/(rdx*delt)
112 *delete femom.1370
113      g=frgh*gc*grav(j)
114 */
115 */ subroutine femomx changes
116 *delete femomx.335
117      2      +frgh*a(lgravr+j-1)
118 *delete femomx.342
119      2      +frgh*a(lgravr+j-1)
120 */
121 */ subroutine femomy changes
122 *delete femomy.345
123      2      +frgh*a(lgravt+j-1)
124 *delete femomy.351
125      2      +frgh*a(lgravt+j-1)
126 */
127 */ subroutine femomz changes
128 *delete femomz.344
129      2      +frgh*gravz
130 *delete femomz.350
131      2      +frgh*gravz
132 */
133 */ subroutine input changes
134 *delete input.81
135 *delete fixfr.2
136      1      chm14 ,chm15 ,chm22 ,chm23 ,chm24 ,chm25 ,
137      2      cpuflg,dtstrt,fdh1 ,frgh ,hd3 ,hstn ,htcwl ,
138 *delete fixfr.3,fixfr.5
139      call reecho('rrrr ',chm25,dtstrt,fdh1,frgh,dum,
140      1      chm25,dtstrt,fdh1,frgh,dum,
141      2      'chm25','dtstrt','fdh1','frgh',' ')
142 *insert units.3167
143      if (frgh.ne.1.0) then
144          write(imout,1278) frgh
145          write(iout,1278) frgh
146 *if -def,unicos,1
147          write( itty,1278) frgh
148 *if def,unicos,1
149          write(      *,1278) frgh
150      1278      format(/' frgh =' ,lp,ell.4,' is a multiplier to the',
151      1      ' gravity-head term of all motion equations')
152      endif
153 c
154 */
155 */ subroutine namlst changes
156 *delete fixfr.20
157      1      ' should lie between 0.0 and 1.0')
158 *insert fixfr.24
159 c      check the value of the gravity-head term multiplier
160 c
161      if(abs(frgh).gt.1000.0) then
162          write(imout,238) frgh
163          write(iout,238) frgh
164 *if -def,unicos,1

```



```

165         write( itty,238) frgh
166 *if def,unicos,1
167         write(      *,238) frgh
168     238     format(/' *namlst*  namelist variable frgh =',1p,e12.4,
169         1         ' should lie between -1000.0 and 1000.0')
170         jflag=1
171         call error(2,'*namlst*  frgh has out-of-range value',4)
172     endif
173 c
174 */
175 */ subroutine tf1ds1 changes
176 *delete tf1ds1.674                                tf1ds1
177         g=frgh*gc*grav(j)
178 *delete tf1ds1.803                                tf1ds1
179         g=frgh*gc*grav(j)
180 */
181 */ subroutine tf3ds1 changes
182 *delete tf3ds1.596                                tf3ds1
183         2      +frgh*gravz*delt
184 *delete tf3ds1.601                                tf3ds1
185         2      +frgh*gravz*delt
186 *delete tf3ds1.754                                tf3ds1
187         2      +frgh*a(lgravr+j-1)*delt
188 *delete tf3ds1.759                                tf3ds1
189         2      +frgh*a(lgravr+j-1)*delt
190 *delete tf3ds1.851                                tf3ds1
191         2      +frgh*a(lgravt+j-1)*delt
192 *delete tf3ds1.856                                tf3ds1
193         2      +frgh*a(lgravt+j-1)*delt
194 */
195 *compile contrllr,blkdat,femom,femomx,femomy
196 *compile femomz,input,namlst,tf1ds1,tf3ds1
197 */
198 */ -----

```

Appendix B

ZIONPWR Test Problem Results

ZPWR1IN (ZIONPWR File with Namelist Variable FRGH = 1.0 Defined by Default)

castor:/export/castor1/rgs/trac> cp zionpwr zpwrlin

castor:/export/castor1/rgs/trac> cp zpwrlin tracin

Terminal Output from Test Problem ZPWR1

castor:/export/castor1/rgs/trac> trac

.....

input data is being processed

h2o properties are used

restart dump generated at problem time 0.000000 s after 0 time steps

time domain data to be used							
minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit	
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)	step (s)
1.000E-03	1.000E-03	5.000E-03	1.000E-03	1.000E-03	5.100E-03	1.000E-03	1.000E-03

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
0	0.000000	0.001000	2		0.0057	0.0060	0	3 3
1	0.001000	0.001000	2					
2	0.002000	0.001000	2					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
3	0.003000	0.001000	2					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
4	0.004000	0.001000	2					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
5	0.005000	0.001000	2					

time domain data to be used							
minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit	
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)	step (s)
1.000E-03	2.500E-01	2.000E+01	2.100E+01	5.000E-01	2.100E+01	2.100E+01	

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell

10	0.010000	0.001000	2	0.0053	0.0053	0	2	3
20	0.022027	0.001551	2	0.0080	0.0080	0	2	3
30	0.041539	0.002527	2	0.0137	0.0138	0	3	3
40	0.073323	0.004116	2	0.0219	0.0219	0	2	3
50	0.125095	0.006705	1	0.0357	0.0357	0	2	3
60	0.209427	0.010921	1	0.0582	0.0582	0	2	3
70	0.346794	0.017790	1	0.0948	0.0950	0	3	3
80	0.570551	0.028978	1	0.1545	0.1554	0	3	3
90	0.935027	0.047201	1	0.2516	0.2544	0	3	3
100	1.528721	0.076886	1	0.4099	0.4169	0	3	3
110	2.495786	0.125239	1	0.6678	0.6854	0	3	3

at 3.894929 s, the trip 1 signal crossed setpoint s1 = 5.312300E+02 f
 at 4.071032 s, the trip 1 signal is 5.312281E+02 f

at 4.071032 s, trip 1 is reset from 0 to 1 with a set status of on-forward

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
120	4.071032	0.204002	1		1.0879	1.1331	1	3 4
130	6.448270	0.250000	1		1.3334	1.4156	1	3 4
140	8.948270	0.250000	1		1.3335	1.4348	1	3 4
150	11.448270	0.250000	1		1.3335	1.4474	1	3 4
160	13.948270	0.250000	1		1.3336	1.4557	1	3 4
170	16.448270	0.250000	1		1.3336	1.4611	1	3 4
180	18.948270	0.250000	1		1.3336	1.4645	1	3 4

time domain data to be used

minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-02	1.000E+00	5.800E+01	3.800E+01	1.000E+00	3.900E+01	3.800E+01

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
190	21.648748	0.335024	1		1.7872	1.9657	1	3 4
200	25.862643	0.545719	1		2.9111	3.2062	1	3 4
210	32.726633	0.888918	1		4.7419	5.2272	1	3 4
220	42.528948	1.000000	1		5.3344	5.8825	1	3 4
230	52.528948	1.000000	1		5.3344	5.8830	1	3 4
236	58.528948	1.000000	1					

time domain data to be used

minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-02	1.000E+00	6.000E+01	5.000E-01	1.000E+00	2.000E+00	5.000E-01

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
237	59.528948	1.000000	1					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
238	60.528948	1.000000	1					

```
computative timing statistics
cpu time is          s
```

ZPWR1OUT (TRCOUT File Results from Test Problem ZPWR1
for Later Comparison with ZPWR2OUT)

```
castor:/export/castor1/rgs/trac> mv trcout zpwrlout
```

```
castor:/export/castor1/rgs/trac> tedi zpwrlout
zpwrlout 13085 Lines
```

tp/frgh

```
238      chm25 = 1.0000E+00,      dtstrt = -1.0000E+00,      fdfhl = 1.0000E+00,      frgh = 1.0000E+00
```

```
*end
```

zpwr1out 13085 Lines

ZPWR2IN (ZIONPWR File with Namelist Variable FRGH = 1.0 Input)

```
castor:/export/castor1/rgs/trac> cp zionpwr zpwr2in
```

```
castor:/export/castor1/rgs/trac> tedi zpwr2in
```

zpwr2in 1884 Lines

*t70,5

70 &inopts

```
71  cpuflg=1, iadded=10, idiag=4, inlab=3, iogrf=1,
```

```
72  iolab=1, ioout=1, iunlab=2, nhtstr=2, noair=0,
```

```
73  nosets=0, nrs1v=1, nsdl=0, nsdu=5, nspl=0, nspu=5
```

74 &end

75 *

```
*rp71/iadd/frgh=1.0, iadd
```

```
71  cpuflg=1, frgh=1.0, iadded=10, idiag=4, inlab=3, iogrf=1,
```

```
*end
```

zpwr2in 1884 Lines

```
castor:/export/castor1/rgs/trac> cp zpwr2in tracin
```

Terminal Output from Test Problem ZPWR2

```
castor:/export/castor1/rgs/trac> trac
```

• • • • •

input data is being processed

h2o properties are used

```
restart dump generated at problem time      0.000000 s after      0 time steps
```

		time domain data to be used				
minimum	maximum	time	long	graphics	dump	short

time	time	domain	edit	edit	edit	edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-03	1.000E-03	5.000E-03	1.000E-03	1.000E-03	5.100E-03	1.000E-03

convective energy-error controller is 3.4121E+20 btu/hr

time-step	problem	time-step	outer-it.	cpu	courant	numbers	sets	location
number	time (s)	size (s)	number	time (s)	1-d	3-d	flag	cmp cell
0	0.000000	0.001000	2		0.0057	0.0060	0	3 3
1	0.001000	0.001000	2					
2	0.002000	0.001000	2					

time-step	problem	time-step	outer-it.	cpu	courant	numbers	sets	location
number	time (s)	size (s)	number	time (s)	1-d	3-d	flag	cmp cell
3	0.003000	0.001000	2					

time-step	problem	time-step	outer-it.	cpu	courant	numbers	sets	location
number	time (s)	size (s)	number	time (s)	1-d	3-d	flag	cmp cell
4	0.004000	0.001000	2					

time-step	problem	time-step	outer-it.	cpu	courant	numbers	sets	location
number	time (s)	size (s)	number	time (s)	1-d	3-d	flag	cmp cell
5	0.005000	0.001000	2					

time domain data to be used

minimum	maximum	time	long	graphics	dump	short
time	time	domain	edit	edit	edit	edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-03	2.500E-01	2.000E+01	2.100E+01	5.000E-01	2.100E+01	2.100E+01

convective energy-error controller is 3.4121E+20 btu/hr

time-step	problem	time-step	outer-it.	cpu	courant	numbers	sets	location
number	time (s)	size (s)	number	time (s)	1-d	3-d	flag	cmp cell
10	0.010000	0.001000	2		0.0053	0.0053	0	2 3
20	0.022027	0.001551	2		0.0080	0.0080	0	2 3
30	0.041539	0.002527	2		0.0137	0.0138	0	3 3
40	0.073323	0.004116	2		0.0219	0.0219	0	2 3
50	0.125095	0.006705	1		0.0357	0.0357	0	2 3
60	0.209427	0.010921	1		0.0582	0.0582	0	2 3
70	0.346794	0.017790	1		0.0948	0.0950	0	3 3
80	0.570551	0.028978	1		0.1545	0.1554	0	3 3
90	0.935027	0.047201	1		0.2516	0.2544	0	3 3
100	1.528721	0.076886	1		0.4099	0.4169	0	3 3
110	2.495786	0.125239	1		0.6678	0.6854	0	3 3

at 3.894929 s, the trip 1 signal crossed setpoint s1 = 5.312300E+02 f
at 4.071032 s, the trip 1 signal is 5.312281E+02 f

at 4.071032 s, trip 1 is reset from 0 to 1 with a set status of on-forward

time-step	problem	time-step	outer-it.	cpu	courant	numbers	sets	location
number	time (s)	size (s)	number	time (s)	1-d	3-d	flag	cmp cell
120	4.071032	0.204002	1		1.0879	1.1331	1	3 4
130	6.448270	0.250000	1		1.3334	1.4156	1	3 4
140	8.948270	0.250000	1		1.3335	1.4348	1	3 4
150	11.448270	0.250000	1		1.3335	1.4474	1	3 4
160	13.948270	0.250000	1		1.3336	1.4557	1	3 4
170	16.448270	0.250000	1		1.3336	1.4611	1	3 4
180	18.948270	0.250000	1		1.3336	1.4645	1	3 4

time domain data to be used						
minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-02	1.000E+00	5.800E+01	3.800E+01	1.000E+00	3.900E+01	3.800E+01

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
190	21.648748	0.335024	1		1.7872	1.9657	1	3 4
200	25.862643	0.545719	1		2.9111	3.2062	1	3 4
210	32.726633	0.888918	1		4.7419	5.2272	1	3 4
220	42.528948	1.000000	1		5.3344	5.8825	1	3 4
230	52.528948	1.000000	1		5.3344	5.8830	1	3 4
236	58.528948	1.000000	1					

time domain data to be used						
minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-02	1.000E+00	6.000E+01	5.000E-01	1.000E+00	2.000E+00	5.000E-01

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
237	59.528948	1.000000	1					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
238	60.528948	1.000000	1					

restart dump generated at problem time 60.528948 s after 238 time steps

end of problem

computative timing statistics
cpu time is s

ZPWR2OUT (TRCOUT File Results from Test Problem 2)

castor:/export/castor1/rgs/trac> mv trcout zpwr2out

castor:/export/castor1/rgs/trac> diff zpwr1out zpwr2out

No difference was found between ZPWR1OUT and ZPWR2OUT
and their solutions are the same as expected

ZPWR3IN (ZIONPWR File with Namelist Variable FRGH = 0.0 Input)

castor:/export/castor1/rgs/trac> cp zpwr2in zpwr3in

castor:/export/castor1/rgs/trac> tedi zpwr3in

zpwr3in 1884 Lines

*t70,5

70 &inopts

```
castor:/export/castor1/rqs/trac> cp zpwr3in tracin
```

```
castor:/export/castor1/rgs/trac> trac
```

• • • • •

h2o properties are used

```
restart dump generated at problem time      0.000000 s after      0 time steps
```

		time domain data to be used				
minimum	maximum	time	long	graphics	dump	short
time	time	domain	edit	edit	edit	edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-03	2.500E-01	2.000E+01	2.100E+01	5.000E-01	2.100E+01	2.100E+01

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
10	0.010000	0.001000	2		0.0053	0.0053	0	2 3
20	0.022027	0.001551	2		0.0078	0.0078	0	2 3
30	0.041539	0.002527	2		0.0137	0.0138	0	3 3
40	0.073323	0.004116	2		0.0217	0.0217	0	2 3
50	0.125095	0.006705	1		0.0355	0.0355	0	2 3
60	0.209427	0.010921	1		0.0578	0.0578	0	2 3
70	0.346794	0.017790	1		0.0941	0.0942	0	3 3
80	0.570551	0.028978	1		0.1534	0.1541	0	3 3
90	0.935027	0.047201	1		0.2499	0.2523	0	3 3
100	1.528721	0.076886	1		0.4070	0.4136	0	3 3
110	2.495786	0.125239	1		0.6631	0.6798	0	3 3

at 2.881992 s, the trip 1 signal crossed setpoint s1 = 5.312300E+02 f

at 2.890603 s, the trip 1 signal is 5.312289E+02 f

at 2.890603 s, trip 1 is reset from 0 to 1 with a set status of on-forward

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
120	4.071032	0.204002	1		1.0802	1.1232	1	3 3
130	6.448270	0.250000	1		1.3240	1.3989	1	3 3
140	8.948270	0.250000	1		1.3240	1.4176	1	3 4
150	11.448270	0.250000	1		1.3241	1.4299	1	3 4
160	13.948270	0.250000	1		1.3241	1.4380	1	3 4
170	16.448270	0.250000	1		1.3241	1.4433	1	3 4
180	18.948270	0.250000	1		1.3241	1.4467	1	3 4

time domain data to be used

minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-02	1.000E+00	5.800E+01	3.800E+01	1.000E+00	3.900E+01	3.800E+01

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
190	21.648748	0.335024	1		1.7745	1.9417	1	3 4
200	25.862643	0.545719	1		2.8905	3.1670	1	3 4
210	32.726633	0.888918	1		4.7083	5.1633	1	3 4
220	42.528948	1.000000	1		5.2966	5.8107	1	3 4
230	52.528948	1.000000	1		5.2966	5.8111	1	3 4
236	58.528948	1.000000	1					

time domain data to be used

minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-02	1.000E+00	6.000E+01	5.000E-01	1.000E+00	2.000E+00	5.000E-01

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
237	59.528948	1.000000	1					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
238	60.528948	1.000000	1					

restart dump generated at problem time 60.528948 s after 238 time steps

end of problem

computative timing statistics
cpu time is s

ZPWR3OUT (TRCOUT File Results from Test Problem 3 for Later Comparison with ZPWR4OUT)

castor:/export/castor1/rgs/trac> mv trcout zpwr3out

ZPWR4IN (ZIONPWR with Namelist Variable FRGH = 1.0 input and 1D-component GRAVs and 3D-component GZC Reset from 1.0 to 0.0)

castor:/export/castor1/rgs/trac> cp zpwr2in zpwr4in

castor:/export/castor1/rgs/trac> tedi zpwr4in

zpwr4in 1884 Lines

*t70,5

```

70  &inopts
71  cpuflg=1, frgh=1.0, iadded=10, idiag=4, inlab=3, iogrf=1,
72  iolab=1, ioout=1, iunlab=2, nhtstr=2, noair=0,
73  nosets=0, nrslv=1, nsdl=0, nsdu=5, nspl=0, nspu=5
74  &end
75  *

```

*rp72/0/0, nvgrav=1

```

72  iolab=1, ioout=1, iunlab=2, nhtstr=2, noair=0, nvgrav=1,

```

tp/ grav

```

1513 * grav * f 1.0000e+00e
1716 * grav * f 1.0000e+00e
1782 * grav * f 1.0000e+00e
1849 * grav * f 1.0000e+00e
*rp1513,1716/grav * f 1/grav * f 0

```

```

1513 * grav * f 0.0000e+00e
1716 * grav * f 0.0000e+00e

```

tp/ th

```

1545 * th * 3.6000e+02e

```

*all1545

&*

```

&*          gc          gytc          gxrc          gzc
&  9.80665e+0  1.0000e+00  0.0000e+00  0.0000e+00

```

&.

1546 *

```

1547 *          gc          gytc          gxrc          gzc
1548  9.80665e+0  1.0000e+00  0.0000e+00  0.0000e+00

```

*t1549,2

1549 *

```

1550 *          lisrl          lisrc          lisrf          ljuns
1551          1          1          -2          2

```

*end

zpwr4in 1887 Lines

Note: GRAVs on lines 1782 and 1849 are for HTSTRs ROD 6 and SLAB 7

castor:/export/castor1/rgs/trac> cp zpwr4in tracin

Terminal Output from Test Problem ZPWR4

castor:/export/castor1/rgs/trac> trac

.....

input data is being processed

h2o properties are used

restart dump generated at problem time 0.000000 s after 0 time steps

time domain data to be used						
minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-03	1.000E-03	5.000E-03	1.000E-03	1.000E-03	5.100E-03	1.000E-03

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
0	0.000000	0.001000	2		0.0057	0.0060	0	3 3
1	0.001000	0.001000	2					
2	0.002000	0.001000	2					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
3	0.003000	0.001000	2					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
4	0.004000	0.001000	2					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
5	0.005000	0.001000	2					

time domain data to be used						
minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-03	2.500E-01	2.000E+01	2.100E+01	5.000E-01	2.100E+01	2.100E+01

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
10	0.010000	0.001000	2		0.0053	0.0053	0	2 3
20	0.022027	0.001551	2		0.0078	0.0078	0	2 3
30	0.041539	0.002527	2		0.0137	0.0138	0	3 3
40	0.073323	0.004116	2		0.0217	0.0217	0	2 3

50	0.125095	0.006705	1	0.0355	0.0355	0	2	3
60	0.209427	0.010921	1	0.0578	0.0578	0	2	3
70	0.346794	0.017790	1	0.0941	0.0942	0	3	3
80	0.570551	0.028978	1	0.1534	0.1541	0	3	3
90	0.935027	0.047201	1	0.2499	0.2523	0	3	3
100	1.528721	0.076886	1	0.4070	0.4136	0	3	3
110	2.495786	0.125239	1	0.6631	0.6798	0	3	3

at 2.881992 s, the trip 1 signal crossed setpoint s1 = 5.312300E+02 f
 at 2.890603 s, the trip 1 signal is 5.312289E+02 f

at 2.890603 s, trip 1 is reset from 0 to 1 with a set status of on-forward

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
120	4.071032	0.204002	1		1.0802	1.1232	1	3 3
130	6.448270	0.250000	1		1.3240	1.3989	1	3 3
140	8.948270	0.250000	1		1.3240	1.4176	1	3 4
150	11.448270	0.250000	1		1.3241	1.4299	1	3 4
160	13.948270	0.250000	1		1.3241	1.4380	1	3 4
170	16.448270	0.250000	1		1.3241	1.4433	1	3 4
180	18.948270	0.250000	1		1.3241	1.4467	1	3 4

time domain data to be used

minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-02	1.000E+00	5.800E+01	3.800E+01	1.000E+00	3.900E+01	3.800E+01

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
190	21.648748	0.335024	1		1.7745	1.9417	1	3 4
200	25.862643	0.545719	1		2.8905	3.1670	1	3 4
210	32.726633	0.888918	1		4.7083	5.1633	1	3 4
220	42.528948	1.000000	1		5.2966	5.8107	1	3 4
230	52.528948	1.000000	1		5.2966	5.8111	1	3 4
236	58.528948	1.000000	1					

time domain data to be used

minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-02	1.000E+00	6.000E+01	5.000E-01	1.000E+00	2.000E+00	5.000E-01

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
237	59.528948	1.000000	1					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
238	60.528948	1.000000	1					

restart dump generated at problem time 60.528948 s after 238 time steps

end of problem

computative timing statistics
cpu time is s

ZPWR4OUT (TRCOUT File Results from Test Problem 4)

castor:/export/castor1/rgs/trac> mv trcout zpwr4out

castor:/export/castor1/rgs/trac> diff zpwr3out zpwr4out

```
238c238
<      chm25 = 1.0000E+00,      dtstrt = -1.0000E+00,      fdfhl = 1.0000E+00,      frgh = 0.0000E+00
---
>      chm25 = 1.0000E+00,      dtstrt = -1.0000E+00,      fdfhl = 1.0000E+00,      frgh = 1.0000E+00
253c253
<      nvgrav =      0,          p = 1.4504E+16,          pa = 1.4504E+16,          qppp = 1.0000E+20,          timdl = -1.0000E+00
---
>      nvgrav =      1,          p = 1.4504E+16,          pa = 1.4504E+16,          qppp = 1.0000E+20,          timdl = -1.0000E+00
262,263d261
< frgh = 0.0000E+00 is a multiplier to the gravity-head term of all motion equations
<
1849c1847
< grav      1.00000E+00  1.00000E+00  1.00000E+00
---
> grav      0.00000E+00  0.00000E+00  0.00000E+00
1922a1921,1923
>      gc = 3.2174E+01,          gytc = 1.0000E+00,          gxrc = 0.0000E+00,          gzc = 0.0000E+00
>
>      ft/s2
>
2437c2438
< grav      1.00000E+00  1.00000E+00  1.00000E+00
---
> grav      0.00000E+00  0.00000E+00  0.00000E+00
2877c2878
< height change across component  2 from cell  1 to the joining cell of component  3 is  8.87566E+00 ft
---
> height change across component  2 from cell  1 to the joining cell of component  3 is  0.00000E+00 ft
2879c2880
< height change across component  4 from the joining cell of component  3 to cell  2 is  8.38353E+00 ft
---
> height change across component  4 from the joining cell of component  3 to cell  2 is  0.00000E+00 ft
```

castor:/export/castor1/rgs/trac> tedi zpwr3out

```
zpwr3out 13087 Lines
*tp*/frgh =
262 frgh = 0.0000E+00 is a multiplier to the gravity-head term of all motion equations
*t258,8
258
259      tv = 1.8000E+20,          tw = 1.8000E+20,          vl = 3.2808E+20,          vv = 3.2808E+20
260      f          f          ft/s          ft/s
261
262 frgh = 0.0000E+00 is a multiplier to the gravity-head term of all motion equations
263
264 si units of the internally defined units-name labels are
265 lunounit -      luspvol  m3/kg      luprsrat pa/s      luhtc  w/m2/k      luangle rad
266 lutime s      lumass  kg      luminert kg*m2      luihttf w/k      luburnup mwd/mtu
*end
```

All differences between ZPWR3OUT and ZPWR4OUT are expected
and their solutions are the same as expected

ZPWR5IN (ZIONPWR File with Namelist Variable FRGH = 0.6 Input)

castor:/export/castor1/rgs/trac> cp zpwr3in zpwr5in

castor:/export/castor1/rgs/trac> tedi zpwr5in

```
zpwr5in 1884 Lines
*t70,5
70 &inopts
71  cpuflg=1, frgh=0.0, iadded=10, idiag=4, inlab=3, iogrf=1,
72  iolab=1, ioout=1, iunlab=2, nhtstr=2, noair=0,
73  nosets=0, nrslv=1, nsdl=0, nsdu=5, nspl=0, nspu=5
74 &end
75 *
```

```
*rp71/0.0/0.6
 71  cpuflg=1, frgh=0.6, iadded=10, idiag=4, inlab=3, iogrf=1,
*end
zpwr5in 1884 Lines
```

```
castor:/export/castor1/rgs/trac> cp zpwr5in tracin
```

Terminal Output from Test Problem ZPWR5

```
castor:/export/castor1/rgs/trac> trac
```

.....

input data is being processed

h2o properties are used

frgh = 6.0000E-01 is a multiplier to the gravity-head term of all motion equations

restart dump generated at problem time 0.000000 s after 0 time steps

time domain data to be used						
minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-03	1.000E-03	5.000E-03	1.000E-03	1.000E-03	5.100E-03	1.000E-03

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
0	0.000000	0.001000	2		0.0057	0.0060	0	3 3
1	0.001000	0.001000	2					
2	0.002000	0.001000	2					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
3	0.003000	0.001000	2					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
4	0.004000	0.001000	2					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
5	0.005000	0.001000	2					

time domain data to be used						
minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-03	2.500E-01	2.000E+01	2.100E+01	5.000E-01	2.100E+01	2.100E+01

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
10	0.010000	0.001000	2		0.0053	0.0053	0	2 3

20	0.022027	0.001551	2	0.0079	0.0079	0	2	3
30	0.041539	0.002527	2	0.0137	0.0138	0	3	3
40	0.073323	0.004116	2	0.0219	0.0219	0	2	3
50	0.125095	0.006705	1	0.0356	0.0356	0	2	3
60	0.209427	0.010921	1	0.0580	0.0580	0	2	3
70	0.346794	0.017790	1	0.0946	0.0947	0	3	3
80	0.570551	0.028978	1	0.1541	0.1549	0	3	3
90	0.935027	0.047201	1	0.2510	0.2536	0	3	3
100	1.528721	0.076886	1	0.4088	0.4157	0	3	3
110	2.495786	0.125239	1	0.6660	0.6833	0	3	3

at 3.184327 s, the trip 1 signal crossed setpoint s1 = 5.312300E+02 f
at 3.187812 s, the trip 1 signal is 5.312298E+02 f

at 3.187812 s, trip 1 is reset from 0 to 1 with a set status of on-forward

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
120	4.071032	0.204002	1		1.0850	1.1290	1	3 3
130	6.448270	0.250000	1		1.3298	1.4097	1	3 4
140	8.948270	0.250000	1		1.3299	1.4287	1	3 4
150	11.448270	0.250000	1		1.3300	1.4412	1	3 4
160	13.948270	0.250000	1		1.3300	1.4494	1	3 4
170	16.448270	0.250000	1		1.3300	1.4548	1	3 4
180	18.948270	0.250000	1		1.3300	1.4582	1	3 4

time domain data to be used

minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-02	1.000E+00	5.800E+01	3.800E+01	1.000E+00	3.900E+01	3.800E+01

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
190	21.648748	0.335024	1		1.7824	1.9572	1	3 4
200	25.862643	0.545719	1		2.9033	3.1923	1	3 4
210	32.726633	0.888918	1		4.7293	5.2045	1	3 4
220	42.528948	1.000000	1		5.3202	5.8570	1	3 4
230	52.528948	1.000000	1		5.3202	5.8575	1	3 4
236	58.528948	1.000000	1					

time domain data to be used

minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-02	1.000E+00	6.000E+01	5.000E-01	1.000E+00	2.000E+00	5.000E-01

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
237	59.528948	1.000000	1					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
238	60.528948	1.000000	1					

restart dump generated at problem time 60.528948 s after 238 time steps

end of problem

computative timing statistics
cpu time is s

ZPWR5OUT (TRCOUT File Results from Test Problem 5 for Later Comparison with ZPWR6OUT)

castor:/export/castor1/rgs/trac> mv trcout zpwr5out

ZPWR6IN (ZIONPWR with Namelist Variable FRGH = 1.0 input and 1D-component GRAVs and 3D-component GZC Reset from 0.0 to 0.6 and -0.6)

castor:/export/castor1/rgs/trac> cp zpwr4in zpwr6in

castor:/export/castor1/rgs/trac> tedi zpwr6in

zpwr6in 1887 Lines

*t70,5

70 &inopts

71 cpuflg=1, frgh=1.0, iadded=10, idiag=4, inlab=3, iogrf=1,

72 iolab=1, ioout=1, iunlab=2, nhtstr=2, noair=0, nvgrav=1,

73 nosets=0, nrslv=1, nsdl=0, nsdu=5, nspl=0, nspu=5

74 &end

75 *

tp/ grav

1513 * grav * f 0.0000e+00e

1719 * grav * f 0.0000e+00e

1785 * grav * f 1.0000e+00e

1852 * grav * f 1.0000e+00e

*rp1513,1719/grav * f 0.0000e+00/grav * f 6.0000e-01

1513 * grav * f 6.0000e-01e

1719 * grav * f 6.0000e-01e

tp/gzc

1547 * gc gyc gxrc gzc

*t1548

1548 9.80665e+0 1.0000e+00 0.0000e+00 0.0000e+00

*rp1548/1.0000e+00 0.0000e+00 0.0000e+00/8.0000e-01 0.0000e+00 -6.0000e-01

1548 9.80665e+0 8.0000e-01 0.0000e+00 -6.0000e-01

*end

zpwr6in 1887 Lines

TRAC-P requires that $\text{SQRT}(\text{GYTC}*\text{GYTC}+\text{GXRC}*\text{GXRC}+\text{GZC}*\text{GZC}) = 1.0$

Thus, $\text{SQRT}(0.8*0.8+0.0*0.0+(-0.6)*(-0.6)) = \text{SQRT}(0.64+0.0+0.36) = 1.0$

GZC is negative because gravity accelerates in the negative-z direction.

castor:/export/castor1/rgs/trac> cp zpwr6in tracin

Terminal Output from Test Problem ZPWR6

castor:/export/castor1/rgs/trac> trac

.....

input data is being processed

h2o properties are used

restart dump generated at problem time 0.000000 s after 0 time steps

time domain data to be used						
minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-03	1.000E-03	5.000E-03	1.000E-03	1.000E-03	5.100E-03	1.000E-03

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
0	0.000000	0.001000	2		0.0057	0.0060	0	3 3
1	0.001000	0.001000	2					
2	0.002000	0.001000	2					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
3	0.003000	0.001000	2					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
4	0.004000	0.001000	2					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
5	0.005000	0.001000	2					

time domain data to be used						
minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-03	2.500E-01	2.000E+01	2.100E+01	5.000E-01	2.100E+01	2.100E+01

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
10	0.010000	0.001000	2		0.0053	0.0053	0	2 3
20	0.022027	0.001551	2		0.0079	0.0079	0	2 3
30	0.041539	0.002527	2		0.0137	0.0138	0	3 3
40	0.073323	0.004116	2		0.0219	0.0219	0	2 3
50	0.125095	0.006705	1		0.0356	0.0356	0	2 3
60	0.209427	0.010921	1		0.0580	0.0580	0	2 3
70	0.346794	0.017790	1		0.0946	0.0947	0	3 3
80	0.570551	0.028978	1		0.1541	0.1549	0	3 3
90	0.935027	0.047201	1		0.2510	0.2536	0	3 3
100	1.528721	0.076886	1		0.4088	0.4157	0	3 3
110	2.495786	0.125239	1		0.6660	0.6833	0	3 3

at 3.184327 s, the trip 1 signal crossed setpoint s1 = 5.312300E+02 f

at 3.187812 s, the trip 1 signal is 5.312298E+02 f

at 3.187812 s, trip 1 is reset from 0 to 1 with a set status of on-forward

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
120	4.071032	0.204002	1		1.0850	1.1290	1	3 3
130	6.448270	0.250000	1		1.3298	1.4097	1	3 4
140	8.948270	0.250000	1		1.3299	1.4287	1	3 4
150	11.448270	0.250000	1		1.3300	1.4412	1	3 4
160	13.948270	0.250000	1		1.3300	1.4494	1	3 4
170	16.448270	0.250000	1		1.3300	1.4548	1	3 4
180	18.948270	0.250000	1		1.3300	1.4582	1	3 4

time domain data to be used

minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-02	1.000E+00	5.800E+01	3.800E+01	1.000E+00	3.900E+01	3.800E+01

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
190	21.648748	0.335024	1		1.7824	1.9572	1	3 4
200	25.862643	0.545719	1		2.9033	3.1923	1	3 4
210	32.726633	0.888918	1		4.7293	5.2045	1	3 4
220	42.528948	1.000000	1		5.3202	5.8570	1	3 4
230	52.528948	1.000000	1		5.3202	5.8575	1	3 4
236	58.528948	1.000000	1					

time domain data to be used

minimum time	maximum time	time domain	long edit	graphics edit	dump edit	short edit
step (s)	step (s)	end (s)	step (s)	step (s)	step (s)	step (s)
1.000E-02	1.000E+00	6.000E+01	5.000E-01	1.000E+00	2.000E+00	5.000E-01

convective energy-error controller is 3.4121E+20 btu/hr

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
237	59.528948	1.000000	1					

time-step number	problem time (s)	time-step size (s)	outer-it. number	cpu time (s)	courant 1-d	numbers 3-d	sets flag	location cmp cell
238	60.528948	1.000000	1					

restart dump generated at problem time 60.528948 s after 238 time steps

end of problem

computative timing statistics
cpu time is s

ZPWR6OUT (TRCOUT File Results from Test Problem 6)

castor:/export/castor1/rgs/trac> mv trcout zpwr6out

castor:/export/castor1/rgs/trac> diff zpwr5out zpwr6out

```

238c238
<      chm25 = 1.0000E+00,      dtstrt = -1.0000E+00,      fdhfl = 1.0000E+00,      frgh = 6.0000E-01
---
>      chm25 = 1.0000E+00,      dtstrt = -1.0000E+00,      fdhfl = 1.0000E+00,      frgh = 1.0000E+00
253c253

```

```

<   nvgrav =      0,      p = 1.4504E+16,      pa = 1.4504E+16,      qppp = 1.0000E+20,      timdl = -1.0000E+00
---
>   nvgrav =      1,      p = 1.4504E+16,      pa = 1.4504E+16,      qppp = 1.0000E+20,      timdl = -1.0000E+00
262,263d261
<   frgh = 6.0000E-01 is a multiplier to the gravity-head term of all motion equations
<
1849c1847
<   grav      1.00000E+00  1.00000E+00  1.00000E+00
---
>   grav      6.00000E-01  6.00000E-01  6.00000E-01
1922a1921,1923
>      gc = 3.2174E+01,      gyc = 8.0000E-01,      gxrc = 0.0000E+00,      gzc = -6.0000E-01
>      ft/s2
>
2437c2438
<   grav      1.00000E+00  1.00000E+00  1.00000E+00
---
>   grav      6.00000E-01  6.00000E-01  6.00000E-01
2877c2878
<   height change across component  2 from cell  1 to the joining cell of component  3 is  8.87566E+00 ft
---
>   height change across component  2 from cell  1 to the joining cell of component  3 is  5.32539E+00 ft
2879c2880
<   height change across component  4 from the joining cell of component  3 to cell  2 is  8.38353E+00 ft
---
>   height change across component  4 from the joining cell of component  3 to cell  2 is  5.03012E+00 ft
9879c9880
<   -11  1.695711E-03      -12  -1.483429E-06      -13  5.846770E+06      -14  9.998422E-01      -15  0.000000E+00
---
>   -11  1.695711E-03      -12  -1.483430E-06      -13  5.846770E+06      -14  9.998422E-01      -15  0.000000E+00
9905c9906
<   -310  1.695711E-03      -311  1.695711E-03      -312  -1.483429E-06      -313  5.846894E+06      -314  9.998422E-01
---
>   -310  1.695711E-03      -311  1.695711E-03      -312  -1.483430E-06      -313  5.846894E+06      -314  9.998422E-01

```

castor:/export/castor1/rgs/trac> tedi zpwr6out

zpwr6out 13088 Lines

tp/large

```

2909  trac large edit
3991  trac large edit
5088  trac large edit
6189  trac large edit
7290  trac large edit
8391  trac large edit
9761  trac large edit
10878 trac large edit
11979 trac large edit
*end

```

Control blocks -12 and -312 have a difference of 1 in the seventh least-significant digit in the 7th large edit (of 9 large edits). Both define the time derivative of the pressure in PUMP 2, cell 1.

All differences between ZPWR5OUT and ZPWR6OUT are expected and their solutions are the same except for the control blocks -12 and -312 values in the 7th large edit