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Upgrading HULL Hydrocode for Spherical Airblast Calculations

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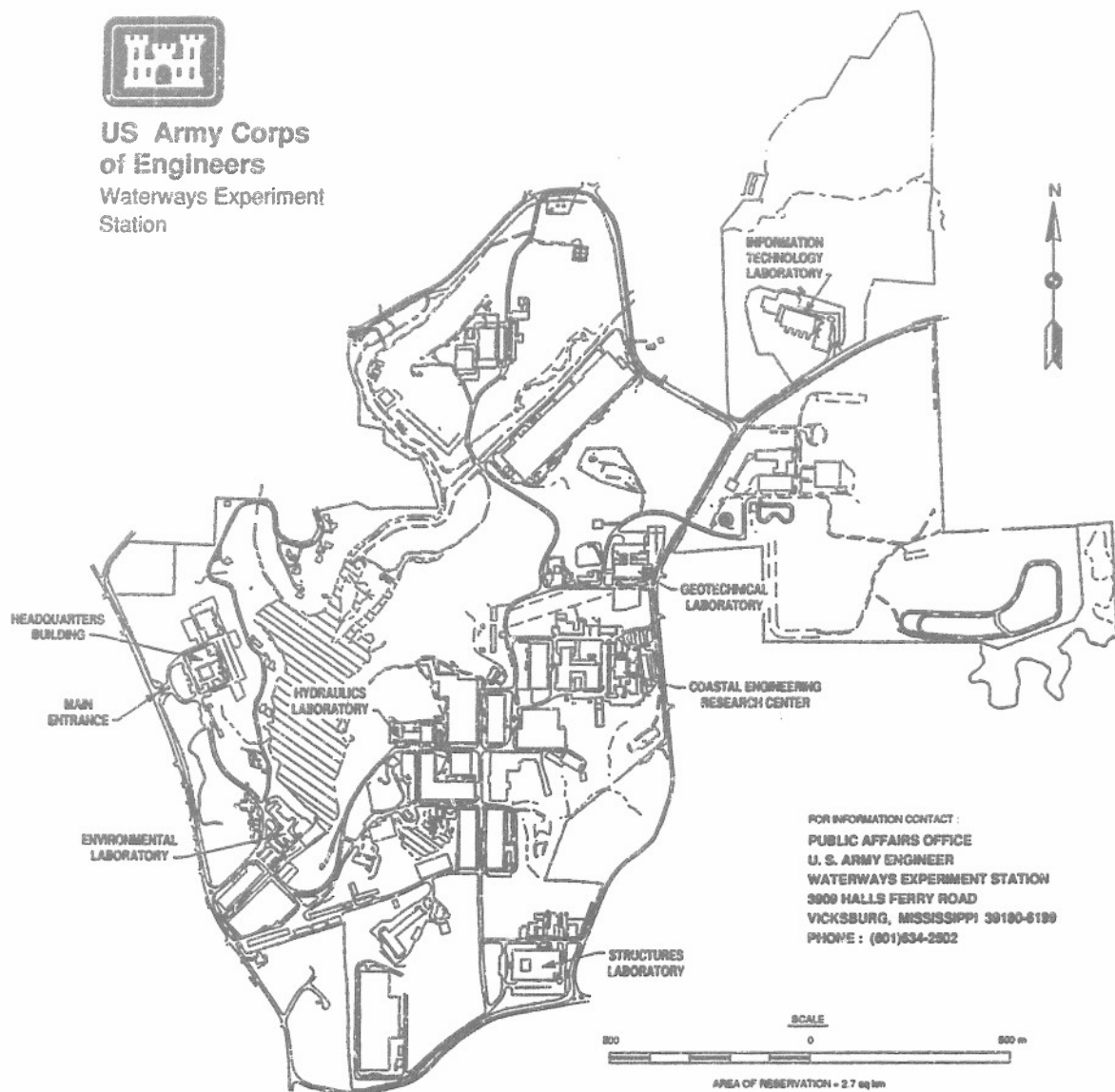
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PREFACE

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This research effort was under the overall direction of Messrs. C. R. Welch, and H. G. White, EED. Mr. L. K. Davis was Chief, EED, and Mr. B. Mather was Director, SL.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Leonard G. Hassell, EN.

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Introduction

HULL is a complex and versatile hydrodynamic computer code. The original version was developed at the Air Force Weapons Laboratory in 1976 [1]. It has the capability to run Eulerian or Lagrangian modes of calculations and has a wide range of options representing material selection and various physical behavior. One of the drawbacks of HULL is its explicit mode of calculation with a severe time-step limitation. The time-step of calculation, restricted by the Courant, Friedrichs and Lewy (CFL) condition, often hampers its efficiency in solving large multidimensional problems. Mere size and complexity of the code adds a certain amount of rigidity in upgrading HULL. It would be ideal if calculations of interest to the Army could be speeded up substantially.

A prior report [2] by the author noted certain anomalies along the centerline of HULL axisymmetric calculations. In the previous study, airblast velocity profiles, pressure plots, and the time of arrival at ground zero, were computed from an airburst detonation. The need for a quicker solution in such an airblast calculation was apparent. The present effort concentrates on upgrading HULL by adding a one-dimensional spherical airblast code, SAP (Spherical Air Puff).

The original SAP code was developed at the Air Force Weapons Laboratory in the 1960's [3]. However, the version [4] which was used in this study was developed by the S-Cubed Corporation in the mid 1980's. It has a stand-alone capability of airblast calculations. SAP can also prepare station plots or feed in inputs to HULL or SHARC calculations. Unfortunately, the version that was available to the author lacked several subroutines. The need for complete documentation resulted in redefining several system parameters and options. The program was added to the HULL library in UNICOS and VAX modes. However, thorough testing of SAP against measured airblasts still needs to occur.

This report presents the discussion of the parameters and options in the newly added capability. For brevity, only the important details will be presented here. The executable versions and procedures are given in program listings in the appendix.

HULL SYSTEM

Before the discussion of SAP begins, it is important to recognize and understand the HULL framework. The HULL system consists of several programs which furnish pre- and post-processing needs in addition to the HULL program, which performs the hydrodynamic calculations. The programs share a common library of utility routines. HULL is very flexible in being able to run on several computer systems and can be upgraded very easily because of its modular structure. HULL is prepared by a proprietary program called SAIL, developed by Shalimar Research, Inc [5]. This code guides the flow of

instructions in the HULL system by using statements, called SAIL directives, which prepare or change the compilable HULL. This is important to recognize because the SAP code which was added to the HULL system would not function itself without being processed by SAIL.

The details of the SAIL program cannot be published because of the proprietary guidelines. It operates under three major modes - executive/maintenance, update/generate and copy/convert. The SAIL maintenance and executive directives are its normal mode of operation. However, they cannot be processed simultaneously with the update/generate mode. Once a program is transported between systems using the copy/convert mode, it can be added or upgraded for another installation using proper SAIL directives. Finally, once system parameters and options are defined and available, a program can be executed in the normal mode.

The normal mode of execution is prepared for HULL with the pre-processing programs PLANK and KEEL. The preparation of the compilable HULL is achieved by PLANK, which defines the options block. KEEL utilizes the material library and generates the input/restart tape for hydrodynamic calculations of HULL. Finally, there are post-processing programs such as PULL and STATION to plot the results of hydrodynamic calculations and analyze data.

SAP Code

SAP is similar to the program HULL. It already contains post-processing programs such as SAPPLT and STAPLT. It was therefore unnecessary to share those programs from the HULL system. Further, SAP does not need the HULL material library "MATLIB", since materials are furnished in several subprograms within SAP which can be compiled upon need. Currently SAP has 24 materials in its library (these include burned and unburned materials). They are - AIR, TNT, BTNT, PBX, BPBX, PENT, BPENT, ANFO, BANFO, METH, BMETH, WATER, HMX, BHMx, COMB, BCOMB, FOAM, CFOUR, BCFOUR, PETN, BPETN, IRMT, BIRMT and PLUG. The material names beginning with the letter "B" represent burned explosives. A continuous burn routine, based upon the Chapman Jouget Theory, is available in SAP.

SAP also has the capability of using six different ambient models. They are: Tropical, Temperate, Arctic, Exponential, Constant Energy and Hiroshima. SAP calculations can incorporate radiation loss. There are three radiation loss schemes - one based upon SPUTTER calculations, one using emissivity data by Gilmer [3], and a radiation-diffusion package with free streaming at the edge of the temperature gradient. SAP uses a real atmosphere that is stable under an r^{-2} gravity field, and an equation of state for air that is an empirical fit to Hilsenrath's data [6].

SAP can be run with a cartesian, cylindrical or spherical system of coordinates. It has two differencing schemes. The original scheme is

Lagrangian, whereas the second scheme, which is also utilized in the HULL code, and can be run as Eulerian or Lagrangian, as set by an option. SAP can incorporate artificial viscosity in linear or quadratic form. It even has a routine for an artificial compression method. The SAP plot routines can furnish overpressures, overdensity, and velocity vectors versus radius. SAP was originally developed for a CDC or CRAY machine under the CTSS mode. Therefore to run under CRAY-UNICOS at WES, some parameters needed to be altered and some new ones introduced that would be suitable to the system.

SAP Options

SAP has more than 50 options which need to be defined to prepare a compilable version. If one prepared a PLANK version of SAP, that program could define the options in the pre-processing run. The main SAP run can use those defaults, or modify some dynamic options during the executable processing. Such a program was prepared by the author and currently resides in the SAP directory under the name SPLANK. However, unlike HULL, fewer options in SAP require dynamic alteration. Therefore one could skip the use of SPLANK and directly introduce the options during the update/generate mode of SAIL.

Some options also have dependency on other options. Therefore care must be exercised in altering them. Appendix A shows a list of default and redefined options as listed by SAIL during pre-processing of SAP. SAP was added to the HULL system as the procedure RUNSAP. Some of the printed options in the list therefore come from the HULL options and the system parameters. Appendix B, which was reproduced from [4], gives a list of SAP options and overviews of the subroutines in SAP. One must keep the default options in mind while upgrading the SAP system. The defaults need not be altered at all if the physical problem does not require it. In the present CRAY version of SAP, the user needs to choose the following options:

- 1) SAPNM - represents the number of materials in the problem.
- 2) SAPMX - represents the maximum grid size.
- 3) SPGEOM - chooses the type of geometry in the run.
(Cartesian - 1, Cylindrical - 2 and Spherical -3)
- 4) SPMTHD - chooses between differencing techniques in the solution process.
- 5) NMAT - represents the number of material boundaries in the problem. Note that this number may be larger than SAPNM, depending on the arrangement of materials.
- 6) RESTART & HYDRA - These are similar options. The latter should be chosen to generate a restart file, whereas the former should be chosen when a restart file already exists.
- 7) BURN - 1 must be used if explosives are present in the problem. In those cases, the explosives can have both burned and unburned choices (material name preceded by "B").
- 8) Other important options include RAD, VISC, ACM and FCT to specify physical and computational choices, whereas SPUTIN, HCUTIN and PLOTIT give pre- and post-processing choices.

SAP INPUT

After the pre-processing SAIL run produces a compilable SAP, it must be compiled, linked and executed with a proper SAP input. See the example in Appendix C. SAP inputs have generally three sections.

The first section starts with the keyword "sap". This section enters the problem number and starting requests in terms of time and cycles. The problem number and starting information must be carefully inputted on a restart run, the failure of which will immediately abort the run.

The second section starts with the keyword "input". This section has the stopping request, the header block definition and definitions of the "z-block" parameters. These parameters are upgraded at each run and therefore some of these can be considered as dynamic options. A complete list of the z-block parameters are available in appendix D.

The last section starts with the keyword "region". This is similar to the keyword "mesh" in KEEL runs. It has six different variables separated by the word CELLS. These variables are - material name, dx, energy, rho, speed, and bound. Material names have to be used exactly as they were introduced in the SAIL pre-processing. DX represents the width of cells in this part of the mesh.

Energy and rho represent the energy and mass densities. All units are expressed in the CGS (Centimeters, Grams, Seconds) unit system. Speed represents the speed of the material in this part of the mesh. Again, this quantity is expected to be a variable. The first cell must be assigned some initial velocity. A zero velocity input for the first cell will result in aborting the program. Bound represents the maximum number of cells for which the previous five variables hold. The default on bound is IMAX, the maximum number of cells in the problem. If there are several materials present in the problem, the bound values should be inputted carefully.

All of the above six variables may not be specified in a given problem. For example, the sample input in Appendix C has three materials - BPENT, PENT and AIR. The problem stacks up BPENT in the first cell, PENT in Cell 2 through 77 and AIR for Cells 78 through 100. The mesh size is a variable. As may be noticed from this example, only 4 variables (out of 6) were defined in the first three cells, 3 were defined between Cells 4 through 77 and only two were defined for the rest of the mesh. Further descriptions of input variables are presented in Appendix D.

The final word in the sap input is "end". Once these inputs are correctly specified, SAP outputs a "sap.out" and a "tape 4" (if option hydra is chosen).

Results

Appendix E shows the sequence of the batch run "jobsap.com". This batch job prepares the compilable version from the card input [4], compiles, links, and executes the program with the SAP input shown in Appendix C. The output "sap.out" is presented in Appendix F. It can be seen from the output that the program generates the z-block and the mesh configuration correctly.

This particular run has a problem in the subroutine "BURN", as reflected in the output. This code, like any other newly developed capability, has to be tested in various physical problems before confident statements can be made regarding its advantages and drawbacks. The error source is probably among input or material properties data or methodology of calculations. Further testings are currently in progress.

Conclusions and Recommendations

The SAP code was added to the HULL library of programs at WES. This code will provide an input for the HULL calculations, or it can produce one-dimensional solutions for airblast problems independently. The code remains to be tested in various physical problems.

One very useful application of the code will be to use it in the airblast calculations presented in [2]. It would be interesting to know whether SAP outputs can be inputted into HULL calculations with significant improvement in the overall run time of the HULL calculations. Another interest would be to see if the HULL input thus generated by the "firein" option in KEEL would produce a better arrival time of the shock at ground zero in the HULL run than was obtained previously.

SAP can also be used in the reverse mode, where HULL outputs are used as input to SAP by the program HULLCUT, which takes a slice of the multidimensional output. Finally, the newly-added capability of one-dimensional calculations can produce approximate and quick answers to significantly large problems as a stand-alone capability, where an early prediction can influence later decision making.

References

1. M.A. Fry, R.E. Durrett, G.P. Ganong, D.A. Matuska, M.D. Stucker, B.S. Chambers, C.E. Needham and C.D. Westmoreland, "The HULL Hydrodynamics Computer Code", Technical Report No. AFWL-TR-76-183, September 1976.
2. A. Ghosh, "Centerline Discrepancies in HULL Axisymmetric Calculations", Final Report, Contract DAAL03-91-C-0034, TCN: 92007, presented to the Waterways Experiment Station, May 15, 1992.
3. W.A. Whitaker, E.A. Nawrocki, C.E. Needham and W.W. Troutman, "Theoretical Calculations of the Phenomenology of HE Detonations", Technical Report No. AFWL-TR-66-141, November 1966.
4. The SAP Code: Source obtained from Applied Research Associates, Inc., Vicksburg, MS 39180, June 19, 1992.
5. D.A. Matuska and J.J. Osborn, "HULL Documentation, Volume I and II", Orlando Technology, Inc., Shalimar, Florida 32579, 1990.
6. J. Hilsenrath, M.S. Green and C.W. Beckett, "Thermodynamic Properties of Highly Ionized Air", SWC-TR-56-35, National Bureau of Standards, Washington, D.C., April 1957

Appendix A

1 sail library for version 124 of system hull
generated 3aug92

0 this library contains 140358 lines
0 generating source from programs on 3aug92
0 program origin program origin
 program origin

0 *sap 210000
0 programs which are marked with an * will generate source in
this run
1 options defined at the beginning of this run

0	inst	=	16	mach	=	1	sail	=	0
0	runsap	=	1	tekcolor	=	0	eos	=	0
0	matlib	=	0	plank	=	0	common	=	0
0	proc-msc	=	0	hull	=	0	plotters	=	0
0	pull	=	0	station	=	0	plotvg	=	0
0	keel	=	0	lrez	=	0	sap	=	2
0	staplt	=	0	hullcut	=	0	sapplt	=	0
0	library	=	0	control	=	0			

loptions defined/redefined during executive processing

cray	=	1
opsys	=	2
vendor	=	1
pf	=	1
objlib	=	0
tapelib	=	3
plotpkg	=	0
remark	=	0
mf	=	0
cdc	=	0
ibm	=	0
cray	=	1
vax	=	0
sel	=	0
vsos	=	0
colour	=	0
word	=	64
byte	=	8
date	=	2
buffer	=	1
sensesw	=	1
nw	=	1
cw	=	8
cardl	=	10

cardo	=	8
double	=	0
exbl	=	0
debugl	=	0
debugs	=	0
mach	=	1
cdc	=	0
univac	=	0
vax	=	0
cel	=	0
ridge	=	0
spsvth	=	0
sapmx	=	100
spgeom	=	3
spmthd	=	1
sapnm	=	3
single	=	0
airopt	=	1
atmos	=	2
compare	=	0
nstat	=	0
nmat	=	3
matt	=	24
air	=	3
tnt	=	0
btnt	=	0
pbx	=	0
bpbx	=	0
pent	=	2
bpent	=	1
anfo	=	0
banfo	=	0
meth	=	0
bmeth	=	0
water	=	0
hmx	=	0
bhmx	=	0
comb	=	0
bcomb	=	0
foam	=	0
cfour	=	0
bcfour	=	0
petn	=	0
bpetn	=	0
irmt	=	0
birmt	=	0
plug	=	0
rezone	=	1
method	=	1
lbnd	=	0
rbnd	=	0
imax	=	100

restart	=	0
ktstd	=	0
weight	=	1
ngroup	=	0
sputin	=	0
hcutin	=	0
hydra	=	1
acm	=	0
burn	=	1
fct	=	0
rad	=	0
nm	=	3
plotit	=	0
geom	=	3
visc	=	1
euler	=	0
jwl	=	1
cray	=	1
unicos	=	1
eos	=	1
sum	=	1
route	=	0
sys	=	2
nchpwd	=	8
nodpwd	=	22
nbitpc	=	8
nchar	=	16
lev	=	1
vector	=	0
asciim	=	1
disspl	=	0
scaler	=	1
nvarpr	=	500
nh	=	5
nbitpw	=	64
nshift	=	32
nshifl	=	56
nchmtn	=	2
nwpcv	=	2
nzblk	=	100
indxz	=	200
nzblk2	=	200
idim	=	300
ijump	=	101
ijptwo	=	201

0 2856 cards generated

1

0 end of normal sail run
system hull version 124

Appendix B

```

*p      options
      20feb87
=
      20feb87
=      option  default      definition
      20feb87
=
      20feb87
=      atmos      2      atmosphere type
      20feb87
=
      20feb87      =1  tropical atmosphere
=
      20feb87      =2  temperate atmosphere
=
      20feb87      =3  arctic atmosphere
=
      20feb87      =4  exponential atmosphere
=
      20feb87      =5  constant energy and pressure
=
      20feb87      =6  hiroshima atmosphere
=
      20feb87
=      airopt      1      air type, this option is for use in
      20feb87
=
      20feb87      conjunction with vector=1, cray=1
=
      20feb87      =1  doan-nickel equation of state
=
      20feb87      =2  gamma law equation of state
=
      20feb87      =3  simple gamma law equation of state
=
      20feb87      =10 four point interpolation
=
      20feb87
=      vector      0      vectorized eularian differencing, to be
used      20feb87
=
      20feb87      only with cray=1
=
      20feb87      =0  no vectorization
=
      20feb87      =1  use vector routines
=
      20feb87
=      cray      0      sap run to be run on cray-1 computer
      20feb87
=
      20feb87      =0  not a cray run
=
      20feb87      =1  cray run
=
      20feb87

```

=	cdc	1	sap run to be run of cdc computer
=	20feb87		
=			=0 not a cdc sap run
=	20feb87		
=			=1 cdc sap run
=	20feb87		
=	restart	0	this option to restart a previous run
=	20feb87		
=			=0 not a restart run
=	20feb87		
=			=1 problem is a restart run
=	20feb87		
=	euler	0	reference frame option
=	20feb87		
=			=0 lagrangian
=	20feb87		
=			=1 eulerian (use only with method 2
=	20feb87		single-material runs.)
=	20feb87		
=	geom	3	geometry option
=	20feb87		
=			=1 cartesian
=	20feb87		
=			=2 cylindrical
=	20feb87		
=			=3 spherical
=	20feb87		
=	ktstd	0	1 kiloton standard left bdry input
condition	20feb87		
=			=0 not included
=	20feb87		
=			=1 included. method 2 should be used.
=	20feb87		
=			subroutines as contained on sail file
=	20feb87		"dytaid" under the name 1ktstd should be
=			loaded with sap if this option is used.
=	20feb87		
=			options lbnd and/or rbnd must be set if
this	20feb87		is to be used.
=			
=	20feb87		
=	lbnd	0	left boundary condition option
=	20feb87		
=			=0 no left boundary input
=	20feb87		
=			=1 there is a left boundary condition
imposed. 20feb87			
=			if ktstd=0, a left boundary subroutine
called 20feb87			

```

=                                "lbound(time,distance,u,rho,i)"
(method 1) 20feb87
=                                "lbound(time,u,rho,i)"
(method 2) 20feb87
=                                which specifies speed, density and energy
as      20feb87
=                                a function of time (and distance, if
method 1) 20feb87
=                                must be loaded.
      20feb87
=                                also, the parameter "lbref" set by input
must    20feb87
=                                be zero, indicating a transmissive left
      20feb87
=                                boundary
      20feb87
=                                right boundary condition option (method 2
only) 20feb87
=                                =0 right boundary condition is defined by
      20feb87
=                                the option 'rezone'
      20feb87
=                                =1 the right boundary is reflective. the
      20feb87
=                                sap variable 'shkcel' will never be
permitted 20feb87
=                                to have values greater than imax - 2, and
the      20feb87
=                                calculation will not terminate when shkcel
      20feb87
=                                reaches a value of imax - 2.
      20feb87
=                                =2 there is a right boundary condition
imposed 20feb87
=                                if ktstd=0, a right boundary subroutine
called 20feb87
=                                "rbound(time,u,rho,i)"
(method 2) 20feb87
=                                which specifies speed, density and energy
as      20feb87
=                                a function of time must be loaded.
      20feb87
=                                differencing scheme option
method    20feb87
      20feb87
=                                =1 old sap differencing
      20feb87
=                                =2 hull differencing
      20feb87
weight    10feb87
      20feb87
=                                weight option for method 2
      20feb87
=                                =1 conventional hull boundary algorithm
      20feb87

```

```

=                                     ( bv=(v1+v2)/2 )
=      20feb87
=                                     =2 mass weighting boundary algorithm
=      20feb87
=      20feb87
=      nstat      0      number of stations in problem
=      20feb87
=      nmat      1      number of material boundaries in
=      20feb87
=                                     problem at any given time (see below).
=      20feb87
=      rezone     1      rezone option
=      20feb87
=                                     =0 no rezone (stop at right edge of mesh)
=      20feb87
=                                     =1 rezone (expand front fourth of mesh
= while      20feb87
=                                     conserving mass, momentum and total
= energy) 20feb87
=                                     =2 rezone (expand front fourth of mesh
= while      20feb87
=                                     conserving mass, momentum and
=      20feb87
=                                     mass*pressure)
=      20feb87
=      nvarpr     400    maximum number of hydro variables per
=      20feb87
=                                     tape4 hydro record
=      20feb87
=                                     =imax*5 for method 1
=      20feb87
=                                     =imax*4 for method 2
=      20feb87
=      imax      100    number of cells in problem
=      20feb87
=      rad      0      radiation option
=      20feb87
=                                     =0 no radiation loss
=      20feb87
=                                     =1 prescribed power out based upon
sputter      20feb87
=                                     calculations
=      20feb87
=                                     =2 emissivity based upon data by gilmer
=      20feb87
=                                     =3 radiation diffusion with
free-streaming at 20feb87
=                                     the edge of the temperature gradient.
=      20feb87
=                                     =4 -hfb must be set if rad=4- radiative
=      20feb87

```

```

=                heating using rate dependant thermal
=                layer model. currently used only when
=                angle=90.
=                20feb87
=                20feb87
=                20feb87
=                ngroup      1      number of frequency groups in problem
(used            20feb87
=                only when rad=3).
=                20feb87
=                sputin      0      sputter input for mesh
=                20feb87
=                =0 input is by means other than a sputter
tape 20feb87
=                =1 input to fill mesh is from a sputter
tape 20feb87
=                this option can be used at any angle with
=                20feb87
=                any geometry.
=                20feb87
=                20feb87
=                20feb87
=                hcutin      0      input is from a tape4 generated by program
20feb87
=                hullcut.
=                20feb87
=                =0 input is by means other than hullcut.
=                20feb87
=                =1 input is for fill the mesh form a
tape4 20feb87
=                generated by hullcut. the tape4
contains 20feb87
=                a z-block, a 'x' coordinate record,
and 20feb87
=                the hydro data. the tape is used as
if 20feb87
=                it were a restart tape. the option
can 20feb87
=                used at any angle with any geometry.
=                20feb87
=                20feb87
=                20feb87
=                plotit      0      plot option
20feb87
=                =0 no plot file is generated
=                20feb87
=                =1 tape1 metafile is generated to plot
over- 20feb87
=                pressure, overdensity and velocity as
a 20feb87
=                function of time.
=                20feb87

```

=	hydra	1	restart option
=	20feb87		
=			=0 no tape 4 is used, i.e., no restart
=	20feb87		capability
=	20feb87		
=	20feb87		=1 a tape4 (restart tape) is written
=	visc	1	artificial viscosity option
=	20feb87		
=			=0 no artificial visc terms added
=	20feb87		
=			=1 constant term added
=	20feb87		
=			=2 variable term added
=	acm	0	artificial compression method option
=	20feb87		
=			=0 no artificial compression used.
=			
=	mass,		=1 artificial compression applied to
=	20feb87		
=			momentum and total energy in
=	compression		
=	20feb87		regions.
=	fct	0	flux corrected transport scheme
=	20feb87		
=			
=	20feb87		
=	burn	0	high explosive material option
=	20feb87		
=			=0 no material is present (isothermal
=	sphere)		
=	20feb87		=1 explosive material is present
=			
=	nm	1	number of materials in the problem
=	20feb87		
=	matt	24	number of materials available in sap
=	20feb87		
=	air	1	=positive value if present in problem
=	20feb87		
=	tnt	0	=positive value if present in problem
=	20feb87		
=	btnt	0	=positive value if present in problem
=	20feb87		
=	pbx	0	=positive value if present in problem
=	20feb87		
=	bpbx	0	=positive value if present in problem
=	20feb87		
=	pent	0	=positive value if present in problem
=	20feb87		

=	bpent	0	=positive value if present in problem
=	20feb87 meth	0	=positive value if present in problem
=	20feb87 bmeth	0	=positive value if present in problem
=	20feb87 anfo	0	=positive value if present in problem
=	20feb87 banfo	0	=positive value if present in problem
=	20feb87 water	0	=positive value if present in problem.
=			(refer to subroutine waters for
instructions)	20feb87		
=	hmx	0	=positive value if present in problem
=	20feb87 bhm	0	=positive value if present in problem
=	20feb87 comb	0	=positive value if present in problem
=	20feb87 bcomb	0	=positive value if present in problem
=	20feb87 foam	0	=positive value if present in problem
=	20feb87 cfour	0	=positive value if present in problem
=	20feb87 bcfour	0	=positive value if present in problem
=	20feb87 petn	0	=positive value if present in problem
=	20feb87 bpetn	0	=positive value if present in problem
=	20feb87 irmt	0	=positive value if present in problem
=	20feb87 birm	0	=positive value if present in problem
=	20feb87 plug	0	=positive value if present in problem
=	20feb87		
=	20feb87		
=	the integers from 1 to nm should be assigned to		
=	20feb87		
=	materials in the problem. all other materials should		
=	20feb87		
=	be set to zero.		
=	20feb87		
=	20feb87		
=	a) air(isothermal sphere)		
=	20feb87		
=	b) bpent,air		
=	20feb87		

```

=      c)  bpent,pent,air
20feb87
=      d)  water,bpent,pent,water
20feb87
=      e)  bpent,pent,tnt,pent,air
20feb87
=
20feb87
=      should have the following options set as shown-
20feb87
=
20feb87
=      nm      nmat matt burn  (material codes)
20feb87
=
20feb87
=      a)  1      1      12      0      air=1
20feb87
=      b)  2      2      12      0      air=2,bpent=1
20feb87
=      c)  3      3      12      1      bpent=1,pent=2,air=3
20feb87
=      d)  3      4      12      1      water=1,bpent=2,pent=3
20feb87
=      e)  4      5      12      1      bpent=1,pent=2,tnt=3,air=4
20feb87
=
20feb87
=      except for a) (obviously) the ordering of the
20feb87
=      material code numbers is arbitrary (the fifth column
20feb87
=      of the above example is not unique). note that the
20feb87
=      last zone in the mesh must be included as a material
20feb87
=      boundary.
20feb87
=
20feb87
=      sap consists of a fair number of subroutines linked by
20feb87
=      blank and labeled common. in addition to the summary
20feb87
=      given below, most of the subroutines contain further
20feb87
=      explanation of their functions. for a detailed
20feb87
=      description of card input to sap, see subroutine in.
20feb87
=      the section labeled "constant" in sap outlines the
20feb87

```

```

=      procedure for adding new materials to sap.
20feb87
=
=      20feb87
=
=      20feb87
=      initializing routines - these are called when setting up
20feb87
=      or restarting a sap problem.  they are not contained
20feb87
=      within the main sap loop.  an asterisk before the routine
20feb87
=      indicates that the routine is included only if the option
in 20feb87
=      parentheses after the description is true.
20feb87
=
=      20feb87
=      in-in2      card input to sap (see in for explanation of
20feb87
=      input format)
20feb87
=      *restart    tape input (tape4,tape9)  restart
20feb87
=      if applicable (hydra)
20feb87
=      cell        sets up mesh using input
20feb87
=      set         defines zblk default values before input is read
20feb87
=      rstzblk     places input that is read into the zblk (from
20feb87
=      tape or card input) into appropriate problem
20feb87
=      parameters
20feb87
=      out         prints the initial zblk and the problem
20feb87
=      configuration.
20feb87
=
=      20feb87
=      main loop routines
20feb87
=
=      20feb87
=      dtime       selects time step for next cycle
20feb87
=      hydro       calculates hydro variable values throughout
20feb87
=      active mesh for the current cycle.
20feb87

```

```

=      lb1          defines left boundary values for method 2
20feb87
=      lb3          defines left bdry fluxes for eulerian method 2
20feb87
=      *burn        advances detonation front, converts h.e.
20feb87
=
20feb87          materials and adds chemical energy released by
=
20feb87          burning to the burning cell. (burn)
=
20feb87          *radlos/fbloss1  energy loss by radiation.  routine
20feb87
=
20feb87          included depends on sail option value. (rad)
=
20feb87          *rezone        redefines mesh coordinates. (rezone)
20feb87
=
20feb87          *stuff        redistributes hydro quantities in the
20feb87
=
20feb87          mesh set up by subroutine rezone. (rezone)
=
20feb87
=
20feb87          utility routines
20feb87
=
20feb87
=
20feb87          *decide        selects material content of a cell according to
20feb87
=
20feb87          the cell-s position wrt the boundary array. (nm
gt1) 20feb87
=
20feb87          *const        selects detonation energy and initial velocity
20feb87
=
20feb87          of detonation for h.e. materials. (burn)
=
20feb87          *eos          calls the appropriate equation of state
20feb87
=
20feb87          routine for the cell in question. (nm gt 1)
=
20feb87          *visc2        determines the magnitude of the linear viscosity
20feb87
=
20feb87          coefficient as a function of maximum density.
(visc2) 20feb87
=
20feb87          *q          determines the artificial viscosity to be added
to 20feb87
=
20feb87          pressure term in the hydro. (visc lt2)
=
20feb87          *acmsub        modifies the mass, momentum and total energy
terms 20feb87
=
20feb87          in regions of compression to preserve
=
20feb87          discontinuities. (acm)
20feb87

```

=	kill	stops the program on a model condition for a
=	20feb87	small number of recognized foul ups in the
=	20feb87	other routines.
=	20feb87	
=	*rated	thermal heating routine. returns ground
=	20feb87	level temperatures as a function of incident
=	20feb87	thermal flux for a given time.(rad4)
=	20feb87	
=	*dairt	the derivative of subroutine airt. returns
=	20feb87	the derivative of temperature wrt energy.
=	20feb87	used in thermal heating calculations.(rad4)
=	20feb87	
=	20feb87	
=	output routines - most called at std times	
=	20feb87	
=	20feb87	
=	edit	writes to file output.
=	20feb87	
=	*wtape4	hydro tape4 output (hydra)
=	20feb87	
=	setz	updates the zblk array.
=	20feb87	
=	*draw	plots of velocity, overdensity and overpressure
=	20feb87	vs radius are produced. (plotit)
=	20feb87	
=	*wtape9	station tape9 output (called from subroutine
=	20feb87	hydro when a station is encountered) (nstat)
=	20feb87	
=	20feb87	
=	20feb87	
=	20feb87	

Appendix C

```
sap prob=111.0  t=1.e-4
cycle=0.0  input  cstop=2100  detcel=1.0  rdw=11.0
angle=0.0  head
  sap run pentolite 100 cells 29 july 92
  hob=0.0 x0=0.0
region
  bpent=1  speed=.01  dx=11.0  bound=1 cells
  speed=.01 pent=2  dx=10.  bound=3  cells
  pent=2 dx=10.0 bound=75  cells
  air=3  dx=30.  bound=77  cells
  air=3 dx=42. cells
end
```

Appendix D

```

subroutine in
20feb87
C
    20feb87
C*****
***** 20feb87
C*
    * 20feb87
C*   this subroutine reads the card input to sap and places the
    * 20feb87
C* values in the proper parameters.
    * 20feb87
C*
    * 20feb87
C*****
***** 20feb87
C
    20feb87
$   parameter          (nmat = _nmat_ )
    11feb87
    equivalence        (what, iws)
    20feb87
=
    20feb87
=   input to sap is divided into several sections separated
    20feb87
=   by keywords given below.  all input is in free format.
    20feb87
=
    20feb87
=   the first keyword is "sap" and must in all cases be the
    20feb87
=   first word of data.  three parameters follow
    20feb87
=   t = (time for start of this run.  if not present, default
    20feb87
=   is to a large value, indicating a restart at the end of
    20feb87
=   the last run.  the time may not be .le. zero.  if input as
    20feb87
=   such the program will stop)
    20feb87
=   prob = (problem number)
    20feb87
=   cycle = (cycle number for start of this run.  for a new
    20feb87
=   problem, cycle=0.0.  default is to a large

```

value, indicating 20feb87
 = a restart at the end of the last run. any other positive
 20feb87
 = number will result in a restart at that cycle number)
 20feb87
 = for a new problem, time and cycle must both be specified.
 20feb87
 = for a restart neither need be input. failure to specify
 20feb87
 = the correct problem number on a restart will cause sap to
 20feb87
 = abort.
 20feb87
 =
 20feb87
 = for the previous two sections, the data input may appear
 more 20feb87
 = than once. the latest value will be the one used by the
 program. 20feb87
 = this is convenient when running two or more problems which
 differ 20feb87
 = only in the values of the input parameters. input cards may
 be 20feb87
 = reordered, rather than redone.
 20feb87
 =
 20feb87
 = the next section is delimited from the first by the word
 20feb87
 = "input". data contained in this section pertain to zblock
 20feb87
 = parameter values, header card information, and the station
 20feb87
 = coordinates if applicable. with the exception of the header
 20feb87
 = card, any values in this section may be defaulted to
 internally 20feb87
 = set values listed below. data in this section may appear in
 20feb87
 = any order with two exceptions. the header card must be
 20feb87
 = on a separate card, preceded by the word "head", and the
 20feb87
 = station coordinates or data for generation of stations must
 20feb87
 = be preceded by the word "stations" (see below).
 20feb87
 =
 20feb87
 = word default definition
 20feb87
 =

```

=      20feb87
up    angle  0.0      angle of run (degrees) +90 degrees - straight
=      20feb87
=      cstop  1.e17   cycle stop
=      20feb87
=      c0      1.80    quadratic artificial viscosity coefficient
=      20feb87
=      c1      .5      linear artificial viscosity coefficient
=      20feb87
=      detcel  0.      number of cell containing detonation wave
=      20feb87
=                               this cell separates burned from unburned
regions. 20feb87
=      dstop  1.e9     distance of max pressure stop (cm)
=      20feb87
=      dt      1.e-9   time increment (input value used only for
=                               first cycle)
=      20feb87
=      dxmul   1.0     increment ratio in exterior cell size (used
=                               in rezone)
=      20feb87
=      hob      0.0    height of burst (cm)
=      20feb87
=      lbref    1      left boundary reflective indicator
=      20feb87
=                               ( a value of 0 - indicating transmissive
=                               left bdry - is sensible only with method 2
=                               and cartesian geometry. it must be used if a
=                               left boundary input condition is used.)
=      20feb87
=      prdw    0.0     radius of detonation wave last cycle (=0.0 for
=      20feb87                               new problem - set by tape4 read on restart)
=      20feb87
=      ptstop  100.    problem time stop (sec)
=      20feb87
=      qmin    .1      minimum artificial viscosity (noise level)
=      20feb87
=      rdw      0.0    radius detonation wave this cycle (=0.0 for
=      20feb87                               for a problem with no burn - isothermal
sphere) 20feb87
=      stabf   0.8     stability factor (safety factor in courant
=      20feb87                               condition time step)
=      20feb87
=      umin    1.e-4   minimum hydro velocity (noise limit)

```

```

20feb87
=      x0      0.0      distance of mesh left edge from origin.  a
non-zero 20feb87
=
20feb87      value makes sense only if geom=1. (cm)
20feb87
=      yield  0.0      yield of device in kt
20feb87
=      hfb      hob      height of fireball above ground (cm) - (rad4)
20feb87
=      grndr  0.0      distance from mesh to ground zero (cm) -
(rad4)      20feb87
=
20feb87
=      any of the above may be rstzbx by specifying the keyword
given      20feb87
=      followed by the desired value.  any such changes must appear
20feb87
=      in the section labeled "input".
20feb87
=      some notes on the keywords -cstop-, -dstop-, and -pstop-, if
20feb87
=      any of the above are found, then the ones found will be the
20feb87
=      only conditions which will stop sap during a run.  if the
20feb87
=      user omits all of the stop conditions, then all three
default      20feb87
=      values will be used for ending sap.
20feb87
=
20feb87
=      the sputin section should follow the input section, and
20feb87
=      it can be before or after the header card sequence.  the
default      20feb87
=      values found here are different once the key word -sputin-
is      20feb87
=      encountered.  following the afore mentioned keyword are the
20feb87
=      following parameters
20feb87
=
20feb87
=      word      default      definition
20feb87
=
20feb87
=      yield 0.0      yield of device in kt.
20feb87
=      scale n/a      if this word is encountered, then the data is
20feb87
=      scaled to user input - i.e. yield and hob.

```

```

20feb87
=   hob    0.0      height of burst in cm.
20feb87
=   fb      none    mandatory name of sputter tape to be used.
the   20feb87
=                                     actual tape itself should be called tape3 in
the   20feb87
=                                     users local file space.
20feb87
=   dx    100.      cell width after the sputter tape input has
been  20feb87
=                                     put into the mesh.
20feb87
=
20feb87
=   note that the parameters yield, hob, and dx are found in
other 20feb87
=   input sections, these values must appear in the -sputin-
20feb87
=   section or the values are not guaranteed to be of value.
20feb87
=   it is also important to note that the -region-
20feb87
=   section is ignored when sputter tapes are used as input.  if
the 20feb87
=   angle in the input section is > 0 and if the -scale-
parameter is 20feb87
=   set, then it will scale the data to a mesh cut at that
angle. 20feb87
=
20feb87
=   stations may be specified if desired in one of two ways
20feb87
=
20feb87
=   stations explicit (nstat values listed in increasing
20feb87
=   order, to be used as coordinates of stations)
20feb87
=   - or -
20feb87
=   stations xs0 = (coordinate of first station)
20feb87
=   dx = (distance between adjacent stations)
20feb87
=   either parameter may be specified first, and both must be
present 20feb87
=   if sail option "nstat" is set to 0, of course no keyword or
20feb87
=   data pertaining to stations should be present in input.
20feb87
=

```

```

20feb87
=   the final section of data is begun with the word "region".
20feb87
=   this section need not be included for a new problem if option
20feb87
=   "sputin" is set.
20feb87
=   this section is used to set up and stuff the mesh.
20feb87
=   data in this section consists of groups of 6 values separated
20feb87
=   by the word "cells".  those values whose defaults suffice
20feb87
=   need not be input.
20feb87
=
20feb87
=   input word    definition
20feb87
=
20feb87
=   (material name) (material code)  material name abbreviation
20feb87
=
20feb87
=   specifies what material is in this part of
20feb87
=   the mesh.  acceptable names are air,tnt,btnt,
20feb87
=   pent,bpent, meth,bmeth, pbx,bpbx, anfo
banfo,water. 20feb87
=   code must agree with the code assigned the
20feb87
=   material in the sail option list
20feb87
=   (default is air=1)
20feb87
=
20feb87
=   dx            width of cells in this part of the mesh
20feb87
=   default is dx=0.0
20feb87
=
20feb87
=   energy        energy density to be inserted in cells in
20feb87
=   this part of the mesh (erg/gm).  default
20feb87
=   is ambient energy of the material.
20feb87
=
20feb87
=   rho           mass density of cells in this part of mesh

```

```

20feb87
=      (gm/cm**3).  default is ambient density.
20feb87
=
20feb87
=      speed      speed of material in this part of the mesh.
20feb87
=      at least the first cell must be assigned some
20feb87
=      small initial velocity (if less than umin,
this 20feb87
=      initial velocity will not be present by cycle
1). 20feb87
=      if there is a zero velocity in the first cell
the 20feb87
=      program will stop.
20feb87
=      default is 0.0 cm/sec.
20feb87
=
20feb87
=      bound      maximum cell number for which the previous
20feb87
=      five values hold (default - bound=imax)
20feb87
=
20feb87
=
20feb87
=      these six words may appear in any order within a group.
20feb87
=      they must be followed by the word "cells".  groups must be
20feb87
=      given in order of increasing distance from the center of the
20feb87
=      problem.  of course groups may not be mixed.
20feb87
=
20feb87
=      the final word of data input on cards must be the
20feb87
=      word "end".
20feb87
=
20feb87
=
20feb87
=
20feb87
=      as an example,  a data set for a new problem consisting
20feb87
=      of 100 cells, 75 pentolite (the first cell must be burned)

```

```

20feb87
= and the remaining 25 cells air at ambient conditions follows.
20feb87
= fifty stations at intervals of 25. cm are generated. the
20feb87
= material codes are presumed to be identical with those input
as 20feb87
= sail options. imax and nstat=no of stations are also set by
20feb87
= sail options.
20feb87
=
20feb87
= sap prob=2001.00 t=1.e-4
20feb87
= cycle=0.0 input cstop=2100. detcel=1.0 rdw=11.0
20feb87
= angle=0.0 head
20feb87
= sap run pentolite 100 cells 4 apr 75
20feb87
= hob=0.0 stations dx=25. xs0=0.0
20feb87
= region
20feb87
= bpent=2 speed=.01 dx=11.0 bound=1 cells
20feb87
= speed=.01 pent=3 dx=10. bound=3 cells
20feb87
= pent=3 bound=75 dx=10.0 cells
20feb87
= air=1 dx=30. bound=77 cells
20feb87
= air=1 dx=42. cells
20feb87
= end
20feb87
=
20feb87
=
20feb87
=
20feb87
= deletion of the statement cycle=0.0 and an increment of
20feb87
= the previous run-s stop limit (cstop, dstop, or ptstop) with
20feb87
= the rest of the data unchanged will result in a restart
20feb87
= beginning where the last run stopped. any changes in input
20feb87
= will take precedence over tape4 values obtained from the

```

```

20feb87
= the zblock, except of course those parameters which change
20feb87
= with time (eg - detcel,rdw,shkcel). if restarting before a
20feb87
= rezone has occurred, the inactive portion of the mesh
20feb87
= (cells shkcel+2 to imax) will be restuffed with the
20feb87
= appropriate data from the "region" section. if a remesh has
20feb87
= taken place in the previous run, the inactive cells are
20feb87
= initialized at ambient air conditions with a width equal to
20feb87
= the last undisturbed cell in the mesh
(x(shkcel+1)-x(shkcel)). 20feb87
= in this case, the "region" data is ignored and may be deleted
20feb87
= (omit the keyword as well). in all cases "end" must mark the
20feb87
= end of the sap card data.
20feb87
=
20feb87
=
20feb87
= an example of a problem using sputter data as input is
the 20feb87
= following.
20feb87
=
20feb87
=
20feb87
= sap t=1.e-3 prob=1313.00 cycle=0.00
20feb87
= input angle=0.0
20feb87
= head
20feb87
= sputter input example$
20feb87
= sputin yield=2.0 hob=5.e5 scale fb=fb21 dx=.2
20feb87
= end
20feb87
=
20feb87
= where the sputter tape fb21 is used with data from a dump
closest 20feb87
= to but latter than 1.e-3sec. this data will be scaled to a

```

2 kt 20feb87
= burst at 5 km. the remaining cells will be .2 cm filled
with 20feb87
= ambient air conditions. note that the '\$' on the header
card 20feb87
= is for disspla plotting routines and must be present
20feb87
= as a string terminator.
20feb87
=
20feb87

Appendix E

```
#
#   Batch File jobsap.com
#
#       embedded NQS options
# @$-eo  # directs stderr to stdout
# @$-lt 0:30:00  # per-process CPU time
# @$-lT 0:30:00  # per-request CPU time
# @$      # end of embedded NQS options
#
#   Add SAP to the HULL Library
#
cd /u2/h5serag0/sap
#
ln /u2/h5serba0/HULL122/hull122.system old
#
cat >sail.in <<EOF
sail version 122.1 update
*i 189999
*b runsap
*keepto runsap runsap eq1
*read modif.cr
*label runsap
EOF
sail <sail.in >sail.s.out
ln new sapv1.system
rm -f new old
#
#   Re-Sequence HULL Library
#
ln sapv1.system old
#
cat >sail.in <<EOF
sail version 123 update
seq program runsap
EOF
sail <sail.in >sail.s.out
ln new sapv2.system
rm -f new old
#
#   This converts the program runsap from the hull binary
#   to ascii format
#                               (Stored in sapv1.system)
#
ln sapv2.system old
#
cat >sail.in <<EOF
sail copy convert
EOF
```

```

sail <sail.in >sail.s.out
ln new runsap.ascii
rm -f new old
#
#       This prepares coded hull library of runsap
#       from runsap.ascii

#
ln runsap.ascii old
#
cat >sail.in <<EOF
sail convert copy
EOF
sail <sail.in >sail.s.out
ln new sapv3.system
rm -f old new
#
#       Now Compile and Run SAP
#
ln sapv3.system old
#
cat >sail.in <<EOF
sail lineno options runsap=1 endoptions program sap
EOF
sail <sail.in >sail.s.out
mv source sap.f
#
#
cat >segldr.in <<EOF
preset=-indef
abs=sap
bin=sap.o
EOF
#
cft77 -a static -l sap.l sap.f
segldr segldr.in
#
time sap <sap.in >sap.out
#

```

Appendix F

1	sap run	pentolite	100 cells	29 july 92
			z	block
	prob		1.1100E+02	
bdry		1.0000E+00		
	airopt		1.0000E+00	
bdry		7.5000E+01		
	angle		0.0000E+00	
bdry		1.0000E+02		
	atmos		2.0000E+00	
		0.0000E+00		
	bsum		0.0000E+00	
		0.0000E+00		
	burnout		0.0000E+00	
		0.0000E+00		
	cstop		2.1000E+03	
		0.0000E+00		
	c0		1.8000E+00	
		0.0000E+00		
	c1		5.0000E-01	
		0.0000E+00		
	cycle		0.0000E+00	
		0.0000E+00		
	detcel		0.0000E+00	
		0.0000E+00		
	dstop		1.0000E+09	
		0.0000E+00		
	dt		1.0000E-09	
		0.0000E+00		
	dtmin		1.0000E+20	
		0.0000E+00		
	dxmul		1.0000E+00	
		0.0000E+00		
	eth		8.3418E+16	
		0.0000E+00		
	euler		0.0000E+00	
		0.0000E+00		
	geom		3.0000E+00	
		0.0000E+00		
	grndr		0.0000E+00	
		0.0000E+00		
	hfb		0.0000E+00	
		0.0000E+00		
	hob		0.0000E+00	

imax	0.0000E+00	1.0000E+02
lbref	0.0000E+00	1.0000E+00
method	0.0000E+00	1.0000E+00
nh	0.0000E+00	5.0000E+00
nstat	0.0000E+00	0.0000E+00
nvarpr	0.0000E+00	2.5000E+01
nzblk	0.0000E+00	4.2000E+01
prdw	0.0000E+00	0.0000E+00
ptstop	0.0000E+00	1.0000E+02
qmin	0.0000E+00	1.0000E-01
rad	0.0000E+00	0.0000E+00
radsum	0.0000E+00	0.0000E+00
rdw	0.0000E+00	1.1000E+01
rezone	0.0000E+00	1.0000E+00
shkcel	0.0000E+00	4.0000E+00
stabf	0.0000E+00	8.0000E-01
t	0.0000E+00	1.0000E-04
thm	0.0000E+00	7.0947E+08
umin	0.0000E+00	1.0000E-04
visc	0.0000E+00	1.0000E+00
yield	0.0000E+00	0.0000E+00
nmat	0.0000E+00	3.0000E+00
bpent	0.0000E+00	1.0000E+00
pent	0.0000E+00	2.0000E+00
air	0.0000E+00	3.0000E+00

1

sap run

pentolite

100 cells

29 july 92

		z	block
1.1000E+01	bpent	1	1
7.5100E+02	pent	2	75
1.7770E+03	air	3	100
1 sap run	pentolite	100 cells	29 july 92

problem 111.00000 cycle = 0. t = 1.00000E-04
total energy eth = 8.34180E+16 total mass thm = 7.09472E+08

mesh values start of this run

j	x	u	p	epg
rho	temp	zm	dx	j
1	1.10000E+01	1.00000E-02	1.03766E+11	5.15500E+10
1.66000E+00	0.00000E+00	2.20946E+03	1.10000E+01	1
2	2.10000E+01	1.00000E-02	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.31638E+04	1.00000E+01	2
3	3.10000E+01	1.00000E-02	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	3.40798E+04	1.00000E+01	3
4	4.10000E+01	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	6.49558E+04	1.00000E+01	4
5	5.10000E+01	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.05792E+05	1.00000E+01	5
6	6.10000E+01	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.56588E+05	1.00000E+01	6
7	7.10000E+01	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.17344E+05	1.00000E+01	7
8	8.10000E+01	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.88060E+05	1.00000E+01	8
9	9.10000E+01	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	3.68736E+05	1.00000E+01	9
10	1.01000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	4.59372E+05	1.00000E+01	10
11	1.11000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	5.59968E+05	1.00000E+01	11
12	1.21000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	6.70524E+05	1.00000E+01	12
13	1.31000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	7.91040E+05	1.00000E+01	13
14	1.41000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	9.21516E+05	1.00000E+01	14
15	1.51000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.06195E+06	1.00000E+01	15
16	1.61000E+02	0.00000E+00	1.01325E+06	1.00000E+08

1.66000E+00	0.00000E+00	1.21235E+06	1.00000E+01	16
17	1.71000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.37270E+06	1.00000E+01	17
18	1.81000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.54302E+06	1.00000E+01	18
19	1.91000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.72330E+06	1.00000E+01	19
20	2.01000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.91353E+06	1.00000E+01	20
21	2.11000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.11373E+06	1.00000E+01	21
22	2.21000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.32388E+06	1.00000E+01	22
23	2.31000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.54400E+06	1.00000E+01	23
24	2.41000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.77408E+06	1.00000E+01	24
25	2.51000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	3.01411E+06	1.00000E+01	25
26	2.61000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	3.26411E+06	1.00000E+01	26
27	2.71000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	3.52406E+06	1.00000E+01	27
28	2.81000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	3.79398E+06	1.00000E+01	28
29	2.91000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	4.07386E+06	1.00000E+01	29
30	3.01000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	4.36369E+06	1.00000E+01	30
31	3.11000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	4.66349E+06	1.00000E+01	31
32	3.21000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	4.97324E+06	1.00000E+01	32
33	3.31000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	5.29296E+06	1.00000E+01	33
34	3.41000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	5.62264E+06	1.00000E+01	34
35	3.51000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	5.96227E+06	1.00000E+01	35
36	3.61000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	6.31187E+06	1.00000E+01	36
37	3.71000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	6.67142E+06	1.00000E+01	37
38	3.81000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	7.04094E+06	1.00000E+01	38
39	3.91000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	7.42042E+06	1.00000E+01	39
40	4.01000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	7.80985E+06	1.00000E+01	40
41	4.11000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	8.20925E+06	1.00000E+01	41
42	4.21000E+02	0.00000E+00	1.01325E+06	1.00000E+08

1.66000E+00	0.00000E+00	8.61860E+06	1.00000E+01	42
43	4.31000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	9.03792E+06	1.00000E+01	43
44	4.41000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	9.46720E+06	1.00000E+01	44
45	4.51000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	9.90643E+06	1.00000E+01	45
46	4.61000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.03556E+07	1.00000E+01	46
47	4.71000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.08148E+07	1.00000E+01	47
48	4.81000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.12839E+07	1.00000E+01	48
49	4.91000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.17630E+07	1.00000E+01	49
50	5.01000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.22520E+07	1.00000E+01	50
1	sap run	pentolite	100 cells	29 july 92

problem 111.00000 cycle = 0. t = 1.00000E-04
total energy eth = 8.34180E+16 total mass thm = 7.09472E+08

mesh values start of this run

j	x	u	p	epg
rho	temp	zm	dx	j
51	5.11000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.27510E+07	1.00000E+01	51
52	5.21000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.32600E+07	1.00000E+01	52
53	5.31000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.37789E+07	1.00000E+01	53
54	5.41000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.43078E+07	1.00000E+01	54
55	5.51000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.48466E+07	1.00000E+01	55
56	5.61000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.53954E+07	1.00000E+01	56
57	5.71000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.59541E+07	1.00000E+01	57
58	5.81000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.65229E+07	1.00000E+01	58
59	5.91000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.71015E+07	1.00000E+01	59
60	6.01000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.76902E+07	1.00000E+01	60
61	6.11000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.82888E+07	1.00000E+01	61
62	6.21000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	1.88973E+07	1.00000E+01	62
63	6.31000E+02	0.00000E+00	1.01325E+06	1.00000E+08

1.66000E+00	0.00000E+00	1.95158E+07	1.00000E+01	63
64	6.41000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.01443E+07	1.00000E+01	64
65	6.51000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.07828E+07	1.00000E+01	65
66	6.61000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.14311E+07	1.00000E+01	66
67	6.71000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.20895E+07	1.00000E+01	67
68	6.81000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.27578E+07	1.00000E+01	68
69	6.91000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.34361E+07	1.00000E+01	69
70	7.01000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.41243E+07	1.00000E+01	70
71	7.11000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.48225E+07	1.00000E+01	71
72	7.21000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.55307E+07	1.00000E+01	72
73	7.31000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.62488E+07	1.00000E+01	73
74	7.41000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.69769E+07	1.00000E+01	74
75	7.51000E+02	0.00000E+00	1.01325E+06	1.00000E+08
1.66000E+00	0.00000E+00	2.77149E+07	1.00000E+01	75
76	7.81000E+02	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	6.46981E+04	3.00000E+01	76
77	8.11000E+02	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	6.98644E+04	3.00000E+01	77
78	8.53000E+02	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	1.06867E+05	4.20000E+01	78
79	8.95000E+02	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	1.17927E+05	4.20000E+01	79
80	9.37000E+02	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	1.29531E+05	4.20000E+01	80
81	9.79000E+02	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	1.41680E+05	4.20000E+01	81
82	1.02100E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	1.54373E+05	4.20000E+01	82
83	1.06300E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	1.67610E+05	4.20000E+01	83
84	1.10500E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	1.81393E+05	4.20000E+01	84
85	1.14700E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	1.95719E+05	4.20000E+01	85
86	1.18900E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	2.10591E+05	4.20000E+01	86
87	1.23100E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	2.26007E+05	4.20000E+01	87
88	1.27300E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	2.41967E+05	4.20000E+01	88
89	1.31500E+03	0.00000E+00	1.01325E+06	2.04448E+09

1.22500E-03	2.87938E+02	2.58472E+05	4.20000E+01	89
90	1.35700E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	2.75521E+05	4.20000E+01	90
91	1.39900E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	2.93115E+05	4.20000E+01	91
92	1.44100E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	3.11254E+05	4.20000E+01	92
93	1.48300E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	3.29937E+05	4.20000E+01	93
94	1.52500E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	3.49165E+05	4.20000E+01	94
95	1.56700E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	3.68937E+05	4.20000E+01	95
96	1.60900E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	3.89254E+05	4.20000E+01	96
97	1.65100E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	4.10115E+05	4.20000E+01	97
98	1.69300E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	4.31521E+05	4.20000E+01	98
99	1.73500E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	4.53472E+05	4.20000E+01	99
100	1.77700E+03	0.00000E+00	1.01325E+06	2.04448E+09
1.22500E-03	2.87938E+02	4.75966E+05	4.20000E+01	100

ltrouble in subroutine burn - abort

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
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13. ABSTRACT (Maximum 200 words) The Spherical Air Puff (SAP) hydrocode was added to the HULL system at the U.S. Army Engineer Waterways Experiment Station (WES) to enhance the capabilities of hydrodynamic calculations. The program is intended to achieve faster execution time and better accuracy in certain hydrodynamic problems. SAP will furnish starting values in HULL hydrodynamic calculations, as well as being an independent capability. The enhanced capability must be tested with different physical problems.				
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