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USER'S GUIDE TO THE PICATINNY HEMP COMPUTER CODE

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An implementation of the HEMP code on the Control Data 6600 Computer is described. The original code, by Mark Wilkins, has been restructured for increased execution speed and reduced memory requirements. Additional features such as line dropping and new gridding options have been included. This guide is intended for use with the original HEMP User's Manual by E. D. Giroux.

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INTRODUCTION

HEMP is a general purpose, two-dimensional, finite-difference, Lagrangian computer code originally written by Mark Wilkins of the Lawrence Livermore Laboratory, Livermore, California. The code was based on Dr. Wilkins' development of the elastic-plastic flow theory (ref 1). This was further documented in a HEMP User's Manual. Numerous versions of the program are in use world-wide for the study of elastic-plastic deformation problems, particularly in the ordnance field. In 1971, the Feltman Research Laboratories at Picatinny Arsenal (PA) received a copy of the code from personnel of the Army Materials Research Center. Responsibility for maintaining this code for PA use was given to this author in 1974.

This PA version of the HEMP computer code is maintained on the Control Data Corporation 6000-series computers at U.S. Army Armament R&D Center. Over the past ten years, this code has been enhanced with numerous input and output options, line dropping capability, and new gridding options, and has been streamlined for efficient use of the resources on the CDC machines. The code is compiled with the FORTRAN IV compiler, under the NOS/BE operating system. With one minor change, the program also runs under the SCOPE 2 operating system on the CDC 7600 mainframe located at the Ballistic Research Laboratory, Aberdeen, Maryland. A grid-plotting package has been developed for displaying the results of the computations on TEKTRONIX and equivalent interactive graphics terminals. The code has been an effective tool for designing anti-armor warheads and for studying other explosive-metal systems and high velocity impact problems. A sample of the graphical output from a HEMP warhead calculation is in figure 1.

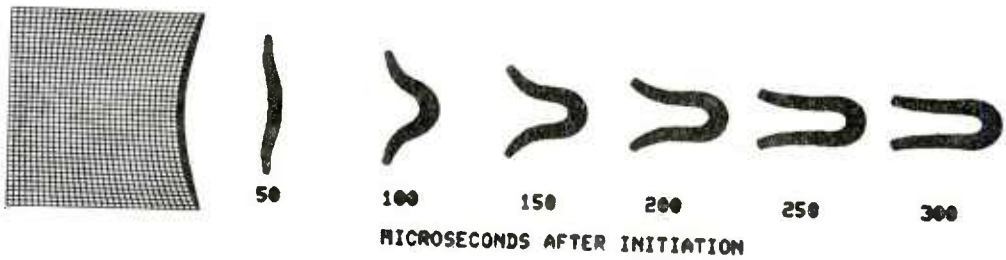


Figure 1. Sample HEMP graphical output

This user guide is intended for use with the HEMP User's Manual (ref 2). New features and major modifications are described in this report. Appendix A contains a complete index to all input cards found in this report and in reference 2. Other minor differences between the original code and the Picatinny version are noted in appendix B.

ACCESSING THE HEMP PROGRAM

The HEMP program is stored as a permanent file on the CDC mainframes, in absolute format. The file, named HEMP, may be attached and run by means of a CDC Control Language file through the following BEGIN statement:

```
BEGIN,HEMP,/RANDERS.
```

Additional parameters may be specified on the BEGIN statement. These are:

PLOT=<permanent file name for plot data>
(Default is none.)

OLDPLOT=<existing permanent file to be overwritten with plot data>
(Use PLOT or OLDPLOT but not both.)

RESOUT=<permanent file name for restart file to be written>
(Default is none.)

RESIN=<permanent file name for restart file to be read in>
(Default is none.)

OLDRES=<existing permanent file to be overwritten with restart data>
(Use RESOUT or OLDRES but not both.)

ID=<permanent file ID for above files>

PRINT=<"HERE" or a terminal ID>
(If omitted, printout will go to central site.)

FL=<initial field length>
(Default is 110 000.)

N=<maximum number of iterations> (overrides "CYCLES" card)

VERSION=<file name containing HEMP>
(Default is HEMPA.)

Typically, the user will first set up a checkout run to run one cycle, catalog a plot file, and return the printout to the terminal:

```
BEGIN,HEMP,/RANDERS,PLOT=TEST1,ID=USER,N=1,PRINT=HERE.
```

At this point the printout is inspected for error messages, needed corrections are made, and the job is resubmitted, if necessary. The plot file is viewed by logging into the CDC with a graphics terminal and typing:

```
FETCH,HEMPG,RANDERS

FETCH,TEST1,USER
```

```
ETL,50

HEMPG,TEST1
```

Then, when the problem seems to be properly set up, the computer is instructed to make the complete run, with a restart file, and with printed output sent to a remote batch terminal:

```
BEGIN,HEMP,/RANDERS,OLDPLOT=TEST1,RESOUT=RESTART1,ID=USER,PRINT=AI.
```

PLOTTING

The plot file, known internally to the HEMP code as "TAPE59," contains a separate binary record for each plot time specified on the "EDITFREQ" input card. This file will be cataloged as a permanent file on the CDC system if "PLOT=FILENAME" and "ID=USER" are included on the "BEGIN" statement which invoked the HEMP calculation. A separate program, "HEMPG," may be used to display the grid plots on a TEKTRONIX or equivalent interactive graphics terminal. This program will display the complete grid for the first time-step encountered in the file. For subsequent time-steps, only that portion of the grid between KMAX and the highest numbered slide line will be shown. (This is typically the liner of a shaped charge or the case of an expanding shell.) If complete grid plots of subsequent time-steps are desired, then the file should be separated into individual files for each time-step by means of CDC COPYBR commands before running HEMPG.

To run HEMPG, type:

```
FETCH,HEMPG,RANDERS

ETL,50.

ATTACH,X,FILENAME,ID=USER.

HEMPG,X.
```

HEMPG will first display velocity plots, if they have been called for on the PLOTTYPE input card, showing the velocity versus radial position for the KMAX nodes only for each time-step.

Next HEMPG will display "xmx=xx.xx" where xx.xx is the largest x-value found on any time-step. The user types "K".

Next HEMPG will display "xmax=xx.xx" where xx.xx is a number taken from the PLOTSCAL input card. This will be the scale limit for the x-ordinate. The user may type "K" if this is satisfactory, or may type in another number, with or without a decimal point, if desired.

HEMPG will then display "xmin=xx.xx", which is the proposed lower scale limit for x-ordinate, which also may be kept with "K" or overridden as desired.

Next will be displayed proposed ymax and ymin values, which are calculated to maintain a one-to-one aspect ratio with the selected xmax and xmin values. When these have been kept or overridden as above, the terminal bell will sound. At this point, the user may type "G" to go on to the plots, or "R" to redo the scale selection.

After the user has typed "G", the screen will be erased and the first grid plot drawn. At the completion of the plot, the terminal bell will sound, and the user will then have the option of typing "R" to redo the scale selections, or "C" to continue without erasing the screen. Further plots will show only the portion of the grid above the highest slide line. When the last grid is completed, the terminal bell will sound again. At this point, the user may switch to LOCAL on the terminal and type in any desired labels or comments.

INTERNAL CHANGES

Numerous internal changes to HEMP were made to improve its utilization of memory and to improve its speed of execution. These include:

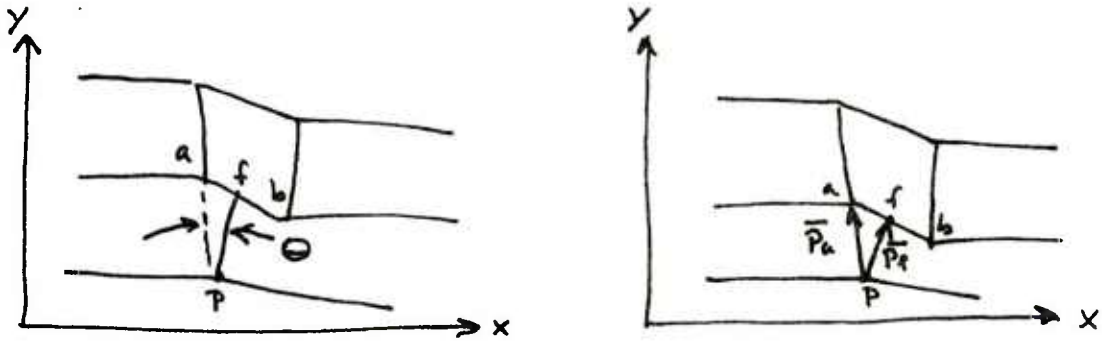
1. Changing numbered COMMON 19 to Blank COMMON, and adjusting its length to fit the problem; storing only those variables actually called for in the calculation; and at the conclusion of problem generation, reducing the job field length to that actually required. After execution of DROPKMIN instruction, field length is reduced again. Field length changes are accomplished by means of an assembler routine.

2. Packing of the variables KT and EQST into the BYTS array.

3. Using only the five k-line SCM group as described in reference 2, page 15, when there is not enough memory available to contain the entire problem. If enough memory is available, all variables are stored in blank COMMON, the disc/memory transfers are eliminated, and only the pointers (in the KAMAX array) are changed. The five k-line method will occur if the job field length is set to a small enough value (or if a large problem is set up). With the 240 000 octal words available on the 6600 machine, problems containing up to approximately 2600 zones can be run in core.

4. Allocating memory for only ten equations of state, to be consistent with the limit imposed by other portions of the code. Data for the equations actually being used are loaded into memory at problem generation time.

5. Eliminating trigonometric calculations in the slide-line search routine described in reference 1, pages 84 and 85. The problem is to determine whether a point "a" lies to the left or to the right of a line defined by two other points "P" and "f" (fig. 2). Instead of calculating the angle between P-a and P-f, a simple vector cross product is calculated, whose sign determines whether the point is to the left or to the right. This method does not require any special treatment when the angle is greater than 90 degrees. Consequently, the slide-line search procedure is simplified, and subroutine ANGADJ is no longer required.



a. Original Scheme: Look for change in sign of theta

b. New scheme: Look for change in sign of $\vec{Pa} \times \vec{Pf}$

Figure 2. Schemes for finding points on slide-line

6. Increasing the KAMAX array from 8 to 10 pointers, setting pointers 6 through 10 to equal pointers 1 through 5, respectively, and cycling "I7" from 3 to 7 instead of from 1 to 5. This enabled the elimination of the COMPUTED GOTO statements in all the velocity calculation routines, since it is no longer necessary to determine whether I7-2, I7-1, I7+1, and I7+2 exist.

7. Using SEGLOAD (ref 3) to reduce the memory required for the HEMP machine code from 150 000 to 55 000 octal (23 000 decimal) 60-bit words. DATA statements referring to COMMON variables were eliminated to give SEGLOAD more flexibility. The directives for performing the segmented load are shown in figure 3.

```
  TREE HEMP-(GENT,CYCLAA-(UT70AA-(U72BAA,U72GAA),VD60AA,PRNTAA,RES0))
GENT TREE GENR-(INGNAA,EQWRIT)
  LEVEL
  TREE WUPBAA
  TREE WUPGAA
  TREE PUTT
  TREE PRSPAA
HEMP INCLUDE EXTNAA,FUNC,PUT,GET,RSGTPT,INCOM=
  GLOBAL FCL.C.,Q8.IO.
  GLOBAL DROP
  GLOBAL BSET,NIDX,MIDX,TIMLIM,JMTAPE,PRESSB,CALCZF
  GLOBAL FILNME,KEEP,COM9,COM7,GETPUT,CONST,PRESS,EQSTP,COM5
GENR INCLUDE BRGNAA,INBPAA,INKLAA,INKPAA,ENEMAA
GENR INCLUDE NZINAA,NZOTAA,BBOTAA,BBINAA,KLINAA,NOIDAA,CRETAA
GENR INCLUDE POLJAA,GBRNAA,HUYGAA,GFORM,MATCON
GENR INCLUDE INPC=,KRAKER=,IOLIM,CPLIM
GENR GLOBAL COM15,COM13,BURN,GRAV,INP,GEN
GENR GLOBAL COM12,COM11,COM10
EQWRIT INCLUDE CRETAA,INBKAA,EQWRIT1
CYCLAA INCLUDE PLPNAA,PLPZAA,PROPAA,UT10AA,UT12AA,UT16AA
CYCLAA INCLUDE UT32AA,UT36AA,UT40AA,UT46AA,UT42AA
CYCLAA INCLUDE BRHEAA,VQPEAA,CZNLAA,EDITAA,DELTAA,MONITOR,IOSEC
CYCLAA INCLUDE UT20AA,U22CAA,U22GAA,U22BAA,UT22AA,UT26AA,UT60AA
CYCLAA INCLUDE UT62AA,UT66AA,U01SAA
CYCLAA GLOBAL DTSAVE-SAVE
PRNTAA GLOBAL LISTS-SAVE
UT70AA INCLUDE UT72AA,UT76AA,UT80AA,UT82AA,U72CAA,UT86AA
UT70AA GLOBAL TPICK80-SAVE
U72GAA INCLUDE U72CAA
WUPGAA INCLUDE WUPVAA,VINGAA,VINVAA
WUPBAA INCLUDE VINBAA
VD60AA INCLUDE UT30AA
PUTT INCLUDE GETT,RESTART,RESDMP,RESBLNK,CORE
PUTT INCLUDE BUFIN=,BUFIO=,BUFOUT=
PUTT GLOBAL KEY-SAVE
PRSPAA INCLUDE PTABAA,WALL,STNDAA
  END HEMP
```

Figure 3. SEGLOAD directives

Other changes were purely cosmetic, improving the readability of the code to make it simpler to maintain. These included:

1. Replacing nonstandard, two-branch IF statements with logical IF statements.

2. Resequencing the statement numbers in ascending order with the aid of the TIDY program (ref 4).

3. Placing the subroutines in alphabetical order.

4. Replacing all "CALL EXIT" statements with STOP statements that print out the reason for stopping.

ADDED FEATURES

z-Factor Calculation

The slide-line calculations make use of a "z-factor," which determines the effective mass associated with a master node (ref 2, page 61). The original HEMP code used a single z-factor which was invariant over a slide-line, and provisions were made to input a z-factor manually. In modeling explosively formed penetrator warheads which are heavily confined, this scheme is inaccurate. Accordingly, a new algorithm for calculating local z-factors was developed. It is used by default unless an SP-SLIDE card is included in the GENERAL input section. The calculation is repeated during each time-step.

The method of calculating local z-factors is as follows:

1. For each slave zone, an effective linear density is calculated. This is the zone mass divided by its length along the slide-line, where the length is the average of the lengths of the two sides of the zone. In the cylindrical geometry case, the result is divided by the radius of the zone centroid.

2. Similarly, the effective linear density of each master zone is calculated.

3. At the point in the calculation where stresses are transmitted across the slide-line (ref 1, pages 88 and 89), the local z-factor is calculated. First an interpolated effective linear density on the slave side is determined from the same two slave zones used in the stress calculations. This is divided by the sum of itself and the effective linear density of the master zone, which yields the local z-factor.

Preventing Time-Limit Aborts

The CYCLE subroutine was modified to enable the HEMP code to detect an upcoming time limit (CP or IO), and automatically create a restart file and plot file, before stopping. Since the CDC 7600 does not have an IO limit, this feature must be disabled when using this mainframe.

Comments

Comments may be included in any section of the input deck by use of a COMMENT card:

Table 1. COMMENT card

Function: Include a comment in the input file

Format: (A10,A70)

Field use	Columns	Input and explanation
Card name	1-10	COMMENT
Comment	11-80	Any desired comments

Specifying the Maximum Number of Cycles

The maximum number of iterations (time-steps) may be specified by means of the CYCLES card. If this card is not included, then the default setting of 2500 cycles will be in effect. The CYCLES input may be overridden by putting "N=<number>" on the BEGIN command that invokes the HEMP calculation. The CYCLES card is placed in the GENERAL input section.

Table 2. CYCLES card

Function: Specify maximum number of calculation cycles.

Format: (A10,F10.0)

Field use	Columns	Input and explanation
Card name	1-10	CYCLES
Cycles	11-20	Number of integration cycles

Line Dropping

Sometimes there is a need to drop out portions of the grid during the calculation. One example is the common practice of dropping out explosive gases after they have been spent and after they no longer contribute to acceleration of the other components, done mainly to save the expense of needless computation.

Another is to drop out small regions of the problem which have become deformed or entangled and are preventing the solution from proceeding; for example, the edge of a shaped charge liner which has thinned out due to the flow of explosive gases over it. This version of the HEMP code has additional input cards which can easily accomplish these tasks, replacing an earlier, somewhat time-consuming method of stopping the program; creating a restart file; operating on the restart file with a rezoning program; and then restarting HEMP calculation from the modified file. In this version, the dropping is done "on the fly"; that is, by including simple instructions to ignore the region in question for the remainder of the computation.

This procedure has been particularly effective in modeling the explosively formed penetrator warhead, also known as the self-forging fragment or ballistic disc. A typical grid which describes such a device was designed experimentally by personnel of the Ballistic Research Laboratory.

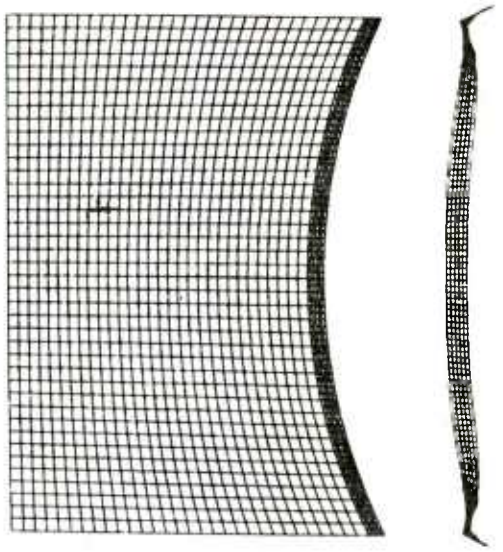


Figure 4. Warhead grid and distorted liner at 20 microseconds

Initially, it was not possible to run the simulation of this problem beyond twenty or thirty microseconds without resorting to coarse gridding and resultant loss of accuracy. This was due to thinning out of the liner edge, seen in figure 4, which resulted in reduction of the integration time step to an unreasonably small value to preserve computational stability. Dropping out the edge of the liner at the appropriate time (several microseconds after the detonation wave strikes the liner edge) permits the computation to resume with a reasonable time step. The results shown in figure 1 were obtained in this manner. In practice, for finely gridded liners, it is necessary to drop the liner edge two or three times at several-microsecond intervals. It should be noted that this part of the liner actually does break off into a ring of fragments in test firings, so the part that remains in the computation is representative of the part that contributes to the actual penetrator.

The input cards are DROPJMIN, DROPJMAX, DROPKMIN, and DROPKMAX, one or more of which may be included in the GENERAL input section. They must be arranged in chronological order. After each drop, the remaining grid must satisfy the minimum requirements shown in figure 1-7 of reference 2.

Table 3. DROPJMIN card

Function: Drop the JMIN line from the problem, between specified K-lines.

Format: (10X,2I5,F10.0)

Field use	Columns	Input and explanation
Card name	1-10	DROPJMIN
Lower K	11-15	Lower K-line end of J-line to be dropped. Must be slide-line or KMIN.
Upper K	16-20	Upper K-line end of J-line to be dropped. Must be slide-line or KMAX.
Time	21-30	Time, in microseconds, for line drop to occur.

Table 4. DROPJMAX card

Function: Drop the JMAX line from the problem, between specified K-lines.

Format: (10X,2I5,F10.0)

Field use	Columns	Input and explanation
Card name	1-10	DROPJMAX
Lower K	11-15	Lower K-line end of J-line to be dropped. Must be slide-line or KMIN.
Upper K	16-20	Upper K-line end of J-line to be dropped. Must be slide-line or KMAX.
Time	21-30	Time, in microseconds, for line drop to occur.

Table 5. DROPKMIN card

Function: Drop all K-lines from the problem, below specified K-line. Establish a new KMIN line, and reduce memory requirement.

Format: (10X,2I5,F10.0)

Field use	Columns	Input and explanation
Card name	1-10	DROPKMIN
Lower K	11-15	Lower K-line end of region to be dropped. Must be the old KMIN.
Upper K	16-20	Upper K-line end of region to be dropped. Will be the new KMIN.
Time	21-30	Time, in microseconds, for line drop to occur.

Table 6. DROPKMAX card

Function: Drop all K-lines from the problem, above specified K-line. Establish a new KMAX line.

Format: (10X,2I5,F10.0)

Field use	Columns	Input and explanation
Card name	1-10	DROPKMAX
Lower K	11-15	Lower K-line end of region to be dropped. Will be the new KMAX.
Upper K	16-20	Upper K-line end of region to be dropped. Must be the old KMAX.
Time	21-30	Time, in microseconds, for line drop to occur.

Changing Units

The HEMP code runs in the CGS system of units. Frequently it is more convenient to specify the geometry in other units, such as inches. The UNITS card

is provided to make this possible. This card, when included in the GENERAL input section, will cause the coordinates of each mesh point to be multiplied by the specified factor. The only other variables affected by the UNITS card are the burn constant and detonation points specified on the HEPARAM card.

Table 7. UNITS card

Function: Specify multiplication factor for grid input.

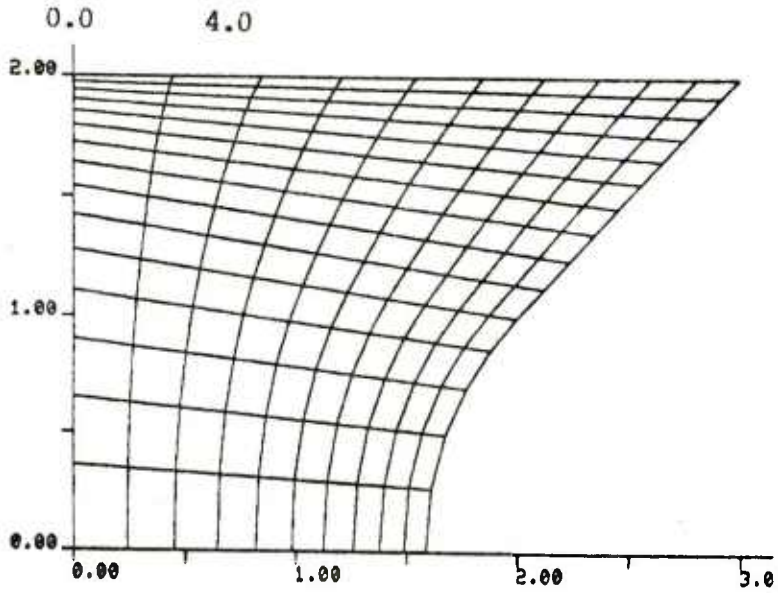
Format: (A10,F10.0)

Field use	Columns	Input and explanation
Card name	1-10	UNITS
Units	11-20	Multiplication factor

Geometrically Expanded Grids

Sometimes grids are desired which have a geometric progression in grid size to avoid discontinuity in grid size between finely and coarsely gridded regions. The EXPANDK, EXPANDIN, and EXPANDOUT input cards provide this capability. These cards may be used only in the BLOCK input section. If a ratio less than 1.0 is specified, then a geometric reduction will be obtained. For cartesian regions, the distance between nodes is geometrically increased or decreased, and for polar regions the angle is increased or decreased. An example of the use of this feature is shown in figure 5.

```
HMP,CM170000,T10,IO20,ST66B.
COMMENT.(XXX-HMP,55555F),RANDERS-PEHRSON
BEGIN,HEMP,/RANDERS,PLOT=EX59,N=1,PRINT=HERE.
*EOR
GENERAL     1 11 16 2      EXPAND EXAMPLE
PLOTTYPE  1000001
PLOTSCALE 1     1 0.0        6.0        0.0        4.0
FINI
NKZONESBLK 10
MATNO        1  1
JZOUTC      10
JZOUTP           5
JZINNC      15
CORNRMAX  3.0      2.0      2.0      1.0
CORNRMIN  0.0      2.0      0.0      0.0
RADIUSOUT            1.414
JMN-KX-ANG           135.0
JMX-KX-ANG           180.0
XKMAXSHIFT           3.0
EXPANDK     0.90
EXPANDOUT   1.05     1.10
EXPANDIN    1.20
FINI
FINI
```



a. Input cards

b. Expanded grid

Figure 5. Geometrically expanded grid example

Table 8. EXPANDIN card

Function: Specify geometric expansion ratio in the J-direction for one or more regions at the K-min end of a block.

Format: (A10,8F8.0)

Field use	Columns	Input and explanation
Card name	1-10	EXPANDIN
Ratio for region 1	11-18	Geometric expansion ratio for the region at J-Max end of the block, to be applied to grid points at the K-min end of the block. If zero or blank, region will not be expanded.

Table 8. (cont)

Reg 2 ratio	19-26	Ratio for region 2
Reg 3 ratio	27-34	Ratio for region 3
Reg 4 ratio	35-42	Ratio for region 4
Reg 5 ratio	43-50	Ratio for region 5
Reg 6 ratio	51-58	Ratio for region 6
Reg 7 ratio	59-66	Ratio for region 7
Reg 8 ratio	67-74	Ratio for region 8

Table 9. EXPANDOUT card

Function: Specify geometric expansion ratio in the J-direction for one or more regions at the K-max end of a block.

Format: (A10,8F8.0)

Field use	Columns	Input and explanation
Card name	1-10	EXPANDOUT
Ratio for region 1	11-18	Geometric expansion ratio for the region at J-max end of the block, to be applied to grid points at K-max end of the block. If zero or blank, region will not be expanded.
Reg 2 ratio	19-26	Ratio for region 2
Reg 3 ratio	27-34	Ratio for region 3
Reg 4 ratio	35-42	Ratio for region 4
Reg 5 ratio	43-50	Ratio for region 5
Reg 6 ratio	51-58	Ratio for region 6
Reg 7 ratio	59-66	Ratio for region 7
Reg 8 ratio	67-74	Ratio for region 8

Table 10. EXPANDK card

Function: Specify geometric expansion ratio in the K-direction for a block.

Format: (A10,F10.0)

Field use	Columns	Input and explanation
Card name	1-10	EXPANDK
Ratio	11-20	Geometric expansion ratio for the block

Cycle-by-Cycle Printout

The MONITOR input card provides a means of specifying variables to be printed out cycle-by-cycle (see also PRINT-OUT card). Up to nine variables may be printed. Each is specified by name along with the K and J indices identifying the node whose value is to be printed. Available names are:

X	X-coordinate of node
Y	Y-coordinate of node
XD	X-velocity
YD	Y-velocity
MH	Mass*2
RO	Original density
AR	Area*2 or alpha
V	Relative volume
P	Pressure
E	Specific energy
QB	Q or beta
F	Burn fraction
SS	Sound Speed squared
SX	Sigma xx (elastic stress)

SY	Sigma yy
ST	Sigma 00 (hoop stress)
TX	Tau xy (shear stress)
QX	Navier-Stokes Q x
QY	Navier-Stokes Q y
XY	Navier-Stokes Q xy
QT	Navier-Stokes Q theta
XO	Original X-coordinate
YO	Original Y-coordinate
OS	Octagonal shear stress
PX	Pressure - max(s1,s2,s3)
ID	Internal plastic distortion
KE	Kinetic energy
DX	X-Displacement
DY	Y-Displacement

See pages 18 and 19 of reference 2 for more details on most of the variables.

Table 11. MONITOR card

Function: Specify variable to be printed cycle-by-cycle. Up to nine variables may be specified in all; up to seven on one input card. Usual usage is to place one variable on each of nine separate MONITOR cards.

Format: (A10,7(1X,A2,2A3))

Field use	Columns	Input and explanation
Card name	1-10	MONITOR
Name 1	12-13	Name of first variable to be printed
K 1	14-16	K-index of first variable
J 1	17-19	J-index of first variable

Table 11. (cont)

Name 2	21-22	Second name
K 2	23-25	Second K
J 2	26-28	Second J
Name 3	30-31	Third name
K 3	32-34	Third K
J 3	35-37	Third J
Name 4	39-40	Fourth name
K 4	41-43	Fourth K
J 4	44-46	Fourth J
Name 5	48-49	Fifth name
K 5	50-52	Fifth K
J 5	53-55	Fifth J
Name 6	57-58	Sixth name
K 6	59-61	Sixth K
J 6	62-64	Sixth J
Name 7	66-67	Seventh name
K 7	68-70	Seventh K
J 7	71-73	Seventh J

Limiting Printout

The PRINT-OUT input card provides means of limiting the print-out. This card has been given additional capabilities beyond those described in reference 2.

Table 12. Modified PRINT-OUT card

Function: Limit print-out

Format: (A10,I1,6I3)

Field use	Columns	Input and explanation
Card name	1-10	PRINT-OUT
Interfaces	11	If set to one, only K-max, K-min, and slidelines will be printed.

Table 12. (cont)

Field use	Columns	Input and explanation
Higher K	12-14	If not zero, K-lines higher than this number will not be printed.
Lower K	15-17	If not zero, K-lines lower than this number will not be printed.
J print interval	18-20	If not zero, only every nth J-line will be printed.
No generator	21-23	If not zero, the generator output will not be printed.
No elastic	24-26	If not zero, elastic printout will be skipped.
Cycle-by-cycle print interval	27-29	If not zero, the cycle-by-cycle printout will only be printed every nth cycle. This also affects the output of "MONITOR" card.

REFERENCES

1. Mark Wilkins, "Calculation of Elastic-Plastic Flow," Report UCRL-7322, rev. 1, Lawrence Livermore Laboratory, Livermore, CA, December 1973.

2. E. D. Giroux, "HEMP User's Manual," Report UCRL-51079, rev. 1, Lawrence Livermore Laboratory, Livermore, CA, December 1973

3. NOS/BE Version 1 Reference Manual, CDC Publication 60493800, Control Data Corporation, Sunnyvale, CA, revision February 1979.

4. Forrest L. McMains, "CDC 6000 User Guide," Information Report MISD-IR 71-21, Management Information Systems Directorate, ARRADCOM, Dover, NJ, January 1981.

APPENDIX A

INPUT CARDS DESCRIBED IN HEMP USER'S MANUAL AND IN USER'S GUIDE TO PA HEMP COMPUTER CODE

Table A-1. Input cards

Card name	Page references: HEMP User's Manual	Page references: PA User's Guide	Format
BBPPXOUT	93		(A8,8F8.0)
BBTIED	94		(A8,64I1)
CALC-OPT	70		(A10,7I3)
COMMENT		7	(A10,A70)
CORNRMAX	79		(A10,10F7.0)
CORNRMIN	80		(A10,10F7.0)
CUTOFFS	37		(A10,7F7.0)
CYCLES		7	(A10,F10.0)
DELTAT	36		(A10,8F5.0,3I6,I2,F6.0)
DENSITY	78		(A10,8F8.0)
DROPJMAX		8	(A10,2I5,F10.0)
DROPJMIN		8	(A10,2I5,F10.0)
DROPKMAX		8	(A10,2I5,F10.0)
DROPKMIN		8	(A10,2I5,F10.0)
EDITFREQ	38		(A10,10F5.0)
ENERGY	78		(A10,8F8.0)
EXPANDIN		11	(A10,8F8.0)
EXPANDK		11	(A10,F10.0)
EXPANDOUT		11	(A10,8F8.0)
FINI	73,92		(A10,A70)
GENERAL	35		(A10,I2,I3,I3,I2,A60)
GRAVITY	71		(A10,10F7.0)
HEBURN	89		(A10,8I3)
HEPARAM	90		(A10,8F8.0)
JMAX-ANG	47		(A10,I2,5F8.0)
JMIN-ANG	48		(A10,I2,5F8.0)
JMN-KN-ANG	84		(A10,8F8.0)
JMN-KX-ANG	81		(A10,8F8.0)
JMN-KX-ANG	84		(A10,8F8.0)
JMX-KN-ANG	84		(A10,8F8.0)
JPOLAR	84		(A10,I1)
JZINNC	75		(A10,8I3)
JZINNP	75		(A10,8I3)
JZOUTC	74		(A10,8I3)
JZOUTP	74		(A10,8I3)
KLINENZ	95		(A10,8I3)
KLPPX	96		(A10,8F8.0)
KMAX-ANG	47		(A10,I2,5F8.0)
KMIN-ANG	47		(A10,I2,5F8.0)
KTOK	92		(A10,2I3)
MATINPUT	68		(A8,I2,5(A4,F10.0))

Table A-1. (cont)

Card name	Page references HEMP User's Manual	PA User's Guide	Format
MATNO	77		(A10,8I3)
MONITOR		13	
NKZONESBL	73		(A10,I3)
PBOUNDARY	52		(A10,6I1)
PJMAX	33		(A10,3I1,2I3,6F9.0)
PJMIN	58		(A10,3I1,2I3,6F9.0)
PKMAX	53,56		(A10,3I1,2I3,6F9.0)
PKMIN	55		(A10,3I1,2I3,6F9.0)
PLOTSCAL	39		(A10,I1,I4,6F10.0)
PLOTTYPE	40		(A10,28I1)
PRESJMAX	57		(A10,10F6.0)
PRESJMIN	59		(A10,10F6.0)
PRESKMAX	54		(A10,10F6.0)
PRESKMIN	56		(A10,10F6.0)
PRINT-OUT	39	15	(A10,I1,6I3)
QCONTROL	70		(A10,3F8.0)
RADIUSIN	84		(A10,8F8.0)
RADIUSOUT	80		(A10,8F8.0)
REG.BIN	41		(NOT IMPLEMENTED)
RESTART	104		(A10)
RING	50		(A10,8F7.0)
SEIS.BIN	42		(NOT IMPLEMENTED)
SHADOW	90		(A10,5I1)
SLIDE-ANG			(A10,2I1,4F12.0)
SLIDE-TY	86		(A10,2I1)
SP-SLIDE	62	6	(A10,4F8.0)
STONEWALLS	45		(A10,8I1,F8.0,I3)
TIEBREAK	64		(A10,8F8.0)
UNITS		16	(A10,F10.0)
VAR.BIN	42		(NOT IMPLEMENTED)
VARPJMAX	57		(A10,10F6.0)
VARPJMIN	58		(A10,10F6.0)
VARPKMAX	54		(A10,10F6.0)
VARPKMIN	54		(A10,10F6.0)
VARWALL	51		(A10,2I3,2F12.0,2I3,2F12.0)
VELBLOCK	88		(A10,4F8.0)
VOLUME	78		(A10,8F8.0)
XKMAXSHIFT	82		(A10,8F8.0)
XKMINSHIFT	82		(A10,8F8.0)
XVELMAT	88		(A10,8F8.0)
XVELMATJ	88		(A10,8F8.0
XVELMATK	88		(A10,8F8.0)
XYQUAD	49		(A10,6I1)
YKMAXSHIFT	82		(A10,8F8.0)
YKMINSHIFT	82		(A10,8F8.0)

APPENDIX B

DIFFERENCES BETWEEN ORIGINAL HEMP CODE AND PA VERSION

HEMP User's Manual	Comments applicable to PA version
Page 7.	"Triangle Q" is not available.
Page 15.	The two overlays mentioned have been replaced with SEGLOAD controlled loading of subroutines.
Page 15.	Disk is used instead of LCM for storage. The five-line SCM group is only used if the problem cannot be wholly contained in core.
Page 17,18.	The number of variables has been reduced from 32 to 30 by combining the variables KTYPE, EQST, and BYTS into a single structured word (BYTS). Variables 23-30 are only carried in memory if they are actually used.
Page 20.	Common Block "A001" has been moved to "KEEP." Common Block 19 has been moved to blank COMMON, whose length is calculated at the time of problem generation.
Page 21.	The number of permissible equation-of-state numbers has been increased to 99.
Page 22.	The main program is called HEMP. It calls the GENR and CYCL subroutines, which may be overlaid by use of CDC SEGLOAD procedure.
Page 27.	Subroutines BINOAA and CHSPAA are not used.
Pages 28-30.	Only non-teletype operation (batch processing) is recommended. This can be done with actual card decks or with batch job streams created on an interactive terminal and submitted by means of the BATCH command.
Pages 40-41.	REG.BIN and VAR.BIN are not implemented. Use MONITOR instead.
Page 45.	"X-dot at K-max is not calculated" should read "X-double-dot at K-Max is set to zero," etc.
Pages 61-62.	The "z-factor" is now calculated locally during each calculation cycle.
Page 68.	The equation-of-state form number can be overridden by means of a card containing MATINPUT[eq]FORM [no] where "no" is the numerical equivalent of the form desired (for example, for form "E", "no" would be "5").

HEMP User's Manual	Comments applicable to PA version
Page 70.	An additional variable has been added to the CALC-OPT input card. A non- zero integer may be placed in columns 29-31 to inform the program that no inverted slide-lines will be present in the problem. This allows making a more efficient storage allocation.
Page 80.	Table 3-57: "58" should read "59".
Page 98.	Tapes are not used. "Teletype output" is not normally used, but is available on a file called "TAPE3." A MONITOR card may be used to change the variables to be printed out on every cycle. The PRINT-OUT card can cause these variables to be printed out every nth cycle.
Page 99.	The "on-line" and "off-line" printouts are combined and directed to a file called OUTPUT.
Page 103.	Plot files are directed to a file called "TAPE59."
Page 104.	Only the word "RESTART" is used on a restart card. The restart file must be known to the HEMP job as a file called "TAPE12."
Page 106.	Only Switch 1 is available, and it can only be set by the central site operator.

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