

KEPLER

Users' Manual

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CHAPTER 1

INTRODUCTION

KEPLER is a general purpose stellar evolution/explosion code that incorporates implicit hydrodynamics and a detailed treatment of nuclear burning processes. It has been used to study the complete evolution of massive and supermassive stars, all major classes of supernovae, hydrostatic and explosive nucleosynthesis, and x- and gamma-ray bursts on neutron stars and white dwarfs. Many aspects of the physics it currently includes has been briefly summarized in Weaver, Zimmerman, and Woosley (1978, *Ap.J.* 225, 1021), Weaver, Woosley, and Fuller (1983, *Proc. of the Conf. on Numerical Astrophysics: A Meeting in Honor of James R. Wilson*, R. Bowers, J. Centralla, J. LeBlanc, and M. LeBlanc, eds. (Science Books, Portola, CA)), and many other papers describing the results of its calculations. Additional documentation is in progress. KEPLER does not currently contain detailed models of neutrino transport and the equation of state of hot matter near nuclear density, but it has the capability to be linked to codes (such as that of Wilson et. al.) that do or to treat these processes in parameterized form.

After more a decade of specialized residence on the CDC 7600, a general (almost standard FORTRAN) version of KEPLER has been developed for use on UNIX super-minicomputers with X-Window graphics (such as P Group's 4D/240VGX computer, *leonardo*), and in a more limited form on CRAY computers. This new version of KEPLER includes calculations of detailed isotopic nucleosynthesis ("BURN coprocessing"), extensive graphics, interactive post-processing, updated nuclear reaction rates, and many other new and/or improved edit and physics capabilities.

The current UNIX version of KEPLER on which this manual is based is **kepler.1may91**. The form of the input files ("generators") needed for KEPLER is discussed in Chapter 2, while a list of the user-changeable KEPLER parameters is given in Chapter 3 by function and in Chapter 4 by number. Chapter 5 describes how to run a KEPLER problem and also the interactive keyboard commands that are available for editing and job-control. Chapter 6 describes the form of the "LINK" input file need to link the results of core collapse calculations

performed by other codes to KEPLER, while Chapter 7 presents a functional list of the zonal edit variables that may be edited, graphed, or stored in post-processor dumps. Chapter 8 lists both the user-unchangeable edit ('Q') parameters and the non-zonal, time-dependent ("time-edit") variables, which can be graphed vs. time. Chapter 9 briefly describes the form of some of the (less obvious) edits that KEPLER produces. Finally, Appendices A, B, and C provide alphabetical reference lists of the terminal commands, the user-changeable parameters, and the zonal edit variables, respectively.

CONVENTIONS

Terminal commands and input file cards are listed according to the following conventions:

COMMAND *REQUIRED-INPUT1 REQUIRED-INPUT2* [*OPTIONAL-INPUT1*]

Here the words in capital italics are to be replaced by specific input values, and words in brackets are optional parameters. Usually a specific example, shown as a quoted, bold-face character string, is given directly below the command or card to clarify the input format. All specific KEPLER variables, parameters, subroutine names and commands are shown in upper case for clarity (although all communication with the computer must currently be made in lower case and character strings must not be enclosed in quotes). The symbols for edit variables of all kinds are shown in bold-face, lower-case letters.

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CHAPTER 2

GENERATOR INPUT FILES

The initial setup of a KEPLER problem is specified by a series of instructions (known as "cards" for historical reasons) that each occupy one line in an input file termed a "generator" file. (Or sometimes a generator "deck" for the same historical reasons -- backup versions of KEPLER were kept on punch cards until 1978). Running KEPLER always requires the regular KEPLER generator specified in the next section. In addition, a separate BURN generator, specified in the section following, is required if BURN co-processing is specified by the inclusion of a GENBURN card in the regular generator. Both files must be in the working directory in which the problem is being run.

A generator card may be up to 120 characters long and contain up to 60 blank, tab, or equal-sign delimited words, each at most 60 characters long. Words are interpreted as being integer, character or floating point depending on their format and must match the type specified for each card or a fatal error message will be sent. Except as noted below, words representing input character variables are truncated to 8 characters, while numerical input is "field-free," except that floating point numbers must be distinguished from integers by a decimal point or exponent.

Card types allowed in the regular KEPLER generator file are listed below. Each card keyword is given in bold capital letters, followed by its arguments, if any, in italic capital letters. For each commands, an example printed in boldface characters and enclosed in quotes is given, which also serves to indicate the expected type of the arguments. Note that, as indicated by the examples, actual communication with the computer should be made in lower case and that character parameters are never enclosed in quotes.

Except as noted, generator cards may occur in any order, but must always include **NET**, **M**, and **G** cards (and a **BOX** card on the CRAY). BURN generator files must always include **NET**, **M**, and **G** cards of the type separately specified below.

Complete sample KEPLER and BURN generator files are listed in the final sections, along with some useful variants. These are taken directly from recently executed KEPLER jobs.

KEPLER GENERATOR INPUT CARDS

BOX BOX# [ID-WORD]

'box v98 weaver'

Identification Card. (Required on CRAY, optional on UNIX systems).

BOX# is the user's output box and must be three characters long. It is used for directing output files on the CRAY.

ID-WORD is an identification word (≤ 8 characters), usually the user's name.

GENBURN NAMEBG

'genburn sol160bg'

Burn Generator Card. (Optional). Inclusion of this card causes KEPLER to read the BURN generator file, **NAMEBG**, immediately after normal problem generation and to initiate BURN co-processing.

NAMEBG can be up to 16 characters long and is not restricted, though by normal convention it ends in the letters 'bg'.

C COMMENT

'c s25s1a -- 25 solar mass star of solar composition'

Comment Card(s). (Optional).

COMMENT is an arbitrary alphanumeric string that is ignored by the code. Note that it must be separated from the 'c' by at least one space.

NET NETWORK# IONSYM(1) [IONSYM(2) IONSYM(3).....]

'net 1 h1 he3 he4 n14 c12 o16 ne20 mg24 si28 s32

net 1 ar36 ca40 ti44 cr48 fe52 ni56 fe54 pt1 nt1'

Network Card(s). (Required).

NETWORK# is the identification number of the network being specified. For the current version of KEPLER, the network specified must be the APPROX network given in the example, and the network number must be 1.

ISOTOPE(I) is the symbol for the *I*th ion in the network. (See the "M" card description given below for how to format these symbols). They can be specified in any order. If there are more than 10 ions in the network, continue on a new "NET" card with the same network number.

ISENET

' isenet '

ISE Network Card. (Optional). This card is a flag that the standard ISE and NSE networks (NETNUM = 2 and 3, respectively) are to be set up for possible later use, in addition to the usual APPROX network (NETNUM = 1). Zones should never be specified on a "G" card to initially be either ISE or NSE, but they should instead be allowed to make the transition (or not) while the problem is running depending on the physical conditions encountered and the setting of various control parameters (see Chapter 3).

M MIX-NAME MASSFRAC(1) IONSYM(1) [MASSFRAC(2) IONSYM(2)...]

' m solcomp .70 h1 .28 he4 .02 n14 '

Materials Card(s). (Required).

MIX-NAME is the name of this mixture of ions (≤ 8 characters).

MASSFRAC(I) is the mass-fraction of the *I*th ion in the mixture.

IONSYM(I) is the symbol for the *I*th ion in the mixture and consists of an lower case elemental symbol followed by the atomic weight (without a space), e.g. he4. Also, each IONSYM listed here must be one of the ions in a specific network specified by the "NET" card(s). Pairs of such mass fractions and ion symbols are listed for each ion in the mixture. Continue if necessary on a new "M" card with the same MIX-NAME. After all such cards have been read, the code renormalizes the sum of the mass fractions to insure it equals 1.

G ZONE# EXTERIOR-MASS NETWORK# MIX-NAME TEMP DENSITY [VELOCITY]

' g 0 4.e+34 1 solcomp 1.1e+7 0.9 0. '

Grid Cards. (At least 2 required).

ZONE# is the number of the zonal interface being described (J). This should always be 0 for the first "G" card and be equal to the total number of zones desired for the last "G" card. For intermediate "G" cards, J should increase monotonically between these values. Not every interface need be specified, and conditions at intermediate interfaces will be calculated as described below.

EXTERIOR-MASS is the mass (in grams) *exterior* to the zonal interface being specified. (YM(J)). Specified values must increase monotonically with zonal interface number (J). Exterior masses for zonal interfaces between those specified will be interpolated from the specified values by minimizing the sum of the squares of the fractional changes in zone mass across each interface (See subroutine ZONIT).

NETWORK# is the number of the nuclear-burning network to be used between this zonal interface and the next one specified. (NETNUM(J)). Currently must be 1 (see "NET").

MIX-NAME is name of the material (as specified by the appropriate "M" cards) that lies between this zonal interface and the next one specified. (IMSEN(J)).

TEMP is the temperature (in degrees K) of the zones that lie between this interface and the next one specified. (TN(J)).

DENSITY is the density (in g/cc) of the zones that lie between this interface and the next one specified. (DN(J)).

VELOCITY is the velocity (in cm/s) of this zonal interface. (UN(J)). If not specified, it is assumed to be 0. Velocities for zonal interfaces between those specified are determined by interpolating linearly with radius.

HSTAT

' hstat '

Hydrostatic Equilibrium Card. (Optional).

Forces the specified initial configuration into hydrostatic equilibrium by adjusting the temperature.

DSTAT

' dstat '

Degenerate Hydrostatic Equilibrium Card. (Optional).

Forces the specified initial configuration into hydrostatic equilibrium by adjusting the density. Useful in very degenerate cases, such as white dwarfs or neutron stars.

P PARAMETER# PARAMETER-VALUE

' p 1 1.e-5 '

Parameter Card(s). (Optional -- Parameters are otherwise set to their default values).

PARAMETER# is the number or name of the parameter to be specified. See Chapters 3 and 4 and Appendix B for a list of the changeable parameters in the code and their units and default values.

PARAMETER-VALUE is the value to be assigned to this parameter. Note that fixed point parameters must have fixed pointed values specified , and floating point parameters must be given floating point values ($1 \neq 1.$)

DUMP DUMPVAR RATZDUMP RATIODEZ RATIOADZ

'dump convect .1 -1. 0.'

Dump Card(s). (Optional). Add dump variable *DUMPVAR* to the list of variables to be dumped to the qq post-processor dump file and set its dump parameters. *DUMPVAR* may be any zonal edit variable listed in Chapter 7, and in addition it may take the values:

parm -- to dump the values of the changeable ('p') parameters, or

qparm -- to dump the values of the edit ('q') parameters.

The associated dump parameters which must be given for each variable are:

RATZDUMP -- the maximum allowed fractional change between dumps of the specified zonal dump variable.

RATIODEZ -- the minimum fractional change of this zonal dump variable allowed between two adjacent dump grid points before the dump grid for the variable is dezoned.

RATIOADZ -- the maximum fractional change of this zonal dump variable allowed between two adjacent dump grid points before the dump grid for the variable is adzoned.

In the case of *parm* and *qparm* the values of *RATIOADZ* and *RATIODEZ* are ignored but must be given. Note that the **DUMP** command for new variables may also be given interactively from the keyboard while the problem is already running (see Chapter 5).

ZEDIT IZED NCYCZED EDITVAR1 [EDITVAR2....EDITVAR10] [ZEDMASS1 [ZEDMASS2]]

'zedit 1 50 dn tn sige sigi sigr 0. 2.'

Zonal Edit Card(s). (Optional). This card causes a special multiple column ASCII edit of the specified zonal edit variables (*EDITVAR1*, etc.) to be written every *NCYCZED* cycles. A detailed list of the allowed zonal edit variables and their corresponding values of *EDITVAR* is given in Chapter 7. Here *IZED* is an index number (max of *NZEDZ*, which currently is 30 -- see *KEPCOMS*) that distinguishes separate **ZEDIT** requests, and *ZEDMASS1* and *ZEDMASS2* specify an optional interior mass range (in *SCALEM* (P 273) units) to be edited. If only *ZEDMASS1* is specified, a $\pm 1\%$ range around it is edited, and if no masses are specified, an edit of the whole star is made. Previously specified edits can be changed or terminated by overwriting them with a **ZEDIT** command issued from the terminal with the same index number (See Chapter 5). (Note: setting *NCYCZED* = 0 terminates the edit.)

KEPLER GENERATOR RESTRICTIONS

Restrictions corresponding to current FORTRAN parameter settings in include-file KEPCOMS and subroutine GENER are listed below (where the name of the FORTRAN parameter is shown in capital letters). These may be changed by editing and recompiling KEPLER.

NNIZ.....Maximum Number of Networks = 5. (But see "NET" Card discussion).

NHIZ.....Maximum Number of Ion Types per Network = 20.

NMIZ.....Maximum Number of Material Mixtures = 10.

NIMZ.....Maximum Number of Ion Types per Mixture = 20.

NITZ.....Maximum Number of Ion Types Overall = 100.

NDATQZ. Maximum Number of **DUMP** cards = 250.

NZEDZ....Maximum Number of **ZEDIT** cards = 30.

JMZ.....Maximum Number of Zones = 650.

BURN GENERATOR CARDS

C COMMENT

' c sol160bg -- burn generator with solar composition, 160 zones, & 149 BURN isotopes '

Comment Card(s). (Optional).

COMMENT is an arbitrary alphanumeric string that is ignored by the code. Note that it must be separated from the ' c ' by at least one space.

NET NETWORK# ISOTOPE(1) [ISOTOPE(2) ISOTOPE(3)]

' net 1 nt1 h1 h2 h3 he3 he4 li7 be7 b10 b11 '

Network Card(s). (Required).

NETWORK# is the identification number of the network being specified. For the current version of KEPLER, only one network may be specified, and its BURN network number (*NETNUMB*) must be 1 .

ISOTOPE(I) is the symbol for the *I*th isotope in the network. (See the "M" card description given below for how to format these symbols). They can be specified in any order. If there are more than 10 isotopes in the network, continue on a new "NET" card with the same BURN network number. The limits and contents of the network depends of the information currently available in the BDAT nuclear data deck stored in /usr/local/bin/bdat (see Chapter 5).

M MIX-NAME MASSFRAC(1) ISOSYM(1) [MASSFRAC(2) ISOSYM(2)...]

' m solcomp 7.057e-1 h1 4.801e-5 h2 2.929e-5 he3 '

Materials Card(s) (Required).

MIX-NAME is the name of this mixture of isotopes (≤ 8 characters).

MASSFRAC(I) is the mass-fraction of the *I*th isotope in the mixture.

ISOSYM(I) is the symbol for the *I*th isotope in the mixture and consists of an elemental symbol followed by the atomic weight (without a space), e.g. he4. Also, each *ISOSYM* listed here must be one of the isotopes in the specific BURN network specified by the "NET" card(s).

Pairs of such mass fractions and isotope symbols are listed for each isotope in the mixture.

Continue if necessary on a new "M" card with the same *MIX-NAME*. After all such cards have been read, the code renormalizes the sum of the mass fractions to insure it equals 1.

G ZONE# NETWORK# MIX-NAME
' g 0 1 solcomp '

Grid Cards. (At least 2 required).

ZONE# is the number of the zonal interface being described (J). This should always be 0 for the first "G" card and be equal to the total number of zones desired for the last "G" card. For intermediate "G" cards, J should increase monotonically between these values. Not every interface need be specified, and conditions at intermediate interfaces will be calculated as described below. Normally, the total number of zones should be the same as specified in the regular KEPLER generator file.

NETWORK# is the number of the BURN nuclear-burning network to be used between this zonal interface and the next one specified. (NETNUMB(J)). Currently it must be 1 (see "NET").

MIX-NAME is name of the material (as specified by the appropriate "M" cards) that lies

P PARAMETER# PARAMETER-VALUE

' p 1 1.e-5 '

Parameter Card(s). (Optional -- Parameters are otherwise set to their default values).

PARAMETER# is the number or name of the parameter to be specified. See Chapters 3 and 4 and Appendix B for a list of the changeable parameters in the code and their units and default values.

PARAMETER-VALUE is the value to be assigned to this parameter. Note that fixed point parameters must have fixed pointed values specified , and floating point parameters must be given floating point values ($1 \neq 1.$)

BURN GENERATOR RESTRICTIONS

Restrictions corresponding to current FORTRAN parameter settings in include-file KEPCOMS and subroutine GENBURN are listed below (where the name of the FORTRAN parameter is shown in capital letters). These may be changed by editing and recompiling KEPLER.

- NNIZB..... Maximum Number of BURN Networks = 1. (See "NET" Card discussion).
- NHIZB..... Maximum Number of Isotope Types per BURN Network = 300, if NBURN is changed.
- NBURN... 'Actual' Number of Isotopes in the BURN Network = 150. (vs. 149 specified?)
- NMIZB.... Maximum Number of BURN Material Mixtures = 2.
- NIMZB.... Maximum Number of BURN Isotope Types per Mixture = 150.
- NITZB.....Maximum Number of BURN Isotope Types Overall = 300.
- JMZB..... Maximum Number of BURN Zones = JMZ (Maximum number of KEPLER zones).

SAMPLE KEPLER GENERATOR

```

c s25sha--25 solar mass star of solar composition
c abundances from anders and grevesse (geochem et cosmochem 1988)
c semi-convection and convective overshoot mixing turned on everywhere
c outer region of the star (abar.ge.abarsemi (p324) = 4.)
c note drmult (p24) = 0.1; woversht (p148) = 0.01
c note drmultlo (p325) = 0.1; woverslo (p326) = 0.01
c note cl2(ag) rate is 0.5 times the cf88 current value
c
c box and id information:
box v98 weaver
c
c specify burn-generator-file name to turn on isotopic co-processing
genburn soll60bg
c
c input for approx network (network #1):
net 1 h1 he3 he4 n14 c12 o16 ne20 mg24 si28 s32
net 1 ar36 ca40 ti44 cr48 fe52 ni56 fe54 pn1 nt1
c
c include ise and nse networks (networks #2 and #3)
isenet
c
c solar abundances (weight %):
m sol 70.57 h1 2.929e-3 he3 27.52 he4 0.3069 c12
m sol 0.1109 n14 0.9618 o16 0.1753 ne20 0.06935 mg24
m sol 7.688e-2 si28 4.259e-2 s32 9.619e-3 ar36
m sol 6.571e-3 ca40 2.947e-4 cr48 1.813e-3 fe52
m sol 0.1285 fe54
c
c initial grid (zone #, exterior mass(g), network #, temp(K), rho(g/cc)):
g 0 5.0e+34 1 sol 6.0e+6 1.e-1
g 1 4.9996e+34 1 sol 5.e+6 8.e-2
g 2 4.9990e+34 1 sol 5.e+6 8.e-2
g 3 4.9980e+34 1 sol 5.e+6 8.e-2
g 4 4.9962e+34 1 sol 5.e+6 8.e-2
g 5 4.9930e+34 1 sol 5.e+6 8.e-2
g 6 4.9900e+34 1 sol 5.e+6 8.e-2
g 7 4.9850e+34 1 sol 5.e+6 8.e-2
g 20 4.9e+34 1 sol 1.e+6 7.e-2
g 30 4.8e+34 1 sol 1.e+6 6.e-2
g 45 4.5e+34 1 sol 1.e+6 5.e-2
g 65 4.0e+34 1 sol 1.e+6 4.e-2
g 85 3.0e+34 1 sol 3.e+5 3.5e-2
g 115 1.0e+34 1 sol 1.e+5 3.e-2
g 130 1.0e+33 1 sol 1.e+4 2.e-2
g 140 1.0e+32 1 sol 1.e+4 1.e-2
g 150 1.e+31 1 sol 1.e+4 6.e-3
g 160 0.0 1 sol 5.e+3 1.e-3
c
c adjust initial temperature to yield hydrostatic equilibrium
hstat

```


Sample KEPLER Generator (Cont.)

```

c reset default parameter values:
c
c time-step and back-up controls
p 6 .07
p 7 .05
p 8 .15
p 9 .07
p 46 .15
p 47 1.e-3
c
c problem termination criteria
p 158 999999
p 306 9.e+7
p 307 .05
c
c linear artificial viscosity coefficient (reset to 0.1 at zero-age ms)
p 13 1000.
c
c edit and dump controls
p 16 20
p 18 10
p 156 25
p 268 53
c
c semiconvection and overshoot mixing coefficients
p 24 0.1
p 148 0.01
p 324 4.
p 325 0.1
p 326 0.01
c
c graphics parameters
p 42 10240750
p 64 50
p 113 31
c
c minimum nuclear burning temperature (K)
p 65 1.e+7
c
c rezoning criteria
p 83 1.e+4
p 84 1.e-4
p 86 0
p 87 1
p 138 .15
p 139 .5
p 150 .008
p 151 .01
p 152 .02
p 193 .1
p 195 .005

```

Sample KEPLER Generator (Cont.)

```

c ise control parameters
p 185 1.5e+9
p 185 .04
p 203 1.e+5
c
c c12(a,g) rate multipliers
p 227 0.5
p 228 0.5
c
c post-processor-dump control parameters
p 303 0.5
c
c set the time at which to make zero-age-main-sequence parameter changes
p 308 1.e+12
c
c turn on rezoner at the zero-age main sequence by resetting p 86
c to the value of p 309
p 309 1
c
c turn down the linear artificial viscosity at the zero-age main
c sequence by resetting p 13 to the value of p 310
p 310 .1
c
c set the core temperature at which to make pre-carbon-burning
c parameter changes
p 311 5.e+8
c
c raise floor on abundances considered in calculating the time-step
c just before carbon ignition by resetting p47 to the value of p312
p 312 .003
c
c finely zone the central 2-4 solar masses just before carbon ignition
c by resetting p195 to the value of p313 and p150 to the value of p314
p 313 .0015
p 314 .004
c
c list of dump variables (name, dump ratio, dezone ratio, adzone ratio):
c
c thermodynamic quantities
dump rn      .01   .01   .025
dump tn      .01   .01   .025
dump dn      .03   .03   .1
dump un      .03   .03   .1
dump pn      .03   .03   .1
dump sgain   .05   .05   .15
dump sloss   .05   .05   .15
dump sneut   .05   .05   .15
c
c convection sentinels
dump convect .1   -1.   0.

```

Sample KEPLER Generator (Cont.)

c entropies

dump sig	.01	.01	.025
dump sigi	.01	.01	.025
dump sige	.01	.01	.025
dump sigr	.01	.01	.025
dump sigp	.01	.01	.025
dump sigion	.01	.01	.025

c

c approx and ise ions

dump ionnt1	.02	.02	.06
dump ionh1	.02	.02	.06
dump ionpn1	.02	.02	.06
dump ionhe3	.02	.02	.06
dump ionhe4	.02	.02	.06
dump ionc12	.02	.02	.06
dump ionn14	.02	.02	.06
dump iono16	.02	.02	.06
dump ionne20	.02	.02	.06
dump ionmg24	.02	.02	.06
dump ionsi28	.02	.02	.06
dump ions32	.02	.02	.06
dump ionar36	.02	.02	.06
dump ionca40	.02	.02	.06
dump ionti44	.02	.02	.06
dump ioncr48	.02	.02	.06
dump ionfe52	.02	.02	.06
dump ionfe54	.02	.02	.06
dump ionni56	.02	.02	.06
dump ionfe56	.02	.02	.06
dump ion'fe'	.02	.02	.06
dump ionye	.001	.001	.0025
dump ionyq	.003	.003	.01
dump ioneb0	.001	.001	.0025
dump ionyf	.003	.003	.01

c

c parameters

dump qparm	1.	1.	1.
dump parm	1.	1.	1.

c

c misc. zonal edit quantities

dump netnum	.1	.1	.3
dump en	.03	.03	.1
dump zn	.03	.03	.1
dump etan	.01	.01	.025
dump abar	.01	.01	.025
dump zbar	.01	.01	.025
dump xkn	.02	.02	.06
dump gamma	.001	.001	.0025
dump xln	.03	.03	.1
dump taumix	.05	.05	.15
dump mixlen	.05	.05	.15

Sample KEPLER Generator (Cont.)

```

c weak rates and neutrino losses
dump wrate      .05      .05      .15
dump rectot     .05      .05      .15
dump rpdtot     .05      .05      .15
dump redtot     .05      .05      .15
dump snuw       .05      .05      .15
dump snubps     .05      .05      .15
c
c burn variables
dump yeburn     .001     .001     .0025
dump sburn      .05      .05      .15
c
c burn isotopes
dump isont1     .02      .02      .06
dump isoh1      .02      .02      .06
dump isoh2      .02      .02      .06
dump isohe3     .02      .02      .06
dump isohe4     .02      .02      .06
dump isoli7     .02      .02      .06
dump isobe7     .02      .02      .06
dump isoc12     .02      .02      .06
dump isoc13     .02      .02      .06
dump ison14     .02      .02      .06
dump isool6     .02      .02      .06
dump isool8     .02      .02      .06
dump isone20    .02      .02      .06
dump isone22    .02      .02      .06
dump isona22    .02      .02      .06
dump isomg24    .02      .02      .06
dump isoal26    .02      .02      .06
dump isosi28    .02      .02      .06
dump isosi30    .02      .02      .06
dump isos32     .02      .02      .06
dump isos34     .02      .02      .06
dump isoar36    .02      .02      .06
dump isoca40    .02      .02      .06
dump isoti44    .02      .02      .06
dump isofe52    .02      .02      .06
dump isofe54    .02      .02      .06
dump isofe56    .02      .02      .06
dump isofe58    .02      .02      .06
dump isoni56    .02      .02      .06
dump isoni58    .02      .02      .06
c
c
c

```

Sample KEPLER Generator (Cont.)

```

c special ascii edit requests:
c zedit 1 10 sig sige sigi sigr sigion sigp
c
c
c parameter changes before silicon ignition:
c (when o16.lt. 5 wt.% and tn(1).gt.tqselim (p184) -- use p307)
c
c tighten up time-step controls on radius, temp, and density changes
c p 6 .02
c p 7 .02
c p 8 .02
c
c relax convergence criteria for radius and temperature
c p 11 1.e-5
c p 12 1.e-5
c
c tolerate more convergence error in temperature and density
c before backing up
c p 54 10.
c p 55 10.
c
c make code insensitive to convergence errors in luminosity
c p 70 1.d+99
c p 73 1.d+99
c
c tolerate larger abundance changes before backing up
c p 206 3.e-3
c
c turn off stop at oxygen depletion
c p 307 -1.e+99
c
c zero the problem time to achieve more precision
c zerotime

```

SAMPLE KEPLER GENERATOR VARIATIONS

Listed below are typical variations in the sample generator given above. Only (non-comment) cards, or sets of cards, that differ from the original generator are listed.

LMC Abundances

c lmc abundances (weight %):

m	lmc	74.60	h1	2.929e-3	he3	25.00	he4	0.0522	c12
m	lmc	0.0122	n14	0.2500	o16	0.0561	ne20	0.0354	mg24
m	lmc	4.300e-2	si28	1.830e-2	s32	5.290e-3	ar36		
m	lmc	3.020e-3	ca40	1.240e-4	cr48	7.610e-4	fe52		
m	lmc	0.0797	fe54						

Restricted Semiconvection

c semiconvection and overshoot mixing coefficients

p 24 1.e-4

p 148 0.0

p 324 4.

p 325 1.e-4

p 326 0.0

Nominal deJager Mass Loss Rate

c mass loss parameters

p 220 1.

p 225 .01

Sample KEPLER Generator Variations (Cont.)

8 Solar Mass Star

c initial grid (zone #, exterior mass(g), network #, temp(K), rho(g/cc)):

g	0	1.6e+34	1	sol	6.0e+6	1.e-1
g	1	1.5996e+34	1	sol	5.e+6	8.e-2
g	2	1.5990e+34	1	sol	5.e+6	8.e-2
g	3	1.5980e+34	1	sol	5.e+6	8.e-2
g	4	1.5962e+34	1	sol	5.e+6	8.e-2
g	5	1.5930e+34	1	sol	5.e+6	8.e-2
g	6	1.5900e+34	1	sol	5.e+6	8.e-2
g	7	1.5850e+34	1	sol	5.e+6	8.e-2
g	20	1.5e+34	1	sol	1.e+6	7.e-2
g	30	1.4e+34	1	sol	1.e+6	6.e-2
g	50	1.2e+34	1	sol	1.e+6	5.e-2
g	70	1.0e+34	1	sol	1.e+6	4.e-2
g	100	5.0e+33	1	sol	1.e+5	3.e-2
g	130	1.0e+33	1	sol	1.e+4	2.e-2
g	140	1.0e+32	1	sol	1.e+4	1.e-2
g	150	1.e+31	1	sol	1.e+4	6.e-3
g	160	0.0	1	sol	5.e+3	1.e-3

c

c rezoning criteria

p 83 1.e+4

p 84 1.e-4

p 86 0

p 87 1

p 138 .4

p 139 .5

p 150 .008

p 151 .01

p 152 .02

p 193 .27

p 195 .005

c

c finely zone the central 2-4 solar masses just before carbon ignition

c by resetting p195 to the value of p313 and p150 to the value of p314

p 313 .003

p 314 .007

Sample KEPLER Generator Variations (Cont.)

15 Solar Mass Star

c initial grid (zone #, exterior mass(g), network #, temp(K), rho(g/cc)):

g	0	3.0e+34	1	sol	6.0e+6	1.e-1
g	1	2.9996e+34	1	sol	5.e+6	8.e-2
g	2	2.9990e+34	1	sol	5.e+6	8.e-2
g	3	2.9980e+34	1	sol	5.e+6	8.e-2
g	4	2.9962e+34	1	sol	5.e+6	8.e-2
g	5	2.9930e+34	1	sol	5.e+6	8.e-2
g	6	2.9900e+34	1	sol	5.e+6	8.e-2
g	7	2.9850e+34	1	sol	5.e+6	8.e-2
g	20	2.9e+34	1	sol	1.e+6	7.e-2
g	30	2.8e+34	1	sol	1.e+6	6.e-2
g	45	2.5e+34	1	sol	1.e+6	5.e-2
g	70	2.0e+34	1	sol	1.e+6	4.e-2
g	115	1.0e+34	1	sol	1.e+5	3.e-2
g	130	1.0e+33	1	sol	1.e+4	2.e-2
g	140	1.0e+32	1	sol	1.e+4	1.e-2
g	150	1.e+31	1	sol	1.e+4	6.e-3
g	160	0.0	1	sol	5.e+3	1.e-3

c

c rezoning criteria

p 83 1.e+4

p 84 1.e-3

p 86 0

p 87 1

p 138 .24

p 139 .5

p 150 .008

p 151 .01

p 152 .02

p 193 .16

p 195 .005

c

c finely zone the central 2-4 solar masses just before carbon ignition

c by resetting p195 to the value of p313 and p150 to the value of p314

p 313 .002

p 314 .005

Sample KEPLER Generator Variations (Cont.)

40 Solar Mass Star

```

c initial grid (zone #, exterior mass(g), network #, temp(K), rho(g/cc)):
g 0 8.0e+34 1 sol 6.0e+6 1.e-1
g 1 7.9996e+34 1 sol 5.e+6 8.e-2
g 2 7.9990e+34 1 sol 5.e+6 8.e-2
g 3 7.9980e+34 1 sol 5.e+6 8.e-2
g 4 7.9962e+34 1 sol 5.e+6 8.e-2
g 5 7.9930e+34 1 sol 5.e+6 8.e-2
g 6 7.9900e+34 1 sol 5.e+6 8.e-2
g 7 7.9850e+34 1 sol 5.e+6 8.e-2
g 20 7.9e+34 1 sol 1.e+6 7.e-2
g 30 7.8e+34 1 sol 1.e+6 6.e-2
g 45 7.5e+34 1 sol 1.e+6 5.e-2
g 57 7.0e+34 1 sol 1.e+6 4.e-2
g 70 6.0e+34 1 sol 1.e+6 4.e-2
g 115 1.0e+34 1 sol 1.e+5 3.e-2
g 130 1.0e+33 1 sol 1.e+4 2.e-2
g 140 1.0e+32 1 sol 1.e+4 1.e-2
g 150 1.e+31 1 sol 1.e+4 6.e-3
g 160 0.0 1 sol 5.e+3 1.e-3
c
c set very small surface boundary pressure to discourage mass loss
p 69 3.
c
c rezoning criteria
p 83 1.e+4
p 84 1.e-4
p 86 0
p 87 1
p 138 .1
p 139 .5
p 150 .005
p 151 .01
p 152 .02
p 193 .065
p 195 .003
c
c finely zone the central 2-4 solar masses just before carbon ignition
c by resetting p195 to the value of p313 and p150 to the value of p314
p 313 .00085
p 314 .00225

```


SAMPLE BURN GENERATOR (SOLAR ABUNDANCES)

c sol160bg -- burn generator deck with standard 149 isotope burn network,
 c solar composition (anders and grevesse, geochem et
 c cosmochem 1988) and 160 initial zones.
 c

c standard 149 isotope burn network:

net 1	nt1	h1	h2	h3	he3	he4	li7	be7	b10	b11
net 1	c11	c12	c13	c14	n13	n14	n15	o15	o16	o17
net 1	o18	f17	f18	f19	ne19	ne20	ne21	ne22	ne23	na22
net 1	na23	na24	mg23	mg24	mg25	mg26	mg27	al26	al27	al28
net 1	si27	si28	si29	si30	si31	p30	p31	p32	p33	s31
net 1	s32	s33	s34	s35	s36	s37	cl35	cl36	cl37	cl38
net 1	ar36	ar37	ar38	ar39	ar40	ar41	k39	k40	k41	k42
net 1	ca40	ca41	ca42	ca43	ca44	ca45	ca46	ca47	sc43	sc44
net 1	sc45	sc46	sc47	ti44	ti45	ti46	ti47	ti48	ti49	ti50
net 1	ti51	v47	v48	v49	v50	v51	v52	cr48	cr49	cr50
net 1	cr51	cr52	cr53	cr54	cr55	mn51	mn52	mn53	mn54	mn55
net 1	mn56	fe52	fe53	fe54	fe55	fe56	fe57	fe58	fe59	fe60
net 1	fe61	co55	co56	co57	co58	co59	co60	co61	ni56	ni57
net 1	ni58	ni59	ni60	ni61	ni62	ni63	ni64	ni65	cu59	cu60
net 1	cu61	cu62	cu63	cu64	zn60	zn61	zn62	zn63	zn64	

c

c define solar composition (anders and grevesse, geochem et cosmochem 1988):

m solcomp	7.057e-1	h1	4.801e-5	h2	2.929e-5	he3
m solcomp	2.752e-1	he4	9.349e-9	li7	1.067e-9	b10
m solcomp	4.730e-9	b11	3.032e-3	c12	3.650e-5	c13
m solcomp	1.105e-3	n14	4.363e-6	n15	9.592e-3	o16
m solcomp	3.887e-6	o17	2.167e-5	o18	4.051e-7	f19
m solcomp	1.619e-3	ne20	4.127e-6	ne21	1.302e-4	ne22
m solcomp	3.339e-5	na23	5.148e-4	mg24	6.766e-5	mg25
m solcomp	7.760e-5	mg26	5.805e-5	al27	6.530e-4	si28
m solcomp	3.426e-5	si29	2.352e-5	si30	8.155e-6	p31
m solcomp	3.958e-4	s32	3.222e-6	s33	1.866e-5	s34
m solcomp	9.379e-8	s36	2.532e-6	cl35	8.545e-7	cl37
m solcomp	7.740e-5	ar36	1.538e-5	ar38	2.529e-8	ar40
m solcomp	3.472e-6	k39	5.545e-9	k40	2.634e-7	k41
m solcomp	5.990e-5	ca40	4.196e-7	ca42	8.973e-8	ca43
m solcomp	1.425e-6	ca44	2.793e-9	ca46	3.893e-8	sc45
m solcomp	2.234e-7	ti46	2.081e-7	ti47	2.149e-6	ti48
m solcomp	1.636e-7	ti49	1.644e-7	ti50	9.258e-10	v50
m solcomp	3.767e-7	v51	7.424e-7	cr50	1.486e-5	cr52
m solcomp	1.716e-6	cr53	4.357e-7	cr54	1.329e-5	mn55
m solcomp	7.130e-5	fe54	1.169e-3	fe56	2.855e-5	fe57
m solcomp	3.697e-6	fe58	3.358e-6	co59	4.944e-5	ni58
m solcomp	1.958e-5	ni60	8.594e-7	ni61	2.776e-6	ni62
m solcomp	7.269e-7	ni64	5.753e-7	cu63	9.924e-7	zn64

c

c specify grid composition (for 160 zone problem):

g 0 1 solcomp
 g 160 1 solcomp

SAMPLE BURN GENERATOR (LMC ABUNDANCES)

```

c lmcl60bg -- burn generator deck with standard 149 isotope burn network,
c           lmc composition (isotopes scaled to anders and
c           grevesse, 1988) and 160 initial zones.
c
c standard 149 isotope burn network:
net 1  nt1  h1  h2  h3  he3  he4  li7  be7  b10  b11
net 1  c11  c12  c13  c14  n13  n14  n15  o15  o16  o17
net 1  o18  f17  f18  f19  ne19  ne20  ne21  ne22  ne23  na22
net 1  na23  na24  mg23  mg24  mg25  mg26  mg27  al26  al27  al28
net 1  si27  si28  si29  si30  si31  p30  p31  p32  p33  s31
net 1  s32  s33  s34  s35  s36  s37  cl35  cl36  cl37  cl38
net 1  ar36  ar37  ar38  ar39  ar40  ar41  k39  k40  k41  k42
net 1  ca40  ca41  ca42  ca43  ca44  ca45  ca46  ca47  sc43  sc44
net 1  sc45  sc46  sc47  ti44  ti45  ti46  ti47  ti48  ti49  ti50
net 1  ti51  v47  v48  v49  v50  v51  v52  cr48  cr49  cr50
net 1  cr51  cr52  cr53  cr54  cr55  mn51  mn52  mn53  mn54  mn55
net 1  mn56  fe52  fe53  fe54  fe55  fe56  fe57  fe58  fe59  fe60
net 1  fe61  co55  co56  co57  co58  co59  co60  co61  ni56  ni57
net 1  ni58  ni59  ni60  ni61  ni62  ni63  ni64  ni65  cu59  cu60
net 1  cu61  cu62  cu63  cu64  zn60  zn61  zn62  zn63  zn64
c
c define lmc composition:
m lmcomp 7.460e-1 h1 4.801e-5 h2 2.929e-5 he3
m lmcomp 2.500e-1 he4 9.349e-9 li7 1.067e-9 b10
m lmcomp 4.730e-9 b11 5.150e-4 c12 6.210e-6 c13
m lmcomp 1.210e-4 n14 4.800e-7 n15 2.490e-3 o16
m lmcomp 1.010e-6 o17 5.630e-6 o18 1.050e-7 f19
m lmcomp 5.180e-4 ne20 1.320e-6 ne21 4.170e-5 ne22
m lmcomp 1.070e-5 na23 2.630e-4 mg24 3.450e-5 mg25
m lmcomp 3.960e-5 mg26 1.510e-5 al27 3.660e-4 si28
m lmcomp 1.920e-5 si29 1.320e-5 si30 4.570e-6 p31
m lmcomp 1.700e-4 s32 1.390e-6 s33 8.020e-6 s34
m lmcomp 4.030e-8 s36 8.600e-7 cl35 2.910e-7 cl37
m lmcomp 4.260e-5 ar36 8.460e-6 ar38 1.390e-8 ar40
m lmcomp 1.740e-6 k39 2.770e-9 k40 1.320e-7 k41
m lmcomp 2.760e-5 ca40 1.930e-7 ca42 4.130e-8 ca43
m lmcomp 6.660e-7 ca44 1.280e-9 ca46 2.490e-8 sc45
m lmcomp 5.140e-8 ti46 4.790e-8 ti47 4.940e-7 ti48
m lmcomp 3.760e-8 ti49 3.780e-8 ti50 4.440e-10 v50
m lmcomp 1.810e-7 v51 3.560e-7 cr50 7.130e-6 cr52
m lmcomp 8.240e-7 cr53 2.090e-7 cr54 6.650e-6 mn55
m lmcomp 4.420e-5 fe54 7.250e-4 fe56 1.770e-5 fe57
m lmcomp 2.290e-6 fe58 1.680e-6 co59 2.770e-5 ni58
m lmcomp 1.100e-5 ni60 4.810e-7 ni61 1.550e-6 ni62
m lmcomp 4.070e-7 ni64 2.780e-7 cu63 4.960e-7 zn64
c
c specify grid composition (for 160 zone problem):
g 0 1 lmcomp
g 160 1 lmcomp

```


23.VII.93
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CHAPTER 3

PARAMETER LIST BY FUNCTION

This chapter lists by functional grouping the 330 changeable ('P') parameters in KEPLER that may be edited changed before or during execution. A reference list of these parameters arranged in numerical order is given in Chapter 4. Initial values for these parameters may be specified by P cards in the problem generator file (see Chapter 2). If no explicit such specification is made, their values are initially set equal to the default values listed below.

These parameters may also be edited or changed during program execution by the following set of keyboard commands (also described in Chapter 5):

P N

Display the value of parameter name or number *N*: 'p 113' or 'p time'

P N VALUE

Change the value of parameter name or number *N* to *VALUE*: 'p 113 31'

P N DELTA ADD

Add *DELTA* to the value of parameter name or number *N*: 'p 1 -1.e+14 add'

Note that, although printed in capital letters for clarity, the parameter names listed below must be given as unquoted, lowercase character strings when communicating with KEPLER. The mode of the parameters (fixed or floating point) follows the normal FORTRAN convention.

The current values of the parameters are remembered in the restart dumps and more may readily be added. They are located in the general COMMON in include file KEPCOMS (starting with DTNEW) and their ASCII names and types are listed respectively in the *nameparm* and *iptype* arrays loaded in data block KEPDAT. Newly added parameters are initialized in subroutine *RESTART* (see Chapter 5).

TIME AND STATUS PARAMETERS

#	Name	Default	Description
2	TIME	0.	Initial or current time (sec).
315	TOFFSET	0.	Cumulative amount of time by which the problem time has been offset by ZEROTIME commands (sec). In other words, TOFFSET should be added to the current problem time to get the actual time since the beginning of the problem. Normally, TOFFSET is reset internally when the ZEROTIME command is issued and should not be reset by the user.
157	NITERBAR	1	Total number of cycles used to compute ITERBAR, the average number of iterations per cycle. (Internally set.)

PARAMETER-CHANGE PARAMETERS

308	TIMEZMS	1.E+99	Time at which to make the zero-age-main-sequence parameter changes and restart dump (typically 1.E+12). (sec).
309	IZONEZMS	1	Reset the value of IZONEF (P 86) to IZONEZMS at the time specified by TIMEZMS (P 308).
310	Q1FACZMS	0.1	Reset the value of Q1FAC (P 13) to Q1FACZMS at the time specified by TIMEZMS (P 308).
311	TEMPCIG	1.E+99	Central temperature at which to make the pre-carbon-ignition parameter changes and restart dump (typically 5.E+8). (K).
312	YFLRXCIG	0.003	Reset the value of YFLOORX (P 47) to YFLRXCIG when the central temperature specified by TEMPCIG (P 311) is reached.
313	FMAXMCIG	1.	Reset the value of FMAXM (P 195) to FMAXCIG when the central temperature specified by TEMPCIG (P 311) is reached.
314	FMAX0CIG	1.	Reset the value of FMAX0 (P 150) to FMAX0CIG when the central temperature specified by TEMPCIG (P 311) is reached.

PROBLEM TERMINATION PARAMETERS

14	NSTOP	100000	Maximum number of cycles.
15	TSTOP	1.E+30	Stop time (sec).
158	ITERBARM	100	Maximum allowed value of NITERBAR without terminating the problem.
304	TEMPSTOP	1.E+99	Terminate the problem when the central temperature reaches TEMPSTOP (K).
305	DENSTOP	1.E+99	Terminate the problem when the central density reaches DENSTOP (g/cc).
306	VINSTOP	1.E+99	Terminate the problem when the infall velocity exceeds VINSTOP (cm/sec). Note that positive values of VINSTOP correspond to negative (infalling) velocities.
307	O16STOP	-1.	Terminate the problem when the O16 mass-fraction drops below O16STOP provided the central temperature exceeds TQSELIM (P 184). Basically this corresponds to a time near the end of core oxygen burning for values of O16STOP about 0.05.

SPECIAL COMMAND EXECUTION AND DUMP PARAMETERS

331	TEMPCDEP	1.E+99	If the central temperature is $\geq$ TEMPCDEP, then make a restart dump labeled '#cdep', execute the alias-defined "cdep" command, and reset TEMPCDEP to 1.E+99. Normally, this parameter is used to reset certain parameter values following carbon depletion.
332	O16ODEP	-1.E+99	If the central oxygen abundance is $\leq$ O16ODEP and the central temperature is $\geq$ TQSELIM (P 184), then make a restart dump labeled '#odep', execute the alias-defined "odep" command, and reset O16ODEP to -1.E+99. Normally, this parameter is used to reset certain parameter values at oxygen depletion.
333	TEMPCHAR	1.E+99	If the central temperature is $\geq$ TEMPCHAR, then make a restart dump labeled with '#tn' and the current cycle number, reset TEMPCHAR to 1.E+99, and finally execute the alias-defined

"tnchar" command.

Note that the user -defined "tnchar" command can change the value of TEMPCHAR in such a way as to cause the "tnchar" command to be issued recursively (i.e., by using the command: "P N DELTA ADD" -- see Chapter 5).

334 DENCHAR 1.E+99

If the central density is $\geq$ DENCHAR, then make a restart dump labeled with '#dn' and the current cycle number, reset DENCHAR to 1.E+99, and *finally* execute the alias-defined "dnchar" command.

Note that the user -defined "dnchar" command can change the value of DENCHAR in such a way as to cause the "dnchar" command to be issued recursively (i.e., by using the command: "P N DELTA ADD" -- see Chapter 5).

335 ABARCHAR 1.E+99

If the central mean atomic weight (ABAR) is $\geq$ ABARCHAR, then make a restart dump labeled with '#ab' and the current cycle number, reset ABARCHAR to 1.E+99, and *finally* execute the alias-defined "abchar" command.

Note that the user -defined "abchar" command can change the value of ABARCHAR in such a way as to cause the "abchar" command to be issued recursively (i.e., by using the command: "P N DELTA ADD" -- see Chapter 5).

343 TSHOCK 1.E+99

If the problem time is $\geq$ TSHOCK, then make a restart dump labeled '#shock', reset TSHOCK to 1.E+99, and *finally* execute the alias-defined "tshock" command.

Normally, this command is used to reset certain parameter values and/or make edits at the time of the piston-induced bounce of the collapsing iron core that creates an out-going shock wave.

344 TNUCLEO 1.E+99

If the problem time is $\geq$ TNUCLEO, then make a restart dump labeled '#nucleo', reset TNUCLEO to 1.E+99, and *finally* execute the alias-defined "tnucleo" command.

Normally, this command is used to reset certain parameter values and/or make edits at a time just after explosive nucleosynthesis is complete.

345 TENVEL 1.E+99

If the problem time is $\geq$ TENVEL, then make a restart dump labeled '#envel', reset TENVEL to 1.E+99, and *finally* execute the alias-defined "tenvel" command.

Normally, this command is used to reset certain parameter values and/or make edits just before the supernova shock wave breaks through the surface of the presupernova star.

OTHER EXECUTION CONTROL PARAMETERS

- 159 IAUTOOUT 0 Send out two copies of the ASCII output if IAUTOOUT>1. Also send out two copies of the graphics output if IAUTOOUT>2. Note: No output files are destroyed. (CRAY only! -- this is an obsolescent parameter that should not be used on UNIX machines without recasting.)
- 161 FRACCORE 1.1 The effective number of zones used in REGESS (JMCALC) shall be the minimum needed to contain the inner FRACCORE mass-fraction of the initial mass of the star.
- 162 JMCALC JM Effective number of zones used in subroutine REGESS. JMCALC is internally calculated from FRACCORE and should not be changed.
- 192 JPAUSE -1 Pause the code at the end of the calculation for zone J = JPAUSE in REGESS ("PAUSE 1") and in UPDATE ("PAUSE 2"). Do not pause if JPAUSE < 0. Type a carriage return to continue.

GENERAL EDIT CONTROL PARAMETERS

16	NEDIT	20	Number of cycles between ASCII edits.
17	DTEDIT	0.	Time between ASCII edits (0. = ∞) (sec).
64	NPIXEDIT	50	Graphics edits to the monitor are made every NPIXEDIT KEPLER cycles (if P 127 > 0).
128	ABUNLIM	1.E-3	Least elemental mass fraction plotted or listed in a terminal ion edit.
197	NNEWOUTF	2000	Start a new labeled ASCII output file every NNEWOUTF cycles.
268	NPAGE	53	Number of lines printed per "page" of ASCII output. The value 53 causes zone lists to be printed in 50-zone blocks.
273	SCALEM	1.9892E+33	Mass unit used for the mass coordinate employed in making ASCII and terminal edits (g).
274	NEDITZ1	10	Make an ascii edit of primary zonal quantities every NEDITZ1*NEDIT (P 16) cycles.
275	NEDITZ2	20	Make an ascii edit of secondary zonal quantities every NEDITZ2*NEDIT (P 16) cycles.
243	NEDITA	10	Make an elemental abundance edit every NEDITA*NEDIT (P 16) cycles.
278	NEDITP	50	Make an ascii edit of all changeable parameters every NEDITP*NEDIT (P 16) cycles.
276	MEDIT	0	Flag determining the minimum amount of information printed in an ascii cycle edit regardless of the settings of other edit parameters: ≤ 0 means minimum is a 1 page "short" edit; ≥ 1 means minimum includes a primary zonal edit; ≥ 2 means minimum includes a secondary zonal edit; ≥ 3 means minimum includes an ion abundance edit; ≥ 4 means minimum includes an ISE abundance edit; ≥ 5 means minimum includes a BURN isotope edit; ≥ 6 means minimum includes a BURN isotope edit for all

RESTART-DUMP CONTROL PARAMETERS

18	NDUMP	10	Number of cycles between restart dumps.
156	NSDUMP	10	Save every NSDUMP restart dumps.
269	NSAVEZ	24	Total number of nonBURN zonal arrays to save in restart dumps. These arrays are listed in KEPCOMS, starting with YM and numbering NZONEI + NZONEC in total. NSAVEZ must be at least 14 and no greater than NZONEI + NZONEC. Saving more than the minimum number of arrays needed to restart the problem is often useful for edit purposes.
270	NSAVEB	10	Total number of BURN zonal arrays to save in restart dumps. These arrays are listed in KEPCOMS, starting with NETNUMB and numbering NZONEB in total. NSAVEB must be at least 6 and no greater than NZONEB. Saving more than the minimum number of arrays needed to restart the problem is often useful for edit purposes.
308	TIMEZMS	1.E+99	Time at which to make the zero-age-main-sequence parameter changes and restart dump (typically 1.E+12). (sec).
311	TEMPCIG	1.E+99	Central temperature at which to make the pre-carbon-ignition parameter changes and restart dump (typically 5.E+8). (K).

zones;

≥ 7 means minimum includes a parameter edit.

277 MEDITFIN 7 Effective value of MEDIT (P 276) used in determining the scope of the final edit made when the problem is finished.

ISE EDIT PARAMETERS

168 NJEDITQ 5 Make a ISE edit every NJEDITQ zones.

180 NEDITQ 20 Make a detailed edit of the ISE zones every NEDITQ general numerical edits.

183 XTHRES 1.E-4 Edit only those ISE isotopes with mass fractions exceeding XTHRES.

198 NEDITQ1 5 Make an ISE edit for the central zone every NEDITQ1 * NEDIT (P 16) cycles.

BURN EDIT PARAMETERS

241 NEDITB 5 Make a BURN isotopic abundance edit every NEDITB*NEDIT (P 16) KEPLER cycles.

244 JMEDITB 1 Edit only zones whose zone number is $\leq$ JMEDITB during normal BURN isotopic abundance edits.

245 NEDITALL 100 Make a BURN isotopic abundance edit for all zones every NEDITALL*NEDIT (P 16) cycles regardless of the value of NEDITB (P 241).

272 ABUNLIMB 1.E-5 Edit only those BURN isotope mass-fractions whose values exceed ABUNLIMB in making terminal edits (including isotopic mass-fraction sums over zones).

250 NCOMP 999999 Make a complete ASCII edit of the nuclear processes in all zones considered by the BURN coprocessor every NCOMP cycles.

251 NCENT 999999 Make an ASCII edit of the nuclear processes in the central zone considered by the BURN coprocessor every NCENT cycles.

252 NEDT 999999 Make an ASCII edit of the nuclear processes involved every nedt BURN coprocessor matrix inversions (debugging only).

POST-PROCESSOR-DUMP CONTROL PARAMETERS

299	NCYCQQ	5	Number of KEPLER cycles between post-processor dump cycles (i.e.. calls to DUMPQ).
44	LENQMAX	3000000	Maximum length of a post-processor dump file (bytes).
164	NIONDUMP	40	Number of dump cycles between forced dumps of all dump-grid points of all 'ions' specified as dump variables.
165	NISODUMP	400	Number of dump cycles between forced dumps of all dump-grid points of all 'BURN' isotopes' specified as dump variables.
166	NZONDUMP	40	Number of dump cycles between forced dumps of all dump-grid points of all arrays specified as dump variables except 'ions' and 'isotopes.'
297	DSCALEM	1.9892E+33	Mass units used for the internal mass coordinate, YMASS, used for dumping purposes (g). -- See subroutine DUMPQ.
298	NGRIDMIN	10	Minimum number of points allowed in a dump grid. See DUMPQ.
300	LENTRACK	16384	Length of the track(s) assigned to each dump variable in the post-processor dump(s) (bytes). See DUMPQ.
303	BACKFACQ	0.5	If the fractional change in a dump variable since the last dump cycle exceeds BACKFAC*RATZDUMP(IDAT), then also dump the old value of that variable at the previous (dump cycle) time point, where RATZDUMP(IDAT) is the (previously specified) maximum allowed fractional change between dumps of this zonal dump variable (indexed by IDAT). See Chapter 2 on Generator Input.
346	NFIRSTQ	0	Default value of the first cycle to be read or plotted in making post-processor edits, time plots, or timemaps. Note that this parameter is reset by the NEWDUMPS command to the current value of NCYC+NCYCQQ-MOD(NCYC,NCYCQQ) so that KEPLER will not try to read old dumps.

TIMESTEP CONTROL PARAMETERS

1	DTNEW	1.	Initial or current timestep (sec).
25	DTMAX	1.E+99	Maximum timestep allowed (sec).
6	DTCR	0.05	Maximum desired fractional change in radius per step.
7	DTCT	0.05	Maximum desired fractional change in temperature per step.
8	DTCD	0.10	Maximum desired fractional change in density per step.
9	DTCQ	0.05	Maximum desired fractional linear contraction per step.
10	DTCDT	0.99	Maximum fractional change in the timestep per step.
72	DTCL	1.E+99	Maximum desired fractional change in luminosity per step.
46	DTCP	0.1	Maximum desired fractional change in abundances per step.
47	YFLOORX	1.E-3	Minimum elemental mass fraction that effects the timestep.
312	YFLRXCIG	0.003	Reset the value of YFLOORX (P 47) to YFLRXCIG when the central temperature specified by TEMPCIG (P 311) is reached.
39	DYEMULT	200.	If IYTSFLAG $\geq$ 1, increase the timestep sensitivity to changes in YE by a factor of DYEMULT.
40	DYQMULT	2.5	IF IYTSFLAG $\geq$ 1, increase the timestep sensitivity to changes in YQ by a factor of DYQMULT.
67	IYTSFLAG	1	Consider only changes in YE, YQ, YF, YSI, and Y56 in ISE zones when computing the timestep if IYTSFLAG $\geq$ 1.

EXTRAPOLATION CONTROL PARAMETERS

3	EXTRAP	1.	Extrapolation Parameter used in guessing new R, T, and L values. 0. gives old values; 1. gives linear extrapolation.
26	FCREXT	10.	Factor used to reduce noise in radius extrapolation. (See subroutine GESS)
27	FCTEXT	10.	Factor used to reduce noise in temperature extrapolation.
71	FCLEXT	1.E-5	Factor used to reduce noise in luminosity extrapolation.

CONVERGENCE CONTROL PARAMETERS

11	FCRMAX	1.E-6	Maximum allowed relative convergence error in radius.
12	FCTMAX	1.E-6	Maximum allowed relative convergence error in temperature.
70	FCLMAX	1.	Maximum allowed relative convergence error in luminosity.
51	THICKFAC	1.E-3	If the timestep is greater than the thermal timescale for a zone by a factor $\geq 0.5 \cdot \text{THICKFAC}$, then consider the zone to be in thermal steady-state and deal with any residual non-convergence in the solution of the energy equation by recalculating the luminosity in terms of the final iterated value of the internal energy. Otherwise, recalculate the internal energy in terms of the final iterated luminosity. (See subroutine UPDATE).
213	DENCONV	1.E-7	Allowed fractional convergence error in density when calculating a hydrostatic initial stellar configuration in the generator using the DSTAT option. (See GENER).

BACKUP CONTROL PARAMETERS

5	MAXIT	40	Maximum number of times subroutine REGESS is called to iterate R, T, and L estimates before the timestep is reduced by DTCUT and the step repeated (termed a "backup").
52	MAXBAK	5	Maximum number of times a given step is redone before the code quits.
53	DTCUT	0.1	Fractional timestep reduction when a step is redone.

BACKUP CONTROL PARAMETERS (Cont.)

22	FCRBU	0.01	Reduce timestep by DTCUT and redo step if convergence error in radius is still greater than FCRBU after MAXIT iterations.
23	FCTBU	0.01	Reduce timestep by DTCUT and redo step if convergence error in temperature is still greater than FCTBU after MAXIT iterations.
73	FCLBU	1.	Reduce timestep by DTCUT and redo step if convergence error in luminosity is still greater than FCLBU after MAXIT iterations.
54	TFCRBU	2.	If the maximum fractional change in radius during a timestep exceeds TFCRBU*DTCT then redo step.
55	TFCTBU	2.	If the maximum fractional change in temperature during a timestep exceeds TFCTBU*DTCT then redo step.
74	TFCLBU	1.E+99	If the maximum fractional change in luminosity during a timestep exceeds TFCLBU*DTCL then redo step.
205	TFCYBU	0.5	Maximum allowed fractional change in abundance before an abundance backup is made. (See P 204).
204	ABUNMINX	-1.E-5	Force a backup after a call to subroutine BURN from subroutine SDOT if a calculated elemental mass fraction change would cause the resulting mass fraction to be less than ABUNMINX or to change by a fractional amount greater than TFCYBU. Such backups are made only if the elemental mass fractions involved are greater than YFLOORBX .
206	YFLOORBX	0.001	Elemental mass fraction floor for making abundance backups. (See P 204).
207	IQERRFLG	1	Fatal errors in QBURN encountered during a normal REGESS iteration will cause KEPLER to back-up if IQERRFLG $\geq$ 1, or to terminate if IQERRFLG $<$ 1.
224	XMRATBAK	0.2	Redo the timestep ("backup") if the fractional change of mass in the mass-losing zone exceeds XMRATBAK.

BOUNDARY CONDITION PARAMETERS

60	RADIUS0	0.	Radius of inner boundary (cm).
61	SUMM0	0.	Mass inside inner boundary (g).
62	XLUM0	0.	Luminosity emerging from inner surface (erg/s).
68	TBOUND	0.	Temperature at outer boundary (K).
69	PBOUND	0.	Pressure at outer boundary (erg/cc).
271	VLOSS	1.E+99	Remove the outer zone if its velocity exceeds VLOSS, but do not change the previous values of PBOUND (P 69) or TBOUND (P 68) (cm/sec).

ACCRETION PARAMETERS

211	ACCRATE	0.	Mean rate at which mass in the form of new zones is added to the surface of the star (solar masses per year). The accumulated mass is stored in XMACRETE (P 212) until it is large enough to be added as a whole zone. The surface boundary pressure is gradually increased at a rate proportional to ACCRATE until a mass (in XMACRETE) equal to that in the current outer zone is reached. Then a new zone, the mirror image of the old outer zone, is added. Accretion composition is set by the COMPSURF command in TTYCOM. This prescription will work best for coarse and roughly equal surface zoning.
212	XMACRETE	0.	Mass of phantom outer zone used to mediate mass accretion (g). (See P 211).

MASS-LOSS PARAMETERS

- | | | | |
|-----|----------|------|---|
| 220 | XMLOSSM | 0. | Multiplier on the de Jager mass-loss rate. (See CYCLE and <i>Ann. Rev. Astron. Astrophys.</i> 24, 336 (1986)). |
| 221 | XMLOSS0 | 0. | Nominal mass loss rate from the surface of the star (solar masses/year). This constant mass loss rate is added to whatever de Jager-prescription mass loss may have been specified by XMLOSSM (P 220). |
| 222 | TOTM0 | 0. | The original total mass of the star (g). This is set during generation and is used in interpreting edit, dump, and rezoning parameters involving stellar mass fractions rather than the current mass of the star (TOTM) which may change due to mass loss, accretion, etc. Normally, the internally set value of TOTM0 should not be changed by the user. |
| 223 | FRACDEZ | 0.5 | Dezone the mass-losing zone if its mass drops below FRACDEZ times the average mass of the zones on either side of it. |
| 224 | XMRATBAK | 0.2 | Redo the timestep ("backup") if the fractional change of mass in the mass-losing zone exceeds XMRATBAK. |
| 225 | XFRACML | 0.01 | Subtract any "surface" mass loss specified by XMLOSSM (P 220) or XMLOSS0 (P 221) from the zone closest to the surface that still has more than XFRACML*TOTM0 (P 222) grams of material overlying it. This should be set so that mass is not extracted from zones too near the surface in order to avoid excessive dezoneing, small timesteps, and luminosity fluctuations. |
| 217 | NSURFZ | -10 | If NSURFZ > 0 and IZONEF (P 86) > 0, maintain a logarithmic ramp in zonal mass of the NSURFZ zones at the surface of the star, where FRACSZ0 (P 218) is twice the desired mass-fraction of the surface zone and FRACSZ1 (P 219) is twice the desired mass-fraction of the NSURFZth zone from the surface. Otherwise, NSURFZ has no effect. (See REZONE.) This is an obsolescent parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE. |
| 218 | FRACSZ0 | 1. | Inner surface zoning parameter (see REZONE and the discussion under P 217). This is an obsolescent parameter |

MASS-LOSS PARAMETERS (Cont.)

			involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.
219	FRACSZ1	1.	Outer surface zoning parameter (see REZONE and the discussion under P 217). This is an obsolescent parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.
348	BINM10	TOTM0	The initial mass of the star being evolved (primary) in solar masses that is used in calculating the possibility of mass loss to a binary companion, following the formalism of Podsiadlowski, Joss, and Hsu, ApJ, 391, 246, (1992). The star loses mass when its radius exceeds its Roche radius, with a power-law cutoff to avoid numerical discontinuities. The formalism also involves parameters 349 - 354, defined below. See subroutine CYCLE.
349	BINM20	0.	The initial mass of the binary companion star (in solar masses) used in calculating the possibility of binary mass transfer. No mass transfer is performed if $BINM20 \leq 0$. See P 348.
350	BINALP	1.	PJH's alpha parameter, related to the angular momentum of the mass lost in binary transfer. See P 348.
351	BINBET	1.	PJH's beta parameter. Fraction of the total mass spilling over from the Roche lobe of the primary that is transferred to the secondary rather than being lost from the system. BINBET equals 1. for conservative binary mass transfer.
352	BINA0	2.	Initial binary separation in AU used in calculating the possibility of binary mass transfer. See P 348.
353	BINMDT	1.E-3	Mass loss rate due to binary mass transfer assumed when the primary stars exceeds its Roche radius (solar masses per year). See P 348.
354	ROCHER	1.E+99	Current Roche radius (cm). This is a calculated quantity and should normally not be changed by the user. See P 348.

ARTIFICIAL VISCOSITY PARAMETERS

4	Q2FAC	4.	Quadratic artificial viscosity (Q) factor. Shock transitions are spread over about $2 \cdot \text{SQRT}(\text{Q2FAC})$ zones. (see WZW78)
13	Q1FAC	0.1	Linear artificial viscosity factor. Helps damp sound waves during hydrostatic evolution. Should be set to 0. during hydrodynamic phases. Normally set to 1000. in the generator until the star settles down onto the zero-age main sequence (from an initially rather arbitrary configuration), at which point it is reset to 0.1.
107	ARTV1	1.	Multiply Q1FAC by ARTV1 in zone J if $\text{JARTV1} \leq \text{JARTV2}$.
108	ARTV2	1.	Multiply Q1FAC by ARTV2 in zone J if $\text{JARTV2} \leq \text{JM} - \text{JARTV3}$.
109	ARTV3	1.	Multiply Q1FAC by ARTV3 in zone J if $\text{J} \geq \text{MAX}(\text{JARTV1}, \text{JARTV2}, \text{JM} - \text{JARTV3})$
110	JARTV1	1000	(See P 107-109).
111	JARTV2	1000	(See P 107-109).
112	JARTV3	1000	(See P 107-109).
310	Q1FACZMS	0.1	Reset the value of Q1FAC (P 13) to Q1FACZMS at the time specified by TIMEZMS (P 308).

EQUATION-OF-STATE PARAMETERS

34	PIMULT	1.	Ion energy and pressure multiplier.
35	PRMULT	1.	Radiation energy and pressure multiplier.
36	PEMULT	1.	Electron energy and pressure multiplier.
56	XIPOT	13.6053	Ionization potential (eV) --see subroutine ES.
57	DZERO	0.1	Characteristic density for pressure ionization (g/cc).
58	NPFLAG	1	Pairs are included in EOS calculation only if NPFLAG>0.
92	ETACONV	1.E-5	Relative convergence required in calculating the electron Fermi degeneracy parameter, ETA.
149	XMIMULT	1.	The mass used in calculating ion degeneracy is XMIMULT times the mass of a neutron.
196	EIONMULT	1.	Multiplier on the contribution of ionization potential energy to the equation of state. (See subroutine ES).
199	WILSONMT	-1.	Multiplier on the Wilson-based nuclear EOS (except for the thermal ion component) if it is ≥ 0 . Otherwise, the old non-relativistic, partial degeneracy model for the ion EOS is used. WARNING...setting this parameter ≥ 0 appears to cause anomalous contributions to the pressure and energy at densities far below nuclear density and probably should not be used without revision. (See subroutine ES).
200	T11CUT	1.	Upper bound on the temperature used to calculate the energy in nuclear excited states and nuclear partition functions (E+11 K units). (See subroutines ES and SDOTQ).
215	COULMULT	1.	Multiplier on the Wigner-Seitz Coulomb corrections to the ion energy and pressure (See Clayton, p. 152, and ES).

EQUATION-OF-STATE PARAMETERS (Cont.)

- | | | | |
|-----|---------|--------|---|
| 337 | ICALCNE | 0 | Calculate more accurate electron densities in partially ionized regions if ICALCNE > 0 using Lisa Ensmann's multiple-ion, Saha equilibrium subroutine, CALCNE. Generally this more accurate, but very time-consuming routine is turned on just before shock-breakout while doing supernova light-curve calculations. |
| 338 | XNECONV | 1.E-05 | Maximum allowable fractional convergence error in the electron density calculated by subroutine CALCNE (see P 337). |
| 339 | IONFLAG | 0 | <p>If IONFLAG ≤ 0 and the density and temperature have changed by a fraction less than DDSFRAC (P 153) and DTSFRAC (P 154), respectively, since the last iteration, then extrapolate the value of the electron density from its partial derivatives with respect to density and temperature instead of calling CALCNE (when ICALCNE > 0 -- see p 337), unless this is the first iteration.</p> <p>Otherwise call CALCNE all the time, provided ICALCNE > 0.</p> |
| 340 | XNEMIN | 1.E-05 | Minimum mass fraction for which an element is included in the calculation of Saha ionization equilibrium done in subroutine CALCNE (see P 337). |

HEAT DIFFUSION PARAMETERS

37	TRANSM	1.	Multiplier on diffusive heat transport.
49	T7PEEK	1.E+50	Opacity will be no larger than $XKMIN + T7PEEK * D * T7^{**4}$. (cgs units, except $T7 = T / (10^{**7} \text{ K})$)
50	XKMIN	1.E-10	Least upper opacity bound (cm^{**2}/g). (see P 49 and KAPPA)
91	ZBOUND	0.1	Mass fraction of heavy elements above which IBEN1 opacities are used.
29	XK1MT	1.	Multiplier on IBEN1 opacity.
30	XK2MT	1.	Multiplier on IBEN2 opacity.
31	XK3MT	1.	Multiplier on Christy opacity.
32	XK4MT	1.	Multiplier on Compton opacity.
33	RXKCMT	1.	Multiplier on conductive opacity.

CONVECTION PARAMETERS

19	XMLLEN	1.	Ratio of the convective mixing length to the pressure scale height.
20	FUDGC	0.01	Fudge factor for convection (about 0.01). Reduces convective efficiency for very small departures from adiabatic gradients and thus makes the numerical onset of convection less abrupt and unstable. (see subroutines REGESS and UPDATE)
21	DIFIM	1.	Multiplier for the rate of convective mixing.
59	FRACNEUT	0.05	If the semiconvective test parameter, W, is less than zero but greater than -FRACNEUT*ABS(LOG(T1/T0)), then the zonal interface is flagged convectively neutral ("NEUT" or ","). (see subroutine UPDATE)
146	FRC SOUND	0.1	Don't do convection if the absolute value of the zone velocity exceeds FRC SOUND times the local sound speed.
147	CONVLIM	1.	Limit the convective velocity to a fraction CONVLIM of the local sound speed.
209	XLTAU CON	0.	Don't allow the convective velocity to increase by a factor greater than EXP (DT/(XLTAU CON*TAU CON V)) in one timestep, where DT is the current timestep and TAU CON V is the timescale for convective mixing (see REGESS and UPDATE). Useful in modeling detonations. (See P 214 for studying deflagrations).
210	NOQSECON	0	Don't force zones that are convectively coupled to ISE zones to go to ISE if NOQSECON > 0. This parameter should be kept zero unless you <i>really</i> understand what you're doing.

SEMICONVECTION AND OVERSHOOT PARAMETERS

- | | | | |
|-----|----------|----------|---|
| 24 | DRMULT | 0.1 | Semi-convective mixing will be slower than thermal transport by at least DRMULT (about 0.1) in zones with mean atomic weight, ABAR, is $\geq$ ABARSEMI (P 324). (See sub.UPDATE) (Also see DRMULTLO (P 325), WOVERSHT (P 148), and WOVERSLO (P 326)). |
| 75 | DTSMULT | 1.E+99 | The fractional amount of semiconvective mixing that can occur in one timestep is limited to approximately DTSMULT. |
| 148 | WOVERSHT | 0.01 | The semiconvective test parameter, W, is taken to be $W = \text{WOVERSHT} * \text{ABS}(\text{LOG}(T1/T0))$ for the special overshoot semiconvective zones where W would otherwise be less than 0 and when $\text{ABAR} \geq \text{ABARSEMI}$ (P 324). Overshoot mixing occurs at a rate calculated from this value of W, but limited by the thermal diffusion timescale as in normal semiconvection. (see UPDATE & WZW78). If WOVERSHT=0 no overshoot mixing is done. (Also see WOVERSLO -- P 326). |
| 324 | ABARSEMI | 4. | Value of the zonal mean atomic weight, ABAR, used to divide the star into two regions with separately specifiable values of the semiconvective mixing rate and the overshoot mixing coefficient (g/mole). (See the definitions of DRMULT (P 24), WOVERSHT (P 148), DRMULTLO (P 325), and WOVERSLO (P 326)). |
| 325 | DRMULTLO | DRMULT | Semiconvective mixing will be slower than thermal transport by at least DRMULTLO (about 0.1) in zones where the mean atomic weight, ABAR, is below ABARSEMI (P 324). (See UPDATE and discussion of DRMULT (P 24), WOVERSHT (P 148), and WOVERSLO (P 326)). |
| 326 | WOVERSLO | WOVERSHT | The semiconvective test parameter, W, is taken to be $W = \text{WOVERSLO} * \text{ABS}(\text{LOG}(T1/T0))$ for the special overshoot semiconvective zones where W would otherwise be less than 0 and when $\text{ABAR} < \text{ABARSEMI}$ (P 324). Overshoot mixing occurs at a rate calculated from this value of W, but is limited by the thermal diffusion timescale as in normal semiconvection. (see UPDATE & WZW78). If WOVERSLO=0 no overshoot mixing is done. (Also see WOVERSHT -- P 148). |

NUCLEAR REACTION PARAMETERS

101	SNEUTMT	1.	Neutrino energy loss rate multiplier (APPROX only).
102	SNUCMT	1.	Non-neutrino nuclear energy generation rate multiplier (APPROX only).
208	C12AGMLT	1.	Multiplier on the overall C12(a,g) rate (APPROX only). This parameter is obsolescent . It is better to use E1MLTC12 P 227) and E2MLTC12 (P 228).
227	E1MLTC12	1.	Multiplier on the E1 part of the C12(a,g) cross-section (affects both APPROX and the the BURN coprocessor, but currently has no effect on the C12(a,g) rate used to calculate photodisintegration flows in ISE.)
228	E2MLTC12	1.	Multiplier on the E2 part of the C12(a,g) cross-section. (affects both APPROX and the the BURN coprocessor, but currently has no effect on the C12(a,g) rate used to calculate photodisintegration flows in ISE.)
65	TNUCMIN	0.	Don't calculate nuclear burning in APPROX if the temperature is less than TNUCMIN (K). Note that unless the hydrogen burning rate is significant, no APPROX network calculations will be done below 1.E+7 K, even if TNUCMIN < 1.E+7 K. (See P 89).
89	DYPMIN	1.E-10	Minimum amount of potential hydrogen burn in the present timestep needed to trigger the use of any reaction network (moles/g). (APPROX only).
90	DYMGMIN	1.E-10	Minimum amount of Mg24 production required in the last timestep to trigger the use of the full reaction network (moles/g). (APPROX only).
28	IPUP	1	Abundance update parameter. Update abundances only if IPUP≠0.
38	TIMEX0	-1.E+99	Time at which any Ni56 present in low temperature regions (as determined by P 89 and P 65) of the star is assumed to have been produced and begun to decay, first to Co56 and then to Fe56 (sec). If TIMEX0 ≥ -1.E+50 and the zonal Ni56

			abundance, $Y_{NI} \geq 3.E-5$, then the nuclear energy generation is take equal to that generated by an initial Ni56 abundance Y_{NI} after having decayed for a time interval $TIME (P 2) - TIMEX0$. Note that the value of Y_{NI} in the abundance array is not changed by this "decay", and always represents the initial amount produced. DO NOT set $TIMEX0 > TIME (P 2)$.
341	XKAPGAM	0.054	Assumed effective opacity (cm^2/g) for the deposition of gamma ray energy from the radioactive decay of Ni56 and Co56, as controlled by $TIMEX0 (P 38)$.
342	EGAMP	0.60	Dimensionless correction factor used in calculating the escape of gamma rays from the radioactive decay of Ni56 and Co56, as controlled by $TIMEX0 (P 38)$. See subroutine SDOT for details.
63	IRNET	0	If $IRNET=0$, use APPROX network. If $IRNET=1$, use SDOT1 (H and He burning network). Otherwise use SDOT2 (NOVA network). Note that SDOT1 and SDOT2 are replaced by dummy routines in the current version of KEPLER and an error message will result if they are entered. The old routines would have to be extensively updated before being used again.
103	DSNUM	1.E-6	Fractional density and temperature perturbations used to get nuclear energy generation rate derivatives (APPROX only).
153	DDSFRAC	0.01	Maximum fractional change in density since the last iteration for which ABAR changes and energy generation rates can be extrapolated from their previous values (APPROX only).
154	DTSFRAC	0.001	Maximum fractional change in temperature since the last iteration for which ABAR changes and energy generation rates can be extrapolated from their previous values (APPROX only).
155	IUDFLAG	0	Extrapolate energy generation rates and ABAR changes in cases of small temperature and density change only if IUDFLAG is also ≤ 0 .

NUCLEAR REACTION PARAMETERS (Cont.)

- 163 IUPDFLAG 1 Don't calculate derivatives in subroutine SDOT when called from subroutine UPDATE if IUPDFLAG $\geq$ 0 (APPROX only).
- 160 IFLGABAR 0 The mean atomic weight, ABAR, calculated in subroutine SDOT is implicitly coupled to the ion equation of state only if IFLGABAR $\neq$ 0 and the normal APPROX network (IN=1) is being used. (This is an obsolescent parameter and the coding should be carefully rechecked if it is set $\neq$ 0).

CARBON DEFLAGRATION PARAMETERS

- 209 XLTAUCON 0. Don't allow the convective velocity to increase by a factor greater than $\text{EXP}(\text{DT}/(\text{XLTAUCON} * \text{TAUCONV}))$ in one timestep, where DT is the current timestep and TAUCONV is the timescale for convective mixing (see REGESS and UPDATE). Useful in modeling detonations. (See P 214 for studying deflagrations).
- 214 FLAMERAD 0. Characteristic flame radius for carbon deflagration studies (cm). If XLTAUCON > 0 and FLAMERAD > 0, multiply the convective timescale, TAUCON, used to calculate the maximum allowed rate that the convective luminosity can increase (see P 209) by an additional factor of FLAMERAD/RFLAME, where RFLAME is the maximum radius at which a temperature above 2.E+9 K exists. This parameter effectively varies the velocity at which a deflagration can propagate and should be used *only* when studying carbon detonations. Note that larger values of FLAMERAD imply slower deflagration speeds, and that the relationship is not linear.
- 279 FLAMVA 0. If FLAMVA $\neq$ 0., the current problem is a study of a carbon deflagration in a white dwarf. The current radius of the deflagration flame is taken as the radius of the outermost zone where the temperature exceeds 2.E+9 K and is edited as JFLAM (P 283) by KEPLER. The outward speed of the flame is controlled by adjusting the opacity for heat conduction between zones JFLAM and JFLAM + 1 up or down by a factor, XKAPFLAM (P 284), between 0. and 1. Such "gating" is performed in KAPPA and UPDATE and sets the velocity of advance of the 2.E+9 K temperature front to a comoving value that averages:

$$\text{VFLAME} = \text{VCOND} * (\text{RFLAME} / \text{XLAMBMIN}) ** (\text{FLAMVB} - 2.),$$
where: $\text{XLAMBMIN} = 4\pi * \text{VCOND} ** 2 / \text{GEFF}$ and VCOND is FLAMVC (P 281) times the heat conduction velocity, RFLAME is the current radius of the flame front, and GEFF is FLAMVA times the acceleration of gravity at the flame front. The calculated flame velocity is bounded below by VCOND and above by FLAMVD (P 282) times the speed of sound behind the flame front.
Basically the flame front wrinkles as it propagates in a fractal manner and the extra area it thus enjoys causes the flame to

burn the entrained material more rapidly. See CYCLE for more details.

FLAMVA would typically be set to a value about 0.2 corresponding to a 20% delta- ρ/ρ across the burning front to study "plausible" carbon deflagrations using this model.

- | | | | |
|-----|----------|-------|--|
| 280 | FLAMVB | 2.6 | Fractal exponent helping determine the relationship between the velocity of heat conduction and the velocity of the carbon deflagration flame based on its degree of "wrinkling." FLAMVB is equivalent to the fractal dimension of the burning front which is 2. for a smooth surface, 2.7 corresponds to fully developed turbulence, and 3. corresponds to filled space. |
| 281 | FLAMVC | 50. | Multiplier on the heat conduction velocity used to calculate the velocity of the carbon deflagration front. See the discussion given for FLAMVA (P 279) for a more detailed explanation of its use. The default value of 50 corresponds to the laminar flame speed in a 50/50 carbon-oxygen mixture at 2.E+9 g/cc. |
| 282 | FLAMVD | 1. | The velocity of the carbon deflagration flame front is limited to FLAMVD times the local sound speed. (See the discussion for FLAMVA (P 279)). |
| 283 | JFLAM | 0 | The zone where the carbon deflagration flame is currently located. This parameter is internally set by KEPLER to be the outermost zone whose temperature exceeds 2.E+9 K and its value should not be changed by the user. |
| 284 | XKAPFLAM | 0.001 | Carbon deflagration opacity gating factor. Must be > 0. and <1. See the discussion given for FLAMVA (P 279) for a more detailed explanation of its use. |
| 285 | XMFLAM | 0. | The mass in the current carbon deflagration flame-front zone JFLAM (P 283) that has already been burned (g). This parameter is set internally by KEPLER and should not be changed. When the entire mass of zone JFLAM (P 283) has been burned the opacity coupling it to zone JFLAM + 1 is changed from being divided by XKAPFLAM (P 284) to being multiplied by it. This causes the flame front to advance to the next zone. See the discussion given for FLAMVA (P 279). |
| 347 | FLAMVE | 0.805 | Density power dependence of the heat conduction velocity used in calculating the velocity of nuclear deflagrations in Type I supernovae. (0.805 for C/O, 1.06 for Ne/O)
See P 279-285 and subroutine CYCLE for details. |

ISE NETWORK TRANSITION PARAMETERS

184	TQSELIM	1.5E+9	A sufficient condition to change a zone from the APPROX to ISE network is if its temperature exceeds TQSELIM, its O16 mass fraction is less than O16LIM, its iron peak mass fraction exceeds QN56LIM, and its density exceeds DQSELIM.
185	O16LIM	0.04	(See P 184).
186	QN56LIM	0.	(See P 184).
189	SIQSELIM	1.E-3	A sufficient condition to change a zone from the ISE to the NSE network is for the sum of the silicon and sulfur "group" elemental mass fractions to be less than or equal to SIQSELIM.
203	DQSELIM	1.E+5	Nominal minimum density for changing a zone from the APPROX to the ISE network (g/cc). (See P 184).
210	NOQSECON	0	Don't force zones that are convectively coupled to ISE zones to go to ISE if NOQSECON > 0. This parameter should be kept zero unless you <i>really</i> understand what you're doing.
290	NOILAND	1	If NOILAND > 0, prevent separated islands of zones employing the ISE network from developing by not letting zone J go to ISE unless zone J - 1 has already done so.
106	JQSE	0	Change all APPROX network zones with J < JQSE to the ISE network.
188	JNSE	0	Change all ISE zones with J < JNSE to the NSE network.

ISE NETWORK PHYSICS PARAMETERS

201	Y56GESSM	1.E-4	Initial guess made in SDOT for the Y56 abundance when initializing a new ISE zone (moles/g). If Y56GESSM is within 1.E-3 of 1., the temperature is greater than TQSEMIN, and $J > 1$, then the initial guesses for the proton, neutron, and Fe56 abundances used in the ISE iteration are taken equal to their values in the next innermost zone (which typically is already in ISE).
323	YEMAX	0.498	Maximum value of Ye allowed when initializing a new ISE zone (moles/g). This simulates the small amount of neutronization that usually occurs before the end of oxygen burning.
41	YEMIN	0.02	No further changes in YE are allowed for $YE < YEMIN$ (moles/g).
105	TQSEMIN	2.E+9	Floor on the temperature used in the ISE calculation (K).
187	SNUWMULT	1.	Multiplier on neutrino energy losses from weak processes on nuclei and nucleons. (ISE only)
137	BETHEMT	0.	Multiplier on fudged Co63 electron decay rate as suggested by Gerry Brown and Hans Bethe (11/89).
171	IEXCITEH	1	Include excited states in ISE calculations only if $IEXCITEH > 0$.
200	T11CUT	1.	Upper bound on the temperature used to calculate the energy in nuclear excited states and nuclear partition functions (E+11 K units). (See subroutines ES and SDOTQ).
202	ISI30BRN	1	Neutron-rich-silicon-burning flows are included in the ISE network if $ISI30BRN \geq 1$. (See subroutine SDOTQ)
167	IFLAGYE	1	The electron EOS is implicitly coupled to nuclear-burning-induced changes in the electron abundance, YE, provided $IFLAGYE \neq 0$ and the ISE or NSE network is being used.

ISE NETWORK CONVERGENCE PARAMETERS

172	ITERQMH	1000	Maximum number of iterations allowed in ISE calculation.
173	YPCONVH	1.E-8	Allowed relative convergence error in the proton abundance in the ISE calculation.
174	YNCONVH	1.E-8	Allowed relative convergence error in the neutron abundance in the ISE calculation.
175	YSICONVH	1.E-8	Allowed relative convergence error in the Si28 abundance in the ISE calculation.
176	CNSEH	1.	Increment the proton, neutron, and Si28 abundances by a fraction CNSEH of that calculated by the Newton-Raphson method for an ISE iteration.
177	FYPH	0.05	Maximum allowed relative change in proton abundance during an ISE iteration.
178	FYNH	0.05	Maximum allowed relative change in neutron abundance during an ISE iteration.
179	FYSIH	0.15	Maximum allowed relative change in Si28 abundance during an ISE iteration.
181	XITER1QE	0.5	If the relative change of the proton, neutron, or Si28 abundance is opposite in sign and more than XITER1QE in magnitude with respect to the corresponding change during the previous ISE iteration cycle, then cut the current step size in half if more than ITER1NSE iterations have been done.
182	ITER1QE	10	(See P 181).
207	IQERRFLG	1	Fatal errors in QBURN encountered during a normal REGESS iteration will cause KEPLER to back-up if $IQERRFLG \geq 1$, or to terminate if $IQERRFLG < 1$.
169	DTQNUM	1.E-4	Relative temperature change used in calculating numerical derivatives in SDOTQ.
170	DDQNUM	1.E-4	Relative density change used in calculating numerical derivatives in SDOTQ.

BURN COPROCESSING CONTROL PARAMETERS

267	INBURN	0	BURN coprocessing and related edits are done only if INBURN > 0. Note that INBURN is set to 1 by subroutine GENBURN if a BURN generator deck has been specified in the regular generator deck or by command GENBURN. It is an internal flag and should not be changed by the user, except to permanently turn off BURN coprocessing in a problem.
230	DTFRAC	0.01	When BURN coprocessing is initiated (or when the ZEROTIME or RESET commands are given), (re)set the zonal timesteps used by the BURN coprocessor to DTFRAC*DTNEW (P 1).
240	NETMAX	1	BURN coprocessing is skipped if a zone's network number, NETNUM, is greater than NETMAX.
231	BMASSMIN	-1.	BURN coprocessing is skipped if a zone's exterior mass coordinate is less than BMASSMIN (g).
232	BMASSMAX	1.E+99	BURN coprocessing is skipped if a zone's exterior mass coordinate is greater than BMASSMAX (g).
233	BTEMPMIN	1.E+6.	BURN coprocessing is skipped if a zone's temperature is less than BTEMPMIN (K).
234	BTEMPMAX	1.E+99	BURN coprocessing is skipped if a zone's temperature is greater than BTEMPMAX (K).
235	SNUCMIN	1.E-99	BURN coprocessing is skipped if the absolute value of a zone's normal nuclear energy generation rate (SNN) is less than SNUCMIN (erg/g/s).
236	BDENMIN	1.E-99	BURN coprocessing is skipped if a zone's density is less than BDENMIN (g/cc).
237	BDENMAX	1.E+99	BURN coprocessing is skipped if a zone's density is greater than BDENMAX (g/cc).
229	NUUPDATE	100	Do a forced update of BURN isotopic abundances in every zone every NUUPDATE cycles.

BURN COPROCESSING CONTROL PARAMETERS (Cont.)

- 238 TCHANGE .02 Force a zone to be updated by the BURN coprocessor if its fractional temperature change since its last BURN processing exceeds TCHANGE.
- 239 DCHANGE .05 Force a zone to be updated by the BURN coprocessor if its fractional density change since its last BURN processing exceeds DCHANGE.
- 264 NSUBCYCM 1 Number of coupled BURN coprocessing / BURN isotope convection subcycles per KEPLER cycle.

BURN COPROCESSING PHYSICS PARAMETERS

- 265 MAZFUL 1 Use Fuller et. al.'s weak rates in the BURN coprocessor if MAZFUL=1, otherwise use the old rates of Mazurek and Hansen.
- 286 TAUNU 0. Time scale for the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse (sec).
- 287 ENU53 3. Total energy (in units of 10^{53} ergs) for the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse.
- 288 TMUNU 8. Temperature of the mu and tau neutrinos in the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse (MeV).
- 289 TENU 4. Temperature of the electron neutrinos in the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse (MeV).

BURN COPROCESSING ZONAL BURN CONTROL PARAMETERS

258	IRATSTOP	-1	Pause while updating zone IRATSTOP if IRATSTOP > 0. Type return to continue.
247	DELCHI	.15	Maximum desired fractional change of an isotopic abundance used in determining the zonal timestep used in the BURN coprocessor.
246	CHIMIN	1.E-6	Minimum isotopic abundance that affects the calculation of the zonal timestep in the BURN coprocessor (moles/g).
266	AL26MULT	100.	Decrease the abundance threshold for Al26 to affect the BURN coprocessor zonal timestep from CHIMIN (P 246) to CHIMIN/AL26MULT.
248	FDTN	2.	Maximum factor by which the zonal timestep in the BURN coprocessor can be increased in one zonal cycle.
253	NZRO	1	Set newly calculated negative BURN isotope abundances to 0. if NZRO not equal to 0.
254	AMAGLIM	0.	Minimum absolute magnitude of a BURN matrix element for which Gauss-Jordan elimination is carried out in solving for changes in isotopic abundances.
255	NINV	0	Total number of BURN-coprocessor matrix inversions so far (internally incremented).
249	DTBKUP	.5	Back up to the previous zonal cycle in the BURN coprocessor if the new zonal timestep is less than DTBKUP times the previous timestep.
261	BKUPMASS	1.E-13	Minimum absolute magnitude of a negative isotopic abundance (except of protons) that can cause a zonal backup in the BURN coprocessor (moles/g).
260	BKUPDIV	10.	Factor by which to reduce the BURN coprocessor zonal timestep when a negative isotopic abundance backup occurs.
262	BKUPMP	1.E-19	Minimum absolute magnitude of a negative proton abundance that can cause a zonal backup in the BURN coprocessor (moles/g).

BURN COPROCESSING ZONAL BURN CONTROL PARAMETERS (Cont.)

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|-----|----------|----|--|
| 263 | NBKUPMAX | 10 | Maximum number of consecutive negative isotopic abundance backups allowed in the BURN coprocessor before quitting. |
| 256 | NBKUP | 0 | Total number of BURN-coprocessor backups so far (internally incremented). |
| 259 | NEGBKUP | 0 | Cumulative number of BURN coprocessor backups due to encountering negative isotopic abundances (incremented internally). |
| 257 | NTTY | 6 | FORTTRAN I/O unit number for ZBURN messages sent to the user's terminal. |

NEUTRINO DEPOSITION PARAMETERS

93	JSHELL0	1	Innermost zone in which there is neutrino deposition.
94	JSHELL1	1000	Outermost zone in which there is neutrino deposition.
95	EEXPLODE	0.	Total neutrino deposition energy (erg).
96	TEXPLODE	1.E+99	Time of neutrino deposition (sec).
97	TAUEXP	1.E-2	Time scale for neutrino deposition (sec).
98	P0CORE	0.	Artificial neutrino core pressure is given by: $PCORE = P0CORE * D^{DOPOWER} * EXP(-D0CORE/D),$ where D is the density in g/cc, PCORE is in erg/cc, and P0CORE is in appropriate cgs units.
99	D0CORE	3.E+11	Core density cutoff (g/cc) -- (see P 98).
100	D0POWER	1.	Core pressure density dependence exponent. (See P 98).

GENERAL REZONING PARAMETERS

- 86 IZONEF 1 Rezoning Flag: ≤ 0 means no rezoning (including dezoning);
 $=1$ means normal rezoning;
 $=2$ means rezoning with before and after edits;
 $=3$ means stop after hydrostatic adzoning.
- 87 IDZONEF 1 Dezoning Flag: ≤ 0 means no dezoning;
 $=1$ means normal dezoning;
 $=2$ means dezoning with before and after edits;
 $=3$ means dezone, edit, then stop.
- 309 IZONEZMS 1 Reset the value of IZONEF (P 86) to IZONEZMS at the time specified by TIMEZMS (P 308).
- 85 JMMIN 10 Minimum number of zones allowed after dezoning.
- 216 IRZOPT 0 Rezoning Option Flag.
 IRZOPT = 1 or ≥ 3 : Modify the density gradient considered in adzoning by the factor $(ZBAR+1)/ABAR$ in order to suppress runaway adzoning of the density discontinuities that sometimes form at composition interfaces (esp. H/He).
 Note that for a nondegenerate, perfect gas this is equivalent to considering the gradient in the matter pressure instead of in the density when adzoning. Dezoning is not affected.
 IRZOPT ≥ 2 : Don't adzone across the boundaries of fully convective regions.
 IRZOPT ≤ 0 . Normal rezoning.
 (See REZONE).
- 190 JLCALC 0 Remove the inner JLCALC zones from the problem and reset the inner boundary conditions on radius (RADIUS0 (P 60)) and mass (SUMM0 (P 61)), but don't change the central luminosity (XLUM0 (P 62) -- note default is 0.).
- 136 ETACUT 10. Electron degeneracy parameter, ETA, above which to use temperature interpolation in ADZONE.

PHYSICAL REZONING PARAMETERS

76	RNRATMAX	0.25	Maximum fractional radius change allowed between zones before adzoning.
77	RNRATMIN	0.1	Minimum fractional radius change allowed between zones before dezoning.
78	TNRATMAX	0.25	Maximum fractional temperature change allowed between zones before adzoning.
79	TNRATMIN	0.1	Minimum fractional temperature change allowed between zones before dezoning.
80	DNRATMAX	0.25	Maximum fractional density change allowed between zones before adzoning.
81	DNRATMIN	0.1	Minimum fractional density change allowed between zones before dezoning.
82	RNMIN	1.E-99	Minimum radius for which adzoning is considered (cm).
88	RNMAX	1.E+99	Maximum radius for which rezoning is considered (cm).
83	TNMIN	1.	Minimum temperature for which adzoning is considered (K).
84	DNMIN	1.E-99	Minimum density for which adzoning is considered (g/cc).

MASS-FRACTION-BASED REZONING PARAMETERS

193	FRACRZ0	-1.	(See P 138 and P 150).
138	FRACRZ1	1.	The effective values of the density, temperature, and radius gradients used to determine the necessity for adzoning or dezoning are multiplied by: RZMULTM if $\text{FRACM} \leq \text{FRACRZ0}$, RZMULT0 if $\text{FRACRZ0} < \text{FRACM} \leq \text{FRACRZ1}$, RZMULT1 if $\text{FRACRZ1} < \text{FRACM} \leq \text{FRACRZ2}$, and RZMULT2 if $\text{FRACM} > \text{FRACRZ2}$, where FRACM is the cumulative mass fraction measured from the center of the star. (See also P 104 and P 150).
139	FRACRZ2	1.	(See P 138 and P 150).
194	RZMULTM	1.	(See P 138).
140	RZMULT0	1.	(See P 138).
141	RZMULT1	1.	(See P 138).
142	RZMULT2	1.	(See P 138).
195	FMAXM	1.	(See P 150).
150	FMAX0	1.	Always adzone if the total mass fraction of any pair of zones exceeds: FMAXM if $\text{FRACM} \leq \text{FRACRZ0}$, FMAX0 if $\text{FRACRZ0} < \text{FRACM} \leq \text{FRACRZ1}$, FMAX1 if $\text{FRACRZ1} < \text{FRACM} \leq \text{FRACRZ2}$, and FMAX2 if $\text{FRACM} > \text{FRACRZ2}$, where FRACM is the cumulative mass fraction measured from the center of the star.
151	FMAX1	1.	(See P 150).
152	FMAX2	1.	(See P 150).
336	ZONEMMIN	1.E-99	ZONEMMIN is the minimum mass (g) that a zone may have and still be allowed to be adzoned (as part of a zone pair).

MASS-FRACTION-BASED REZONING PARAMETERS (Cont.)

- 313 FMAXMCIG 1. Reset the value of FMAXM (P 195) to FMAXCIG when the central temperature specified by TEMPCIG (P 311) is reached.
- 314 FMAX0CIG 1. Reset the value of FMAX0 (P 150) to FMAX0CIG when the central temperature specified by TEMPCIG (P 311) is reached.
- 143 ABARRAT0 2. The effective values of the density, radius, and temperature gradients used for adzoning are formed by multiplying the actual gradients by the factor:

$$(1.+ABARRATM*ABARRAT0*ABARRAT / (ABARRAT0+ABARRAT));$$
and for dezoning by the factor:

$$(1.+1.5*ABARRATM*ABARRAT0*ABARRAT / (ABARRAT0+ABARRAT)),$$
where ABARRAT is the average relative ABAR change between adjacent zones.
Do this for adzoning only if the sum of the masses in the involved zones divided by the total mass of the star exceeds FRACMLIM.
- 144 ABARRATM 1.3 (See P 143).
- 145 FRACMLIM 0.01 (See P 143).
- 104 TCOREFAC 1. Increase the rezoner's sensitivity to temperature gradients by a factor of TCOREFAC in the region where FRACM, the culmulative mass fraction measured from the center of the star, is less than or equal FRACRZ1.

MASS-LOSS-CONNECTED REZONING PARAMETERS

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|-----|---------|--------|--|
| 271 | VLOSS | 1.E+99 | Remove the outer zone if its velocity exceeds VLOSS, but do not change the previous values of PBOUND (P 69) or TBOUND (P 68) (cm/sec). |
| 217 | NSURFZ | -10 | <p>If NSURFZ > 0 and IZONEF (P 86) > 0, maintain a logarithmic ramp in zonal mass of the NSURFZ zones at the surface of the star, where FRACSZ0 (P 218) is twice the desired mass-fraction of the surface zone and FRACSZ1 (P 219) is twice the desired mass-fraction of the NSURFZth zone from the surface.</p> <p>Otherwise, NSURFZ has no effect. (See REZONE.)</p> <p>This is an obsolescent parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.</p> |
| 218 | FRACSZ0 | 1. | <p>Inner surface zoning parameter (see REZONE and the discussion under P 217). This is an obsolescent parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.</p> |
| 219 | FRACSZ1 | 1. | <p>Outer surface zoning parameter (see REZONE and the discussion under P 217). This is an obsolescent parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.</p> |
| 223 | FRACDEZ | 0.5 | <p>Dezone the mass-losing zone if its mass drops below FRACDEZ times the average mass of the zones on either side of it.</p> |

MISCELLANEOUS PARAMETERS

- | | | | |
|----|---------|-------|---|
| 43 | HSTATM | 1. | Multiplier on the inertial terms in the momentum balance equation. Nominally forces hydrostatic equilibrium for for HSTATM = 0., but may result in convergence and consistency problems. This parameter should be kept set to 1. (normal hydrodynamics) unless the user is prepared to make a very careful study of its actual effects (see subroutines REGESS and UPDATE). |
| 48 | CENU | 1.0 | Velocity centering parameter (Range: 0.5,1.):
0.5 gives exact energy conservation;
1.0 gives greatest stability.
Actually, KEPLER only behaves reasonably if CENU=1, so the user should NOT change the default value without careful study and a willingness to bear full responsibility for whatever nonsense may result. |
| 66 | SETPARM | XK+1. | Initialize new parameters in RESTART if SETPARM $\leq$ XK. XK represents a floating point number used in RESTART as an index for the version of KEPLER in which the last set new parameters has been introduced. After such a new parameter update is made SETPARM is reset to XK+1. This allows restart dumps written by older versions of KEPLER with fewer parameters to be used by any later version of the code. |

OBSOLETE PARAMETERS

- | | | | |
|-----|---------|-------|-----------|
| 117 | IGRIDM | 498 | Obsolete. |
| 118 | IGRIDV | 496 | Obsolete. |
| 129 | IVPLOT | 1 | Obsolete. |
| 226 | MLCOMPF | 0 | Obsolete. |
| 242 | EDMASSL | 1.E-4 | Obsolete. |
| 295 | WIDTHTD | 60. | Obsolete. |

DEVICE-CONTROL GRAPHICS PARAMETERS

- 127 ITVSTART 0 Graphics device control parameter.
 = 0 means no graphics processes are active.
 = 1 means start an X-window graphics display and reset ITVSTART to 2.
 = -1 means stop the X-window graphics display and reset ITVSTART to 0.
 = 2 means keep the X-window display open and display graphs and timeplots as requested. (This value is internally set).
 = 3 means initialize a portrait-orientation Postscript File and reset ITVSTART to 5.
 = 4 means initialize a landscape-orientation Postscript File and reset ITVSTART to 5.
 = 5 means keep the postscript file open for further input (under development).
 Note that ITVSTART is reset to zero when a problem is restarted.
- 64 NPIXEDIT 50 Graphics edits to the monitor are made every NPIXEDIT KEPLER cycles (if P 127 > 0).
- 42 IWINSIZE 10240750 Size of graphics window to be created in the form xxxxyyyy, where xxxx is the number of pixels wide to make the window and yyyy is the number of pixels wide it should be. Be sure to include leading zeros if yyyy is less than 4 digits.
- 45 IWINLOC 0 Location of the upper-left-hand corner of the graphics window given in the form xxxxyyyy, where yyyy is the number of pixels below the top of the screen this corner should be, and xxxx is the number of pixels from the left-hand edge of the screen it begins. Be sure to include leading zeros if yyyy is less than 4 digits.
- 296 IBACKGND -1 Graphics window background color is white if IBACKGND $\geq$ 0 and black if IBACKGND < 0. The foreground color is always the inverse of the background color.

PLOT-TYPE GRAPHICS PARAMETER

113	IPIXTYPE	31	Graphics picture-type control parameter: <0 graphics window is not updated, but is still open. =0 only header info is displayed. =1 thermodynamics (TD) graph only. =2 velocity graph only. =3 mass-fraction graph only. =4 entropy graph only. =5 density-temperature graph only. =6 isotopic mass-fraction graph (use the SETISO command first to determine the ions to be displayed). =7 thru 9: only header info is displayed. =10 thru 99: Two graphs will be displayed in split-screen fashion with the type of the top graph determined by the value of the first digit and the type of the second graph determined by the value of second digit as specified above.
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'RADIAL'-COORDINATE-CONTROL GRAPHICS PARAMETERS

132	IRTYPE	3	Use the interior mass fraction as the independent coordinate in all graphs if IRTYPE =2; use the interior mass in solar mass units if IRTYPE=3; Otherwise use the radius (in cm).
116	IGRIDT	370	Grid choice for the radial coordinate: If IRTYPE = 1, then the radial coordinate will be log ₁₀ (radius) if IGRIDT > 10 and linear in radius otherwise. If IRTYPE ≠ 1, IGRIDT has no effect.
119	JP0	1	Innermost zone to plot. (See P 121).
120	JP1	0	Outermost zone to plot is JM (outermost zone) - JP1. (See P 122)
121	RPMINO	1.E+7	Minimum radius plotted when JP0 < 0 (cm).
122	RPMAX0	1.E+14	Maximum radius plotted when JP1 < 0 (cm).
134	YPLOTMIN	0.	Minimum mass coordinate plotted (fraction of total mass).
135	YPLOTMAX	1.	Maximum mass coordinate plotted (fraction of total mass).

THERMODYNAMICS-GRAPH PARAMETERS

123	YMINTD	1.	Lower bound of thermodynamics graph ordinate shall be no greater than YMINTD (nominally g/cc).
124	YMAXTD	1.E+8	Upper bound of thermodynamics graph ordinate shall be no less than YMAXTD (nominally g/cc).
125	SSCALEM	1.E-3	Energy generation rate graph scale multiplier in the TD graph.
126	PSCALEM	1.E-1	Pressure graph scale multiplier in the TD graph.
130	VSCALEM	1.E-5	Velocity graph scale multiplier in the TD graph.
131	RSCALEM	1.E-5	Radius graph scale multiplier in the TD graph.
115	TSCALEM	1.E+7	Characteristic temperature for choosing the location of the temperature plotting grid in Thermodynamics graph (K). Equivalent to the temperature plotted at the same ordinate value as a density of 1 g/cc.
133	CONVORD	3.	Ordinate value at which to plot convection sentinels in the TD graph (nominally g/cc).

VELOCITY AND ABUNDANCE GRAPH PARAMETERS

191	VLIMSET	-1.	The ordinate bounds of the velocity graph are $\pm$ VLIMSET if VLIMSET > 0. Otherwise the ordinate bounds are rescaled automatically. (cm/s).
128	ABUNLIM	1.E-3	Least elemental mass fraction plotted or listed in a terminal ion edit.
316	ABUNMINB	1.E-4	Lower mass-fraction limit of the isotopic abundance plot.
317	ABUNMAXB	1.	Upper mass-fraction limit of the isotopic abundance plot.
318	NUMISO	0	Number of BURN isotopes to be plotted, starting from the first one listed by the most recent SETISO command. Normally NUMISO is set to the total number of isotopes listed in the SETISO command at the time that command is processed and does not need to be set by the user.

GRAPHICS LABELING PARAMETERS

291	CHARSIZG	1.0	Graphics character size for grid labels (relative to MONGO's default character size).
292	CHARSIZC	0.85	Graphics character size for curve labels (relative to MONGO's default character size).
293	CHARSIZZ	0.85	Graphics character size for zone sentinels (relative to MONGO's default character size).
294	CHARSIZH	1.0	Graphics character size for header info (relative to MONGO's default character size).
114	NPLOTSYM	8	Label each curve with NPLOTSYM character symbols.
59	FRACNEUT	0.05	If the semiconvective test parameter, W, is less than zero but greater than -FRACNEUT*ABS(LOG(T1/T0)), then the zonal interface is flagged convectively neutral ("NEUT" or "N"). (see UPDATE)

POST-PROCESSOR GRAPHICS PARAMETERS

- | | | | |
|-----|---------|---------|---|
| 301 | IDTMAXL | 40 | <p>Maximum number of post-processor dump cycles beyond the currently-specified dump cycle (LTIME) that READQ will search to try to get values for each point in the 'advanced' grid formed from dump variable values at or beyond LTIME.</p> <p>In PLOTMAP, IDTMAXL is used as a flag for the plot and interpolation mode to be used:</p> <ul style="list-style-type: none"> if IDTMAXL = 0, strips of retarded-value rectangles are plotted, based on the reconstructed grids (best for very discontinuous variables, esp. CONVECT). if IDTMAXL = 1, forward and backward facing triangles are plotted for each dump point. These triangles have a uniform color determined by the value at their most retarded vertex (best for moderately discontinuous variables, such as abundances). if IDTMAXL > 1, forward and backward triangles are plotted for each dump point which are Gouraud-shaded to interpolate between the variable values at each corner (fastest and smoothest for continuous variables, worst for discontinuous variables). |
| 302 | IDTLOOK | 10 | <p>Default number of post-processor dump cycles between LOOK plots or prints or reconstructed TIMEMAP grids.</p> |
| 328 | VMINMAP | 1.E+99 | <p>Minimum value of the timemap variable to be mapped.</p> <p>If VMINMAP > 1.E+98, then the actual minimum value of the current variable is used as the map limit, except as limited by VRATMAP (P 330), below.</p> |
| 329 | VMAXMAP | -1.E+99 | <p>Maximum value of the timemap variable to be mapped. If VMAXMAP < -1.E+98, then the actual maximum value of the current variable is used as the map limit.</p> |
| 330 | VRATMAP | 1.E-99 | <p>Minimum ratio of the minimum timemap variable limit to the maximum timemap variable limit in the case when the actual minimum value of the current timemap variable would otherwise be used as the minimum timemap limit.</p> |

TIME-COORDINATE GRAPHICS PARAMETERS

- 327 MAPTIME 2** Flag indicating the desired time coordinate in timeplots and timemaps (see PLOT and TIMEMAP):
 0 => use cycle number;
 1 => use linear time (sec);
 2 => use negative logarithmic time (-log (sec)).
 3 => use positive logarithmic time (log (sec)).
 Note that the time coordinate is calculated relative to TIMEREF (P 319) + TOSETREF (P 320).
- 321 TIMECMIN 0.** Minimum value of the time-coordinate to be plotted in timeplots and timemaps (time coordinate units--see P 327).
 If both TIMECMIN (P 321) = 0 and TIMECMAX (P 322) = 0, all available time-points will be plotted.
- 322 TIMECMAX 0.** Maximum value of the time-coordinate to be plotted in timeplots and timemaps (time coordinate units--see P 327).
 If both TIMECMIN (P 321) = 0 and TIMECMAX (P 322) = 0, all available time-points will be plotted.
- 319 TIMEREF -1.E+99** Reference time used in calculating the time coordinate in timeplots and timemaps (sec). If TIMEREF < -1. E+98, then a time 10 timesteps beyond the last timepoint is used in its place.
- 320 TOSETREF 0.** Reference offset time used in calculating the time-coordinate for timeplots and timemaps (sec). If TIMEREF < -1. E+98, then the value of TOFFSET prevailing for the last timestep is used for TOSETREF.

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CHAPTER 4

PARAMETER LIST BY NUMBER

This chapter lists in numerical order the 354 changeable ('P') parameters in KEPLER that may be edited changed before or during execution. A list of these parameters grouped by function was given in Chapter 3. Initial values for these parameters may be specified by P cards in the problem generator file (see Chapter 2). If no explicit such specification is made their values are initially set equal to the default values listed below.

These parameters may also be edited or changed during program execution by they following set of keyboard commands (also described in Chapter 5):

P N

Display the value of parameter name or number N: 'p 113' or 'p time'

P N VALUE

Change the value of parameter name or number N to VALUE: 'p 113 31'

P N DELTA ADD

Add DELTA to the value of parameter name or number N: 'p 1 -1.e+14 add'

Note that, although printed in capital letters for clarity, the parameter names listed below must be given as unquoted, lowercase character strings when communicating with KEPLER. The mode of the parameters (fixed or floating point) follows the normal FORTRAN convention.

The current values of the parameters are remembered in the restart dumps and more may readily be added. They are located in the general COMMON in include file KEPCOMS (starting with DTNEW) and their ASCII names and types are listed respectively in the **nameparm** and **iptype** arrays loaded in data block KEPDAT. Newly added parameters are initialized in subroutine **RESTART** (see Chapter 5).

#	Name	Default	Description
1	DTNEW	1.	Initial or current timestep (sec).

2	TIME	0.	Initial or current time (sec).
3	EXTRAP	1.	Extrapolation Parameter used in guessing new R, T, and L values. 0. gives old values; 1. gives linear extrapolation.
4	Q2FAC	4.	Quadratic artificial viscosity (Q) factor. Shock transitions are spread over about $2*\text{SQRT}(Q2FAC)$ zones. (see WZW78)
5	MAXIT	40	Maximum number of times subroutine REGESS is called to iterate R, T, and L estimates before the timestep is reduced by DTCUT and the step repeated (termed a "backup").
6	DTCR	0.05	Maximum desired fractional change in radius per step.
7	DTCT	0.05	Maximum desired fractional change in temperature per step.
8	DTCD	0.10	Maximum desired fractional change in density per step.
9	DTCQ	0.05	Maximum desired fractional linear contraction per step.
10	DTCDT	0.99	Maximum fractional change in the timestep per step.
11	FCRMAX	1.E-6	Maximum allowed relative convergence error in radius.
12	FCTMAX	1.E-6	Maximum allowed relative convergence error in temperature.
13	Q1FAC	0.1	Linear artificial viscosity factor. Helps damp sound waves during hydrostatic evolution. Should be set to 0. during hydrodynamic phases. Normally set to 1000. in the generator until the star settles down onto the zero-age main sequence (from an initially rather arbitrary configuration), at which point it is reset to 0.1.
14	NSTOP	100000	Maximum number of cycles.
15	TSTOP	1.E+30	Stop time (sec). Before terminating the problem, make a restart dump labeled '#final' and execute the alias-defined "tfinal" command. Normally this command is used to make final plots and edits.
16	NEDIT	20	Number of cycles between edits.
17	DTEDIT	0.	Time between edits (0. = ∞) (sec).

18	NDUMP	10	Number of cycles between restart dumps.
19	XMLLEN	1.	Ratio of the convective mixing length to the pressure scale height.
20	FUDGC	0.01	Fudge factor for convection (about 0.01). Reduces convective efficiency for very small departures from adiabatic gradients and thus makes the numerical onset of convection less abrupt and unstable. (see subroutines REGESS and UPDATE)
21	DIFIM	1.	Multiplier for the rate of convective mixing.
22	FCRBU	0.01	Reduce timestep by DTCUT and redo step if convergence error in radius is still greater than FCRBU after MAXIT iterations.
23	FCTBU	0.01	Reduce timestep by DTCUT and redo step if convergence error in temperature is still greater than FCTBU after MAXIT iterations.
24	DRMULT	0.1	Semi-convective mixing will be slower than thermal transport by at least DRMULT (about 0.1) in zones with mean atomic weight, ABAR, is $\geq$ ABARSEMI (P 324). (See sub.UPDATE) (Also see DRMULTLO (P 325), WOVSERSHT (P 148), and WOVSERSLO (P 326)).
25	DTMAX	1.E+99	Maximum timestep allowed (sec).
26	FCREXT	10.	Factor used to reduce noise in radius extrapolation. (See subroutine GESS)
27	FCTEXT	10.	Factor used to reduce noise in temperature extrapolation.
28	IPUP	1	Abundance update parameter. Update abundances only if IPUP $\neq$ 0.
29	XK1MT	1.	Multiplier on IBEN1 opacity.
30	XK2MT	1.	Multiplier on IBEN2 opacity.
31	XK3MT	1.	Multiplier on Christy opacity.
32	XK4MT	1.	Multiplier on Compton opacity.

33	RXKCMT	1.	Multiplier on conductive opacity.
34	PIMULT	1.	Ion energy and pressure multiplier.
35	PRMULT	1.	Radiation energy and pressure multiplier.
36	PEMULT	1.	Electron energy and pressure multiplier.
37	TRANSM	1.	Multiplier on diffusive heat transport.
38	TIMEX0	-1.E+99	Time at which any Ni56 present in low temperature regions (as determined by P 89 and P 65) of the star is assumed to have been produced and begun to decay, first to Co56 and then to Fe56 (sec). If $TIMEX0 \geq -1.E+50$ and the zonal Ni56 abundance, YNI, $\geq 3.E-5$, then the nuclear energy generation is take equal to that generated by an initial Ni56 abundance YNI after having decayed for a time interval TIME (P 2) -TIMEX0. Note that the value of YNI in the abundance array is not changed by this "decay", and always represents the initial amount produced. DO NOT set $TIMEX0 > TIME$ (P 2).
39	DYEMULT	200.	If $IYTSFLAG \geq 1$, increase the timestep sensitivity to changes in YE by a factor of DYEMULT.
40	DYQMULT	2.5	IF $IYTSFLAG \geq 1$, increase the timestep sensitivity to changes in YQ by a factor of DYQMULT.
41	YEMIN	0.02	No further changes in YE are allowed for $YE < YEMIN$ (moles/g).
42	IWINSIZE	10240750	Size of graphics window to be created in the form xxxxyyyy, where xxxx is the number of pixels wide to make the window and yyyy is the number of pixels wide it should be. Be sure to include leading zeros if yyyy is less than 4 digits.
43	HSTATM	1.	Multiplier on the inertial terms in the momentum balance equation. Nominally forces hydrostatic equilibrium for for HSTATM = 0., but may result in convergence and consistency problems. This parameter should be kept set to 1. (normal hydrodynamics) unless the user is prepared to make a very careful study of its actual effects (see subroutines REGESS and UPDATE).

44	LENQMAX	3000000	Maximum length of a post-processor file (bytes).
45	IWINLOC	0	Location of the upper-left-hand corner of the graphics window given in the form xxxxyyyy, where yyyy is the number of pixels below the top of the screen this corner should be, and xxxx is the number of pixels from the left-hand edge of the screen it begins. Be sure to include leading zeros if yyyy is less than 4 digits.
46	DTCP	0.1	Maximum desired fractional change in abundances per step.
47	YFLOORX	1.E-3	Minimum elemental mass fraction that effects the timestep.
48	CENU	1.0	Velocity centering parameter (Range: 0.5,1.): 0.5 gives exact energy conservation; 1.0 gives greatest stability. Actually, KEPLER only behaves reasonably if CENU=1, so the user should NOT change the default value without careful study and a willingness to bear full responsibility for whatever nonsense may result.
49	T7PEEK	1.E+50	Opacity will be no larger than $XKMIN + T7PEEK * D * T7^{**4}$. (cgs units, except $T7 = T / (10^{**7} \text{ K})$)
50	XKMIN	1.E-10	Least upper opacity bound (cm^{**2}/g). (see P 49 and KAPPA)
51	THICKFAC	1.E-3	If the timestep is greater than the thermal timescale for a zone by a factor $\geq 0.5 * THICKFAC$, then consider the zone to be in thermal steady-state and deal with any residual non-convergence in the solution of the energy equation by recalculating the luminosity in terms of the final iterated value of the internal energy. Otherwise, recalculate the internal energy in terms of the final iterated luminosity. (See UPDATE).
52	MAXBAK	5	Maximum number of times a given step is redone before the code quits.
53	DTCUT	0.1	Fractional timestep reduction when a step is redone.
54	TFCRBU	2.	If the maximum fractional change in radius during a timestep exceeds $TFCRBU * DTCT$ then redo step.
55	TFCTBU	2.	If the maximum fractional change in temperature during a timestep exceeds $TFCTBU * DTCT$ then redo step.

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| 56 | XIPOT | 13.6053 | Ionization potential (eV) --see subroutine ES. |
| 57 | DZERO | 0.1 | Characteristic density for pressure ionization (g/cc). |
| 58 | NPFLAG | 1 | Pairs are included in EOS calculation only if NPFLAG>0. |
| 59 | FRACNEUT | 0.05 | If the semiconvective test parameter, W, is less than zero but greater than -FRACNEUT*ABS(LOG(T1/T0)), then the zonal interface is flagged convectively neutral ("NEUT" or "N"). (see UPDATE) |
| 60 | RADIUS0 | 0. | Radius of inner boundary (cm). |
| 61 | SUMM0 | 0. | Mass inside inner boundary (g). |
| 62 | XLUM0 | 0. | Luminosity emerging from inner surface (erg/s). |
| 63 | IRNET | 0 | If IRNET=0, use APPROX network. If IRNET=1, use SDOT1 (H and He burning network). Otherwise use SDOT2 (NOVA network). Note that SDOT1 and SDOT2 are replaced by dummy routines in the current version of KEPLER and an error message will result if they are entered. The old routines would have to be extensively updated before being used again. |
| 64 | NPIXEDIT | 50 | Graphics edits to the monitor are made every NPIXEDIT KEPLER cycles (if P 127 > 0). |
| 65 | TNUCMIN | 0. | Don't calculate nuclear burning in APPROX if the temperature is less than TNUCMIN (K). Note that unless the hydrogen burning rate is significant, no APPROX network calculations will be done below 1.E+7 K, even if TNUCMIN < 1.E+7 K. (See P 89). |
| 66 | SETPARM | XK+1. | Initialize new parameters in RESTART if SETPARM ≤ XK. XK represents a floating point number used in RESTART as an index for the version of KEPLER is which the last set new parameters has been introduced. After such a new parameter update is made SETPARM is reset to XK+1. This allows restart dumps written by older versions of KEPLER with fewer parameters to be used by any later version of the code. |

67	IYTSFLAG	1	Consider only changes in YE, YQ, YF, YSI, and Y56 in ISE zones when computing the timestep if IYTSFLAG $\geq$ 1.
68	TBOUND	0.	Temperature at outer boundary (K).
69	PBOUND	0.	Pressure at outer boundary (erg/cc).
70	FCLMAX	1.	Maximum allowed relative convergence error in luminosity.
71	FCLEXT	1.E-5	Factor used to reduce noise in luminosity extrapolation.
72	DTCL	1.E+99	Maximum desired fractional change in luminosity per step.
73	FCLBU	1.	Reduce timestep by DTCUT and redo step if convergence error in luminosity is still greater than FCLBU after MAXIT iterations.
74	TFCLBU	1.E+99	If the maximum fractional change in luminosity during a timestep exceeds TFCLBU*DTCL then redo step.
75	DTSMULT	1.E+99	The fractional amount of semiconvective mixing that can occur in one timestep is limited to approximately DTSMULT.
76	RNRATMAX	0.25	Maximum fractional radius change allowed between zones before adzoning.
77	RNRATMIN	0.1	Minimum fractional radius change allowed between zones before dezoning.
78	TNRATMAX	0.25	Maximum fractional temperature change allowed between zones before adzoning.
79	TNRATMIN	0.1	Minimum fractional temperature change allowed between zones before dezoning.
80	DNRATMAX	0.25	Maximum fractional density change allowed between zones before adzoning.
81	DNRATMIN	0.1	Minimum fractional density change allowed between zones before dezoning.
82	RNMIN	1.E-99	Minimum radius for which adzoning is considered (cm).
83	TNMIN	1.	Minimum temperature for which adzoning is considered (K).
84	DNMIN	1.E-99	Minimum density for which adzoning is considered (g/cc).

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| 85 | JMMIN | 10 | Minimum number of zones allowed after dezoning. |
| 86 | IZONEF | 1 | Rezoning Flag: ≤ 0 means no rezoning (including dezoning);
=1 means normal rezoning;
=2 means rezoning with before and after edits;
=3 means stop after hydrostatic adzoning. |
| 87 | IDZONEF | 1 | Dezoning Flag: ≤ 0 means no dezoning;
=1 means normal dezoning;
=2 means dezoning with before and after edits;
=3 means dezone, edit, then stop. |
| 88 | RNMAX | 1.E+99 | Maximum radius for which rezoning is considered (cm). |
| 89 | DYPMIN | 1.E-10 | Minimum amount of potential hydrogen burn in the present timestep needed to trigger the use of any reaction network (moles/g). (APPROX only). |
| 90 | DYMGMIN | 1.E-10 | Minimum amount of Mg24 production required in the last timestep to trigger the use of the full reaction network (moles/g). (APPROX only). |
| 91 | ZBOUND | 0.1 | Mass fraction of heavy elements above which IBEN1 opacities are used. |
| 92 | ETACONV | 1.E-5 | Relative convergence required in calculating the electron Fermi degeneracy parameter, ETA. |
| 93 | JSHELL0 | 1 | Innermost zone in which there is neutrino deposition. |
| 94 | JSHELL1 | 1000 | Outermost zone in which there is neutrino deposition. |
| 95 | EEXPLODE | 0. | Total neutrino deposition energy (erg). |
| 96 | TEXPLODE | 1.E+99 | Time of neutrino deposition (sec). |
| 97 | TAUEXP | 1.E-2 | Time scale for neutrino deposition (sec). |
| 98 | POCORE | 0. | Artificial neutrino core pressure is given by:
$PCORE = P0CORE * D^{D0POWER} * EXP(-D0CORE/D)$,
where D is the density in g/cc, PCORE is in erg/cc,
and P0CORE is in appropriate cgs units. |

99	D0CORE	3.E+11	Core density cutoff (g/cc) -- (see P 98).
100	D0POWER	1.	Core pressure density dependence exponent. (See P 98).
101	SNEUTMT	1.	Neutrino energy loss rate multiplier (APPROX only).
102	SNUCMT	1.	Non-neutrino nuclear energy generation rate multiplier (APPROX only).
103	DSNUM	1.E-6	Fractional density and temperature perturbations used to get nuclear energy generation rate derivatives (APPROX only).
104	TCOREFAC	1.	Increase the rezoner's sensitivity to temperature gradients by a factor of TCOREFAC in the region where FRACM, the cumulative mass fraction measured from the center of the star, is less than or equal FRACRZ1.
105	TQSEMIN	2.E+9	Floor on the temperature used in the ISE calculation (K).
106	JQSE	0	Change all APPROX network zones with $J < JQSE$ to the ISE network.
107	ARTV1	1.	Multiply Q1FAC by ARTV1 in zone J if $JARTV1 \leq J < JARTV2$.
108	ARTV2	1.	Multiply Q1FAC by ARTV2 in zone J if $JARTV2 \leq J < JM - JARTV3$.
109	ARTV3	1.	Multiply Q1FAC by ARTV3 in zone J if $J \geq \text{MAX}(JARTV1, JARTV2, JM - JARTV3)$
110	JARTV1	1000	(See P 107-109).
111	JARTV2	1000	(See P 107-109).
112	JARTV3	1000	(See P 107-109).
113	IPIXTYPE	31	Graphics picture-type control parameter: <0 graphics window is not updated, but is still open. =0 only header info is displayed. =1 thermodynamics (TD) graph only. =2 velocity graph only. =3 mass-fraction graph only. =4 entropy graph only. =5 density-temperature graph only. =6 isotopic mass-fraction graph (use the SETISO command

- first to determine the ions to be displayed).
 =7 thru 9: only header info is displayed.
 =10 thru 99: Two graphs will be displayed in split-screen fashion with the type of the top graph determined by the value of the first digit and the type of the second graph determined by the value of second digit as specified above.
- 114 NPLOTSYM 8 Label each curve with NPLOTSYM character symbols.
- 115 TSCALEM 1.E+7 Characteristic temperature for choosing the location of the temperature plotting grid in Thermodynamics graph (K).
 Equivalent to the temperature plotted at the same ordinate value as a density of 1 g/cc.
- 116 IGRIDT 370 Grid choice for the radial coordinate:
 If IRTYPE = 1, then the radial coordinate will be log₁₀(radius) if IGRIDT > 10 and linear in radius otherwise.
 If IRTYPE ≠ 1, IGRIDT has no effect.
- 117 IGRIDM 498 Obsolete.
- 118 IGRIDV 496 Obsolete.
- 119 JP0 1 Innermost zone to plot. (See P 121).
- 120 JP1 0 Outermost zone to plot is JM (outermost zone) - JP1.
 (See P 122)
- 121 RPMIN0 1.E+7 Minimum radius plotted when JP0 < 0 (cm).
- 122 RPMAX0 1.E+14 Maximum radius plotted when JP1 < 0 (cm).
- 123 YMINTD 1. Lower bound of thermodynamics graph ordinate shall be no greater than YMINTD (nominally g/cc).
- 124 YMAXTD 1.E+8 Upper bound of thermodynamics graph ordinate shall be no less than YMAXTD (nominally g/cc).
- 125 SSCALEM 1.E-3 Energy generation rate graph scale multiplier in the TD graph.
- 126 PSCALEM 1.E-1 Pressure graph scale multiplier in the TD graph.
- 127 ITVSTART 0 Graphics device control parameter.
 = 0 means no graphics processes are active.
 = 1 means start an X-window graphics display and reset

- ITVSTART to 2.
 = -1 means stop the X-window graphics display and reset
 ITVSTART to 0.
 = 2 means keep the X-window display open and display graphs
 and timeplots as requested. (This value is internally set).
 = 3 means initialize a portrait-orientation Postscript File
 and reset ITVSTART to 5.
 = 4 means initialize a landscape-orientation Postscript File
 and reset ITVSTART to 5.
 = 5 means keep the postscript file open for further input (under
 development).
 Note that ITVSTART is reset to zero when a problem is
 restarted.
- | | | | |
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| 128 | ABUNLIM | 1.E-3 | Least elemental mass fraction plotted or listed in a terminal ion
edit. |
| 129 | IVPLOT | 1 | Obsolete. |
| 130 | VSCALEM | 1.E-5 | Velocity graph scale multiplier in the TD graph. |
| 131 | RSCALEM | 1.E-5 | Radius graph scale multiplier in the TD graph. |
| 132 | IRTYPE | 3 | Use the interior mass fraction as the independent coordinate
in all graphs if IRTYPE =2;
use the interior mass in solar mass units if IRTYPE=3;
Otherwise use the radius (in cm). |
| 133 | CONVORD | 3. | Ordinate value at which to plot convection sentinels in the TD
graph (nominally g/cc). |
| 134 | YPLOTMIN | 0. | Minimum mass coordinate plotted (fraction of total mass). |
| 135 | YPLOTMAX | 1. | Maximum mass coordinate plotted (fraction of total mass). |
| 136 | ETACUT | 10. | Electron degeneracy parameter, ETA, above which to use
temperature interpolation in ADZONE. |
| 137 | BETHEMT | 0. | Multiplier on fudged Co63 electron decay rate as suggested by
Gerry Brown and Hans Bethe (11/89). |
| 138 | FRACRZ1 | 1. | The effective values of the density, temperature, and radius
gradients used to determine the necessity for adzoning or
dezoning are multiplied by:
RZMULTM if $FRACM \leq FRACRZ0$, |

- RZMULT0 if $\text{FRACRZ0} < \text{FRACM} \leq \text{FRACRZ1}$,
RZMULT1 if $\text{FRACRZ1} < \text{FRACM} \leq \text{FRACRZ2}$, and
RZMULT2 if $\text{FRACM} > \text{FRACRZ2}$,
where FRACM is the cumulative mass fraction measured
from the center of the star. (See also P 104 and P 150).
- 139 FRACRZ2 1. (See P 138 and P 150).
- 140 RZMULT0 1. (See P 138).
- 141 RZMULT1 1. (See P 138).
- 142 RZMULT2 1. (See P 138).
- 143 ABARRAT0 2. The effective values of the density, radius, and temperature
gradients used for adzoning are formed by multiplying the
actual gradients by the factor:
 $(1 + \text{ABARRATM} * \text{ABARRAT0} * \text{ABARRAT} / (\text{ABARRAT0} + \text{ABARRAT}))$;
and for dezoning by the factor:
 $(1 + 1.5 * \text{ABARRATM} * \text{ABARRAT0} * \text{ABARRAT} / (\text{ABARRAT0} + \text{ABARRAT}))$,
where ABARRAT is the average relative ABAR change
between adjacent zones.
Do this for adzoning only if the sum of the masses in the
involved zones divided by the total mass of the star exceeds
FRACMLIM.
- 144 ABARRATM 1.3 (See P 143).
- 145 FRACMLIM 0.01 (See P 143).
- 146 FRCSOUND 0.1 Don't do convection if the absolute value of the zone velocity
exceeds FRCSOUND times the local sound speed.
- 147 CONVLIM 1. Limit the convective velocity to a fraction CONVLIM of
the local sound speed.
- 148 WOVSHT 0.01 The semiconvective test parameter, W, is taken to be
 $W = \text{WOVSHT} * \text{ABS}(\text{LOG}(T1/T0))$ for the special
overshoot semiconvective zones where W would otherwise
be less than 0 and when $\text{ABAR} \geq \text{ABARSEMI}$ (P 324).
Overshoot mixing occurs at a rate calculated
from this value of W, but limited by the thermal diffusion
timescale as in normal semiconvection. (see UPDATE &

- WZW78). If WOVERSHT=0 no overshoot mixing is done. (Also see WOVERSLO -- P 326).
- | | | | |
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| 149 | XMIMULT | 1. | The mass used in calculating ion degeneracy is XMIMULT times the mass of a neutron. |
| 150 | FMAX0 | 1. | Always adzone if the total mass fraction of any pair of zones exceeds:
FMAXM if $\text{FRACM} \leq \text{FRACRZ0}$,
FMAX0 if $\text{FRACRZ0} < \text{FRACM} \leq \text{FRACRZ1}$,
FMAX1 if $\text{FRACRZ1} < \text{FRACM} \leq \text{FRACRZ2}$, and
FMAX2 if $\text{FRACM} > \text{FRACRZ2}$,
where FRACM is the cumulative mass fraction measured from the center of the star. |
| 151 | FMAX1 | 1. | (See P 150). |
| 152 | FMAX2 | 1. | (See P 150). |
| 153 | DDSFRAC | 0.01 | Maximum fractional change in density since the last iteration for which ABAR changes and energy generation rates can be extrapolated from their previous values (APPROX only). |
| 154 | DTSFRAC | 0.001 | Maximum fractional change in temperature since the last iteration for which ABAR changes and energy generation rates can be extrapolated from their previous values (APPROX only). |
| 155 | IUDFLAG | 0 | Extrapolate energy generation rates and ABAR changes in cases of small temperature and density change only if IUDFLAG is also ≤ 0 . |
| 156 | NSDUMP | 10 | Save every NSDUMP restart dumps. |
| 157 | NITERBAR | 1 | Total number of cycles used to compute ITERBAR, the average number of iterations per cycle. (Internally set.) |
| 158 | ITERBARM | 100 | Maximum allowed value of NITERBAR without terminating the problem. |
| 159 | IAUTOOUT | 0 | Send out two copies of the ASCII output if IAUTOOUT>1. Also send out two copies of the graphics output if IAUTOOUT>2. Note: No output files are destroyed. (CRAY only! -- this is an obsolescent parameter that should |

- not be used on UNIX machines without recasting.)
- 160 IFLGABAR 0 The mean atomic weight, ABAR, calculated in subroutine SDOT is implicitly coupled to the ion equation of state only if IFLGABAR $\neq$ 0 and the normal APPROX network (IN=1) is being used. (This is an obsolescent parameter and the coding should be carefully rechecked if it is set $\neq$ 0).
- 161 FRACCORE 1.1 The effective number of zones used in REGESS (JMCALC) shall be the minimum needed to contain the inner FRACCORE mass-fraction of the initial mass of the star.
- 162 JMCALC JM Effective number of zones used in subroutine REGESS. JMCALC is internally calculated from FRACCORE and should not be changed.
- 163 IUPDFLAG 1 Don't calculate derivatives in subroutine SDOT when called from subroutine UPDATE if IUPDFLAG $\geq$ 0 (APPROX only).
- 164 NIONDUMP 40 Number of dump cycles between forced dumps of all dump-grid points of all 'ions' specified as dump variables.
- 165 NISODUMP 400 Number of dump cycles between forced dumps of all dump-grid points of all 'BURN' isotopes' specified as dump variables.
- 166 NZONDUMP 40 Number of dump cycles between forced dumps of all dump-grid points of all arrays specified as dump variables except 'ions' and 'isotopes.'
- 167 IFLAGYE 1 The electron EOS is implicitly coupled to nuclear-burning-induced changes in the electron abundance, YE, provided IFLAGYE $\neq$ 0 and the ISE or NSE network is being used.
- 168 NJEDITQ 5 Make a ISE edit every NJEDITQ zones.
- 169 DTQNUM 1.E-4 Relative temperature change used in calculating numerical derivatives in SDOTQ.
- 170 DDQNUM 1.E-4 Relative density change used in calculating numerical derivatives in SDOTQ.
- 171 IEXCITEH 1 Include excited states in ISE calculations only if IEXCITEH $>$ 0.

172	ITERQMH	1000	Maximum number of iterations allowed in ISE calculation.
173	YPCONVH	1.E-8	Allowed relative convergence error in the proton abundance in the ISE calculation.
174	YNCONVH	1.E-8	Allowed relative convergence error in the neutron abundance in the ISE calculation.
175	YSICONVH	1.E-8	Allowed relative convergence error in the Si28 abundance in the ISE calculation.
176	CNSEH	1.	Increment the proton, neutron, and Si28 abundances by a fraction CNSEH of that calculated by the Newton-Raphson method for an ISE iteration.
177	FYPH	0.05	Maximum allowed relative change in proton abundance during an ISE iteration.
178	FYNH	0.05	Maximum allowed relative change in neutron abundance during an ISE iteration.
179	FYSIH	0.15	Maximum allowed relative change in Si28 abundance during an ISE iteration.
180	NEDITQ	20	Make a detailed edit of the ISE zones every NEDITQ general numerical edits.
181	XITER1QE	0.5	If the relative change of the proton, neutron, or Si28 abundance is opposite in sign and more than XITER1QE in magnitude with respect to the corresponding change during the previous ISE iteration cycle, then cut the current step size in half if more than ITER1NSE iterations have been done.
182	ITER1QE	10	(See P 181).
183	XTHRES	1.E-4	Edit only those ISE isotopes with mass fractions exceeding XTHRES.
184	TQSELIM	1.5E+99	A sufficient condition to change a zone from the APPROX to ISE network is if its temperature exceeds TQSELIM, its O16 mass fraction is less than O16LIM, its iron peak mass fraction exceeds QN56LIM, and its density exceeds DQSELIM.
185	O16LIM	0.04	(See P 184).

186	QN56LIM	0.	(See P 184).
187	SNUWMULT	1.	Multiplier on neutrino energy losses from weak processes on nuclei and nucleons. (ISE only)
188	JNSE	0	Change all ISE zones with $J < \text{JNSE}$ to the NSE network.
189	SIQSELIM	1.E-3	A sufficient condition to change a zone from the ISE to the NSE network is for the sum of the silicon and sulfur "group" elemental mass fractions to be less than or equal to SIQSELIM.
190	JLALC	0	Remove the inner JLALC zones from the problem and reset the inner boundary conditions on radius (RADIUS0 (P 60)) and mass (SUMM0 (P 61)), but don't change the central luminosity (XLUM0 (P 62) -- note default is 0.).
191	VLIMSET	-1.	The ordinate bounds of the velocity graph are $\pm \text{VLIMSET}$ if $\text{VLIMSET} > 0$. Otherwise the ordinate bounds are rescaled automatically. (cm/s).
192	JPAUSE	-1	Pause the code at the end of the calculation for zone $J = \text{JPAUSE}$ in REGESS ("PAUSE 1") and in UPDATE ("PAUSE 2"). Do not pause if $\text{JPAUSE} < 0$. Type a carriage return to continue.
193	FRACRZO	-1.	(See P 138 and P 150).
194	RZMULTM	1.	(See P 138).
195	FMAXM	1.	(See P 150).
196	EIONMULT	1.	Multiplier on the contribution of ionization potential energy to the equation of state. (See ES).
197	NNEWOUTF	2000	Start a new labeled ascii output file every NNEWOUTF cycles.
198	NEDITQ1	5	Make an ISE edit for the central zone every $\text{NEDITQ1} * \text{NEDIT}$ (P 16) cycles.
199	WILSONMT	-1.	Multiplier on the Wilson-based nuclear EOS (except for the thermal ion component) if it is ≥ 0 . Otherwise, the old non-relativistic, partial degeneracy model for the ion EOS is used. WARNING...setting this parameter ≥ 0 appears

- to cause anomalous contributions to the pressure and energy at densities far below nuclear density and probably should not be used without revision. (See subroutine ES).
- 200 T11CUT 1. Upper bound on the temperature used to calculate the energy in nuclear excited states and nuclear partition functions (E+11 K units). (See subroutines ES and SDOTQ).
- 201 Y56GESSM 1.E-4 Initial guess made in SDOT for the Y56 abundance when initializing a new ISE zone (moles/g). If Y56GESSM is within 1.E-3 of 1., the temperature is greater than TQSEMIN, and $J > 1$, then the initial guesses for the proton, neutron, and Fe56 abundances used in the ISE iteration are taken equal to their values in the next innermost zone (which typically is already in ISE).
- 202 ISI30BRN 1 Neutron-rich-silicon-burning flows are included in the ISE network if ISI30BRN ≥ 1 . (See SDOTQ)
- 203 DQSELIM 1.E+5 Nominal minimum density for changing a zone from the APPROX to the ISE network (g/cc). (See P 184).
- 204 ABUNMINX -1.E-5 Force a backup after a call to BURN in SDOT if a calculated elemental mass fraction change would cause the resulting mass fraction to be less than ABUNMINX or to change by a fractional amount greater than TFCYBU. Such backups are made only if the elemental mass fractions involved are greater than YFLOORBX.
- 205 TFCYBU 0.5 Maximim allowed fractional change in abundance before an abundance backup is made. (See P 204).
- 206 YFLOORBX 0.001 Elemental mass fraction floor for making abundance backups. (See P 204).
- 207 IQERRFLG 1 Fatal errors in QBURN encountered during a normal REGESS iteration will cause KEPLER to back-up if IQERRFLG ≥ 1 , or to terminate if IQERRFLG < 1 .
- 208 C12AGMLT 1. Multiplier on the overall C12(a,g) rate (APPROX only). This parameter is obsolescent. It is better to use E1MLTC12 P 227) and E2MLTC12 (P 228).
- 209 XLTAUCON 0. Don't allow the convective velocity to increase by a factor greater than EXP (DT/(XLTAUCON*TAUCONV)) in one

- timestep, where DT is the current timestep and TAUCONV is the timescale for convective mixing (see REGESS and UPDATE). Useful in modeling detonations. (See P 214 for studying deflagrations).
- 210 NOQSECON 0 Don't force zones that are convectively coupled to ISE zones to go to ISE if NOQSECON > 0. This parameter should be kept zero unless you *really* understand what you're doing.
- 211 ACCRATE 0. Mean rate at which mass in the form of new zones is added to the surface of the star (solar masses per year). The accumulated mass is stored in XMACRETE (P 212) until it is large enough to be added as a whole zone. The surface boundary pressure is gradually increased at a rate proportional to ACCRATE until a mass (in XMACRETE) equal to that in the current outer zone is reached. Then a new zone, the mirror image of the old outer zone, is added. Accretion composition is set by the COMPSURF command in TTYCOM. This prescription will work best for coarse and roughly equal surface zoning.
- 212 XMACRETE 0. Mass of phantom outer zone used to mediate mass accretion (g). (See P 211).
- 213 DENCONV 1.E-7 Allowed fractional convergence error in density when calculating a hydrostatic initial stellar configuration in the generator using the DSTAT option. (See GENER).
- 214 FLAMERAD 0. Characteristic flame radius for carbon deflagration studies (cm). If XLTAUCON > 0 and FLAMERAD > 0, multiply the convective timescale, TAUCON, used to calculate the maximum allowed rate that the convective luminosity can increase (see P 209) by an additional factor of FLAMERAD/RFLAME, where RFLAME is the maximum radius at which a temperature above 2.E+9 K exists. This parameter effectively varies the velocity at which a deflagration can propagate and should be used *only* when studying carbon detonations. Note that larger values of FLAMERAD imply slower deflagration speeds, and that the relationship is not linear.
- 215 COULMULT 1. Multiplier on the Wigner-Seitz Coulomb corrections to the ion energy and pressure (See Clayton, p. 152, and ES).
- 216 IRZOPT 0 Rezoning Option Flag.

- IRZOPT = 1 or ≥ 3 : Modify the density gradient considered in adzoning by the factor $(ZBAR+1)/ABAR$ in order to suppress runaway adzoning of the density discontinuities that sometimes form at composition interfaces (esp. H/He).
Note that for a nondegenerate, perfect gas this is equivalent to considering the gradient in the matter pressure instead of in the density when adzoning. Dezoning is not affected.
IRZOPT ≥ 2 : Don't adzone across the boundaries of fully convective regions.
IRZOPT ≤ 0 . Normal rezoning.
(See REZONE).
- 217 NSURFZ -10 If NSURFZ > 0 and IZONEF (P 86) > 0, maintain a logarithmic ramp in zonal mass of the NSURFZ zones at the surface of the star, where FRACSZ0 (P 218) is twice the desired mass-fraction of the surface zone and FRACSZ1 (P 219) is twice the desired mass-fraction of the NSURFZth zone from the surface.
Otherwise, NSURFZ has no effect. (See REZONE.)
This is an obsolescent parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.
- 218 FRACSZ0 1. Inner surface zoning parameter (see REZONE and the discussion under P 217). This is an obsolescent parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.
- 219 FRACSZ1 1. Outer surface zoning parameter (see REZONE and the discussion under P 217). This is an obsolescent parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.
- 220 XMLOSSM 0. Multiplier on the de Jager mass-loss rate. (See CYCLE and *Ann. Rev. Astron. Astrophys.* 24, 336 (1986)).
- 221 XMLOSS0 0. Nominal mass loss rate from the surface of the star (solar masses/year). This constant mass loss rate is added to whatever de Jager-prescription mass loss may have been specified by XMLOSSM (P 220).
- 222 TOTMO 0. The original total mass of the star (g). This is set during generation and is used in interpreting edit, dump, and rezoning parameters involving stellar mass fractions rather than the current mass of the star (TOTM) which may change

- due to mass loss, accretion, etc. Normally, the internally set value of TOTM0 should not be changed by the user.
- 223 FRACDEZ 0.5 Dezone the mass-losing zone if its mass drops below FRACDEZ times the average mass of the zones on either side of it.
- 224 XMRATBAK 0.2 Redo the timestep ("backup") if the fractional change of mass in the mass-losing zone exceeds XMRATBAK.
- 225 XFRACML 0.01 Subtract any "surface" mass loss specified by XMLOSSM (P 220) or XMLOSS0 (P 221) from the zone closest to the surface that still has more than XFRACML*TOTM0 (P 222) grams of material overlying it. This should be set so that mass is not extracted from zones too near the surface in order to avoid excessive de zoning, small timesteps, and luminosity fluctuations.
- 226 MLCOMPF 0 Obsolete.
- 227 E1MLTC12 1. Multiplier on the E1 part of the C12(a,g) cross-section (affects both APPROX and the the BURN coprocessor, but currently has no effect on the C12(a,g) rate used to calculate photodisintegration flows in ISE.)
- 228 E2MLTC12 1. Multiplier on the E2 part of the C12(a,g) cross-section. (affects both APPROX and the the BURN coprocessor, but currently has no effect on the C12(a,g) rate used to calculate photodisintegration flows in ISE.)
- 229 NUPDATE 100 Do a forced update of BURN isotopic abundances in every zone every NUPDATE cycles.
- 230 DTFRAC 0.01 When BURN coprocessing is initiated (or when the ZEROTIME or RESET commands are given), (re)set the zonal timesteps used by the BURN coprocessor to DTFRAC*DTNEW (P 1).
- 231 BMASSMIN -1. BURN coprocessing is skipped if a zone's exterior mass coordinate is less than BMASSMIN (g).
- 232 BMASSMAX 1.E+99 BURN coprocessing is skipped if a zone's exterior mass coordinate is greater than BMASSMAX (g).
- 233 BTEMPMIN 1.E+6 BURN coprocessing is skipped if a zone's temperature

		is less than BTEMPMIN (K).
234	BTEMPMAX 1.E+99	BURN coprocessing is skipped if a zone's temperature is greater than BTEMPMAX (K).
235	SNUCMIN 1.E-99	BURN coprocessing is skipped if the absolute value of a zone's normal nuclear energy generation rate (SNN) is less than SNUCMIN (erg/g/s).
236	BDENMIN 1.E-99	BURN coprocessing is skipped if a zone's density is less than BDENMIN (g/cc).
237	BDENMAX 1.E+99	BURN coprocessing is skipped if a zone's density is greater than BDENMAX (g/cc).
238	TCHANGE .02	Force a zone to be updated by the BURN coprocessor if its fractional temperature change since its last BURN processing exceeds TCHANGE.
239	DCHANGE .05	Force a zone to be updated by the BURN coprocessor if its fractional density change since its last BURN processing exceeds DCHANGE.
240	NETMAX 1	BURN coprocessing is skipped if a zones's network number, NETNUM, is greater than NETMAX.
241	NEDITB 5	Make a BURN isotopic abundance edit every NEDITB*NEDIT (P 16) KEPLER cycles.
242	EDMASSL 1.E-4	Obsolete.
243	NEDITA 10	Make an elemental abundance edit every NEDITA*NEDIT (P 16) cycles.
244	JMEDITB 1	Edit only zones whose zone number is $\leq$ JMEDITB during normal BURN isotopic abundance edits.
245	NEDITALL 100	Make a BURN isotopic abundance edit for all zones every NEDITALL*NEDIT (P 16) cycles regardless of the value of NEDITB (P 241).
246	CHIMIN 1.E-6	Minimum isotopic abundance that affects the calculation of the zonal timestep in the BURN coprocessor (moles/g).
247	DELCHI .15	Maximum desired fractional change of an isotopic abundance

used in determining the zonal timestep used in the BURN coprocessor.

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| 248 | FDTN | 2. | Maximum factor by which the zonal timestep in the BURN coprocessor can be increased in one zonal cycle. |
| 249 | DTBKUP | .5 | Back up to the previous zonal cycle in the BURN coprocessor if the new zonal timestep is less than DTBKUP times the previous timestep. |
| 250 | NCOMP | 999999 | Make a complete ascii edit of the nuclear processes in all zones considered by the BURN coprocessor every NCOMP cycles. |
| 251 | NCENT | 999999 | Make an ascii edit of the nuclear processes in the central zone considered by the BURN coprocessor every NCENT cycles. |
| 252 | NEDT | 999999 | Make an ascii edit of the nuclear processes involved every nedt BURN coprocessor matrix inversions (debugging only). |
| 253 | NZRO | 1 | Set newly calculated negative BURN isotope abundances to 0. if NZRO not equal to 0. |
| 254 | AMAGLIM | 0. | Minimum absolute magnitude of a BURN matrix element for which Gauss-Jordan elimination is carried out in solving for changes in isotopic abundances. |
| 255 | NINV | 0 | Total number of BURN-coprocessor matrix inversions so far (internally incremented). |
| 256 | NBKUP | 0 | Total number of BURN-coprocessor backups so far (internally incremented). |
| 257 | NTTY | 6 | FORTTRAN I/O unit number for messages sent to the user's terminal. |
| 258 | IRATSTOP | -1 | Pause while updating zone IRATSTOP if IRATSTOP > 0. Type return to continue. |
| 259 | NEGBKUP | 0 | Cumulative number of BURN coprocessor backups due to encountering negative isotopic abundances (incremented internally). |
| 260 | BKUPDIV | 10. | Factor by which to reduce the BURN coprocessor zonal timestep when a negative isotopic abundance backup occurs. |

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| 261 | BKUPMASS | 1.E-13 | Minimum absolute magnitude of a negative isotopic abundance (except of protons) that can cause a zonal backup in the BURN coprocessor (moles/g). |
| 262 | BKUPMP | 1.E-19 | Minimum absolute magnitude of a negative proton abundance that can cause a zonal backup in the BURN coprocessor (moles/g). |
| 263 | NBKUPMAX | 10 | Maximum number of consecutive negative isotopic abundance backups allowed in the BURN coprocessor before quitting. |
| 264 | NSUBCYCM | 1 | Number of coupled BURN coprocessing / BURN isotope convection subcycles per KEPLER cycle. |
| 265 | MAZFUL | 1 | Use Fuller et. al.'s weak rates in the BURN coprocessor if MAZFUL=1, otherwise use the old rates of Mazurek and Hansen. |
| 266 | AL26MULT | 100. | Decrease the abundance threshold for Al26 to affect the BURN coprocessor zonal timestep from CHIMIN (P 246) to CHIMIN/AL26MULT. |
| 267 | INBURN | 0 | BURN coprocessing and related edits are done only if INBURN > 0. Note that INBURN is set to 1 by subroutine GENBURN if a BURN generator deck has been specified in the regular generator deck or by command GENBURN. It is an internal flag and should not be changed by the user, except to permanently turn off BURN coprocessing in a problem. |
| 268 | NPAGE | 53 | Number of lines printed per "page" of ascii output. The value 53 causes zone lists to be printed in 50-zone blocks. |
| 269 | NSAVEZ | 24 | Total number of nonBURN zonal arrays to save in restart dumps. These arrays are listed in KEPCOMS, starting with YM and numbering NZONEI + NZONEC in total. NSAVEZ must be at least 14 and no greater than NZONEI + NZONEC. Saving more than the minimum number of arrays needed to restart the problem is often useful for edit purposes. |
| 270 | NSAVEB | 10 | Total number of BURN zonal arrays to save in restart dumps. These arrays are listed in KEPCOMS, starting with NETNUMB and numbering NZONEB in total. NSAVEB must be at least 6 and no greater than NZONEB. Saving more than the minimum number of arrays needed to restart the problem is often useful for edit purposes. |

- 271 VLOSS 1.E+99 Remove the outer zone if its velocity exceeds VLOSS, but do not change the previous values of PBOUND (P 69) or TBOUND (P 68) (cm/sec).
- 272 ABUNLIMB 1.E-5 Edit only those BURN isotope mass-fractions whose values exceed ABUNLIMB in making terminal edits (including isotopic mass-fraction sums over zones).
- 273 SCALEM 1.9892E+33 Mass unit used for the mass coordinate employed in making ascii and terminal edits (g).
- 274 NEDITZ1 10 Make an ascii edit of primary zonal quantities every NEDITZ1*NEDIT (P 16) cycles.
- 275 NEDITZ2 20 Make an ascii edit of secondary zonal quantities every NEDITZ2*NEDIT (P 16) cycles.
- 276 MEDIT 0 Flag determining the minimum amount of information printed in an ascii cycle edit regardless of the settings of other edit parameters:
 ≤ 0 means minimum is a 1 page "short" edit;
 ≥ 1 means minimum includes a primary zonal edit;
 ≥ 2 means minimum includes a secondary zonal edit;
 ≥ 3 means minimum includes an ion abundance edit;
 ≥ 4 means minimum includes an ISE abundance edit;
 ≥ 5 means minimum includes a BURN isotope edit;
 ≥ 6 means minimum includes a BURN isotope edit for all zones;
 ≥ 7 means minimum includes a parameter edit.
- 277 MEDITFIN 7 Effective value of MEDIT (P 276) used in determining the scope of the final edit made when the problem is finished.
- 278 NEDITP 50 Make an ascii edit of all changeable parameters every NEDITP*NEDIT (P 16) cycles.
- 279 FLAMVA 0. If FLAMVA $\neq 0.$, the current problem is a study of a carbon deflagration in a white dwarf. The current radius of the deflagration flame is taken as the radius of the outermost zone where the temperature exceeds 2.E+9 K and is edited as JFLAM (P 283) by KEPLER. The outward speed of the flame is controlled by adjusting the opacity for heat conduction between

zones JFLAM and JFLAM + 1 up or down by a factor, XKAPFLAM (P 284), between 0. and 1. Such "gating" is performed in KAPPA and UPDATE and sets the velocity of advance of the 2.E+9 K temperature front to a comoving value that averages:

VFLAME =

VCOND * (RFLAME / XLAMBMIN)**(FLAMVB - 2.),

where: XLAMBMIN = $4\pi * VCOND^{**2} / GEFF$ and

VCOND is FLAMVC (P 281) times the heat conduction velocity (given by $1.E+5*(dn(j+1)/2.E+9)^{**}FLAMVE$ (P 347)),

RFLAME is the current radius of the flame front, and

GEFF is FLAMVA times the acceleration of gravity at the flame front. The calculated flame velocity is bounded below by VCOND and above by FLAMVD (P 282) times the speed of sound behind the flame front.

Basically the flame front wrinkles as it propagates in a fractal manner and the extra area it thus enjoys causes the flame to burn the entrained material more rapidly. See CYCLE for more details.

FLAMVA would typically be set to a value about 0.2 corresponding to a 20% delta-rho/rho across the burning front to study "plausible" carbon deflagrations using this model.

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| 280 | FLAMVB | 2.6 | Fractal exponent helping determine the relationship between the velocity of heat conduction and the velocity of the carbon deflagration flame based on its degree of "wrinkling." FLAMVB is equivalent to the fractal dimension of the burning front which is 2. for a smooth surface, 2.7 corresponds to fully developed turbulence, and 3. corresponds to filled space. |
| 281 | FLAMVC | 50. | Multiplier on the heat conduction velocity used to calculate the velocity of the carbon deflagration front. See the discussion given for FLAMVA (P 279) for a more detailed explanation of its use. The default value of 50 corresponds to the laminar flame speed in a 50/50 carbon-oxygen mixture at 2.E+9 g/cc. |
| 282 | FLAMVD | 1. | The velocity of the carbon deflagration flame front is limited to FLAMVD times the local sound speed. (See the discussion for FLAMVA (P 279)). |
| 283 | JFLAM | 0 | The zone where the carbon deflagration flame is currently located. This parameter is internally set by KEPLER to be the outermost zone whose temperature exceeds 2.E+9 K and its value should not be changed by the user. |

- 284 XKAPFLAM 0.001 Carbon deflagration opacity gating factor. Must be > 0 . and < 1 . See the discussion given for FLAMVA (P 279) for a more detailed explanation of its use.
- 285 XMFLAM 0. The mass in the current carbon deflagration flame-front zone JFLAM (P 283) that has already been burned (g). This parameter is set internally by KEPLER and should not be changed. When the entire mass of zone JFLAM (P 283) has been burned the opacity coupling it to zone JFLAM + 1 is changed from being divided by XKAPFLAM (P 284) to being multiplied by it. This causes the flame front to advance to the next zone. See the discussion given for FLAMVA (P 279).
- 286 TAUNU 0. Time scale for the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse (sec).
- 287 ENU53 3. Total energy (in units of 10^{53} ergs) for the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse.
- 288 TMUNU 8. Temperature of the mu and tau neutrinos in the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse (MeV).
- 289 TENU 4. Temperature of the electron neutrinos in the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse (MeV).
- 290 NOILAND 1 If NOILAND > 0 , prevent separated islands of zones employing the ISE network from developing by not letting zone J go to ISE unless zone J - 1 has already done so.
- 291 CHARISZG 1.0 Graphics character size for grid labels (relative to MONGO's default character size).
- 292 CHARISZC 0.85 Graphics character size for curve labels (relative to MONGO's default character size).
- 293 CHARISZZ 0.85 Graphics character size for zone sentinels (relative to MONGO's default character size).
- 294 CHARISZH 1.0 Graphics character size for header info (relative to MONGO's default character size).

- 295 WIDTHTD 60. Obsolete.
- 296 IBACKGND -1 Graphics window background color is white if IBACKGND ≥ 0 and black if IBACKGND < 0 . The foreground color is always the inverse of the background color.
- 297 DSCALEM 1.9892E+33 Mass units used for the internal mass coordinate, YMASS, used for dumping purposes (g). -- See subroutine DUMPQ.
- 298 NGRIDMIN 10 Minimum number of points allowed in a dump grid. See DUMPQ.
- 299 NCYCQQ 5 Number of KEPLER cycles between post-processor dump cycles (i.e.. calls to DUMPQ).
- 300 LENTRACK 16384 Length of the track(s) assigned to each dump variable in the post-processor dump(s) (bytes). See DUMPQ.
- 301 IDTMAXL 40 Maximum number of post-processor dump cycles beyond the currently-specified dump cycle (LTIME) that READQ will search to try to get values for each point in the 'advanced' grid formed from dump variable values at or beyond LTIME. In PLOTMAP, IDTMAXL is used as a flag for the plot and interpolation mode to be used:
 if IDTMAXL = 0, strips of retarded-value rectangles are plotted, based on the reconstructed grids (best for very discontinuous variables, esp. CONVECT).
 if IDTMAXL = 1, forward and backward facing triangles are plotted for each dump point. These triangles have a uniform color determined by the value at their most retarded vertex (best for moderately discontinuous variables, such as abundances).
 if IDTMAXL > 1, forward and backward triangles are plotted for each dump point which are Gouraud-shaded to interpolate between the variable values at each corner (fastest and smoothest for continuous variables, worst for discontinuous variables).
- 302 IDTLOOK 10 Default number of post-processor dump cycles between LOOK plots or prints or reconstructed TIMEMAP grids.
- 303 BACKFACQ 0.5 If the fractional change in a dump variable since the last dump cycle exceeds BACKFAC*RATZDUMP(IDAT), then also dump the old value of that variable at the previous (dump cycle)

- time point, where RATZDUMP(IDAT) is the (previously specified) maximum allowed fractional change between dumps of this zonal dump variable (indexed by IDAT). See Chapter 2 on Generator Input.
- 304 TEMPSTOP 1.E+99 Terminate the problem when the central temperature reaches TEMPSTOP (K).
- 305 DENSTOP 1.E+99 Terminate the problem when the central density reaches DENSTOP (g/cc).
- 306 VINSTOP 1.E+99 Terminate the problem when the infall velocity exceeds VINSTOP (cm/sec). Note that positive values of VINSTOP correspond to negative (infalling) velocities. Before terminating the problem, make a restart dump labeled '#presn' and execute the alias-defined "presn" command. Normally this command is used to make final plots and edits.
- 307 O16STOP -1. Terminate the problem when the O16 mass-fraction drops below O16STOP provided the central temperature exceeds TQSELIM (P 184). Basically this corresponds to a time near the end of core oxygen burning for values of O16STOP about 0.05.
- 308 TIMEZMS 1.E+99 Time (sec) at which to make zero-age-main-sequence parameter changes and a restart dump labeled '#zms'. TIMEZMS is typically set to 1.E+12 sec.
- 309 IZONEZMS 1 Reset the value of IZONEF (P 86) to IZONEZMS at the time specified by TIMEZMS (P 308).
- 310 Q1FACZMS 0.1 Reset the value of Q1FAC (P 13) to Q1FACZMS at the time specified by TIMEZMS (P 308).
- 311 TEMPCIG 1.E+99 Central temperature (K) at which to make the pre-carbon-ignition parameter changes and a restart dump labeled '#cig'. TEMPCIG is typically set to 5.E+8.
- 312 YFLRXCIG 0.003 Reset the value of YFLOORX (P 47) to YFLRXCIG when the central temperature specified by TEMPCIG (P 311) is reached.
- 313 FMAXMCIG 1. Reset the value of FMAXM (P 195) to FMAXCIG when the central temperature specified by TEMPCIG (P 311) is reached.
- 314 FMAX0CIG 1. Reset the value of FMAX0 (P 150) to FMAX0CIG when the

- central temperature specified by TEMPCIG (P 311) is reached.
- 315 TOFFSET 0. Cumulative amount of time by which the problem time has been offset by ZEROTIME commands (sec). In other words, TOFFSET should be added to the current problem time to get the actual time since the beginning of the problem. Normally, TOFFSET is reset internally when the ZEROTIME command is issued and should **not** be reset by the user.
- 316 ABUNMINB 1.E-4 Lower mass-fraction limit of the isotopic abundance plot.
- 317 ABUNMAXB 1. Upper mass-fraction limit of the isotopic abundance plot.
- 318 NUMISO 0 Number of BURN isotopes to be plotted, starting from the first one listed by the most recent SETISO command. Normally NUMISO is set to the total number of isotopes listed in the SETISO command at the time that command is processed and does not need to be set by the user.
- 319 TIMEREF -1.E+99 Reference time used in calculating the time coordinate in timeplots and timemaps (sec). If TIMEREF < -1. E+98, then a time 10 timesteps beyond the last timepoint is used in its place.
- 320 TOSETREF 0. Reference offset time used in calculating the time-coordinate for timeplots and timemaps (sec). If TIMEREF < -1. E+98, then the value of TOFFSET prevailing for the last timestep is used for TOSETREF.
- 321 TIMECMIN 0. Minimum value of the time-coordinate to be plotted in timeplots and timemaps (time coordinate units--see P 327). If both TIMECMIN (P 321) = 0 and TIMECMAX (P 322) = 0, all available time-points will be plotted.
- 322 TIMECMAX 0. Maximum value of the time-coordinate to be plotted in timeplots and timemaps (time coordinate units--see P 327). If both TIMECMIN (P 321) = 0 and TIMECMAX (P 322) = 0, all available time-points will be plotted.
- 323 YEMAX 0.498 Maximum value of Ye allowed when initializing a new ISE zone (moles/g). This simulates the small amount of neutronization that usually occurs before the end of oxygen burning.
- 324 ABARSEMI 4. Value of the zonal mean atomic weight, ABAR, used to divide the star into two regions with separately specifiable values of the semiconvective mixing rate and the overshoot mixing coefficient

- (g/mole). (See the definitions of DRMULT (P 24), WOVERSHT (P 148), DRMULTLO (P 325), and WOVERSLO (P 326)).
- 325 **DRMULTLO** **DRMULT** Semiconvective mixing will be slower than thermal transport by at least DRMULTLO (about 0.1) in zones where the mean atomic weight, ABAR, is below ABARSEMI (P 324). (See UPDATE and discussion of DRMULT (P 24), WOVERSHT (P 148), and WOVERSLO (P 326)).
- 326 **WOVERSLO** **WOVERSHT** The semiconvective test parameter, W, is taken to be $W = \text{WOVERSLO} * \text{ABS}(\text{LOG}(T1/T0))$ for the special overshoot semiconvective zones where W would otherwise be less than 0 and when $\text{ABAR} < \text{ABARSEMI}$ (P 324). Overshoot mixing occurs at a rate calculated from this value of W, but is limited by the thermal diffusion timescale as in normal semiconvection. (see UPDATE & WZW78). If WOVERSLO=0 no overshoot mixing is done. (Also see WOVERSHT -- P 148).
- 327 **MAPTIME** 2 Flag indicating the desired time coordinate in timeplots and timemaps (see PLOT and TIMEMAP):
 0 => use cycle number;
 1 => use linear time (sec);
 2 => use negative logarithmic time (-log (sec)).
 3 => use positive logarithmic time (log (sec)).
 Note that the time coordinate is calculated relative to **TIMEREF** (P 319) + **TOSETREF** (P 320).
- 328 **VMINMAP** 1.E+99 Minimum value of the timemap variable to be mapped. If **VMINMAP** > 1.E+98, then the actual minimum value of the current variable is used as the map limit, except as limited by **VRATMAP** (P 330), below.
- 329 **VMAXMAP** -1.E+99 Maximum value of the timemap variable to be mapped. If **VMAXMAP** < -1.E+98, then the actual maximum value of the current variable is used as the map limit.
- 330 **VRATMAP** 1.E-99 Minimum ratio of the minimum timemap variable limit to the maximum timemap variable limit in the case when the actual minimum value of the current timemap variable would otherwise be used as the minimum timemap limit.

- 331 TEMPCDEP 1.E+99 If the central temperature is $\geq$ TEMPCDEP, then make a restart dump labeled '#cdep', execute the alias-defined "cdep" command, and reset TEMPCDEP to 1.E+99.
Normally, this parameter is used to reset certain parameter values following carbon depletion.
- 332 O16ODEP -1.E+99 If the central oxygen abundance is $\leq$ O16ODEP *and* the central temperature is $\geq$ TQSELIM (P 184), then make a restart dump labeled '#odep', execute the alias-defined "odep" command, and reset O16ODEP to -1.E+99.
Normally, this parameter is used to reset certain parameter values at oxygen depletion.
- 333 TEMPCHAR 1.E+99 If the central temperature is $\geq$ TEMPCHAR, then make a restart dump labeled with '#tn' and the current cycle number, reset TEMPCHAR to 1.E+99, and *finally* execute the alias-defined "tnchar" command.
Note that the user -defined "tnchar" command can change the value of TEMPCHAR in such a way as to cause the "tnchar" command to be issued recursively (i.e., by using the command: "P N DELTA ADD" -- see Chapter 5).
- 334 DENCHAR 1.E+99 If the central density is $\geq$ DENCHAR, then make a restart dump labeled with '#dn' and the current cycle number, reset DENCHAR to 1.E+99, and *finally* execute the alias-defined "dnchar" command.
Note that the user -defined "dnchar" command can change the value of DENCHAR in such a way as to cause the "dnchar" command to be issued recursively (i.e., by using the command: "P N DELTA ADD" -- see Chapter 5).
- 335 ABARCHAR 1.E+99 If the central mean atomic weight (ABAR) is $\geq$ ABARCHAR, then make a restart dump labeled with '#ab' and the current cycle number, reset ABARCHAR to 1.E+99, and *finally* execute the alias-defined "abchar" command.
Note that the user -defined "abchar" command can change the value of ABARCHAR in such a way as to cause the "abchar" command to be issued recursively (i.e., by using the command: "P N DELTA ADD" -- see Chapter 5).
- 336 ZONEMMIN 1.E-99 ZONEMMIN is the minimum mass (g) that a zone may have and still be allowed to be adzoned (as part of a zone pair).

- 337 ICALCNE 0 Calculate more accurate electron densities in partially ionized regions if ICALCNE > 0 using Lisa Ensman's multiple-ion, Saha equilibrium subroutine, CALCNE. Generally this more accurate, but very time-consuming routine is turned on just before shock-breakout while doing supernova light-curve calculations.
- 338 XNECONV 1.E-05 Maximum allowable fractional convergence error in the electron density calculated by subroutine CALCNE (see P 337).
- 339 IONFLAG 0 If IONFLAG $\leq$ 0 and the density and temperature have changed by a fraction less than DDSFRAC (P 153) and DTSFRAC (P 154), respectively, since the last iteration, then extrapolate the value of the electron density from its partial derivatives with respect to density and temperature instead of calling CALCNE (when ICALCNE > 0 -- see p 337), unless this is the first iteration. Otherwise call CALCNE all the time, provided ICALCNE > 0.
- 340 XNEMIN 1.E-05 Minimum mass fraction for which an element is included in the calculation of Saha ionization equilibrium done in subroutine CALCNE (see P 337).
- 341 XKAPGAM 0.054 Assumed effective opacity (cm^2/g) for the deposition of gamma ray energy from the radioactive decay of Ni56 and Co56, as controlled by TIMEX0 (P 38).
- 342 EGAMP 0.60 Dimensionless correction factor used in calculating the escape of gamma rays from the radioactive decay of Ni56 and Co56, as controlled by TIMEX0 (P 38). See subroutine SDOT for details.
- 343 TSHOCK 1.E+99 If the problem time is $\geq$ TSHOCK, then make a restart dump labeled '#shock', reset TSHOCK to 1.E+99, and *finally* execute the alias-defined "tshock" command. Normally, this command is used to reset certain parameter values and/or make edits at the time of the piston-induced bounce of the collapsing iron core that creates an out-going shock wave.
- 344 TNUCLEO 1.E+99 If the problem time is $\geq$ TNUCLEO, then make a restart dump labeled '#nucleo', reset TNUCLEO to 1.E+99, and *finally* execute the alias-defined "tnucleo" command. Normally, this command is used to reset certain parameter values and/or make edits at a time just after explosive nucleosynthesis is complete.

- 345 TENVEL 1.E+99 If the problem time is $\geq$ TENVEL, then make a restart dump labeled '#envel', reset TENVEL to 1.E+99, and *finally* execute the alias-defined "tenvel" command.
Normally, this command is used to reset certain parameter values and/or make edits just before the supernova shock wave breaks through the surface of the presupernova star.
- 346 NFIRSTQ 0 Default value of the first cycle to be read or plotted in making post-processor edits, time plots, or timemaps. Note that this parameter is reset by the NEWDUMPS command to the current value of NCYC+NCYCQQ-MOD(NCYC,NCYCQQ) so that KEPLER will not try to read old dumps.
- 347 FLAMVE 0.805 Density power dependence of the heat conduction velocity used in calculating the velocity of nuclear deflagrations in Type I supernovae. (0.805 for C/O, 1.06 for Ne/O)
See P 279-285 and subroutine CYCLE for details.
- 348 BINM10 TOTM0 ^X
should be ~ M₀ The initial mass of the star being evolved (primary) in solar masses that is used in calculating the possibility of mass loss to a binary companion, following the formalism of Podsiadlowski, Joss, and Hsu, ApJ, 391, 246, (1992). The star loses mass when its radius exceeds its Roche radius, with a power-law cutoff to avoid numerical discontinuities. The formalism also involves parameters 349 - 354, defined below. See subroutine CYCLE.
- 349 BINM20 0. The initial mass of the binary companion star (in solar masses) used in calculating the possibility of binary mass transfer.
No mass transfer is performed if $\text{BINM20} \leq 0$. See P 348.
- 350 BINALP 1. PJH's alpha parameter, related to the angular momentum of the mass lost in binary transfer. See P 348.
- 351 BINBET 1. PJH's beta parameter. Fraction of the total mass spilling over from the Roche lobe of the primary that is transferred to the secondary rather than being lost from the system. BINBET equals 1. for conservative binary mass transfer.
- 352 BINA0 2. Initial binary separation in AU used in calculating the possibility of binary mass transfer. See P 348.
- 353 BINMDT 1.E-3 Mass loss rate due to binary mass transfer assumed when the primary stars exceeds its Roche radius (solar masses per year).

See P 348.

354 ROCHER 1.E+99 Current Roche radius (cm). This is a calculated quantity and should normally not be changed by the user. See P 348.

23.VII.93

DRAFT

CHAPTER 5

TERMINAL INPUT

GENERAL

All terminal input is in the form of space delimited words. All normal floating point and fixed point formats are recognized (termed "field-free" format). Floating point numbers must be distinguished from integers by a decimal point or exponent. All actual communication with the computer should be made in lower case and character parameters are never enclosed in quotes.

STARTING AND RESTARTING

KEPLER is initiated by typing:

KEPLER *NAMEP* *NAMEG/Z* [*OPTIONS*]

e.g.: ' kepler s25s2a s25s2ag s '

KEPLER is the version of KEPLER which is to be run. Possible choices include:

kepler.....The most tested current 'floor' version of KEPLER,

keplerx.....The less tested, but 'new and improved,' experimental version, or

kepler.ddmmmyy... An old version of KEPLER made on *ddmmmyy*, e.g. ' kepler.13apr91 '

On UNIX machines, **kepler** and **keplerx** are stored in */usr/local/bin*, while old versions of KEPLER are archived in */usr/local/bin/oldkep* on the General Studies ('P') Group Silicon Graphics UNIX computer *leonardo* (Internet address 128.115.10.33).

The version used for a given run and its date are recorded at the beginning of each ASCII output file.

NAMEP is the ≤ 8 character name given to the current problem. This name is also used to begin the names for various output and dump files created during this problem (see below).

NAMEG/Z is a ≤ 16 character name of either a generator file (in which case its name must end in 'g' (e.g., 's25s2ag'), or a restart dump (in which case its name must not end in 'g' (e.g., 's25s2az' or 's25s2a#10350' or 's25s2a#presn')).

Special Cases: Meaning:

g..... To generate from file *NAMEP*// 'g'.

z..... To restart from file *NAMEP*// 'z'.

p..... To restart from file *NAMEP*(with last character deleted)// '#presn'.

OPTIONS (optional) is a set of one or more space delimited words in arbitrary order chosen from among the following possibilities:

Option: Meaning:

s..... To suspend the code after starting.

d..... To destroy the ASCII output files after sending them to the microfiche printer (not currently implemented -- see also the discussion of parameter *IAUTOOUT* (P 159) given in Chapter 4).

h..... To automatically make a paper copy of the ASCII output files (not currently implemented).

INITIAL OPERATION

In the absence of any *OPTIONS*, the code will begin calculations immediately and keep its ASCII output files on disk. It will either generate from cycle 0 if *NAMEG/Z* is the name of a valid generator file (see Chapter 2) or restart a previous problem if *NAMEG/Z* is the name of a restart dump compatible with this version of KEPLER. The code will attempt to restart from restart dumps created by older versions of KEPLER by setting any newly added parameters to their default values, and printing warning messages concerning possible incompatibilities. Such compatibility, however, is **not** guaranteed, and it is the user's responsibility to carefully check whether such a restart operation has been performed correctly (see subroutine *RESTART*). If equation of state routine changes have been made in the interim, the *NEWE* or *EOSTRANS* commands (see below) may be helpful.

REQUIRED INPUT FILES

The current working directory must contain the specified compiled version of KEPLER or (more desirably) a *PATH* specification to */usr/local/bin* or */usr/local/bin/oldkep*, where such files are likely to be located. The named generator or restart file must also be physically resident in the

current directory, as must any BURN generator file specified in the generator file (see Chapter 2).

If BURN co-processing has been specified, the directory in which KEPLER is run must also contain the file BDAT, which contains the needed nuclear cross-sections for detailed isotopic networks. This file should be stored as `/usr/local/bin/bdat` and can be soft-linked to the current working directory by the command `'ln -s /usr/local/bin/bdat bdat'`.

The 'qlib' library file and the 'qq' post-processor dump file corresponding to the named restart dump (see below for definitions) are also required for restarting a problem making post-processor dumps. Note that KEPLER will overwrite information generated by the previous problem for duplicated cycles. Post-processor dump files not containing the restart cycle may also be in the working directory, but are not required.

POST-PROCESSOR FILES

If post-processor dumps have been requested in the generator file (or less desirably initiated by a command from the terminal), KEPLER will create a ('qlib') library file with a name in the form *NAMEP.lib* (e.g. 's25s2a.lib') which maintains a record of zonal mass coordinates and stores a time history of the time edit variables. A series of post-processor dump ('qq') files are also created starting with a file named in the form *NAMEP.qa* (e.g. 's25s2a.qa') which stores a compressed time history of the dump variables specified by DUMP commands or generator cards. These files are updated every NCYCQQ (P 299) cycles. The 'qlib' library file can store information for up to 20,000*NCYCQQ KEPLER cycles and up to 17,999 distinct grid points before becoming full. For ease in handling, however, the post-processor dump files are limited to a size of LENQMAX (P 44) whose default value is 3,000,000 bytes. New post-processor dumps will be created as required with suffixes in the sequence: .qa, .qb,.... .qz, .q0... .q9, .ra, .rb,.... .rz, .r0... .r9, etc.

The qlib library file must always stay on-line while the problem it corresponds to is running, but all but the most recent post-processor dump ('qq') files may be stored elsewhere if disk space is a problem. This will limit the range of possible LOOK and TIMEMAP commands (see below), however.

RESTART DUMP FILES

KEPLER will create a running restart ('z') file named in the form *NAMEPz* (e.g. 's25s2az'), which it overwrites every NDUMP (P 18) cycles. It will also create labeled restart dumps with names in the form *NAMEP#NCYC* (e.g. 's25s2az#12750') every NDUMP*NSDUMP (P 156) cycles, where where NCYC is the current cycle number. If a file with the name *NAMEP#NCYC* already exists, it will be overwritten.

ASCII OUTPUT FILES

KEPLER will also create ASCII output files with names in the form *NAMEP_NCYC0* (e.g. : 's25s2az_0'), where *NCYC0* is the cycle number at which the problem is being generated or restarted. To prevent such files from becoming too large, however, the current output file is closed whenever $\text{MOD}(\text{NCYC}, \text{NNEWOUTF}(\text{P } 197)) = 0$ (by current default every 2000 cycles) and a new output file with a name in the form *NAMEP_NCYC* (e.g. : 's25s2az_2000') is created. Both of these types of ASCII output file will overwrite any file by the same name that might already exist.

DUMP-GRID STATUS FILES

If post-processor dumps are being made, KEPLER will also alternately create, read, and destroy files with names in the form *NAMEP.0* and *NAMEP.1* (e.g. : 's25s2a.0' and 's25s2a.1') which contain information about the grids currently being used to represent each requested dump variable. This reduces the size of the KEPLER executable file at the cost of some extra files on disk. If for any reason (restart, disk crash, etc.), these files are not available, KEPLER will automatically generate a new set of dump grids along with a warning message. This is not really a problem except that it takes up a little extra space in the post-processor dumps.

INTERACTIVE KEYBOARD COMMANDS

At the beginning of each cycle, the code checks for and executes commands that the user may have typed during the cycle. If it is in "stepping" mode (see the S command below), it acknowledges completion of the command with a '.' which serves as a prompt for the next command. If the code is in normal running mode, command completion is acknowledged by an 'ok' and code execution continues. 'oops!' is returned if the command can't be understood or if an argument has an inappropriate value, and code execution (or suspension) is continued.

Interactive keyboard commands may be entered more than one to a line by using commas as delimiters. The resulting construct is termed a "keyboard message." The keyboard message may be up to 80 characters long and may contain any possible number of comma-delimited command lines, which are executed sequentially. Except as noted below, words representing input character variables are truncated to 8 characters, while numerical input is "field-free," except that floating point numbers must be distinguished from integers by a decimal point or exponent. The number of blank-delimited symbol(s)/word(s) in the current command line is limited to a maximum of 60.

Allowed interactive keyboard commands are listed below. Each command keyword is given in bold capital letters, followed by its arguments, if any, in italic capital letters. For the more complex commands, an example printed in boldface characters and enclosed in quotes is given, which also serves to indicate the type of the arguments. Note that, as indicated by the examples, actual communication with the computer should be made in lower case and that character parameters are never enclosed in quotes.

NORMAL PROGRAM MANAGEMENT COMMANDS

Here *J*, *N* and *M* stand for integers corresponding to allowed zone number where $N > M$; *IONSYM* is the ASCII symbol for one of the 'ions' in the APPROX, ISE or NSE networks, *ISOSYM* is the ASCII symbol for one of the isotopes in the current BURN coprocessor network, and *REACSYM* is the ASCII symbol for the editable nuclear reaction rates. A more detailed explanation of the edits that result from some of these commands is given in Chapter 9.

<u>Command:</u>	<u>Meaning:</u>
-----------------	-----------------

- | | |
|-------------|--|
| D..... | Force the restart dump to be updated to the current cycle. |
| D NAME..... | Make a restart dump called <i>NAME</i> at the current cycle. |

Normal Program Management Commands (Cont.)

- E**..... Make a current energy edit on the terminal.
- ED**..... Force an edit of the current cycle to be written in the Ascii output file.
- ED M**..... Force an edit with MEDIT (P 276) = *M*
- EDP**..... Force a parameter edit for the current cycle to be written in the output file.
- END**..... Terminate the problem.
- FIN**..... Same as **END**.
- G**..... Resume normal calculations after a suspension.
- J** Make a current edit for zone *J* on the terminal.
- J I**..... Make a current edit of ion mass fractions for zone *J* on the terminal.
- J I IONSYM** Edit the mass fraction of ion type *IONSYM* on the terminal.
- J B**..... Make an edit of BURN isotope mass fractions for zone *J* on the terminal.
- J B ISOSYM** Edit the mass fraction of BURN isotope type *ISOSYM* on the terminal.
- J Q**..... Make a QNSE edit for zone *J* on the terminal.
- SUMB M N**..... Display an edit of the mass of all BURN isotopes in zones *M* thru *N* (M_0).
- SUMB M N ISOSYM**... Display an edit of the mass of burn isotope *ISOSYM* in zones *M* thru *N* (M_0).
- SUMI M N**..... Display an edit of the mass of all ions in zones *M* thru *N* (M_0).
- SUMI M N IONSYM**... Display an edit of the mass of ion *IONSYM* in zones *M* thru *N* (M_0).
- P N**..... Display the value of parameter name or number *N*.
- P N VALUE**..... Change the value of parameter name or number *N* to *VALUE*.
- P N DELTA ADD**..... Add *DELTA* to the value of parameter name or number *N*.
- Q N**..... Display the value of 'edit' parameter name or number *N*.
- S**..... Suspend execution, or step one cycle if suspended.
- S N**..... Run the problem for *N* more cycles, then suspend
- T**..... Make a current time edit on the terminal.
- TED**..... Display a 'short' ASCII edit on the terminal.
- TED M**..... Display an ASCII edit on the terminal with MEDIT (P 276) = *M*.
- TIME**..... Make an edit of computer time usage (in seconds).
- TN**..... Make a nuclear reaction rate edit on the terminal (moles/s -- over whole star).
- TQ**..... Make a combined time and surface edit on the terminal.

OTHER TERMINAL EDIT COMMANDS

EDITISO [JINNER [JOUTER]]

EDISO [JINNER [JOUTER]] (abbreviated form)

' ediso 171 417 '

Make an edit of the isotopic yields, summed between zones *JINNER* and *JOUTER* inclusive, both on the terminal and in a special file with suffix '.yield'//*JINNER*. If *JINNER*=1, it is omitted from the suffix. This file overwrites any such existing file and is automatically sent to the laser printer ('lpr') to be printed.

TEST TESTVAR J T D

' test p 1 3.E+9 2.E+7 '

Gives a terminal edit of quantity *A* for the materials in zone *J*, but at the temperature *T*(K) and density *D* (g/cc) specified. *TESTVAR* is a variable symbol which may be any one of the following:

- k..... Opacity (cm**2 /g).
- s..... Energy Production Rate (ergs/g/s).
- p..... Pressure (erg/cc).
- e..... Energy (erg/g).

TN REACSYM

' tn he3+he4 '

Make an edit of the total rate of nuclear reaction *REACSYM* on the terminal.

Allowed values for *REACSYM* are:

p+p	he3+he3	he3+he4	c12(pg)	n14(pg)	(1-5)
o16(pg)	3a-c12	n14(ag)	c12(ag)	c12+c12	(6-10)
c12+o16	o16+o16	o16(ag)	ne20(ag)	mg24(ag)	(11-15)
si28(ag)	s32(ag)	ar36(ag)	ca40(ag)	ti44(ag)	(16-20)
cr48(ag)	fe52(ag)	fe52:2ng	fe52:a2p	fe54:2pg	(21-25)
he4-2n2p	p(e-nu)n	n(e+nu)p	weak		(26-29)

Here *p* denotes a proton; *n*, a neutron; *a*, an alpha particle; *g*, a gamma-ray; *nu*, a neutrino; and *ecap*, the rate for electron capture (ISE zones only). The values edited are the total net rates (forward-back) summed over the whole star (in moles/s).

**add reference by reaction number

Other Terminal Edit Commands (Cont.)

V EDITVAR [JMIN [JMAX]]

'v ionye 1 100'

To make a terminal edit of the zonal edit variable denoted by *EDITVAR* from zones *JMIN* to *JMAX*, inclusive. If only *JMIN* is specified, *JMAX* is assumed = *JMIN*. If neither *JMIN* or *JMAX* is given, then *JMIN* = 1 and *JMAX* = *JM*, the index of the current outer zone. A detailed list of the allowed edit variables and their corresponding values of *EDITVAR* is given in Chapter 7.

VERSION

Type out information about the dates on which the current code modules were last modified.

VF EDITVAR [JMIN [JMAX]]

'vf ionye 1 100'

Same as the **V** command except that edited values are given to 14 decimal places instead of 3.

Z EDITVAR1 [EDITVAR2....EDITVAR10] [JMIN [JMAX]]

'z dn tn sige sigi sigr 1 100'

This command makes a columnar zonal edit of arrays *EDITVAR1* through *EDITVAR10* (if requested) for zones *JMIN* through *JMAX*. If only *JMIN* is specified, *JMAX* is assumed = *JMIN*. If neither *JMIN* or *JMAX* is given, then *JMIN* = 1 and *JMAX* = *JM*, the index of the current outer zone. A detailed list of the allowed edit variables and their corresponding values of *EDITVAR* is given in Chapter 7. The first column in the edit gives the convection sentinel and the zone number, while the second column lists the interior mass in SCALEM (P 273) units. Values of the requested arrays start in column 3. At least one array must be requested, up to a maximum of 10. Note that 5 array requests fit nicely in an 80-column screen window, while 10 fill a 132 column edit page.

OTHER ASCII-OUTPUT-FILE EDIT COMMANDS

EDITISO [*JINNER* [*JOUTER*]]

EDISO [*JINNER* [*JOUTER*]] (abbreviated form)

' ediso 171 417 '

Make an edit of the isotopic yields, summed between zones *JINNER* and *JOUTER* inclusive, both on the terminal and in a special file with suffix '.yield'//*JINNER*. If *JINNER*=1, it is omitted from the suffix. This file overwrites any such existing file and is automatically sent to the laser printer ('lpr') to be printed.

EOSTABLE *JJ* *TLOW* *THI* *NTEMP* *DLOW* *DHI* *NRHO*

' eostable 1 1.E+6 1.E+9 20 1. 1.E+6 30 '

Using the composition from zone *JJ*, a table of EOS and opacity information is written into the normal ASCII output file for a logarithmic grid of temperatures (from *TLOW* to *THI* with *NTEMP* + 1 grid points) and densities (from *DLOW* to *DHI* with *NRHO* + 1 grid points). Here *TLOW* and *THI* are in degrees K and *DLOW* and *DHI* are in g/cc.

EOSTRANS *TRANSMULT*

' eostrans 1. '

Add *TRANSMULT* times the energy in nuclear excited states to all zonal specific energies. Useful in certain EOS transitions.

EOSWRITE *JTAB* *JJ* *NTEMP* *NRHO* *NEOSM*

' eoswrite 626 1 20 30 10 '

This command writes an EOS table identified by EOS # *JTAB* based on the composition of zone *JJ*, and having *NTEMP* temperature points and *NRHO* density points. This file is written after the last entry in ASCII file EOSKEP. If file EOSKEP does not exist, it is created with a sufficiently large size to contain *NEOSM* table sets. Before the **EOSWRITE** command is used, the *TZ* array must be set by the **TVAL** command so that it contains the *NTEMP* temperature points (in keV), immediately followed by the *NRHO* density points (in g/cc). *NRHO* and *NTEMP* can sum to at most *NTEMPZ* (a parameter in **KEPCOMS** currently set to 60).

WARNING, WARNING, WARNING.....this command is no longer supported -- see version .tw:kepn:kepn3/25 for the old coding if you want to try to revive it, but see **EOSTABLE** first.

Other Ascii-Output-File Edit Commands (Cont.)

LINKEDIT

Make an ascii file containing terse information on structure and composition, e.g. for linking a presupernova model to Wilson (or others). File name will be in the form probname@cyclenumber.

TVAL *N VAL1 [VAL2 VAL3 VAL10]*

' tval 1 .1 .3 1. 3. 10. 30. 100. '

This command sets values in the temporary array TZ such that TZ(*N*), TZ(*N* + 1),etc. are respectively reset to VAL1, VAL2,...etc. At least one, and up to 10 values may be specified on each line. This command can be used (repeatedly if necessary) to set or change the TZ array so that it contains the *NTEMP* EOS table temperature points (in keV), immediately followed by the *NRHO* density points (in g/cc) required to specify EOS tables. (See the **EOSWRITE** command). Attempts to write beyond TZ(*NTEMPZ*), where *NTEMPZ* is a parameter currently set to 60, will generate an error message. Note that this information is not saved in the restart dump.

WARNING, WARNING, WARNING.....this command is no longer supported -- see version .tw:kepn:kepn3/25 for the old coding if you want to try to revive it, but see **EOSTABLE** first.

VED EDITVAR [JMIN [JMAX]]

' ved ionye 1 100 '

This command makes an ASCII-output-file edit of the zonal edit variable denoted by *EDITVAR* from zones *JMIN* to *JMAX*, inclusive. If only *JMIN* is specified, *JMAX* is assumed = *JMIN*. If neither *JMIN* or *JMAX* is given, then *JMIN* = 1 and *JMAX* = *JM*, the index of the current outer zone. A detailed list of the allowed edit variables and their corresponding values of *EDITVAR* is given in Chapter 7.

VEDF EDITVAR [JMIN [JMAX]]

' vedf ionye 1 100 '

Same as the **VED** command except that edited values are given to 14 decimal places instead of 3.

ZED EDITVAR1 [EDITVAR2....EDITVAR10] [JMIN [JMAX]]

' zed dn tn sigi sigi sigr 1 100 '

This command makes a columnar zonal edit of arrays *EDITVAR1* through *EDITVAR10* (if requested) for zones *JMIN* through *JMAX* in the current ASCII-output file. If only *JMIN* is specified, *JMAX* is assumed = *JMIN*. If neither *JMIN* or *JMAX* is given, then *JMIN* = 1 and *JMAX* = *JM*, the index of the current outer zone. A detailed list of the allowed edit variables and their corresponding

Other Ascii-Output-File Edit Commands (Cont.)

values of *EDITVAR* is given in Chapter 7. The first column in the edit gives the convection sentinel and the zone number, while the second column lists the interior mass in SCALEM (P 273) units. Values of the requested arrays start in column 3. At least one array must be requested, up to a maximum of 10. Note that 5 array requests fit nicely in an 80-column screen window, while 10 fill a 132 column edit page.

```
ZEDIT IZED NCYCZED EDITVAR1 [EDITVAR2....EDITVAR10] [ ZEDMASS1 [ZEDMASS2]]
' zedit 1 50 dn tn sige sigi sigr 0. 2.'
```

This command causes a special multiple column ASCII edit of the specified zonal edit variables (*EDITVAR1*, etc.) to be written every *NCYCZED* cycles. A detailed list of the allowed zonal edit variables and their corresponding values of *EDITVAR* is given in Chapter 7. Here *IZED* is an index number (max of NZEDZ, which currently is 30 -- see KEPCOMS) that distinguishes separate **ZEDIT** requests, and *ZEDMASS1* and *ZEDMASS2* specify an optional interior mass range (in SCALEM (P 273) units) to be edited. If only *ZEDMASS1* is specified, a $\pm 1\%$ range around it is edited, and if no masses are specified, an edit of the whole star is made. Previously specified edits can be changed or terminated by overwriting them with a new **ZEDIT** command with the same index number. (Note: setting *NCYCZED* = 0 terminates the edit.)

GRAPHICS EDIT COMMANDS

ADDISO ISOSYM1 [ISOSYM2 ... ISOSYM50]

‘ addiso h1 he4 c12 o16 mg25 al26 ’

This command adds the detailed isotopic abundances listed to those to be plotted by the "plot 6" or "look 6" commands. At least 1 and no more than 50 isotopic symbols (isosym1...isosym20) must be specified in the form: "addiso h1 he4 c12 o16 mg25 al26"

LISTISO

List the current set of isotopes to be plotted as set by the SETISO command.

LOOK NPLOT NCYCLO [NCYCLI [NDELCYCL]]

L NPLOT NCYCLO [NCYCLI [NDELCYCL]] (Alternate form)

‘ look 31 10000 15000 1000 ’

This command makes a movie of plot type *NPLOT* starting as closely as possible to cycle *NCYCLO* and ending as closely as possible to cycle *NCYCLI* at intervals as close as possible to *NDELCYCL* using information from the qq-files specified by SETQ or (by default) those available for the current problem. Plot types and output modes are as specified in the PLOT command and by the values of ITVSTART (P 127). Plot limits are assumed the same as those displayed for the current cycle by PLOT for this plot type, and can be adjusted using the usual graphics parameters (see Chapter 3). If not specified, *NCYCLI* is assumed to be equal to *NCYCLO*, and *NDELCYCL* is assumed to be the cycle interval between post-processor dump writes multiplied by IDTLOOK (P 302).

LPRINTL NPLOT NCYCLO [NCYCLI [NDELCYCL]] [FILENAME]

LPL NPLOT NCYCLO [NCYCLI [NDELCYCL]] [FILENAME] (Abbreviated form)

‘ lpl 3 10000 15000 1000 s25n2a.abun ’

Make a Postscript plot of plot-type *NPLOT* at cycle *NCYCLO* in landscape orientation on the local laser printer, where *NPLOT* is as defined in the plot command and use is made of information from the qq-files specified by SETQ or (by default) those available for the current problem. If a *FILENAME* is specified, then the picture is also saved in a Postscript file with that name. If *NCYCLI*, or both *NCYCLI* and *NDELCYCL*, are given (before *FILENAME*, if any is specified), then a series of prints will be produced starting at ‘look’ cycle *NCYCLO* and continuing to ‘look’ cycle *NCYCLI* at intervals of *NDELCYCL*. A ‘:’ followed by the current ‘look’ cycle number will be appended to the *FILENAME* specified (but limited to a total of 16 characters).

Graphics Edit Commands (Cont.)

LPRINTP *NPLOT* *NCYCLO* [*NCYCLI* [*NDELCYCL*]] [*FILENAME*]
LPP *NPLOT* *NCYCLO* [*NCYCLI* [*NDELCYCL*]] [*FILENAME*] (Abbreviated form)
 'lpp 3 10000 15000 1000 s25n2a.abun'

Make a Postscript plot of plot-type *NPLOT* at cycle *NCYCLO* in portrait orientation on the local laser printer, where *NPLOT* is as defined in the plot command and use is made of information from the qq-files specified by *SETQ* or (by default) those available for the current problem. If a *FILENAME* is specified, then the picture is also saved in a Postscript file with that name. If *NCYCLI*, or both *NCYCL1* and *NDELCYCL*, are given (before *FILENAME*, if any is specified), then a series of prints will be produced starting at 'look' cycle *NCYCLO* and continuing to 'look' cycle *NCYCLI* at intervals of *NDELCYCL*. A ':' followed by the current 'look' cycle number will be appended to the *FILENAME* specified (but limited to a total of 16 characters).

MAPLIM [*VMINMAP* *VMAXMAP* [*VRATMAP*]]
 'maplim 7. 9. 1.e-5'

This command defines the limits of the timemap variable by setting the values of parameters *VMINMAP* (P 328), *VMAXMAP* (P 329), and *VRATMAP* (P 330). If no arguments are given, the entire range of the variable is mapped. If the specified values of *VMINMAP* and *VMAXMAP* are equal, they are reset to 1.E+99 and -1.d+99, respectively, resulting in the actual range of the variable being limited only by *VRATMAP* (see P 328 - 330).

MLIM [*YMLOW* *YMHI*]
MLIM ['OLD']

'mlim 2.1 10.'
 'mlim old'

Set lower and upper limits on the mass coordinate used in making plots and timemaps to *YMLOW* and *YMHI* (in units of solar masses). This is accomplished by resetting *YPLOTMIN* (P 134) to *YMLOW**1.9892d+33/TOTM and *YPLOTMAX* (P 135) to *YMHI**1.9892d+33/TOTM. If no arguments are given, or if *YMLOW*=*YMHI*, then *YPLOTMIN* is set to 0. and *YPLOTMAX* is set to 1. If the second argument is the flag 'old' then the previous values of *YPLOTMIN* and *YPLOTMAX* are restored.

Graphics Edit Commands (Cont.)

MONGO *EDITVAR2* [*EDITVAR3... EDITVAR8*] [*AXISY2* [*AXISY3*]]

MON *EDITVAR2* [*EDITVAR3... EDITVAR8*] [*AXISY2* [*AXISY3*]]

(Abbreviated form)

'mon dn tn log lin '

This command makes an X-Window plot of the first two zonal edit variables listed (*EDITVAR2* and *EDITVAR3*) vs. the mass coordinate specified by the value of parameter *IRTYPE* (P 132). It leaves the user in interactive **MONGO**, where he or she may modify or print the graph before typing 'end' to return to **KEPLER**. Note that either *ITVSTART* must be set to 1 or an X Graphics Window for **KEPLER** must already be open (e.g., as a result of the **PLOT** command) for this command to have any effect. The mass coordinate is loaded into **MONGO** data column 1, and the corresponding values of each zonal edit variable, *EDITVARI*, is loaded into **MONGO** data column *I*.

At least one, and no more than seven zonal edit variables (*EDITVAR2* thru *EDITVAR8*) must be specified from the list given in Chapter 7.

On entry into **MONGO**, graphs of the first one or two (if specified) variables are made automatically vs. the specified mass coordinate. The range of mass coordinate plotted is controlled by *YPLOTMIN* (P 134) and *YPLOTMAX* (P 135) which are the innermost and outermost mass fractions to plot. For most quantities, the ordinate is logarithmic by default (with negative data values, or a small range of values, defaulting the plot instead to linear), but can be set explicitly by setting *AXISY2* and/or *AXISY3* to 'lin' or 'log'. The code assumes that one 'lin' or 'log' value appended to the command line (after at least one *EDITVARI*) refers to *AXISY2*, the flag for plotting *EDITVAR2*. If two 'log' or 'lin' values are appended, they are interpreted as *AXISY2* and *AXISY3*, the flags for plotting *EDITVAR2* and *EDITVAR3*, respectively. The flag 'same' can also be used as the last word on the command line in order to set the axis type for plotting *EDITVAR3* to be the same as for *EDITVAR2*, except that the axis limits are expanded to cover the extremes of both variables. The 'same' flag can be preceded by at most one 'lin' or 'log' flag specifying the common axis type. If an axis type is not given, a default value is chosen according to the character of the data.

Once in interactive **MONGO**, you can (among other things):

Type 'curses' to get mouse coordinate display, corresponding to the values of the last-defined axes.

Type 'help' to get a list of interactive mongo commands.

Type the command sequence: 'psland filename', 'play', 'hard' to get a postscript file named filename containing the currently displayed plot. File filename must not already exist.

Type 'end' to quit interactive **MONGO**.

Graphics Edit Commands (Cont.)

MONPL ARRAYNAME2 ARRAYNAME3 ... ARRAYNAME8 [AXISY2 AXISY3]

Like the 'MONGO' command described above, except that the requested plot is printed in landscape mode on the local laser printer and MONGO quits, instead of the plot being displayed in an x-window and MONGO left in interactive mode.

MONPP ARRAYNAME2 ARRAYNAME3... ARRAYNAME8 [AXISY2 AXISY3]

Like the 'MONGO' command described above, except that the requested plot is printed in portrait mode on the local laser printer and MONGO quits, instead of the plot being displayed in an x-window and MONGO left in interactive mode.

PLOT *NPLOT*

'plot 31'

This command makes an X-Window plot of the status of the current problem of the type specified by plot number *NPLOT*. Note that either ITVSTART (P 127) must be set to 1 or an X Graphics Window for KEPLER must already be open (e.g., as a result a previous **PLOT** command) for this command to have any effect. Currently allowed values of *NPLOT* are the same as those allowed for parameter IPIXTYPE (P 113) and produce the same types of plots:

<0 graphics window is not updated, but is still open.

=0 only header info is displayed.

=1 thermodynamics graph only.

=2 velocity graph only.

=3 elemental ('ion') mass-fraction graph only.

=4 entropy graph only.

=5 density-temperature graph only.

=6 isotopic mass-fraction graph (use the **SETISO** command first to determine the ions to be displayed).

=7 thru 9: only header info is displayed.

=10 thru 99: Two graphs will be displayed in split-screen fashion with the type of the top graph determined by the value of the first digit and the type of the second graph determined by the value of second digit as specified above.

Graphics Edit Commands (Cont.)

PRINTL [*NPLOT* [*FILENAME*]]

PL [*NPLOT* [*FILENAME*]] (Abbreviated form)

'pl 31 k'

This command makes a Postscript plot of the current problem status in landscape orientation on the local laser printer where *NPLOT* is the plot type defined in the same way as in the **PLOT** command. If *NPLOT* is not specified, it is taken to be *IPIXTYPE* (P 113). If *FILENAME* is specified, the picture is also saved in a Postscript file with that name (note that *NPLOT* must also be specified in this case). If 'k' is given for *FILENAME*, a new file-name is generated automatically in the form *NAMEPROB:NCYC*, where *NAMEPROB* is the current problem name and *NCYC* is the current cycle.

PRINTP [*NPLOT* [*FILENAME*]]

PP [*NPLOT* [*FILENAME*]] (Abbreviated form)

'pp 31 k'

This command makes a Postscript plot of the current problem status in portrait orientation on the local laser printer where *NPLOT* is the plot type defined in the same way as in the **PLOT** command. If *NPLOT* is not specified, it is taken to be *IPIXTYPE* (P 113). If *FILENAME* is specified, the picture is also saved in a Postscript file with that name (note that *NPLOT* must also be specified in this case). If 'k' is given for *FILENAME*, a new file-name is generated automatically in the form *NAMEPROB:NCYC*, where *NAMEPROB* is the current problem name and *NCYC* is the current cycle.

SETISO *ISOSYM1* [*ISOSYM2* ... *ISOSYM50*]

'setiso h1 he4 c12 o16 mg25 al26'

This command sets the detailed isotopic abundances to be plotted by the 'PLOT 6' or 'LOOK 6' commands. At least 1 and no more than 50 isotopic symbols (*ISOSYM2* ... *ISOSYM20*) must be specified from the set of current BURN isotopic symbols (see Chapter 7 for the usual list).

SETLIB [*NAMETLIB* [*NCYCT0* [*NCYCT1* [*NCYCTDEL* [*NCYCQQT* [*LENTDMPT* [*NIYMAXT*]...]

'setlib s25s2a.lib 0 18345 10 5 384 20000'

This command sets the dump library file and associated parameters to be used in making time-plots. The optional arguments (and their default values if not specified) are defined as follows:

NAMETLIB..... Name of desired dump library file. The default is the one for the current job.

NCYCT0..... First dump cycle to be read and plotted. (Default is 0)

NCYCT1..... Last dump cycle to be read and plotted. (Default is last cycle in dump library)

NCYCTDEL..... The interval in dump cycles between dump library reads. (Default is *NCYCQQ*)

Graphics Edit Commands (Cont.)

NCYCQQT..... Number of cycles between dump library dumps. (Default is *NCYCQQ*).

LENDMPT..... Length of each time dump in *NAMETLIB*. (Default is 384)

NIYMAXT..... Maximum number of IY coordinate values in *NAMETLIB*. (Default is 20000)

IF *SETLIB* is not called, the default values are set when *TIMEPLOT* or *TP* is first called. Calling *SETLIB* without arguments resets all these variables to their default values if they have previously been changed by a *SETLIB* command.

SETQ [*NAMEQQLO* [*NAMEQQLI*]]

'setq s25s2a.qa s25s2a.qk'

This command sets the names of the qq-files to be post-processed by other commands such as *LOOK*, *LPRINT*, etc., where *NAMEQQLO* and *NAMEQQLI* are the first and last members of the sequence of qq-files to be read. Used without arguments, *SETQ* implies that all the qq files for the current problem in the current working directory are to be used. Note that this is the default situation for most post-processing commands and that *SETQ* only has to be used in this mode to restore the specified qq-files to this default. If only *NAMEQQLO* is specified, all available qq-files in the sequence starting with *NAMEQQLO* will be read. Note that qq-file names can be up to 16 characters long (at least on UNIX machines) and need not be those generated by the current problem.

TIMEMAP NAMEVAR [*LOGFLAG* [*NCYCLO* [*NCYCLI* [*NDELCYCL*]]]]

TM NAMEVAR [*LOGFLAG* [*NCYCLO* [*NCYCLI* [*NDELCYCL*]]]] (Abbreviated form)

'timemap convect lin 0 18750 1'

This command makes a space-time map for zonal edit variable *NAMEVAR* starting as closely as possible to cycle *NCYCLO* and ending as closely as possible to cycle *NCYCLI*. It uses information from the qq-files specified by *SETQ* or (by default) those available for the current problem. *LOGFLAG* can be given as either 'log' or 'lin' to specify the desired scaling for the variable being displayed. The mass coordinate axis type and limits is set by the same parameters as for normal KEPLER plots. (See the comments for the timemap routine for other relevant input parameters). If not specified, *NCYCLI*, is assumed to be the last cycle for which information is available in the qq-files specified by *SETQ*, and *NDELCYCL* is assumed to be the cycle interval between post-processor dump writes multiplied by *IDTLOOK* (P 302). If a colormap whose name is in the form, *NAMEVAR.map* (e.g. 'convect.map'), is available in the local directory (or as a second alternative, is in the directory */usr/local/map*), it will be used to make the plot. Otherwise a simple default rainbow-style map, */usr/local/map/spectral.map*, will be used. After the plot is made, the user can manipulate it further (including changing to a new variable and/or color map) by using the menus

displayed when the right mouse button is depressed. Depressing the left mouse button displays an overlay rectangle that can be positioned and/or stretched to indicate a time-space region to zoom into and replot. WARNING....This command currently only works on a Silicon Graphics terminal.

TIMEPLOT *TIMEVAR2 TIMEVAR3...TIMEVAR8* [*AXISY2 AXISY3*]

TP *TIMEVAR2 TIMEVAR3...TIMEVAR8* [*AXISY2 AXISY3*] (Abbreviated form)

'timeplot eni enk enp log same'

This command makes an X-Window plot of the first two time-edit variables listed (*TIMEVAR2* and *TIMEVAR3*) vs. the time coordinate specified by the value of MAPTIME (P 327). It leaves the user in interactive MONGO, where he or she may modify or print the graph before typing 'end' to return to KEPLER. Note that either ITVSTART must be set to 1 or an X Graphics Window for KEPLER must already be open (e.g., as a result of the PLOT command) for this command to have any effect. Unless a SETLIB command has previously been issued to the contrary, the time histories for these variables are read from the '.lib' file for the current problem for the entire range of available cycles. The time coordinate is loaded into MONGO data column 1, and the corresponding time sequence for each timeplot variable, *TIMEVARI*, is loaded into MONGO data column *I*.

At least one, and no more than seven time-edit variables (*TIMEVAR2* thru *TIMEVAR8*) must be specified from the list given in Chapter 8.

The range of the time coordinates plotted is controlled by TIMECMIN (P 321) and TIMECMAX (P 322) and defaults to the entire available range. For most quantities, the ordinate is logarithmic by default (with negative data values or a small range of values defaulting the plot instead to linear), but axis type can be set explicitly by setting *AXISY2* and/or *AXISY3* to 'lin' or 'log'. The code assumes that one 'lin' or 'log' value appended to the command line (after at least one *TIMEVARI*) refers to *AXISY2*, the flag for plotting *TIMEVAR2*. If two 'log' or 'lin' values are appended, they are interpreted as *AXISY2* and *AXISY3*, the flags for plotting *TIMEVAR2* and *TIMEVAR3*, respectively. The flag 'same' can also be used as the last word on the command line in order to set the axis type for plotting *TIMEVAR3* to be the same as for *TIMEVAR2*, except that the axis limits are expanded to cover the extremes of both variables. The 'same' flag can be proceeded by at most one 'lin' or 'log' flag specifying the common axis type. If an axis type is not given, a default value is chosen according to the character of the data.

Once in interactive MONGO, you can (among other things):

Type 'curses' to get mouse coordinate display, corresponding to the values of the last-defined axes.

Type 'help' to get a list of interactive mongo commands.

Type the command sequence: 'psland filename', 'play', 'hard' to get a postscript file named *filename* containing the currently displayed plot. File *filename* must not already exist.

Type 'end' to quit interactive MONGO.

Graphics Edit Commands (Cont.)

TPPL *TIMEVAR2 TIMEVAR3 ... TIMEVAR8 [AXISY2 AXISY3]*

Like the 'TIMEPLOT' command described above, except that the requested plot is printed in landscape mode on the local laser printer and MONGO quits, instead of the plot being displayed in an x-window and MONGO left in interactive mode.

TPPP *TIMEVAR2 TIMEVAR3 ... TIMEVAR8 [AXISY2 AXISY3]*

Like the 'TIMEPLOT' command described above, except that the requested plot is printed in portrait mode on the local laser printer and MONGO quits, instead of the plot being displayed in an x-window and MONGO left in interactive mode.

TLIM *[TIMECMIN TIMECMAX]*

TLIM *['OLD']*

' tlim -15.3 -10. '

' tlim old '

Set limits on the time coordinate used in making timeplots and timemaps by resetting the values of TIMECMIN (P 321) and TIMECMAX (P 322) to the specified values. If no arguments are given or if TIMECMIN = TIMECMAX, then all available time points are plotted. Note that time-coordinate units are specified by MAPTIME (P 327) and must be floating point numbers. If the second argument is the flag 'old' then the previous values of TIMECMIN (P 321) and TIMECMAX (P 322) are restored.

YLIM *[Y2LOWMON Y2HIMON [SAME]]*

YLIM *[Y2LOWMON Y2HIMON [Y3LOWMON Y3HIMON]]*

' ylim 3. 5. '

' ylim 3. 5. same '

' ylim 3. 5. 0.44 0.5 '

This command sets the y-axes limits on MONGO plots. *Y2LOWMON* and *Y2HIMON* are the lower and upper limits for the variable plotted on the left-hand y-axis, while *Y3LOWMON* and *Y3HIMON* are the lower and upper limits for the variable plotted on the right-hand y-axis. If no arguments are specified for a given axis, or if their high and low values are equal, then the entire range of the corresponding variable will be plotted. If the flag 'same' is specified in place of the right-hand y-axis limits, they will be set to be the same as for the left-hand y-axis.

SPECIAL PURPOSE COMMANDS

ADDATMOS NATMOS RHOATM1 [TEMPATM]

' addatmos 10 3.e-12 '

Add an isothermal, exponential atmosphere to the surface of the star consisting of *NATMOS* zones and extending out to a density of *RHOATM1* (g/cc). The atmospheric conditions are scaled from the surface gravity, density, temperature and radius of the outer zone. The atmosphere is assumed to be thin (slab-like) compared to the star's radius and its composition is taken to be the same as that of the outer zone. If *TEMPATM* (degK) is specified, it is used instead of the temperature of the outer zone in constructing the atmosphere.

ADDLOOK EDITVAR [DELFLAG]

' addlook sneut delete '

Add zonal edit variable *EDITVAR* to the list of ('look') variables that subroutine READQ reads from the qq dump files. *DUMPVAR* may be any zonal edit variable listed in Chapter 7. If the second argument is present and is equal to 'delete', then variable *EDITVAR* is instead deleted from the list of look variables. Note that all current commands such as PLOT automatically load their own 'look' lists and then return the list to its original state when they're finished. Future commands, however, may require the use of ADDLOOK.

ADDSURF NSURF TMSURF TEMPSURF RHOSURF VELSURF

' addsurf 10 1.E+32 1.E+4 1.E-11 0. '

Add *NSURF* zones of equal mass totaling *TMSURF* total mass (g) with temperature, *TSURF* (K), density, *RHOSURF* (g/cc), velocity, *VELSURF* (cm/s), and the composition last specified by the COMPSURF command. Note that each time ADDSURF is called, the sum of the mass fractions in the COMPSURF array is normalized to unity.

ALIAS NAMEA "COMMAND-STRING"

' alias t1 "tq, 1, 1 i" '

Define alias *NAMEA* to invoke the command string *COMMAND-STRING*. *COMMAND-STRING* must be enclosed in double quotes and be less than 71 characters long. The command string may be a series of comma-delimited TTY commands. Note that the entire alias command may not exceed 80 characters and may not, itself, be comma-delimited. There is a limit of 200 (parameter NCSAVEDZ) total aliases.

Special Purpose Commands (Cont.)

BOX BOX#

'box v98'

Change the output box number to *BOX#* (three character symbol).

ADDWIND NWIND WINDMASS RATEWIND VELWIND [VESCMULT[TEFFWIND[RADPWIND]]]

'addwind 5 1.0e-5 1.e-4 10. 1. 3.098e+3 3.443e+13'

Add *NWIND* zones of equal mass totaling *WINDMASS* (Msun) with mass-loss rate *RATEWIND* (Msun/year), terminal velocity *VELWIND* (km/s). Optional inputs are the escape-velocity multiplier *VESCMULT* (default=1.) and the effective photospheric temperature *TEFFWIND* (degK) and radius *RADPWIND* (cm) used in generating the wind profile. The mass-loss rate is assumed to stay constant at *RATEWIND* during the time these zones "took" to leave the surface of the star, and the velocity at any point is the sum of the local escape velocity times *VESCMULT* and the wind's terminal velocity *VELWIND*. The wind's local temperature is calculated by assuming that it is in LTE with the photosphere specified by *TEFFWIND* and *RADPWIND*. If no explicit values of these photospheric variables are given, they default to the existing photospheric temperature (*TEFF*) and radius (*RADIUS*). The composition of the wind is taken to be the same as that of the outer zone. Note that several *ADDWIND* commands can be used in succession to build up a wind with a time-dependent mass-loss rate, or to achieve non-constant-mass zoning.

CHECK

Type out the number of errors (*NIOERR*) the code has encountered sending out ASCII output files since the last restart. This command is only meaningful on a CRAY computer.

CHNGCOMP JMIN JMAX FIRSTION# MFRAC1 [MFRAC2 MFRAC8]

'chngcomp 20 10 1 0. 0. 0. 0. 0. .5 0. .5'

Change the composition in zones *JMIN* through *JMAX* to the ion mass fractions specified. At least one and up to eight mass fractions can be given on each command line. The compositions changed begin with that of the ion corresponding to ion number *FIRSTION#* and continue on in ion number order. For the APPROX network, the ion numbers correspond to: neutrons[1], H1 [2], photodisintegration protons [3], He3 [4], He4 [5], C12 [6], N14 [7], O16 [8], Ne20 [9], Mg24 [10], Si28 [11], S32 [12], Ar36 [13], Ca40 [14], Ti44 [15], Cr48 [16], Fe52 [17], Fe54 [18], and Ni56 [19]. (see Chapter 7 for the ion types and numbers in the ISE and NSE networks.) Repeated use of this command can set all the elements in the *XNWCOMP* array in subroutine *TTYCOM* (which is then used to change the zonal abundances). Mass fractions will be renormalized to sum to unity, and the

Special Purpose Commands (Cont.)

equation of state will be recomputed for the new composition. WARNING --Non-specified abundances are given whatever garbage values may have initially been in XNWCOMP, and multiple use of this command is complicated by the fact that the mass fractions of the current contents of the XNWCOMP array are renormalized to unity after *each* use. All old abundance information from these zones is disregarded. Check zonal compositions afterwards using the "J I" command.

CAUTION

Radically altering the composition in any zone may cause discontinuous changes in its internal energy, pressure, etc. and lead to convergence problems. Take special care in degenerate cases. The NEWE command may be useful here. Note: The user takes full responsibility for any misleading and/or unphysical results that may be produced due to the use of this command.

```
COMPSURF FIRSTION# MFRAC1 [ MFRAC2 MFRAC3 ..... MFRAC10 ]
'compsurf      1      0.      .7      0. 0. .28 0. .02'
```

Starting with its *FIRSTION#* th entry, set the values of the COMPSURF array in KEPCOMS equal respectively to *MFRAC1*, *MFRAC2*, *MFRAC3*, etc. At least one, and up to 10 such values can be given on each command line. Repeated use of this command can thus set all the elements of the COMPSURF array. These elements represent respectively the mass fractions of neutrons[1], H1 [2], photodisintegration protons [3], He3 [4], He4 [5], C12 [6], N14 [7], O16 [8], Ne20 [9], Mg24 [10], Si28 [11], S32 [12], Ar36 [13], Ca40 [14], Ti44 [15], Cr48 [16], Fe52 [17], Fe54 [18], and Ni56 [19] that are used to set the composition of the surface zones added by the ADDSURF command. Note that this array is stored in the restart dump for later use.

```
CUTSURF NSURF
```

```
'cutsurf      3'
```

Remove *NSURF* zones from the surface of the star. PBOUND (P 69) and TBOUND (P 68) are automatically reset to correspond to the innermost zone removed. This option is sometimes useful in removing essentially "frozen" outer layers of the star so that available zones can be concentrated on core processing or to remove high velocity surface zones that are trying to form a stellar wind.

DECAYNI

Convert all Ni56 to Fe54 in such a way as to conserve mass, but with no energy generation.

Special Purpose Commands (Cont.)

DET JDETO JDETI ENDET

'det 1 30 7.867E+17'

Add *ENDET* ergs/g to the specific energies of zones *JETO* to *JDETI*, inclusive, to simulate the passage of a detonation wave through these zones. Also change detonated zones to Ni56. This command should be used only for zones using the APPROX network, and is normally used in conjunction with setting *TIMEX0* (P 38) to the current problem time (*TIME*, P 2), so that the decay energy from this "newly formed" Ni56 is appropriately deposited in the star (see P 38).

DUMP DUMPVAR RATZDUMP RATIODEZ RATIOADZ

'dump convect .1 -1. 0.'

Add dump variable *DUMPVAR* to the list of variables to be dumped to the qq post-processor dump file or change its dump parameters if it is already in the dump list. *DUMPVAR* may be any zonal edit variable listed in Chapter 7, and in addition it may take the values:

parm -- to dump the values of the changeable ('p') parameters, or

qparm -- to dump the values of the edit ('q') parameters.

The associated dump parameters which must be given for each variable are:

RATZDUMP -- the maximum allowed fractional change between dumps of the specified zonal dump variable.

RATIODEZ -- the minimum fractional change of this zonal dump variable allowed between two adjacent dump grid points before the dump grid for the variable is dezoned.

RATIOADZ -- the maximum fractional change of this zonal dump variable allowed between two adjacent dump grid points before the dump grid for the variable is adzoned.

In the case of **parm** and **qparm** the values of **RATIOADZ** and **RATIODEZ** are ignored but must be given. Note that the **DUMP** command for new variables is usually given in the problem generator file (see Chapter 2).

GENBURN NAMEBG

'genburn sol160bg'

Read *BURN* generator, *NAMEBG*, and begin *BURN* co-processing. Note that this command is usually given in the problem generator file (see Chapter 2).

LINK NAMELINK

'link linkwlsn'

Read and execute the *LINK* file named *NAMELINK*. The link file contains the information

Special Purpose Commands (Cont.)

needed to link the results of specialized core collapse calculations or parameterized models back to KEPLER in order to follow the subsequent explosion and nuclear processing. See the LINK subroutine and Chapter 6.

LISTA

List all aliases, including those not yet defined (which are denoted by "null").

MIX NZMIN NZMAX DELMASS

' mix 293 507 0.5 '

Mix composition outwards starting with zone *NZMIN* and ending with zone *NZMAX* in mass increments of *DELMASS* (solar masses). Reset the equation of state in mixed zones. Used for light-curve calculations to simulate Rayleigh-Taylor mixing.

NEWDUMPS

Reset all dump-file names and delete all old dump variables.

NEWE

Calculate new internal energies from current densities and temperatures. This is *usually* wise when changing EOS's in the middle of a problem via code modifications or changing EOS parameter settings. Note that total energies are also readjusted so that the resulting "virtual" energy nonconservation is not reflected in the energy edits.

NEWQNAME

Reset the names of the expected qq-file and qlib-file to reflect the current problem name.

NEWSTART

Reinitialize the problem by making an edit and restart dump of the current status of the problem, putting out output files, and storing dumps. This command is obsolescent and should not be used on UNIX machines without careful checking of the coding involved.

STORE NSDIRECT

' store /usr/leo/weaver/s25s2a '

Set the directory into which ASCII output files and labeled restart dumps will be written to *NSDIRECT*. If *NSDIRECT* is set to **'no-store'** (the default), output files will be placed in the current

Special Purpose Commands (Cont.)

working directory. The name of *NSDIRECT* may be up to 48 characters long.

SYSTEM "COMMAND-STRING"

' system "cd /usr/leo/weaver" '

Execute the system command, *COMMAND-STRING* (which must be enclosed in double quotes and be less than 72 characters long). Note that the entire system command may not exceed 80 characters and may not, itself, be comma-delimited.

UNALIAS NAMEA

' unalias t1 '

Remove the previously defined alias *NAMEA*. If *NAMEA* is "all", then all aliases are removed, including those defined in the generator.

ZEROTIME

Set the problem time, *TIME* (P 2), to 0. Add the old value of *TIME* to *TOFFSET* (P 315). Also reset the *timen* array and take a small time step if *BURN* co-processing is being done.

Special Purpose Commands (Cont.)

working directory. The name of WSDIRECT may be up to 48 characters long.

SYSTEM "COMMAND-STRING"

"system" "ed justifier/weaver"

Execute the system command. COMMAND-STRING (which must be enclosed in double quotes and be less than 73 characters long). Note that the entire system command may not exceed 80 characters and may not itself be comma-delimited.

UNALIAS NAMEA

"unalias" "all"

Remove the previously defined alias NAMEA. If NAMEA is "all", then all aliases are removed, including those defined in the generator.

ZERO TIME

Set the problem time, TIME (P 3) to 0. Add the old value of TIME to TOPSET (P 312). Also reset the timer array and take a small time step if BURN co-processing is being done.

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CHAPTER 6

LINK INPUT FILE

LINK input files allow information derived from other codes (especially detailed core collapse calculations) or from parameterized models to be introduced into KEPLER. Typically this information specifies that a certain mass at the center of the star is to be removed and replaced with a time dependent inner boundary condition whose motion and neutrino emission acts like a "piston" to explode the outer layers of the star. The format conventions in LINK file command lines (called "cards" for historical reasons) and those for generator cards are identical (see Chapter 2).

A link input file named *NAMELINK* is read into KEPLER when the command **LINK *NAMELINK*** (e.g.: 'link linkwlsn ') is issued from the terminal (see Chapter 5). Allowed LINK file cards are listed below.

LINK INPUT CARDS

CUT *JCORE***'cut 57'**

Core Cut Card (optional).

Remove the inner *JCORE* zones from the center of the star. Add their mass to SUMM0 (P 61), the boundary condition parameter giving the mass inside the inner boundary of the calculation.

APPROX *JLO JHI***'approx 1 9'**

APPROX Network Card (optional).

Change zones between *JLO* and *JHI* to the APPROX network (if not already using it). The code

assumes that non-APPROX zones are either NSE or ISE zones and repacks the abundance array appropriately to put it into APPROX format. Since the ISE abundance array does not store information on (the usually very small) abundances of ions *h1*, *he3*, *c12*, *n14*, and *ne20*, these end up being zeroed in going to APPROX. Also, isotopes more neutron rich than ^{54}Fe (e.g. ^{56}Fe) are stored as *fe52* in such a way as to conserve mass (but not Y_e -- also see the "YESET" command below). This command should not be used (or be rewritten) if the resulting abundance of "fe52" is significant. In its current form, it is intended to be used to transform relatively unneutronized zones containing newly synthesized ^{56}Ni and/or ^{54}Fe which the APPROX network is able to deal with sensibly. Remember to turn on low-temperature ^{56}Ni decay (if desired) by resetting TIMEX0 (P 38), and, if desired, TIME (P 2).

PST *TIME(I)* *INNER-RADIUS(I)*

‘ pst 0. 1.0072e+7

 pst 1.e+10 1.0072e+7 ’

Piston Cards (Optional, but at least two required if any are specified).

This card specifies the radius of the inner boundary of the problem, *INNER-RADIUS(I)*, in cm at time, *TIME(I)*, in seconds. A series of such cards with monotonically increasing values of *TIME(I)* are used to build up a discrete time history of the inner problem boundary, which the code uses to get intermediate values by interpolation. If the *INNER-RADIUS(I)* given is 0., this serves as a flag for the code to reset its value to RADIUS0 (P 60), so that a higher precision value can be given. This is sometimes useful in treating compact configurations such as surface layers on neutron stars. The range of times covered must exceed the range of times for which the problem is to be run and at least two piston cards must be specified. The code does not remember data from "PST" cards in any previously read LINK decks, but *does* remember this current "PST" data in restart dumps. Currently, a maximum of NPISTZ = 300 "PST" cards are allowed. (Here, NPISTZ is a FORTRAN parameter set in KEPCOMS).

NFLUX *TBOUNCE* *FLUXNU0* *A0* *CHI0* *A1* *CHI1* *A2* *CHI2*

‘ nflux 0.21569 9.e+24 2.5e-8 8.0e+7 0.25e-8 8.0e+8 0.4e-8 2.2e+9 (typical) ’

‘ nflux 0.223 0. 0. 0. 0. 0. 0. 0. (no flux) ’

Neutrino Flux Card (optional).

This card contains the fitting coefficients for the "reduced" neutrino momentum flux, FLUXNU, in the form:

$$\text{FLUXNU}(\text{TIME}, \text{R0}) = \text{FLUXNU0} / ((1. + \text{EXP}(-\text{A0} * (\text{CHI} - \text{CHI0}))) *$$

$$(1. + \text{EXP}(-A1 * (\text{CHI} - \text{CHII}))) * (1. + \text{EXP}(+A2 * (\text{CHI} - \text{CHI2}))))),$$

where $\text{CHI} = C * (\text{TIME} - \text{TBOUNCE}) - R0$, C is the speed of light (cm/sec), TIME is the current problem time (P 2) in seconds, and $R0$ is the radius in cm. (See REGESS). Here TBOUNCE has units of seconds; CHI , CHIO , CHII , and CHI2 have units of cm; $A0$, $A1$, and $A2$ have units of cm^{-1} ; and FLUXNU and FLUXNU0 have units of $\text{cm}^3 / \text{sec}^2$. Note the positive coefficient of $A2$ in this fit.

Basically, this fit represents the neutrinos as a wave that propagates outward from the inner boundary without significant attenuation. In a typical case, such as that given in the example, this wave turns on exponentially near retarded time CHIO , peaks about retarded time CHII , and decays away exponentially near retarded time CHI2 . The acceleration of the matter due to scattering with this neutrino wave is then given by $\text{ABAR} * \text{FLUXNU} / R0^2$ cm/sec^2 , where ABAR is the average atomic weight. This scattering is currently assumed to be elastic, and no thermal energy is deposited. Typically FLUXNU is derived from edits of neutrino-induced acceleration in the inner mantle zones of detailed core collapse calculations, such as that of Wilson and coworkers. [See 7/25/78 KEPLER notes.]

YE	ARBITRARY	INTERIOR-MASS(I)	YEQ0(I)
' ye	1	0.	0.48
ye	2	2.	0.50 '

Y_e Cards for ISE initialization. (Optional, but at least two are required if any are given).

ARBITRARY is an arbitrary, but required, value that is generally used to number the "YE" cards.

INTERIOR-MASS(I) is the interior mass coordinate (in solar masses) for this Y_e point.

YEQ0(I) (moles/g) is the value of Y_e to be used to initialize new ISE zones at this mass coordinate.

A series of such cards with monotonically increasing values of *INTERIOR-MASS(I)* are used to build up a discrete representation of the post-oxygen burning Y_e profile, which the code uses to get intermediate values by linear interpolation (see subroutine SDOT). Out of the range of mass coordinates specified by such a set of "YE" cards, the code uses the minimum of the current (APPROX-generated) value of Y_e and Y_{EMAX} (P 323 -- default = 0.498 moles/g) in order to initialize a new ISE zone. The code does not remember data from "YE" cards in any previously read LINK decks, but *does* remember this current "YE" data in restart dumps.

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CHAPTER 7

ZONAL EDIT AND DUMP VARIABLES

GENERAL

This chapter lists the currently defined zonal edit variables by type. An alphabetical summary is given in Appendix C. Any of these variables can be edited in various ways by name (or list of names) or specified as a variable to be included in the post-processor dumps using the **DUMP** command or generator card (see Chapters 5 and 2, respectively). The **V**, **VF**, and **Z** commands are used to make terminal edits of these zonal edit variables. Periodic edits to the Ascii output file can be made automatically while the problem is running by using the **ZEDIT** command, while edits on demand to the output file are made in various formats by the **VED**, **VEDF**, and **ZED** commands. In addition, X-Window and Postscript plots can be made of the current values of these variables using the **MONGO** or **MON** commands, while a color-coded 'timemap' of each variable's space-time history can be made on Silicon Graphics workstation monitors using the **TIMEMAP** or **TM** commands.

The list of zonal edit variables given here is easily extensible, as indicated in the sections on **EDITCOM** and miscellaneous edit variables below. In addition, **KEPLER** will automatically incorporate changes in the **BURN** and **ISE** isotope networks into the lists of isotopes and **ISE**-quantities that can be edited.

KEPCOM ZONAL INTERFACE ARRAY VARIABLES

- ym**..... Exterior mass coordinate (g).
- rn**..... Radius of outer zone boundary (cm).
- rd**..... Calculated change in radius (cm) -- during a cycle;
 Radius at last timestep (cm) -- at the end of a cycle.
- un**..... Velocity of the outer zone boundary (cm/s).
- xln**..... Calculated non-neutrino luminosity at the outer zone boundary (erg/s).
- qln**..... Converged non-neutrino luminosity at the outer zone boundary (erg/s).
- qld**..... Calculated change in converged luminosity (erg/s) -- during a cycle;
 Converged luminosity at last timestep (erg/s) -- at the end of a cycle.
- difi**..... Diffusion coefficient for material mixing due to convection (cm**2/s).

KEPCOM ZONE-CENTERED ARRAY VARIABLES

netnum.....Number of the nuclear network currently used in the zone.
xm..... Zonal mass (g).
dn..... Density (g/cc).
tn..... Temperature (K).
td..... Calculated change in temperature (K) -- during a cycle;
 Temperature at last timestep (K) -- at the end of a cycle.
en.....Specific energy density (erg/g).
pn..... Pressure (erg/cc)
zn..... Viscous stress -- including linear and quadratic artificial viscosity (ergs).
etan..... Electron degeneracy parameter (μ_e / kT).
sn..... Total energy generation rate -- including neutrino losses (erg/g/s).
snn..... Nuclear energy generation rate -- excluding neutrino losses (erg/g/s)
abar..... Mean atomic weight (g/mole).
zbar..... Mean atomic charge.
xkn..... Rosseland mean opacity (cm^2/g).
xnei..... Number density of ionized electrons (electrons/cc) -- **not implemented yet**.
stot..... Total zonal entropy (k/baryon).
dsold.....Density at which the energy generation rate was last calculated (g/cc).
tsold..... Temperature at which the energy generation rate was last calculated (K).
snold.....Last calculated energy generation rate (erg/g/s).
snbd..... Last calculated partial derivative of the energy generation rate with respect to
 density ($\text{s} \cdot \text{cm}^5/\text{g}$).
snbt..... Last calculated partial derivative of the energy generation rate with respect to
 temperature (erg/g/s/K).
abarold..... Last calculated value of ABAR
abarnbd..... Last calculated partial derivative of ABAR with respect to density (cc/g).
abarnbt..... Last calculated partial derivative of ABAR with respect to temperature (1/K).
ypbtime.....Last calculated total time derivative of the proton abundance (mole/g/sec).
ynbtime.....Last calculated total time derivative of the proton abundance (mole/g/sec).

KEPCOM BURN COPROCESSOR ARRAY VARIABLES

- netnum**..... Number of the BURN isotopic nuclear network used in this zone.
- limnuc**..... Integer containing the Z and A of the isotope controlling the BURN timestep along with the KEPLER cycle that this zone was last burned coded in the form:

$$\text{LIMNUC} = A + 100 * Z + 10000 * \text{NCYC}$$
- timen**..... Time to which the BURN coprocessing in this zone has been updated (sec).
- dtimen**..... Current timestep for BURN coprocessing in this zone (sec).
- dnold**..... Density at which BURN coprocessing was last done in this zone (g/cc).
- tnold**..... Temperature at which BURN coprocessing was last done in this zone (K).
- ymb**..... Mass interior to the outer boundary of this zone, as last considered by the BURN coprocessor (g).
- sburn**..... BURN nuclear energy generation rate, excluding neutrino losses (erg/g/s).
- etab**..... Burn neutron excess (moles/g). The corresponding BURN electron abundance is given by: $\text{yeburn} = 0.5 * (1. - \text{etab})$
- pbuf**..... Abundance buffer (internal working array -- see CONVECTB) (moles/g).

ZONAL 'ELEMENTAL' MASS FRACTIONS AND RELATED VARIABLES

The edit or dump variables corresponding to the elemental mass fractions of the 'ions' involved in the APPROX, NSE, and ISE networks take the form, 'ionfe54', where fe54 exemplifies any valid network 'ion' symbol. Valid ion symbols are shown below in **bold-face** letters in the table that follows. The symbol with which each ion's curve is labeled in abundance plots is shown in square brackets, followed by (in the case of ISE or NSE) the isotopes whose mass fractions are explicitly summed to get each 'elemental' mass fraction. A list of the precise isotopes included is given on the next page.

ION#	APPROX Network	ISE and NSE Networks
1	nt1 [n]	nt1 [n] (neutron only)
2	h1 [H]	ye [none] (electron abundance)
3	pn1 [p]	pn1 [p] (proton only)
4	he3 [³ He]	yq [none] (A ≥ 24 abundance)
5	he4 [He]	he4 [He] (2 ≤ A ≤ 5)
6	c12 [C]	yf [none] (A > 46 plus ⁴⁶ Ti abundance)
7	n14 [N]	eb0 [none] (binding energy / nucleon)
8	o16 [O]	o16 [O] ('unburned' ¹⁶ O only)
9	ne20 [Ne]	fe56 [⁵⁶ Fe] (⁵⁶ Fe only)
10	mg24 [Mg]	mg24 [Mg] (23 ≤ A ≤ 28, ex. ²⁸ Si)
11	si28 [Si]	si28 [Si] (²⁸ Si only)
12	s32 [S]	s32 [S] (29 ≤ A ≤ 35)
13	ar36 [Ar]	ar36 [Ar] (36 ≤ A ≤ 39)
14	ca40 [Ca]	ca40 [Ca] (40 ≤ A ≤ 43)
15	ti44 [Ti]	ti44 [Ca] (44 ≤ A ≤ 47)
16	cr48 [Cr]	cr48 [Cr] (48 ≤ A ≤ 51)
17	fe52 [⁵² Fe]	'fe' ['Fe'] (A ≥ 2*Z + 4 Iron Peak, ex. ⁵⁶ Fe)
18	fe54 [Fe]	fe54 [Fe] (A ≈ 2*Z + 2 Iron Peak)
19	ni56 [Ni]	ni56 [Ni] (A ≤ 2*Z + 1 Iron Peak)

The distinction between h1 and pn1 in the APPROX network is that the former represents unburned hydrogen, while the latter represents protons resulting from photodisintegration. This separation makes inverting the resulting reaction matrix more efficient. Note also that, while not explicitly included in the APPROX network, flows proceeding through the elements ²⁷Al, ³¹P, ³⁵Cl,

Isotopes

^{39}K , ^{43}Sc , ^{47}V , ^{51}Mn , ^{55}Co , ^{53}Fe , and ^2H are included implicitly by assuming that their abundances are in steady state with their neighboring nuclei (see WZW78).

For zones using the ISE or NSE networks, the exact list of isotopes whose mass fractions are summed to get the edited values for each 'ion' symbol are as follows:

$$\text{ionnt1} = \text{nt1}$$

$$\text{ionpn1} = \text{pn1}$$

$$\text{ionhe4} = \text{h2} + \text{h3} + \text{he3} + \text{he4} + \text{he5} + \text{li5} \quad (2 \leq A \leq 5)$$

$$\text{ionmg24} = \text{na23} + \text{mg24} + \text{mg25} + \text{mg26} + \text{al26} + \text{al27} + \text{al28} \quad (23 \leq A \leq 28)$$

$$\text{iono16} = \text{o16}$$

$$\text{ionsi28} = \text{si28}$$

$$\text{ions32} = \text{si29} + \text{si30} + \text{p30} + \text{p31} + \text{s31} + \text{p32} + \text{s32} + \text{p33} + \text{s33} + \text{s34} + \text{cl35} \quad (29 \leq A \leq 35)$$

$$\text{ionar36} = \text{cl36} + \text{ar36} + \text{cl37} + \text{ar37} + \text{ar38} + \text{ar39} + \text{k39} \quad (36 \leq A \leq 39)$$

$$\text{ionca40} = \text{ar40} + \text{k40} + \text{ca40} + \text{k41} + \text{ca41} + \text{k42} + \text{ca42} + \text{k43} + \text{ca43} + \text{sc43} \quad (40 \leq A \leq 43)$$

$$\text{ionti44} = \text{ca44} + \text{sc44} + \text{ti44} + \text{sc45} + \text{ti45} + \text{ca46} + \text{sc46} + \text{ti46} + \text{sc47} + \text{ti47} + \text{v47} \quad (44 \leq A \leq 47)$$

$$\text{ioncr48} = \text{ca48} + \text{sc48} + \text{ti48} + \text{v48} + \text{cr48} + \text{sc49} + \text{ti49} + \text{v49} + \text{cr49} + \text{ti50} + \text{v50} + \text{cr50} + \text{ti51} + \text{v51} + \text{cr51} + \text{mn51} \quad (48 \leq A \leq 51)$$

$$\begin{aligned} \text{ion'fe'} = & \text{ti52} + \text{v52} + \text{cr52} + \text{v53} + \text{cr53} + \text{v54} + \text{cr54} + \text{mn54} \\ & + \text{cr55} + \text{mn55} + \text{cr56} + \text{mn56} + \text{mn57} + \text{fe57} \\ & + \text{mn58} + \text{fe58} + \text{co58} + \text{fe59} + \text{co59} + \text{fe60} + \text{co60} \\ & + \text{ni60} + \text{fe61} + \text{co61} + \text{ni61} + \text{fe62} + \text{co62} + \text{ni62} \\ & + \text{co63} + \text{ni63} + \text{co64} + \text{ni64} + \text{ni65} + \text{ni66} \end{aligned} \quad (A \geq 2*Z + 4 \text{ Iron Peak})$$

$$\text{ionfe54} = \text{mn52} + \text{mn53} + \text{fe54} + \text{fe55} + \text{co56} + \text{co57} + \text{ni58} + \text{ni59} \quad (A \approx 2*Z + 2 \text{ Iron Peak})$$

$$\text{ionni56} = \text{fe52} + \text{fe53} + \text{co54} + \text{co55} + \text{ni56} + \text{ni57} + \text{cu59} + \text{zn60} \quad (A \leq 2*Z + 1 \text{ Iron Peak})$$

$$\text{ionfe56} = \text{fe56}$$

The special cases where the edit variables formed from the 'ion' symbols listed do not correspond to 'elemental' mass fractions are as follows:

- ionye.....** Electron abundance in any current (non-BURN) network (moles/g).
- ionyq.....** Total abundance of ISE or NSE isotopes with $A \geq 24$ (moles/g).
- ionyf.....** Total abundance of ISE or NSE isotopes with $A > 46$ plus ^{46}Ti (moles/g).
- ioneb0.....** Mean binding energy per nucleon of all ISE or NSE isotopes (MeV).

ISE EDIT QUANTITIES

Zonal edit variables for ISE network isotopic mass-fractions, weak rates, and related quantities can be referenced in the form: 'insefe56' where 'nse' is a fixed flag, 'fe56' represents the symbol of an isotope in the ISE network (stored in array NUCSYMD in subroutine QNSE – see below), and 'i' represents a variable flag depending on which isotopic quantity or rate is desired.

'i' may take the values:

- 'i'to get the isotopic mass fraction,
- 'w'to get the isotopic statistical weight,
- 'r'to get the total weak interaction rate due to this isotope (moles/g/sec),
- 'c'to get the electron capture rate due to this isotope (moles/g/sec),
- 'p'to get the positron emission rate due to this isotope (moles/g/sec),
- 'b'to get the beta decay rate due to this isotope (moles/g/sec),
- 'e'to get the total neutrino energy loss due to this isotope (ergs/g/sec),
- 'k'to get the neutrino energy loss due to e^- capture and e^+ decay on this isotope (erg/g/sec),
- 'x'to get the energy stored in the excited states of this isotope (MeV/nucleus).

The symbols of the 125 isotopes comprising the ISE (and NSE) network are:

n1	h1	h2	h3	he3	he4	he5	li5	c12	o16	(1-10)
ne20	na23	mg24	mg25	mg26	al26	al27	al28	si28	si29	(11-20)
si30	p30	p31	s31	p32	s32	p33	s33	s34	cl35	(21-30)
cl36	ar36	cl37	ar37	ar38	ar39	k39	ar40	k40	ca40	(31-40)
k41	ca41	k42	ca42	k43	ca43	sc43	ca44	sc44	ti44	(41-50)
sc45	ti45	ca46	sc46	ti46	sc47	ti47	v47	ca48	sc48	(51-60)
ti48	v48	cr48	sc49	ti49	v49	cr49	ti50	v50	cr50	(61-70)
ti51	v51	cr51	mn51	ti52	v52	cr52	mn52	fe52	v53	(71-80)
cr53	mn53	fe53	v54	cr54	mn54	fe54	co54	cr55	mn55	(81-90)
fe55	co55	cr56	mn56	fe56	co56	ni56	mn57	fe57	co57	(91-100)
ni57	mn58	fe58	co58	ni58	fe59	co59	ni59	cu59	fe60	(101-110)
co60	ni60	zn60	fe61	co61	ni61	fe62	co62	ni62	co63	(111-120)
ni63	co64	ni64	ni65	ni66						(120-125)

ZONAL NUCLEAR REACTION RATES

The edit or dump variables corresponding to editable nuclear reaction rates are listed below. The values edited are the zonal net rates (forward-back) in moles/g/s, and take into account flows through intermediate nuclei that are only implicitly included in the APPROX network (see WZW78 & SDOT)

1	p+p	p + p	(APPROX only)
2	he3+he3	$^3\text{He} + ^3\text{He}$	(APPROX only)
3	he3+he4	$^3\text{He} + ^4\text{He}$	(APPROX only)
4	c12(pg)	$^{12}\text{C}(p,\gamma)^{13}\text{N}$	(APPROX only)
5	n14(pg)	$^{14}\text{N}(p,\gamma)^{15}\text{O}$	(APPROX only)
6	o16(pg)	$^{16}\text{O}(p,\gamma)^{17}\text{F}$	(APPROX only)
7	3a-c12	$^4\text{He}(2\alpha,\gamma)^{12}\text{C}$	(APPROX only)
8	n14(ag)	$^{14}\text{N}(\alpha,\gamma)^{18}\text{F}$	(APPROX only)
9	c12(ag)	$^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$	(APPROX only)
10	c12+c12	$^{12}\text{C} + ^{12}\text{C}$	(APPROX only)
11	c12+o16	$^{12}\text{C} + ^{16}\text{O}$	(APPROX only)
12	o16+o16	$^{16}\text{O} + ^{16}\text{O}$	(APPROX & ISE)
13	o16(ag)	$^{16}\text{O}(\alpha,\gamma)^{20}\text{Ne}$	(APPROX only)
14	ne20(ag)	$^{20}\text{Ne}(\alpha,\gamma)^{24}\text{Mg}$	(APPROX & ISE)
15	mg24(ag)	$^{24}\text{Mg}(\alpha,\gamma)^{28}\text{Si}$	(APPROX only)
16	si28(ag)	$^{28}\text{Si}(\alpha,\gamma)^{32}\text{S}$	(APPROX only)
17	s32(ag)	$^{32}\text{S}(\alpha,\gamma)^{36}\text{Ar}$	(APPROX only)
18	ar36(ag)	$^{36}\text{Ar}(\alpha,\gamma)^{40}\text{Ca}$	(APPROX only)
19	ca40(ag)	$^{40}\text{Ca}(\alpha,\gamma)^{44}\text{Ti}$	(APPROX only)
20	ti44(ag)	$^{44}\text{Ti}(\alpha,\gamma)^{48}\text{Cr}$	(APPROX only)
21	cr48(ag)	$^{48}\text{Cr}(\alpha,\gamma)^{52}\text{Fe}$	(APPROX only)
22	fe52(ag)	$^{52}\text{Fe}(\alpha,\gamma)^{56}\text{Ni}$	(APPROX only)
23	fe52:2ng	$^{52}\text{Fe}(2n,\gamma)^{54}\text{Fe}$	(APPROX only)
24	fe52:a2p	$^{52}\text{Fe}(\alpha,2p)^{54}\text{Fe}$	(APPROX only)
25	fe54:2pg	$^{54}\text{Fe}(2p,\gamma)^{56}\text{Ni}$	(APPROX only)
26	he4-2n2p	$^4\text{He}(\gamma,2p2n)$	(APPROX only)
27	p(e-nu)n	$p(e^-, \nu)n$	(APPROX & ISE)
28	n(e+nu)p	$n(e^+, \nu)p$	(APPROX & ISE)
29	weak	neutronization rate	(ISE only)

ZONAL BURN ISOTOPE MASS FRACTIONS

The edit or dump variables corresponding to the zonal isotopic mass fractions of the isotopes involved in the BURN coprocessor network take the form, 'isoal26', where al26 exemplifies any valid BURN isotope symbol. Valid isotope symbols depend on the BURN network specified in the BURN generator. A commonly used set of 149 isotopes is given by (see Chapter 2):

nt1	h1	h2	h3	he3	he4	li7	be7	b10	b11	(1-10)
c11	c12	c13	c14	n13	n14	n15	o15	o16	o17	(11-20)
o18	f17	f18	f19	ne19	ne20	ne21	ne22	ne23	na22	(21-30)
na23	na24	mg23	mg24	mg25	mg26	mg27	al26	al27	al28	(31-40)
si27	si28	si29	si30	si31	p30	p31	p32	p33	s31	(41-50)
s32	s33	s34	s35	s36	s37	cl35	cl36	cl37	cl38	(51-60)
ar36	ar37	ar38	ar39	ar40	ar41	k39	k40	k41	k42	(61-70)
ca40	ca41	ca42	ca43	ca44	ca45	ca46	ca47	sc43	sc44	(71-80)
sc45	sc46	sc47	ti44	ti45	ti46	ti47	ti48	ti49	ti50	(81-90)
ti51	v47	v48	v49	v50	v51	v52	cr48	cr49	cr50	(91-100)
cr51	cr52	cr53	cr54	cr55	mn51	mn52	mn53	mn54	mn55	(101-110)
mn56	fe52	fe53	fe54	fe55	fe56	fe57	fe58	fe59	fe60	(111-120)
fe61	co55	co56	co57	co58	co59	co60	co61	ni56	ni57	(121-130)
ni58	ni59	ni60	ni61	ni62	ni63	ni64	ni65	cu59	cu60	(131-140)
cu61	cu62	cu63	cu64	zn60	zn61	zn62	zn63	zn64		(141-149)

EDITCOM ZONAL VARIABLES

Another set of editable zonal quantities are those listed in the EDITCOM common block with an 'ed' appended to the beginning of their names to identify them as edit quantities. Note that the ASCII names of these variables are specified in the the NAMEEDIT array and an ASCII string specifying their units is contained in the UNITEDIT array (see block data KEPDAT). This structure makes it easy to add additional zonal edit variables. The current set of EDITCOM zonal variables is as follows:

Derivative EDITCOM Variables:

- gamma..... Adiabatic exponent defined by $\gamma = \rho^*(dP/d\rho)_{ad} / P = \Gamma_1$.
- gammae..... Adiabatic exponent for electrons defined by $\gamma_e = \rho^*(dP_e/d\rho)_{ad} / P_e = \Gamma_{1e}$.
- gammaf..... Adiabatic exponent defined by $\gamma_f = P^*(dT/dP)_{ad} / T = (\Gamma_2 - 1) / \Gamma_2$.
- eit..... Partial derivative of the ion specific energy with respect to temperature (erg/g/K).
- eet..... Partial derivative of the electron specific energy with respect to temperature including pairs (erg/g/K).
- ept..... Partial derivative of the positron specific energy with respect to temperature (erg/g/K).
- ert..... Partial derivative of the radiative specific energy with respect to temperature (erg/g/K).
- eid..... Partial derivative of the ion specific energy with respect to density (erg/cc/g**2).
- eed..... Partial derivative of the electron specific energy with respect to density including pairs (erg/cc/g**2).
- epd..... Partial derivative of the positron specific energy with respect to density (erg/cc/g**2).
- erd..... Partial derivative of the radiative specific energy with respect to density (erg/cc/g**2). (Not implemented yet).
- pit..... Partial derivative of the ion pressure with respect to temperature (erg/cc/K).
- pet..... Partial derivative of the electron pressure with respect to temperature including pairs (erg/cc/K).
- ppt..... Partial derivative of the positron pressure with respect to temperature (erg/cc/K).
- prt..... Partial derivative of the radiation pressure with respect to temperature (erg/cc/K).

- pid**..... Partial derivative of the ion pressure with respect to density (erg/g).
- ped**..... Partial derivative of the electron pressure with respect to density including pairs (erg/g).
- ppd**..... Partial derivative of the positron pressure with respect to density (erg/g).
- prd**..... Partial derivative of the radiation pressure with respect to density (erg/g).
- xnebt**..... Partial derivative of the electron number density with respect to temperature including pairs (#/cc/K).
- xnebd**..... Partial derivative of the electron number density with respect to density including pairs (#/g).
- etabt**..... Partial derivative of the negatron degeneracy parameter with respect to temperature (1/K).
- etabd**..... Partial derivative of the negatron degeneracy parameter with respect to density (cc/g).
- ent**..... Partial derivative of the total specific energy with respect to temperature (erg/g/K).
- end**..... Partial derivative of the total specific energy with respect to density (erg/cc/g**2).
- pnt**..... Partial derivative of the total pressure with respect to temperature (erg/cc/K).
- pnd**..... Partial derivative of the total pressure with respect to density (erg/g).
- xknt**..... Partial derivative of the total opacity with respect to temperature (cm**2/g/K).
- xknd**..... Partial derivative of the total opacity with respect to density (cm**5/g**2).
- snt**..... Partial derivative of the energy generation rate with respect to temperature (erg/g/K).
- snd**..... Partial derivative of the energy generation rate with respect to density (erg*cc/g**2).
- deriv1**..... Reserved for future derivative edit.
- deriv2**..... Reserved for future derivative edit.
- deriv3**..... Reserved for future derivative edit.
- deriv4**..... Reserved for future derivative edit.
- deriv5**..... Reserved for future derivative edit.

EOS EDITCOM Variables:

sig..... Total entropy (k/baryon).
sigi..... Ion entropy (k/baryon).
sige..... Electron entropy (negatrons only) (k/baryon).
sigp..... Positron entropy (k/baryon).
sigr..... Radiation entropy (k/baryon).
sigion..... Ionization entropy (k/baryon).

ei..... Specific ion energy (erg/g).
ee..... Specific electron energy including pairs (erg/g).
ep..... Specific positron energy (erg/g).
er..... Specific radiation energy (erg/g).
pi..... Ion pressure (erg/cc).
pe..... Electron pressure including pairs (erg/cc).
pp..... Positron pressure (erg/cc).
pr..... Radiation pressure (erg/cc).

xni..... Ion number density (#/cc).
xne..... Electron number density including pairs (#/cc).
xnmc..... Electron number density without contribution from pairs (#/cc).
xnp..... Positron (or pair) number density (#/cc).
eta..... Electron (negatron) degeneracy parameter (μ_e / kT).
etap..... Positron degeneracy parameter ($\mu_{\text{positron}} / kT$).

xkiben1..... IBEN1 Rosseland mean opacity (cm^2/g).
xkiben2..... IBEN2 Rosseland mean opacity (cm^2/g).
xkchrsty..... Christy Rosseland mean opacity (cm^2/g).
xkcompt..... Rosseland mean opacity from Compton scattering (cm^2/g). (Not implemented yet)
xkr..... Total radiative Rosseland mean opacity (cm^2/g).
xkcond..... Effective Rosseland mean opacity due to electron heat conduction (cm^2/g).

eos1..... Reserved for future EOS quantity.
eos2..... Reserved for future EOS quantity.
eos3..... Reserved for future EOS quantity.

ISE EDITCOM Variables:

- dye**..... Total change in Y_e during the current timestep (moles/g).
- dyq**..... Total change in Y_q during the current timestep (moles/g).
- dyf**..... Total change in Y_f during the current timestep (moles/g).
- iternse**..... Total number of iterations it took for ISE/NSE to converge in this zone, or to -1 if convergence was not achieved.
- qxc12**..... Photodisintegration-flow-determined mass fraction of ^{12}C in the ISE calculation.
- qxo16**..... Photodisintegration-flow-determined mass fraction of ^{16}O in the ISE calculation.
- qxne**..... Photodisintegration-flow-determined mass fraction of ^{20}Ne in the ISE calculation.
- betaq**..... The ratio of the actual current abundance of ^{28}Si to its "NSE" value based on the current abundance of neutron and protons.
- wrate**..... Total zonal weak (i.e. neutronization) rate (mole/g/s).
- rectot**..... Total zonal electron capture rate (mole/g/s).
- rpdtot**..... Total zonal positron decay rate (mole/g/s).
- redtot**..... Total zonal electron decay rate (mole/g/s).
- snuw**..... Total zonal specific neutrino energy loss rate due to neutronization-related processes (erg/g/s).
- snubps**..... Specific neutrino energy loss rate due to plasma-related processes (erg/g/s).
- eectot**..... Total zonal electron capture plus positron decay neutrino loss rate (erg/g/s).
- epdtot**..... Formerly, the total zonal positron decay neutrino loss rate (erg/g/s). This quantity is now combined into **eectot**, and **epdtot** is set = 0.
- eedtot**..... Total zonal electron decay neutrino loss rate (erg/g/s).
- ebind0**..... Average zonal nucleon binding energy at the beginning of the timestep (MeV/nucleon), including contribution from energy in nuclear excited states if **IEXCITEH** (P 171) > 0.
- ebind**..... Average zonal nucleon binding energy at the end of the timestep (MeV/nucleon), including contribution from energy in excited states if **IEXCITEH** (P 171) > 0.
- eexcite**..... Average zonal energy in nuclear excited states (MeV/nucleon).

- snucq**..... ISE nuclear energy generation rate (erg/g/s).
- snuc1q**..... ISE nuclear energy generation rate minus plasma neutrino loss rate (erg/g/s).
- sdotq**..... Net ISE energy generation rate including all neutrino losses (erg/g/s).
- tauqse**..... Timescale for the Fe and Si quasiequilibrium blocks to equilibrate (sec).
- yfqse**..... Quasiequilibrium value of Y_Q based on the current abundance of neutron and protons and ^{28}Si (moles/g).
- yffac**..... The actual value of Y_Q is less than **yfqse** by the factor $1 / \text{yffac}$.
- qj**..... Net photodisintegration flow downward from ^{24}Mg (moles/g/sec).
- dyo16q**..... Change in the ^{16}O abundance during this timestep (moles/g)

MISCELLANEOUS EDIT QUANTITIES

The following miscellaneous zonal edit variables are defined in subroutine LOADBUF (and more may easily be added):

- mixlen**..... Mixing length used in calculating convection (cm).
- taumix**..... Convective mixing time (sec).
- nalim**..... Atomic weight of the nucleus limiting the BURN zonal timestep.
- nzlim**..... Atomic number of the nucleus limiting the BURN zonal timestep.
- ncyczb**..... KEPLER cycle at which this zone was last coprocessed by BURN.
- yeburn**..... Electron abundance calculated for this zone by the BURN coprocessor (mole/g).
- rhorr**..... Integral of ρdr for mass exterior to the outer boundary of this zone (g/cm^2).
- sneut**..... Neutrino loss rate (erg/g/s), where a positive value implies net loss.
- sgain**..... Maximum of the net nuclear energy generation rate and zero (erg/g/s).
- sloss**..... Total energy 'loss' rate, incl. neutrino loss and net nuclear loss (if any) (erg/g/s).
- convect**..... Convection flag, where: 0. = 'rad', 1. = 'neut', 2. = 'osht', 3. = 'semi', 4. = 'conv'.

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CHAPTER 8

EDIT ('Q') PARAMETERS AND TIME-EDIT VARIABLES

EDIT ('Q') PARAMETERS

This section lists the 77 unchangeable edit ('Q') parameters in KEPLER that may be edited (but not directly changed) during execution by the Q N command (e.g., 'q 7' or 'q iter'), where N stands for the name or number of the parameters listed below. The mode of these parameters (fixed or floating point) follows the normal FORTRAN convention. They are remembered in the restart dumps and more may readily be added. They are located in the general COMMON in include file KEPCOMS (starting with dt) and their ASCII names and types are listed respectively in the nameqprm and iqtype arrays loaded in data block KEPDAT. They are initialized in subroutine GENER and also (if necessary) subroutine RESTART.

EDIT ('Q') PARAMETER LIST

- 1 dt..... KEPLER timestep (sec).
- 2 jm..... Number of zones.
- 3 dtold..... KEPLER timestep used for the previous cycle (sec)
- 4 ncyc..... KEPLER cycle number.
- 5 fcr..... Maximum fractional zonal radius change since the last iteration.
- 6 fct..... Maximum fractional zonal temperature change since the last iteration.
- 7 iter..... Number of iterations taken for convergence.
- 8 told..... Time at the beginning of the last timestep (sec).
- 9 tfer..... Total maximum fractional zonal radius change during current cycle.
- 10 tfct..... Total maximum fractional zonal temperature change during current cycle.
- 11 fcl..... Maximum fractional zonal luminosity change since the last iteration.
- 12 tfcl..... Total maximum fractional zonal luminosity change since the last iteration.
- 13 idtcon..... Symbol of the ion most limiting the current KEPLER timestep.
- 14 imax..... Total number of ions in the APPROX network (usually 19).

Edit ('Q') Parameter List (Cont.)

- 15 **nnet**..... Number of ion networks specified (usually 3: APPROX(1), ISE(2), and NSE(3))
- 16 **numit**..... Total number of ions specified in the generator (usually 19).
- 17 **totm**..... Current total amount of mass in the problem (incl. SUMM0 -- P 61) (g).
- 18 **nreac**..... Number of nuclear reactions edited (ions only -- usually 29).
- 19 **itert**..... Total number of iterations since problem generation.
- 20 **jfcr**..... Zone with largest fractional radius change since the last iteration.
- 21 **jfct**..... Zone with largest fractional temperature change since the last iteration.
- 22 **jfcl**..... Zone with largest fractional luminosity change since the last iteration.
- 23 **snuc**..... Current nuclear energy generation rate from last call to subroutine SDOT (erg/g/s). Note that this rate applies only to the zone specified in that call.
- 24 **s0exp**..... Neutrino deposition coefficient (erg/g) derived from the values of parameters 93 thru 95 (JSHELL0, JSHELL1, and EEXPLODE) and the current zonal of the star.
- 25 **xlumn**..... Neutrino luminosity (erg/s).
- 26 **enini**..... Total initial internal energy (ergs).
- 27 **enink**..... Total initial kinetic energy (ergs).
- 28 **eninp**..... Total initial potential energy (ergs).
- 29 **enint**..... Total initial energy (ergs) = **enini** + **enink** + **eninp**.
- 30 **ensc**..... Total energy deposited so far from input "source" (ergs). (See XLUM0 -- P 62).
- 31 **eni**..... Total internal energy (ergs).
- 32 **enk**..... Total kinetic energy (ergs).
- 33 **enp**..... Total potential energy (ergs).
- 34 **ent**..... Total current energy (ergs) = **eni** + **enk** + **enp**.
- 35 **epro**..... Total net energy produced so far by nuclear reactions less neutrino losses (ergs).
- 36 **enes**..... Total non-neutrino energy that has so far escaped from the star's surface (ergs).
- 37 **enc**..... Energy check (ergs).
- 38 **enscd**..... Rate of energy deposition by input "source" (erg/s). (See XLUM0 -- P 62).
- 39 **enid**..... Rate of change in the total internal energy (erg/s).
- 40 **enkcd**..... Rate of change in the total kinetic energy (erg/s).
- 41 **enpcd**..... Rate of change in the total potential energy (erg/s).
- 42 **entcd**..... Rate of change in the total energy (erg/s).
- 43 **eprod**..... Total rate of nuclear energy production (erg/s).
- 44 **enesd**..... Total rate of energy escape from the star (erg/s). *(in g/s)*

Edit ('Q') Parameter List (Cont.)

- 45 **encl**..... Total rate of change in the energy check (erg/s). = enesol
- 46 **xlum**..... Surface luminosity in electromagnetic radiation (erg/s).
- 47 **radius**..... Photospheric radius (cm) corresponding to radius with 2/3 optical depth.
- 48 **teff**..... Effective surface temperature (K).
- 49 **ncycb**..... Current cycle number used by the BURN coprocessor (should be same as **ncyc**).
- 50 **ncycbt**..... Number of cycles since BURN co-processing was initiated (usually = **ncyc**).
- 51 **nburnz**..... Number of zones co-processed by BURN during current KEPLER cycle.
- 52 **nburnzt**..... Total number of zones co-processed by BURN since problem generation.
- 53 **imaxb**..... Number of isotopes in the currently specified BURN network (typically 149).
- 54 **nnetb**..... Number of specified BURN isotopic networks (usually 1).
- 55 **numitb**..... Total number of isotopes specified in the BURN generator (typically 149).
- 56 **jlm**..... Number of zones at the end of the last KEPLER cycle.
- 57 **jbmax**..... Maximum zone number for which BURN co-processing is now being done.
- 58 **dtsub**..... Length of a BURN co-processing/Burn ion convection subcycle (see P 264).
- 59 **jpist**..... Index of the piston position now being utilized (see Chapter 6 and CYCLE).
- 60 **jpistm**..... Total number of piston positions specified in the LINK file (see Chapter 6).
- 61 **velocity0**..... Velocity of inner problem boundary due to specified piston (see Chapt. 6--cm/s).
- 62 **tbounce**..... Core bounce time (s). Set by the NFLUX card in the LINK file (See Chapter 6).
- 63 **fluxnu0**..... Neutrino flux parameter. Set by the NFLUX card in the LINK file (See Chapt. 6).
- 64 **fluxnua**..... Neutrino flux parameter. Set by the NFLUX card in the LINK file (See Chapt. 6).
- 65 **chi0**..... Neutrino flux parameter. Set by the NFLUX card in the LINK file (See Chapt. 6).
- 66 **fluxnub**..... Neutrino flux parameter. Set by the NFLUX card in the LINK file (See Chapt. 6).
- 67 **chi1**..... Neutrino flux parameter. Set by the NFLUX card in the LINK file (See Chapt. 6).
- 68 **fluxnuc**..... Neutrino flux parameter. Set by the NFLUX card in the LINK file (See Chapt. 6).
- 69 **chi2**..... Neutrino flux parameter. Set by the NFLUX card in the LINK file (See Chapt. 6).
- 70 **nye**..... Index of the LINK-specified Y_e now being utilized (see Chapter 6 and SDOT).
- 71 **nyem**..... Total number of YE-card -specified Y_e values in the LINK file (see Chapter 6).
- 72 **idmptime**.... Integer index of the next dump time (dump cycle number in subroutine DUMPQ).
- 73 **nylib**..... Number of distinct mass coordinates used so far in describing zoning (ylib entries)
- 74 **nylib0**..... Number of ylib entries (see **nylib** -- Q 73) at the end of the last qq dump cycle.
- 75 **ndatq**..... Current number of zonal edit variables to be dumped(see sub DUMPQ & DUMP)
- 76 **locqnext**..... Location of the next open track in the current 'qq' dump file (see sub. DUMPQ).
- 77 **ndatl**..... Current number of specified 'look' variables (see sub. READQ and ADDLOOK).

TIME-EDIT VARIABLES

A record is automatically made every dump cycle of the values of the following non-zonal "time-edit" variables. These records are stored in the second half of the '.lib' file and are accessed by the **TIMEPLOT** and **LOOK** commands (see Chapter 5). There are nine dummy variables holding space for future time edit variables, but even more could be added if the value of **LENTDUMP** in **DUMPQ** were increased.

TIME-EDIT VARIABLE LIST

ncyc	KEPLER cycle number.
jdte	Zone limiting the timestep.
iter	Number of iterations taken for convergence.
jm	Number of zones.
jmcalc	Number of zones actually updated in the calculation (see JM CALC -- P 162)
nylib	Number of distinct mass coordinates used so far in describing zoning.
ndatq	Number of post-processor-dump variables.
dt	KEPLER timestep (sec).
radius	Photospheric radius (cm) corresponding to radius with 2/3 optical depth.
teff	Effective surface temperature (K).
xlum	Surface luminosity in electromagnetic radiation (erg/s).
dn1	Central density (g/cc).
tn1	Central temperature (K).
xlum	Neutrino luminosity (erg/s).
ensc	Total energy deposited so far from input "source" (ergs). (See XLUM0 -- P 62).
eni	Total internal energy (ergs).
enk	Total kinetic energy (ergs).
enp	Total potential energy (ergs).
ent	Total current energy (ergs) = eni + enk + enp .
epro	Total energy produced so far by nuclear reactions less neutrino losses (ergs).
enes	Total non-neutrino energy that has so far escaped from the star's surface (ergs).
enc	Energy check (ergs).
enscd	Rate of energy deposition by input "source" (erg/s). (See XLUM0 -- P 62).
enid	Rate of change in the total internal energy (erg/s).

Time-Edit Variable List (Cont.)

enkd..... Rate of change in the total kinetic energy (erg/s).
enpd..... Rate of change in the total potential energy (erg/s).
entd..... Rate of change in the total energy (erg/s).
eprod..... Total rate of nuclear energy production (erg/s).
enesd..... Total rate of energy escape from the star (erg/s).
encd..... Total rate of change in the energy check (erg/s).
snuc..... Current nuclear energy generation rate from last call to subroutine SDOT
(erg/g/s). Note that this rate applies only to the zone specified in that call.
sn1..... Central rate of energy production (erg/g/sec).
snn1..... Central rate of nuclear energy generation (erg/g/s).
pn1..... Central pressure (erg/cc).
eta1..... Central degeneracy parameter.
ye1..... Central electron abundance (moles/g).
sig1..... Central entropy (k/baryon).
cmptime..... Total computer time used since generation (sec).
totm..... Total amount of mass in the problem (incl. SUMM0 -- P 61) (g).
d2..... Dummy variable.
d3..... Dummy variable.
d4..... Dummy variable.
d5..... Dummy variable.
d6..... Dummy variable.
d7..... Dummy variable.
d8..... Dummy variable.
d9..... Dummy variable.

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CHAPTER 9

SELECTED ASCII AND GRAPHICS EDIT FORMATS

TERMINAL EDITS

Below are listed examples of the results of issuing several of the terminal edit commands described in Chapter 5. To save space and constant repetition, the output format of these commands is fairly terse, but is explained in detail below. The internal KEPLER variables corresponding to the edited quantities are shown in capital letters in brackets where they are not obvious. Each example starts with the dot that KEPLER uses to prompt the user for input, followed by the command issued. Subsequent line(s) show the results of the command.

Time Edit:

```
.t
11981 5.125483408712E+05 dtd( 1) = 9.66E-03 iter=4 jm=505 zb=0
```

Here '11981' is the current cycle number [NCYC], '5.125483408712E+05' is the current problem time [TIME -- P 2] in seconds (relative to the reference time offset TOFFSET (P 315)), 'dtd' is the symbol of the ion or other quantity whose rate of change is determining the timestep [IDTCSYM(IDTCON)], '1' is the index of the zone where the rate of change of this quantity is most time-step-limiting [JDTC(IDTCON)], '9.66E-03' is the value of the current timestep (DT) in seconds, 'iter=4' gives the number of iterations that KEPLER took to converge during the latest cycle [ITER], 'jm=505' gives the number of zones currently in the problem [JM], and 'zb=0' gives the number of zones processed by the BURN coprocessor during the last KEPLER timestep [NBURNZ] if BURN coprocessing is being done..

Time and Surface Edit:

```
.tq
11981 5.125483408712E+05 dtd( 1) = 9.66E-03 iter=4 jm=505 zb=0
radius = 9.06016E+13 lum = 2.32789E+39 teff = 4.46663E+03
```

The first row of this edit is the same as for the time edit, as given above. The second row lists, respectively, the star's photospheric radius [RADIUS -- Q 47] in cm, it's surface (non-neutrino) luminosity [XLUM -- Q 46] in erg/s, and its effective temperature [TEFF -- Q 48] in degrees K.

Energy Edit:

```
.e
ke = 1.29856E+49 ie = 9.57900E+51 pe = -1.12123E+52 te = -1.62027E+51
kd = 5.96695E+49 id = 2.89362E+51 pd = -3.00413E+51 sd = -5.01087E+49
```

The first row lists respectively in ergs the star's total kinetic energy [ENK -- Q 32], total internal energy [ENI -- Q 31], total potential energy [ENP -- Q 33], and the sum of these three [ENT -- Q 34]. The second row lists respectively the current time derivatives of these quantities in erg/s [ENKD -- Q 40, ENID -- Q 39, ENPD -- Q 41, ENTD -- Q 42].

Ion Mass-Fraction Edit:

```
.1 i
nt1 5.688E-03
he4 1.672E-02
ti44 3.982E-03
cr48 2.429E-01
'fe' 7.303E-01
1-tot 2.883E-07
```

This edit makes a list of mass fractions of all the ions in the zone specified (here '1') that exceed ABUNLIM (P 128). The row labeled '1-tot' gives the difference between unity and the sum of the mass fractions of all ions in the current network. The ion symbols are usually self-explanatory and a complete list for each network is given in Chapter 7.

BURN Isotope Mass-Fraction Edit:

This edit makes a list of mass fractions of all the BURN isotopes in the zone specified (here '1') that exceed ABUNLIMB (P 272). The row labeled '1-tot' gives the difference between unity and the sum of the mass fractions of all BURN isotopes in the current network. The isotope

symbols are self-explanatory and a complete list of isotopes currently used in the BURN network is given in Chapter 7.

Zone Edit:

```
.1
1 m= 0.00000E+00 z= 2.011E-03 t= 2.556E+09 d= 9.897E+07 v=-5.643E-01
conv r= 2.12892E+07 k= 1.020E-02 e= 5.413E+17 p= 2.357E+25 q= 0.000E+00
ise eta= 6.195E+00 l= 1.282E+42 s= 3.425E+11 n= 3.580E+11 ye=0.49799
p33(7390,6322) = 7.148E+01 nb= 1.971E+11 yeb=0.49710
sig= 1.238E+00 x= 2.258E+03 a= 2.751E+01
```

Here:

- '1' Index of the zone being edited [J].
- 'm' Mass interior to the inner boundary of the zone in solar mass units.
- 'z' Mass of the zone in solar masses [XM(J) / SOLMASS].
- 't' Zonal temperature in degrees K [TN(J)].
- 'd' Zonal density in g/cc [DN(J)].
- 'v' Velocity of the outer interface of the zone in cm/s [UN(J)].
- 'r' Radius of the outer interface of the zone [RN(J)].
- 'k' Zonal opacity in cm^2/g [XKN(J)].
- 'e' Specific energy of the zone in erg/g [EN(J)].
- 'p' Zonal pressure in erg/cc [PN(J)].
- 'q' Viscous stress (including artificial viscosity) in ergs [ZN(J)].
- 'eta' Electron degeneracy parameter [ETAN(J)].
- 'l' Luminosity across the outer interface of the zone in erg/s [XLN(J)].
- 's' Net energy generation rate (including neutrino losses) in erg/g/s [SN(J)].
- 'n' Net nuclear energy generation rate (excludes neutrinos losses) in erg/g/s [SNN(J)].
- 'ye' Non-BURN electron abundance in moles/g [ZBAR(J) / ABAR(J)].
- 'nb' Nuclear energy generation rate last calculated by BURN in erg/g/s [SBURN(J)].
- 'yeb' BURN electron abundance in moles/g [yeburn].
- 'sig' Total entropy per baryon in Boltzmann's constant (k) units [STOT(J)].
- 'x' Convective mixing timescale across the outer zonal interface in seconds [taumix].
- 'a' Zone's average atomic weight in g/mole [ABAR(J)].

The symbol 'conv' exemplifies the convection sentinel [ICON(J)] that describes the status of convection between zones J and J+1. Possible values of the convection sentinel are 'conv' to indicate full convection, 'semi' to indicate semiconvection, 'osht' to indicate that overshoot mixing is being

done in zones adjacent to convective regions, 'neut' (for 'neutral') to indicate that while still radiative, the zonal interface is within a small amount (quantified and controlled by FRACNEUT (P 59)) of being convective, and ' ' (4 spaces), otherwise, to indicate that the interface is well into the regime where only radiative transfer takes place across the interface.

The symbol 'ise' exemplifies the network sentinel. Its value is 'ise' if the zone is currently using the ISE network [NETNUM(J) = 2], 'nse', if the NSE network is being used [NETNUM(J) = 3], and ' ' (blank) if the APRROX network is being used [NETNUM(J) = 1].

The construct 'p33(7390,6322) = 7.148E+01' gives the current timestep being used by BURN for this zone [DTIME(J)] and the symbol of the BURN isotope whose rate of change is most limiting this timestep [formed from LIMNUC(J)]. The two numbers in parentheses are the current KEPLER cycle [NCYC] and the KEPLER cycle at which this zone was last processed by BURN [also formed from LIMNUC(J)]. Note that BURN processing is usually not done in ISE or NSE zones (see NETMAX -- P 240).

When BURN coprocessing has not been requested, the fourth line is omitted from this edit.

Zonal Variable Edit:

.z dn tn sig sigi sige 1 10

zone	mass	dn	tn	sig	sigi	sige
1	0.00000	2.593E+09	8.293E+09	1.046E+00	4.610E-01	5.578E-01
2	0.00201	2.554E+09	8.288E+09	1.050E+00	4.620E-01	5.603E-01
3	0.00377	2.517E+09	8.282E+09	1.052E+00	4.623E-01	5.625E-01
4	0.00633	2.474E+09	8.273E+09	1.056E+00	4.628E-01	5.653E-01
5	0.01005	2.398E+09	8.260E+09	1.063E+00	4.637E-01	5.703E-01
6	0.01910	2.280E+09	8.236E+09	1.073E+00	4.651E-01	5.783E-01
7	0.03519	2.177E+09	8.219E+09	1.085E+00	4.675E-01	5.860E-01
8	0.04700	2.095E+09	8.200E+09	1.093E+00	4.688E-01	5.923E-01
9	0.06034	2.022E+09	8.183E+09	1.101E+00	4.699E-01	5.981E-01
10	0.07172	1.953E+09	8.167E+09	1.109E+00	4.712E-01	6.038E-01

This edit lists the current values of each zonal quantity named in the header for the range of zones specified (Here, zones 1 through 10. The default is all current zones.) The first column, labeled 'zone' contains the zones number and a convection sentinel [ICON(J)] that describes the status of convection between zones J and J+1. Possible values of the convection sentinel are 'conv' to indicate full convection, 'semi' to indicate semiconvection, 'osh' to indicate that overshoot mixing is being done in zones adjacent to convective regions, 'neut' (for 'neutral') to indicate that while still radiative, the zonal interface is within a small amount (quantified and controlled by FRACNEUT (P 59)) of being convective, and ' ' (4 spaces) otherwise to indicate that the interface is well into the regime where only radiative transfer takes place across the interface.

The second column, labeled 'mass' gives the mass interior to the inner boundary of each zone in SCALEM (P 273) units (usually solar masses). [This is converted from the internal KEPLER array YM(J) -- the mass exterior to the outer boundary of each zone in grams.]

The following columns list the values of the edit variables specified on the command line for these zones.

GRAPHICS EDITS

Chapter 5 describes the graphics edits that the user asks Kepler to make, while Chapter 3 describes the Graphics Parameters that control many aspects of the resulting plots. Generally the resulting plots are self-explanatory, but sometimes terse formats or labels are used to save space. These cases are explained below.

Standard Plot Header:

Standard plots produced by the PLOT command begin with a three line header that briefly describes the current status of the problem. The first line lists the problem name [NAMEPROB], the current cycle number [NCYC], the current problem time in seconds [TIME -- P 2], and the current timestep in seconds along with the quantity and zone controlling it (see the description of the "Time Edit" above for a more detailed discussion of these quantities).

The labeled quantities listed on the second and third lines have the meaning:

- 'R' Photospheric radius in cm [RADIUS -- Q 47].
- 'Teff' Photospheric temperature in degrees K [TEFF -- Q 48].
- 'L' Non-neutrino surface luminosity in erg/s [XLUM -- Q 46].
- 'Iter' Number of KEPLER iterations it took the current cycle to converge [ITER -- Q 7].
- 'Dc' Density of the innermost zone in g/cc [DN(1)].
- 'Tc' Temperature of the innermost zone in degrees K [TN(1)].
- 'Ln' Neutrino luminosity in erg/s [XLUMN -- Q 25].
- 'Jm' Current number of zones [JM].

The LOOK command generates plots with similar headers for previous cycles using information stored in the '.lib' file(s).

Standard Zone Sentinels:

The current zoning of problem and its convective state are indicated by a set of marks plotted at the position of the outer interface of each zone. Possible values of the convection sentinel are 'I' (vertical bar) to indicate full convection, ';' (semicolon) to indicate semiconvection, "'" (apostrophe) to indicate that overshoot mixing is being done in zones adjacent to convective regions, ',' (comma) to indicate that while still radiative, the zonal interface is within a small amount (quantified and controlled by FRACNEUT (P 59)) of being convective, and '.' (period) to indicate that the interface is well into the

regime where only radiative transfer takes place across the interface.

Thermodynamics Plot (Plot-Type 1):

This plot plots temperature, 'T', in degrees K [TN], the density ' ρ ' in g/cc [DN], and the standard zone sentinels described above. It also plots, in the units given, the pressure, 'P' [PN]; net nuclear energy generation rate (if positive), 'S' [sgain]; rate of energy loss --including neutrino losses and net nuclear energy generation if negative, 'L' [sloss]; and either the radius, 'R' [RN] (if the the radius is not already being used as the radial coordinate) or otherwise the velocity [UN]. Positive (outward) velocities are plotted as a curve labeled 'V', while negative (inward) velocities are labeled 'U'.

Velocity Plot (Plot-Type 2):

This plot should by self-explanatory. See above for an explanation of its header.

Ion Abundance Plot (Plot-Type 3):

This plot should be largely self-explanatory given the information on headers and zone sentinels discussed above. Here "elemental" mass fraction means "ion" mass fraction. A detailed explanation of the ions corresponding to the symbols on the curves is given in Chapter 7. Note that pairs of adjacent points in different networks are not joined by lines.

Entropy Plot (Plot-Type 4):

This plot graphs the total entropy sig (unlabeled curve), the electron entropy, **sige** ('E'), the ion entropy, **sigi** ('I'), radiation entropy, **sigr** ('R'), the positron entropy, **sigp** ('P'), and the entropy due to ionization, **sigion** ('Z'). Currently these entropies are calculated assuming an ideal (but possibly degenerate and relativistic) gas. Probably this should be changed to using partial derivatives of the actual equation of state routines.

Rho-T Plot (Plot-Type 5):

This plot should by self-explanatory. See above for an explanation of its header.

BURN Isotope Plot (Plot-Type 6):

This plot should be self explanatory. The specific isotopes plotted are set by command **SETISO**. See above for an explanation the meaning of its header and the zone sentinels shown. A list the isotopes currently included in the BURN network is given in Chapter 7.

Zonal Edit Plots (MONGO Plots):

Zonal variable plots made by the **MONGO** and **MON** commands are titled by the first line of the standard graphics header described above. Otherwise they should be self-explanatory.

Time Plots:

Time plots made using the **TIMEPLOT** or **TP** commands are titled by the problem name, the current cycle number, and the reference time in seconds used in making the plot. To avoid truncation errors, any offsets involved in calculating the reference time (see subroutine **PLOTIT**) are shown as additive quantities. Otherwise these plots should be self-explanatory.

CYCLE EDITS

Examples of many of the more complex edits that KEPLER can make to show the status of the calculation at a given cycle are listed below, together with an explanation of their formats. The internal KEPLER variables corresponding to the edit quantities are shown in capital letters in parentheses where they are not obvious. These edits are produced automatically in the ASCII output file at intervals during the calculation depending on the settings of various edit control parameters (see Chapter 3). They can also be commanded to appear immediately on the terminal or in the ASCII output file by ASCII edit commands described in Chapter 5.

Cycle Edit Header:

```

Wed May 1 10:33:18 1991    box v98    s25sha    weaver    7390    1.43960996754210E+07    ne20(119) = 1.52E+03    iter = 10

                                dtr(128) = 6.88E+04
                                dtc( 80) = 5.76E+04                                503 zones
                                dtd(127) = 1.31E+04
                                dtq( 80) = 3.79E+05
                                ne20(119) = 1.51E+03
                                dtl(148) = 1.66E+04

energy    source    kinetic    internal    potential    total    produced    escaped    check    mass    25.13573
initial    0.000E+00    8.640E+49    -1.452E+50    -5.881E+49    luminosity    9.993E+38
present    0.000E+00    8.367E+41    1.851E+51    -2.541E+51    -6.900E+50    1.218E+53    1.224E+53    -5.455E+46    neutrino lum    1.026E+44
rates      0.000E+00    2.817E+35    -8.350E+43    1.151E+44    3.158E+43    3.158E+43    9.993E+38    -1.049E+34    eff temp    4.508E+03
                                                radius    5.829E+13

reaction    p+p    he3+he3    he3+he4    c12(pg)    n14(pg)    o16(pg)    3a-c12    n14(ag)    c12(ag)    c12+c12    c12+o16
moles    1.219E+30    3.146E+30    0.000E+00    3.607E+33    4.235E+33    2.307E+31    1.066E+33    4.503E+32    3.969E+32    1.737E+32    2.390E+28
moles/s    2.578E+09    1.804E+08    0.000E+00    9.554E+09    2.253E+09    7.364E+05    -1.205E+17    7.787E+12    -1.180E+21    2.019E+24    1.649E+22
maxzone    300    255    0    297    297    296    255    256    137    137    119

reaction    o16+o16    o16(ag)    ne20(ag)    mg24(ag)    si28(ag)    s32(ag)    ar36(ag)    ca40(ag)    ti44(ag)    cr48(ag)    fe52(ag)
moles    4.287E+31    9.348E+32    3.392E+32    3.389E+31    7.865E+29    -3.260E+28    2.253E+27    -5.875E+24    -2.034E+21    2.858E+21    1.745E+18
moles/s    2.256E+24    -2.489E+25    4.621E+24    2.857E+24    4.049E+23    2.265E+22    8.497E+20    -9.235E+14    -2.071E+14    9.014E+14    4.317E+11
maxzone    85    123    119    119    84    84    82    119    119    82    82

reaction    fe52:2ng    fe52:a2p    fe52:2pg    he4-2n2p    p(e-nu)n    n(e+nu)p    ecap
moles    6.055E+21    3.556E+21    1.027E+24    1.990E-06    8.817E+19    6.052E+13    4.505E+28
moles/s    3.275E+11    8.912E+14    9.668E+14    2.234E-15    3.365E+14    6.543E+07    1.706E+22
maxzone    86    82    82    82    1    1    65

```

In the first line:

'Wed May 1 10:33:18 1991' is the current time and date [DATE].

'box v98' is the output box number [CRAYBOX].

's25sha' is the name of the problem [NAMEPROB].

'weaver' is the ID-word specified in the generator [IDWORD].

'7390' is the current KEPLER cycle number [NCYC].

'1.43960996754210E+07' is the current problem time [TIME -- P 2] in seconds.

'ne20' is the symbol of the ion or other quantity whose rate of change is determining the timestep [IDTCSYM(IDTCON)] in seconds.

'119' is the number of the zone where this rate of change is most time-step-limiting [JDTC(IDTCON)].

'1.52E+03' is the value of the current timestep [DT].

'iter = 10' gives the number of iterations that KEPLER took to converge during the latest cycle [ITER].

The next six lines give the limiting timesteps [DTC(I)] in seconds due to fractional changes in zonal radius ('dtr'), temperature ('dtt'), density ('dtd'), linear contraction ('dtq'), network ion abundance ('ne20' or other ion symbol), and zonal luminosity ('dtl'), respectively [IDTCSYM(1 thru 6)]. The zone limiting the timestep for each quantity [J DTC(I)] is given in parentheses.

Along the right-hand margin is written the current number of zones in the problem [JM], followed by the current total mass in the problem [TOTM / SCALEM] in SCALEM (P 273) units (usually solar masses), the surface luminosity [XLUM -- Q 46] in erg/s, the surface neutrino luminosity [XLUMN -- Q 25] in erg/s, the effective surface temperature [TEFF -- Q 48] in degrees K, and the photospheric radius [RADIUS -- Q 47] in cm.

The energy edit given to the left of these quantities represents various kinds of energies and their rate of change summed over the whole star. The initial and present energies are in ergs and the rates are in ergs/s. This edit summarizes in tabular form edit parameters Q 26 through Q 45 (see Chapter 8).

There follows a table of all editable nuclear reaction rates, summed over the whole star. The reaction symbols [ISYMR(I)] in the row labeled reactions are defined (to the extent they aren't obvious) in Chapter 7 and Appendix C. The next row, labeled 'moles' gives the total net number of times in moles [TOTALR(I)] that each reaction has taken place in the star since the beginning of the problem. (Note here that the total number of backward reactions has been subtracted from the total number of forward reactions.) The row labeled "moles/s" gives the current net rate of each reaction in mole/s [RATER(I)], while the last row lists the zone where the rate of each reaction is currently the largest.

Primary Zonal Cycle Edit:

	zone	mass	zmass	radius	density	temp	energy	sdot	snuc	sburn	abar	lumin	velocity
conv	1	0.00000	0.00201	2.129E+07	9.897E+07	2.556E+09	5.413E+17	3.43E+11	3.58E+11	1.97E+11	27.5	1.282E+42	-5.643E-01
conv	2	0.00201	0.00176	2.630E+07	9.778E+07	2.545E+09	5.385E+17	2.69E+11	2.83E+11	1.76E+11	27.5	2.144E+42	-6.988E-01
conv	3	0.00377	0.00256	3.133E+07	9.668E+07	2.534E+09	5.358E+17	2.13E+11	2.27E+11	1.59E+11	27.5	3.117E+42	-8.354E-01
conv	4	0.00633	0.00373	3.667E+07	9.534E+07	2.520E+09	5.325E+17	1.59E+11	1.72E+11	1.40E+11	27.5	4.133E+42	-9.821E-01
conv	5	0.01005	0.00905	4.571E+07	9.302E+07	2.496E+09	5.267E+17	9.24E+10	1.05E+11	1.00E+11	27.5	5.411E+42	-1.235E+00
conv	6	0.01910	0.01609	5.656E+07	8.938E+07	2.458E+09	5.174E+17	3.50E+10	4.62E+10	6.66E+10	27.5	5.860E+42	-1.549E+00
conv	7	0.03519	0.01180	6.266E+07	8.617E+07	2.424E+09	5.090E+17	1.13E+10	2.12E+10	4.45E+10	27.5	5.640E+42	-1.731E+00
conv	8	0.04699	0.01334	6.853E+07	8.357E+07	2.396E+09	5.021E+17	1.85E+09	1.08E+10	3.08E+10	27.5	5.148E+42	-1.911E+00
conv	9	0.06033	0.01138	7.296E+07	8.125E+07	2.370E+09	4.958E+17	-2.48E+09	5.74E+09	2.19E+10	27.5	4.636E+42	-2.049E+00
conv	10	0.07172	0.01362	7.776E+07	7.906E+07	2.345E+09	4.897E+17	-4.50E+09	3.01E+09	1.58E+10	27.5	3.975E+42	-2.203E+00
conv	11	0.08534	0.01196	8.163E+07	7.697E+07	2.321E+09	4.839E+17	-5.33E+09	1.56E+09	1.14E+10	27.5	3.386E+42	-2.329E+00
conv	12	0.09730	0.01438	8.596E+07	7.493E+07	2.297E+09	4.781E+17	-5.53E+09	7.66E+08	8.40E+09	27.5	2.700E+42	-2.474E+00
conv	13	0.11168	0.01259	8.951E+07	7.296E+07	2.273E+09	4.724E+17	-5.42E+09	3.53E+08	5.95E+09	27.5	2.101E+42	-2.595E+00
conv	14	0.12427	0.01508	9.352E+07	7.103E+07	2.250E+09	4.667E+17	-5.14E+09	1.42E+08	4.28E+09	27.5	1.353E+42	-2.735E+00
conv	15	0.13935	0.01315	9.684E+07	6.916E+07	2.227E+09	4.611E+17	-4.79E+09	3.93E+07	3.09E+09	27.5	7.081E+41	-2.853E+00
osht	16	0.15250	0.01571	1.006E+08	6.732E+07	2.203E+09	4.555E+17	-4.42E+09	-6.34E+06	2.27E+09	27.5	2.745E+36	-2.990E+00
	17	0.16821	0.01367	1.038E+08	6.552E+07	2.184E+09	4.500E+17	-7.04E+09	-2.90E+09	1.65E+09	27.5	1.671E+36	-3.213E+00
	18	0.18188	0.01631	1.074E+08	6.370E+07	2.174E+09	4.450E+17	-7.37E+09	-3.26E+09	1.17E+09	27.6	1.708E+36	-3.465E+00
	19	0.19819	0.01419	1.105E+08	6.192E+07	2.164E+09	4.400E+17	-7.72E+09	-3.61E+09	8.50E+08	27.6	1.732E+36	-3.675E+00
	20	0.21238	0.01691	1.140E+08	6.017E+07	2.154E+09	4.350E+17	-8.09E+09	-3.97E+09	6.18E+08	27.6	1.777E+36	-3.916E+00
etc....													

This edit lists the current values of each quantity named in the header for each zone currently in the problem. The first column, labeled 'zone' contains the zones number and a convection sentinel [ICON(J)] that describes the status of convection between zones J and J+1. Possible values of the convection sentinel are 'conv' to indicate full convection, 'semi' to indicate semiconvection, 'osht' to indicate that overshoot mixing is being done in zones adjacent to convective regions, 'neut' (for 'neutral') to indicate that while still radiative, the zonal interface is within a small amount (quantified and controlled by FRACNEUT (P 59)) of being convective, and ' ' (4 spaces), otherwise, to indicate that the interface is well into the regime where only radiative transfer takes place across the interface.

The second column, labeled 'mass' gives the mass interior to the inner boundary of each zone in SCALEM (P 273) units (usually solar masses), while the third column, labeled 'zmass', give the mass of each zone, also in SCALEM units. (These are converted from the internal KEPLER arrays: YM(J) -- the mass exterior to the outer boundary of each zone in grams, and XM(J), the zonal mass in grams).

The next ten columns correspond to the variables listed below:

'radius' = RN..... Radius of outer zone boundary (cm).

'density' = DN..... Density (g/cc).

'temp' = TN..... Temperature (K).

'energy' = EN..... Specific energy density (erg/g).
 'sdot' = SN..... Total energy generation rate -- including neutrino losses (erg/g/s).
 'snuc' = SNN..... Nuclear energy generation rate -- excluding neutrino losses (erg/g/s).
 'sburn' = SBURN.... Nuclear energy generation rate, excluding neutrino losses (erg/g/s).
 'abar' = ABAR..... Mean atomic weight (g/mole).
 'lumin' = XLN..... Calculated non-neutrino luminosity at the outer zone boundary (erg/s).
 'velocity' = UN..... Velocity of the outer zone boundary (cm/s).

Secondary Zonal Cycle Edit:

	zone	mass	entropy	mixtime	eta	pressure	stress	opacity	ye	yeburn	limnuc(cyczb)	dtburn
conv	1 i	0.00000	1.238E+00	2.258E+03	6.195E+00	2.357E+25	0.000E+00	1.020E-02	0.49799	0.49710	p33(6322)	7.148E+01
conv	2 i	0.00201	1.238E+00	1.768E+03	6.192E+00	2.318E+25	-1.256E+35	1.026E-02	0.49799	0.49710	p33(6322)	8.755E+01
conv	3 i	0.00377	1.238E+00	1.471E+03	6.190E+00	2.282E+25	-3.420E+35	1.031E-02	0.49799	0.49710	p33(6322)	5.257E+02
etc....												

The columns labeled 'zone' and 'mass' list the same values as in the primary zonal edit, except that a network sentinel is also included in an unlabeled column between them. The network sentinel is 'i' if the zone is currently using the ISE network [NETNUM(J) = 2], 'n', if the NSE network is being used [NETNUM(J) = 3], and ' ' (blank) if the APPROX network is being used [NETNUM(J) = 1].

The column labeled 'limnuc(cyczb)', lists the isotope controlling the BURN timestep for each zone, along with the KEPLER cycle when this zone was last burned. This information is calculated from the KEPLER array LIMNUC, defined as:

$LIMNUC = nalim + 100 * nzlim + 10000 * ncyczb$, where:

nalim.....Atomic weight of the nucleus limiting the BURN zonal timestep.

nzlim.....Atomic number of the nucleus limiting the BURN zonal timestep.

ncyczb.....KEPLER cycle at which this zone was last coprocessed by BURN.

The remaining columns correspond to the variables listed below:

'entropy' = STOT..... Total zonal entropy (k/baryon).

'mixtime' = taumix..... Convective mixing time (sec), calculated from the convective mixing coefficient [DIFI(J)] and the zonal convective mixing length [XLMIX] by the equation: $taumix = XLMIX^2 / DIFI(J)$

'eta' = ETAN.....Electron degeneracy parameter (μ_e / kT).

'pressure' = PN..... Pressure (erg/cc).

'stress' = ZN..... Viscous stress -- including linear and quadratic artificial viscosity (ergs).

'opacity' = XKN.....Rosseland mean opacity (cm^2/g).

'ye' = ionye..... Electron abundance in any current (non-BURN) network (moles/g).

'yeburn' = yeburn..... Electron abundance calculated for this zone by the BURN coprocessor (mole/g), derived from the BURN neutron excess, ETAB(J), by the equation: $yeburn = 0.5 * (1 - ETAB(J))$.

'dtburn' = DTIMEN.. Current timestep for BURN coprocessing in this zone (sec).

Ion Abundance Cycle Edit:

	zone	mass	nt1	ye	pn1	yq	he4	yf	eb0	o16	fe56	mg24
conv	1	0.00000	3.231E-18	4.980E-01	8.334E-17	3.635E-02	1.082E-16	2.421E-05	8.426E+00	5.636E-04	9.296E-09	1.370E-01
conv	2	0.00201	3.219E-18	4.980E-01	8.302E-17	3.635E-02	1.077E-16	2.421E-05	8.426E+00	5.636E-04	9.288E-09	1.370E-01
conv	3	0.00377	3.207E-18	4.980E-01	8.270E-17	3.635E-02	1.073E-16	2.421E-05	8.426E+00	5.636E-04	9.280E-09	1.370E-01
...	...											
	79	1.01990	1.283E-19	4.980E-01	1.064E-15	3.409E-02	8.221E-14	2.421E-05	8.439E+00	3.507E-02	2.866E-04	9.875E-06
	80	1.03465	1.107E-19	4.980E-01	1.855E-15	3.392E-02	1.581E-13	2.421E-05	8.439E+00	3.769E-02	4.407E-04	5.361E-06
total		1.05036	2.367E-20	0.000E+00	7.169E-18	0.000E+00	4.972E-16	0.000E+00	0.000E+00	4.167E-04	2.184E-06	3.703E-03
	zone	mass	s128	s32	ar36	ca40	ti44	cr48	'fe'	fe54	ni56	1-tot
conv	1	0.00000	8.018E-01	5.948E-02	1.107E-10	5.066E-17	1.376E-05	9.767E-04	1.881E-04	5.676E-09	6.908E-17	4.441E-15
conv	2	0.00201	8.018E-01	5.948E-02	1.105E-10	5.050E-17	1.375E-05	9.767E-04	1.881E-04	5.670E-09	6.886E-17	4.330E-15
conv	3	0.00377	8.018E-01	5.948E-02	1.103E-10	5.034E-17	1.375E-05	9.767E-04	1.881E-04	5.664E-09	6.863E-17	4.219E-15
...	...											
	79	1.01990	8.910E-01	7.130E-02	1.357E-03	5.253E-07	1.586E-08	8.898E-07	9.829E-04	9.342E-06	4.250E-12	-4.441E-15
	80	1.03465	8.804E-01	7.766E-02	2.988E-03	2.536E-06	2.506E-08	7.584E-07	8.301E-04	1.952E-05	1.571E-11	3.220E-15
total		1.05036	3.502E-02	2.590E-03	1.026E-05	4.811E-09	3.104E-07	3.170E-05	1.590E-05	7.204E-08	3.549E-14	9.582E-01
	zone	mass	nt1	h1	pn1	he3	he4	c12	n14	o16	ne20	mg24
	81	1.05036	2.174E-24	1.653E-34	5.511E-16	1.294E-20	4.163E-13	2.903E-09	2.111E-22	4.287E-02	5.613E-08	2.359E-02
	82	1.06710	2.153E-24	1.443E-34	5.889E-16	1.311E-20	4.653E-13	3.015E-09	2.048E-22	5.052E-02	7.164E-08	2.726E-02
	83	1.08043	1.440E-24	1.203E-34	4.940E-16	1.328E-20	4.641E-13	2.674E-09	2.265E-22	6.213E-02	1.006E-07	3.255E-02
...	...											
	502	25.13510	0.000E+00	7.058E-01	0.000E+00	2.929E-05	2.752E-01	3.070E-03	1.109E-03	9.620E-03	1.753E-03	6.936E-04
	503	25.13542	0.000E+00	7.058E-01	0.000E+00	2.929E-05	2.752E-01	3.070E-03	1.109E-03	9.620E-03	1.753E-03	6.936E-04
total		25.13573	4.025E-27	3.750E-01	1.824E-18	1.073E-05	3.491E-01	6.009E-02	3.442E-03	8.021E-02	6.338E-02	1.485E-02
	zone	mass	s128	s32	ar36	ca40	ti44	cr48	fe52	fe54	ni56	1-tot
	81	1.05036	8.005E-01	1.269E-01	4.626E-03	1.562E-04	1.845E-09	2.947E-06	1.813E-05	1.285E-03	6.960E-13	1.997E-13
	82	1.06710	7.919E-01	1.242E-01	4.611E-03	1.450E-04	1.848E-09	2.947E-06	1.813E-05	1.285E-03	7.560E-13	2.022E-13
	83	1.08043	7.795E-01	1.199E-01	4.508E-03	1.307E-04	1.935E-09	2.947E-06	1.813E-05	1.285E-03	6.534E-13	2.043E-13
...	...											
	502	25.13510	7.689E-04	4.260E-04	9.621E-05	6.572E-05	0.000E+00	2.947E-06	1.813E-05	1.285E-03	0.000E+00	2.920E-14
	503	25.13542	7.689E-04	4.260E-04	9.621E-05	6.572E-05	0.000E+00	2.947E-06	1.813E-05	1.285E-03	0.000E+00	8.153E-13
total		25.13573	9.547E-03	1.187E-03	1.145E-04	6.324E-05	6.490E-11	2.824E-06	1.738E-05	1.232E-03	3.887E-14	4.179E-02

The columns labeled 'zone' and 'mass' list the same values as in the primary zonal edit. The following columns list the zonal mass fraction of the first ten ions in the current (non-BURN) nuclear network being employed in each zone, with each column labeled with the appropriate network ion symbol (see Chapter 7). The special cases where the ion quantity listed is not an ionic mass fraction are as follows:

'ye' = ionye..... Electron abundance in any current (non-BURN) network (moles/g).

'yq' = ionyq..... Total abundance of ISE or NSE isotopes with $A \geq 24$ (moles/g).

'yf' = ionyf..... Total abundance of ISE or NSE isotopes with $A > 46$ plus ^{46}Ti (moles/g).

'eb0' = ioneb0..... Mean binding energy per nucleon of all ISE or NSE isotopes (MeV).

After all the zones with a (non-BURN) network the same as the first zone are listed, a final row labeled 'total' in the 'zone' column summarizes the total mass fraction of each ion (as summed over the entire same-network block of zones) relative to the current total mass [TOTM] of the all the zones in the star. The column labeled 'mass' in this row gives the total mass in the star interior to the outer boundary of this block of zones in SCALEM (P 273) units (usually solar masses).

When the edit described above for the first ten ions of the network employed by the first zone is complete, an essentially similar edit table is begun containing the same 'zone' and 'mass' columns, together with the next ten ions in that network, and so on until all the ions have been listed. A final column labeled '1-tot' is appended that lists the amount by which the sum of the mass fractions of all ions in each zone differs from unity. Note that the total mass fraction given in the '1-tot' column for the 'total' row includes all mass not accounted for by this same-network region, either due to mass-nonconservation in nuclear burning (generally due to zeroing small negative abundances) or to mass being present in *other* same-network regions.

When the edit for the first same-network block of zones is complete, edits in the same format are made for any other same-network region(s) that may be present.

ISE (or NSE) Zone-Cycle Edit:

zone	masscoord	cycle	time	dt	temp	density	ye	dye	yq	dyq	lternse
1	0.000000	7390	1.439609967542E+07	1.517E+03	2.556E+09	9.897E+07	4.980E-01	-8.758E-08	3.635E-02	-1.411E-05	57
yp	yn	ysi	y56	f0	g0	h0	q0	qxc12	qxol6	qxne	betaq
7.968E-16	3.069E-17	2.862E-02	4.582E-10	-6.362E-15	-2.959E-15	-2.290E-16	-2.362E-18	3.107E-05	8.924E-03	1.171E-09	2.608E+51
wrate	rectot	rpdtot	redtot	snuw	snubps	eectot	epdtot	eedtot	ebind0	ebind	eexcite
5.774E-11	5.758E-11	1.969E-13	3.394E-14	6.831E+07	1.538E+10	6.815E+07	0.000E+00	1.638E+05	8.426E+00	8.426E+00	1.613E-04
k	isotope	xk	wk	rtot	rec	rpdtot	red	eec	etot	eex	
1	n1	3.069E-17	2.000E+00	-2.531E-22	-4.629E-08	0.000E+00	8.203E-06	1.201E-07	1.218E-03	0.000E+00	
2	h1	7.968E-16	2.000E+00	1.068E-17	1.340E-02	0.000E+00	0.000E+00	1.339E-02	1.029E+01	0.000E+00	
13	mg24	1.365E-01	1.010E+00	6.187E-15	1.088E-12	2.123E-18	0.000E+00	8.259E-13	4.533E+03	1.368E-02	
15	mg26	4.951E-04	1.001E+00	-3.331E-23	5.012E-18	4.043E-26	6.760E-18	3.551E-18	6.863E-04	2.534E-03	
17	al27	6.547E-05	6.088E+00	2.277E-12	9.391E-07	6.247E-20	1.866E-20	7.247E-07	1.695E+06	1.281E-02	
19	si28	8.013E-01	1.002E+00	1.508E-11	5.271E-10	8.746E-17	0.000E+00	3.740E-10	1.033E+07	2.812E-03	
20	si29	3.367E-03	2.013E+00	2.436E-12	2.087E-08	1.138E-10	1.129E-20	3.910E-08	4.444E+06	8.500E-03	
21	si30	5.647E-02	1.000E+00	1.413E-19	7.552E-17	1.574E-25	4.342E-19	5.496E-17	1.037E-01	4.862E-04	
22	p30	6.197E-10	3.172E+00	1.470E-12	6.279E-02	8.364E-03	0.000E+00	2.847E-01	6.506E+06	3.987E-02	
23	p31	2.933E-05	2.013E+00	1.155E-11	1.220E-05	2.574E-18	1.993E-21	1.087E-05	9.925E+06	8.045E-03	
28	s33	8.306E-08	4.045E+00	1.085E-12	4.311E-04	2.193E-10	0.000E+00	6.187E-04	1.502E+06	9.372E-03	
57	ti47	2.425E-06	9.880E+00	9.901E-12	1.919E-04	3.023E-10	4.814E-16	2.240E-04	1.115E+07	8.872E-02	
61	ti48	8.665E-04	1.058E+00	1.596E-13	8.842E-09	7.558E-20	2.847E-17	7.666E-09	1.335E+05	5.103E-02	
66	v49	2.502E-07	1.409E+01	7.426E-12	1.454E-03	3.843E-08	1.654E-15	2.513E-03	1.238E+07	6.844E-02	
69	v50	3.818E-08	2.153E+01	7.960E-13	1.042E-03	7.641E-07	3.608E-09	1.894E-03	1.398E+06	1.364E-01	
73	cr51	8.708E-08	8.251E+00	3.515E-12	2.058E-03	2.502E-07	2.925E-16	4.249E-03	7.001E+06	2.629E-02	
77	cr52	2.283E-04	1.008E+00	1.532E-13	3.489E-08	3.093E-20	1.901E-18	2.934E-08	1.243E+05	1.102E-02	
82	mn53	1.811E-08	9.053E+00	6.640E-13	1.943E-03	2.405E-08	2.329E-17	2.971E-03	9.794E+05	4.897E-02	
snucq	snucq1	sdotq	tauqse	yf	yfqse	yffac	dyf	qj	yo160	dyo16q	eta
3.580E+11	3.427E+11	3.426E+11	1.603E+10	2.421E-05	8.523E-20	3.885E-15	-2.291E-12	1.264E-08	3.522E-05	-4.619E-06	6.195E+00

The variables listed in this edit and their units are defined on the following pages (EDITCOM variables are identified by being shown in boldface lower case letters, while internal KEPLER variables are shown in upper case):

First Row:

'zone' Index of the zone being edited [J].
 'masscoord' ... Mass interior to the inner boundary of this zone in SCALEM (P 273) units
 (usually solar masses).
 'cycle' Current KEPLER cycle [NCYC].
 'time' Current problem time (sec) [TIME -- P 2].
 'dt' Current timestep (sec) [DT].
 'temp' Zonal temperature (K) [TN(J)].
 'density' Zonal density (g/cc) [DN(J)].
 'ye' Electron abundance (mole/g) [ionye].
 dye Total change in Y_e during the current timestep (moles/g).
 'yq' Total abundance of ISE or NSE isotopes with $A \geq 24$ (moles/g) [ionyq].
 dyq Total change in Y_q during the current timestep (moles/g).
 iternse Total number of iterations it took for ISE/NSE to converge in this zone, or -1 if
 convergence was not achieved.

Second Row:

'yp' Abundance of protons in the ISE/NSE network (moles/g) [YP].
 'yn' Abundance of neutrons in the ISE/NSE network (moles/g) [YN].
 'ysi' Abundance of ^{28}Si in the ISE/NSE network (moles/g) [YSI].
 'y56' Abundance of ^{56}Fe in the ISE/NSE network (moles/g) [Y56].
 'f0' Convergence error for the ISE/NSE mass conservation equation [F0].
 'g0' Convergence error for the ISE/NSE charge conservation equation (moles/g) [G0].
 'h0' Convergence error for the ISE/NSE heavy ($A \geq 24$) isotope abundance conservation
 equation (moles/g) [H0].
 'q0' Convergence error for the ISE/NSE iron peak ($A > 46$ plus ^{46}Ti) isotope abundance
 conservation equation (mole/g) [Q0].
 qxc12 Photodisintegration-flow-determined mass fraction of ^{12}C in the ISE calculation.
 qxo16 Photodisintegration-flow-determined mass fraction of ^{16}O in the ISE calculation.
 qxne Photodisintegration-flow-determined mass fraction of ^{20}Ne in the ISE calculation.
 betaq The ratio of the actual current abundance of ^{28}Si to its "NSE" value based on the current
 abundance of neutron and protons.

Third Row:

- wrate..... Total zonal weak (i.e. neutronization) rate (moles/g/s).
- rectot..... Total zonal electron capture rate (moles/g/s).
- rpdtot..... Total zonal positron decay rate (moles/g/s).
- redtot..... Total zonal electron decay rate (moles/g/s).
- snuw..... Total zonal specific neutrino energy loss rate due to neutronization-related processes (erg/g/s).
- snubps..... Specific neutrino energy loss rate due to plasma-related processes (erg/g/s).
- eectot..... Total zonal electron capture plus positron decay neutrino loss rate (erg/g/s).
- epdtot..... Formerly, the total zonal positron decay neutrino loss rate (erg/g/s). This quantity is now combined into eectot, and epdtot is set = 0.
- eedtot..... Total zonal electron decay neutrino loss rate (erg/g/s).
- ebind0..... Average zonal nucleon binding energy at the beginning of the timestep (MeV/nucleon), including contribution from energy in nuclear excited states if IEXCITEH (P 171) > 0.
- ebind..... Average zonal nucleon binding energy at the end of the timestep (MeV/nucleon), including contribution from energy in excited states if IEXCITEH (P 171) > 0.
- eexcite..... Average zonal energy in nuclear excited states (MeV/nucleon).

Last Row:

- snucq..... ISE nuclear energy generation rate (erg/g/s).
- snuc1q..... ISE nuclear energy generation rate minus plasma neutrino loss rate (erg/g/s).
- sdotq..... Net ISE energy generation rate including all neutrino losses (erg/g/s).
- 'yf'..... Total abundance of ISE or NSE isotopes with $A > 46$ plus ^{46}Ti (moles/g) [ionyf].
- tauqse..... Timescale for the Fe and Si quasiequilibrium blocks to equilibrate (sec).
- yfqse..... Quasiequilibrium value of Y_Q based on the current abundance of neutron and protons and ^{28}Si (moles/g).
- yffac..... The actual value of Y_Q is less than yfqse by the factor $1 / yffac$.
- dyf..... Total change in Y_f during the current timestep (moles/g).
- qj..... Net photodisintegration flow downward from ^{24}Mg (moles/g/sec).
- 'yo160'..... Abundance of unburned ^{16}O in the ISE/NSE network (moles/g) [YO160].
- dyo16q..... Change in the ^{16}O abundance during this timestep (moles/g)
- 'eta'..... Electron (negatron) degeneracy parameter (μ_e / kT) [ETAN(J)].

Detailed ISE Isotope Edit:

The middle section of the ISE/NSE edit gives a list of all the isotopes in the edited zone whose mass fractions exceed XTHRES (P 183), together with quantities specific to each isotope. The edits for neutrons and protons, however, are always given, no matter what their mass fraction. Each isotope is identified by its isotope number 'k' (see the section of Chapter 7 on ISE EDIT Quantities for an ordered list) and by its isotope symbol, 'isotope'. The specific isotopic quantities listed are defined as follows:

- 'xk' Isotopic mass fraction,
- 'wk' Isotopic statistical weight,
- 'rtot' Total weak interaction rate due to this isotope (moles/g/sec),
- 'rec' Electron (e^-) capture rate due to this isotope (moles/g/sec),
- 'rpd' Positron emission rate due to this isotope (moles/g/sec),
- 'red' Beta (e^-) decay rate due to this isotope (moles/g/sec),
- 'eec' Neutrino energy loss due to e^- capture and e^+ decay on this isotope (erg/g/sec),
- 'etot' Total neutrino energy loss due to this isotope (ergs/g/sec),
- 'eex' Energy stored in the excited states of this isotope (MeV/nucleus).

BURN Isotope Abundance Cycle Edit:

burn ion edit:

	zone	mass	nt1	h1	he4	h2	h3	he3	li7	be7	b10	b11
conv	1	0.00000	1.775E-20	8.918E-17	5.461E-14	2.617E-33	1.371E-27	1.735E-28	1.316E-35	2.817E-34	2.754E-29	5.829E-21
conv	2	0.00201	1.775E-20	8.918E-17	5.461E-14	2.617E-33	1.371E-27	1.735E-28	1.316E-35	2.817E-34	2.754E-29	5.829E-21
conv	3	0.00377	1.775E-20	8.918E-17	5.461E-14	2.617E-33	1.371E-27	1.735E-28	1.316E-35	2.817E-34	2.754E-29	5.829E-21
...	...											
	502	25.13510	0.000E+00	7.057E-01	2.752E-01	4.801E-05	0.000E+00	2.929E-05	9.349E-09	0.000E+00	1.067E-09	4.730E-09
	503	25.13542	0.000E+00	7.057E-01	2.752E-01	4.801E-05	0.000E+00	2.929E-05	9.349E-09	0.000E+00	1.067E-09	4.730E-09
	total	25.13573	2.275E-20	3.758E-01	3.480E-01	4.288E-06	1.106E-17	2.444E-05	8.351E-10	6.671E-16	1.001E-10	4.233E-10

	zone	mass	cu61	cu62	cu63	cu64	zn60	zn61	zn62	zn63	zn64	1-tot
conv	1	0.00000	1.014E-11	1.450E-12	1.918E-07	1.008E-09	1.879E-25	2.394E-22	3.619E-16	1.569E-14	5.024E-09	-2.599E-10
conv	2	0.00201	1.014E-11	1.450E-12	1.918E-07	1.008E-09	1.879E-25	2.394E-22	3.619E-16	1.569E-14	5.024E-09	-2.599E-10
conv	3	0.00377	1.014E-11	1.450E-12	1.918E-07	1.008E-09	1.879E-25	2.394E-22	3.619E-16	1.569E-14	5.024E-09	-2.599E-10
...	...											
	501	25.13488	0.000E+00	0.000E+00	5.753E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.924E-07	-6.283E-10
	502	25.13510	0.000E+00	0.000E+00	5.753E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.924E-07	-1.926E-09
	503	25.13542	0.000E+00	0.000E+00	5.753E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.924E-07	-3.003E-09
	total	25.13573	2.245E-11	7.037E-12	5.120E-06	3.376E-08	1.152E-24	1.213E-21	2.222E-15	1.086E-14	1.638E-04	-2.464E-10

The columns labeled 'zone' and 'mass' list the same values as in the primary zonal edit. The following columns list the zonal mass fraction of the first ten isotopes in the current BURN network being employed in each zone, with each column labeled with the appropriate BURN isotope symbol (see Chapter 7 for an ordered list).

After all the zones in the BURN network are listed, a final row labeled 'total' in the 'zone' column summarizes the total mass fraction of each isotope (as summed over all BURN zones) relative to the current total mass [TOTM] of the all the zones in the star. The column labeled 'mass' in this row gives the total mass in the star interior to the outer boundary of this block of BURN zones in SCALEM (P 273) units (usually solar masses).

When the edit described above for the first ten BURN isotopes is complete, an essentially similar edit table is begun containing the same 'zone' and 'mass' columns, together with the next ten BURN isotopes, and so on until all the ions have been listed. A final column labeled '1-tot' is appended that lists the amount by which the sum of the mass fractions of all isotopes in each zone differs from unity. Note that the total mass fraction given in the '1-tot' column for the 'total' row includes all mass not accounted for by this block of BURN zones, either due to mass-nonconservation in nuclear burning (generally due to zeroing small negative abundances) or to mass being present in the problem that is not being co-processed by the BURN coprocessor.

Changeable Parameter Edit:

parameter	name	value	parameter	name	value	parameter	name	value	parameter	name	value
1	dtnew	1.514E+03	51	thickfac	1.000E-03	101	sneutmt	1.000E+00	151	fmax1	1.000E-02
2	time	1.440E+07	52	maxbak	5	102	snucmt	1.000E+00	152	fmax2	2.000E-02
3	extrap	1.000E+00	53	dteut	1.000E-01	103	denum	1.000E-06	153	ddsfrac	1.000E-02
4	q2fac	4.000E+00	54	tfcrbu	1.000E+01	104	tcoufac	1.000E+00	154	dtfrac	1.000E-03
5	maxit	40	55	tfctbu	1.000E+01	105	tqsemin	2.200E+09	155	iudflag	0
6	dtcr	2.000E-02	56	xipot	1.361E+01	106	jqse	0	156	nsdump	25
7	dtct	2.000E-02	57	dzer0	1.000E-01	107	artv1	1.000E+00	157	niterbar	1
8	dtcd	2.000E-02	58	npflag	1	108	artv2	1.000E+00	158	iterbarm	999999
9	dtcq	7.000E-02	59	fracneut	5.000E-02	109	artv3	1.000E+00	159	iautoout	0
10	dtcdt	9.900E-01	60	radius0	0.000E+00	110	jartv1	1000	160	iflgabar	0
11	fcrmax	1.000E-05	61	sum0	0.000E+00	111	jartv2	1000	161	fraccore	1.100E+00
12	fctmax	1.000E-05	62	xlum0	0.000E+00	112	jartv3	1000	162	jmcalc	503
13	qlfac	1.000E-01	63	lrnet	0	113	ipixtype	31	163	iupdfldg	0
14	nstop	100000	64	npixedit	50	114	nplotsym	5	164	niondump	40
15	tstop	1.000E+30	65	tnucmin	1.000E+07	115	tscalem	1.000E+07	165	nisodump	400
16	nedit	20	66	setparm	1.000E+01	116	igriddt	370	166	nzondump	40
17	dtedit	0.000E+00	67	iytsflag	1	117	igriddm	498	167	iflagye	1
18	ndump	10	68	tbound	0.000E+00	118	igriddv	496	168	njeditq	10
19	xmten	1.000E+00	69	pbound	0.000E+00	119	jp0	1	169	dtqnum	1.000E-04
20	fudgc	1.000E-02	70	fclmax	1.000E+99	120	jp1	0	170	ddqnum	1.000E-04
21	difim	1.000E+00	71	fclext	1.000E-05	121	rpmin0	1.000E+07	171	lexciteh	1
22	forbu	1.000E-02	72	dtcl	1.000E+99	122	rpmax0	1.000E+14	172	iterqmh	1000
23	fctbu	1.000E-02	73	fclbu	1.000E+99	123	ymintd	1.000E+00	173	ypconvh	1.000E-08
24	drmult	1.000E-01	74	tfclbu	1.000E+99	124	ymaxtd	1.000E+08	174	ynconvh	1.000E-08
25	dtmax	1.000E+99	75	dtmult	1.000E+99	125	sscalem	1.000E-03	175	ysiconvh	1.000E-08
26	fcext	1.000E+01	76	rnratmax	2.500E-01	126	pscalem	1.000E-01	176	cneeh	1.000E+00
27	fctext	1.000E+01	77	rnratmin	1.000E-01	127	itvstart	0	177	fyph	5.000E-02
28	ipup	1	78	tnratmax	2.500E-01	128	abunlim	1.000E-03	178	fynh	5.000E-02
29	xk1mt	1.000E+00	79	tnratmin	1.000E-01	129	ivplot	1	179	fysih	1.500E-01
30	xk2mt	1.000E+00	80	dnratmax	2.500E-01	130	vscalem	1.000E-05	180	neditq	20
31	xk3mt	1.000E+00	81	dnratmin	1.000E-01	131	rscalem	1.000E-05	181	xiterlqe	5.000E-01
32	xk4mt	1.000E+00	82	rnmin	1.000E-99	132	irtype	3	182	iterlqe	10
33	rxkcmt	1.000E+00	83	tnmin	1.000E+04	133	convord	3.000E+00	183	xthres	1.000E-04
34	pimult	1.000E+00	84	dnmin	1.000E-04	134	yplotmin	0.000E+00	184	tqselim	1.500E+09
35	prmult	1.000E+00	85	jmmin	10	135	yplotmax	2.000E-01	185	o16lim	4.000E-02
36	pemult	1.000E+00	86	izonef	1	136	etacut	1.000E+01	186	qn56lim	0.000E+00
37	transm	1.000E+00	87	idzonef	1	137	bethemt	0.000E+00	187	snuwmult	1.000E+00
38	timex0	-1.000E+99	88	rnmax	1.000E+99	138	fracrz1	1.500E-01	188	jnse	0
39	dyemult	2.000E+02	89	dypmin	1.000E-10	139	fracrz2	5.000E-01	189	sigselim	1.000E-03
40	dyqmult	2.500E+00	90	dymgmin	1.000E-10	140	rzmult0	1.000E+00	190	jlcalc	0
41	yemin	2.000E-02	91	zbound	1.000E-01	141	rzmult1	1.000E+00	191	vlimset	-1.000E+00
42	iwinsize	10240750	92	etaconv	1.000E-05	142	rzmult2	1.000E+00	192	jpause	-1
43	hstatm	1.000E+00	93	jshell0	1	143	abarrat0	2.000E+00	193	fracrz0	1.000E-01
44	lenqmax	3000000	94	jshell1	1000	144	abarratm	1.300E+00	194	rzmultm	1.000E+00
45	iwinloc	0	95	eexplode	0.000E+00	145	fracmlim	1.000E-02	195	fmaxm	1.500E-03
46	dtcp	1.500E-01	96	texplode	1.000E+99	146	frcsound	1.000E+99	196	eionmult	1.000E+00
47	yfloorx	3.000E-03	97	tauxexp	1.000E-02	147	convlim	1.000E+00	197	nnewoutf	2000
48	cenu	1.000E+00	98	p0core	0.000E+00	148	woversht	1.000E-02	198	neditq1	5
49	t7peek	1.000E+50	99	d0core	3.000E+11	149	xmimult	1.000E+00	199	wilsonmt	-1.000E+00
50	xkmin	1.000E-10	100	d0power	1.000E+00	150	fmax0	4.000E-03	200	t11cut	1.000E+00

1:

parameter	name	value	parameter	name	value	parameter	name	value
201	y56geesm	1.000E-04	251	ncent	999999	301	idtmaxl	40
202	isi30brn	1	252	nedt	999999	302	idtlook	10
203	dqselim	1.000E+05	253	nzro	1	303	backfacq	5.000E-01
204	abunminx	-1.000E-05	254	amaglim	0.000E+00	304	tempstop	1.000E+99
205	tfcybu	5.000E-01	255	ninv	1086297	305	denstop	1.000E+99
206	yffloorbx	3.000E-03	256	nbkup	47824	306	vinstop	9.000E+07
207	iqerrflg	1	257	ntty	6	307	ol6stop	-1.000E+99
208	cl2agmlt	1.000E+00	258	iratstop	-1	308	timezms	1.000E+99
209	xltaucon	0.000E+00	259	negbkup	33864	309	izonezms	1
210	noqsecon	0	260	bkupdiv	1.000E+01	310	qlfaczms	1.000E-01
211	accrate	0.000E+00	261	bkupmass	1.000E-13	311	tempcig	1.000E+99
212	xmacrete	0.000E+00	262	bkupmp	1.000E-19	312	yflrx cig	3.000E-03
213	denconv	1.000E-07	263	nbkupmax	10	313	fmaxmcig	1.500E-03
214	flamerad	0.000E+00	264	nsubcycm	1	314	fmax0cig	4.000E-03
215	coulmult	1.000E+00	265	mazful	1	315	toffset	2.526E+14
216	irzopt	1	266	al26mult	1.000E+02	316	abunminb	1.000E-04
217	nsurfz	-10	267	inburn	1	317	abunmaxb	1.000E+00
218	fracsz0	1.000E+00	268	npage	53	318	numiso	0
219	fracsz1	1.000E+00	269	nsavez	22	319	timeref	-1.000E+99
220	xmlossm	0.000E+00	270	nsaveb	10	320	tosetref	0.000E+00
221	xmloss0	0.000E+00	271	vloss	1.000E+99	321	timecmin	0.000E+00
222	totm0	5.000E+34	272	abunlimb	1.000E-05	322	timecmax	0.000E+00
223	fracdez	5.000E-01	273	scalem	1.989E+33	323	yemax	4.980E-01
224	xmratbak	2.000E-01	274	neditz1	10	324	abarsemi	4.000E+00
225	xfracml	1.000E-02	275	neditz2	20	325	drmultlo	1.000E-01
226	mlcompf	0	276	medit	0	326	woverslo	1.000E-02
227	e1mltc12	5.000E-01	277	meditfin	7	327	maptime	2
228	e2mltc12	5.000E-01	278	neditp	50	328	vminmap	1.000E+99
229	nupdate	100	279	flamva	0.000E+00	329	vmaxmap	-1.000E+99
230	dtfrac	1.000E-02	280	flamvb	1.000E+00	330	vratmap	1.000E-99
231	bmssmin	-1.000E+00	281	flamvc	5.000E+01			
232	bmssmax	1.000E+99	282	flamvd	1.000E+00			
233	btempmin	1.000E+06	283	jflam	0			
234	btempmax	1.000E+99	284	xkapflam	1.000E-03			
235	snucmin	1.000E-99	285	xmflam	0.000E+00			
236	bdenmin	1.000E-99	286	taunu	0.000E+00			
237	bdenmax	1.000E+99	287	enu53	3.000E+00			
238	tchange	2.000E-02	288	tmunu	8.000E+00			
239	dchange	5.000E-02	289	tenu	4.000E+00			
240	netmax	1	290	noiland	1			
241	neditb	5	291	charsizg	1.000E+00			
242	edmass1	1.000E-04	292	charsizc	8.500E-01			
243	nedita	10	293	charsizz	8.500E-01			
244	jmeditb	1	294	charsizh	1.000E+00			
245	nedital1	100	295	widthtd	6.000E+01			
246	chimin	1.000E-06	296	ibackgnd	-1			
247	delchi	1.500E-01	297	dscalem	1.989E+33			
248	fdtn	2.000E+00	298	ngridmin	10			
249	dtbkup	5.000E-01	299	ncycqq	5			
250	ncomp	999999	300	lentrack	16384			

1.V.91
DRAFT

APPENDIX A

ALPHABETICAL SYNOPSIS OF INTERACTIVE KEYBOARD COMMANDS

This appendix contains an alphabetic synopsis of the commands that can be interactively entered from the keyboard while running a KEPLER job. Each command keyword is given in bold capital letters followed by its arguments if any in italic capital letters. On the following line a terse summary of the function of the command is given followed by an example printed in boldface letters and enclosed in quotes, which also serves to indicate the type of the arguments. Note that, as indicated by the examples, actual communication with the computer should be made in lower case, floating point numbers must contain a decimal point or exponent, and that character parameters are never enclosed in quotes.

ADDLOOK *EDITVAR* [*DELFLAG*]

Add edit variable to look list: 'addlook sneut delete'

ADDSURF *NSURF* *TMSURF* *TEMPSURF* *RHOSURF* *VELSURF*

Add surface zones: 'addsurf 10 1.E+32 1.E+4 1.E-11 0.'

BOX *BOX#*

Set box number: 'box v98'

CHECK

Check for I/O errors.

CHNGCOMP *JMIN* *JMAX* *FIRSTION#* *MFRAC1* [*MFRAC2* *MFRAC8*]

Change zonal composition: 'chngcomp 20 10 1 0. 0. 0. 0. 0. .5 0. .5'

COMPSURF *FIRSTION#* *MFRAC1* [*MFRAC2* *MFRAC3* *MFRAC10*]

Set composition of added surface zones: 'compsurf 1 0. .7 0. 0. .28 0. .02'

CUTSURF *NSURF*

Remove outer *NSURF* zones: 'cutsurf 3'

D

Make a normal restart dump.

D NAME

Make a restart dump named *NAME*: 'd s25s2a#8657'

DECAYNI

Convert all Ni56 to Fe54 without energy generation (APPROX only).

DET JDET0 JDET1 ENDET

Detonate zones *JDET0* thru *JDET1* with *ENDET* erg/g: 'det 1 30 7.867E+17'

DUMP DUMPVAR RATZDUMP RATIODEZ RATIOADZ

Add *DUMPVAR* to the dump list or change its parameters: 'dump convect .1 -1. 0.'

E

Make an energy edit on the terminal.

ED

Force an edit of the current cycle to be written in the ASCII output file.

ED M

Make an ASCII output file edit of the current cycle with MEDIT (P 276) = *M*.

EDP*

Write a parameter edit to the ASCII output file.

END

Terminate the problem.

EOSTABLE JJ TLOW THI NTEMP DLOW DHI NRHO

Write an EOS table in output file: 'eostable 1 1.E+6 1.E+9 20 1. 1.E+6 30'

EOSTRANS TRANSMULT

Add *TRANSMULT* *(nuclear excited state energy) to all zonal energies: 'eostrans 1.'

EOSWRITE JTAB JJ NTEMP NRHO NEOSM

Unsupported EOS table generator: 'eoswrite 626 1 20 30 10'

FIN

Terminate the problem.

G

Resume normal calculations after a suspension.

GENBURN NAMEBG

Start BURN co-processing by reading burn generator *NAMEBG*: 'genburn sol160bg'

J

Make a current edit for zone *J* on the terminal: '1'

J I

Make a current edit of ion mass fractions for zone *J* on the terminal: '1 i'

J I IONSYM

To edit the mass fraction of ion type *IONSYM* on the terminal: '1 i he4'

J B

Make an edit of BURN isotope mass fractions for zone *J* on the terminal: '1 b'

J B ISOSYM

To edit the mass fraction of BURN isotope type *ISOSYM* on the terminal: '1 b al26'

J Q

Make a QNSE edit for zone *J* on the terminal: '1 q'

LINK NAMEL

Read link deck *NAMEL*: 'link linkwlsn'

LISTISO

List isotopes currently selected for plotting in plot type 6.

LOOK NPLOTC NCYCLO [NCYCLI [NDELCYCL]]

Display a movie of cycle plots of type *NPLOT*: 'look 31 10000 15000 1000'

L NPLOTC NCYCLO [NCYCLI [NDELCYCL]] (Abbreviated form)

Display a movie of cycle plots of type *NPLOT*: 'l 31 10000 15000 1000'

LPRINTL* NPLOTC NCYCLO [NCYCLI [NDELCYCL]] [FILENAME]

Print a series of landscape plots of type *NPLOT*: 'lprintl 3 10000 15000 1000 s25n2a.abun'

LPL NPLOTC NCYCLO [NCYCLI [NDELCYCL]] [FILENAME] (Abbreviated form)

Print a series of landscape plots of type *NPLOT*: 'lpl 3 10000 15000 1000 s25n2a.abun'

LPRINTP NPLOTC NCYCLO [NCYCLI [NDELCYCL]] [FILENAME]

Print a series of portrait plots of type *NPLOT*: 'lprintp 3 10000 15000 1000 s25n2a.abun'

LPP NPLOTC NCYCLO [NCYCLI [NDELCYCL]] [FILENAME] (Abbreviated form)

Print a series of portrait plots of type *NPLOT*: 'lpp 3 10000 15000 1000 s25n2a.abun'

MASSB M N

Make an edit of the mass of all BURN isotopes in zones *M* thru *N* (M_0): 'massb 1 100'

MASSB M N ISOSYM

Make an edit of the mass of burn isotope *ISOSYM* in zones *M* thru *N* (M_0): 'massb 1 50 al26'

MASSI M N

Make an edit of the mass of all ions in zones *M* thru *N* (M_0): 'massi 1 100'

MASSI M N IONSYM

Make an edit of the mass of ion *IONSYM* in zones *M* thru *N* (M_0): 'massi 1 50 al26'

MONGO EDITVAR2 [EDITVAR3... EDITVAR8] [AXISY2 [AXISY3]]

Plot the specified edit variables using MONGO: 'mongo dn tn log lin'

MON EDITVAR2 [EDITVAR3... EDITVAR8] [AXISY2 [AXISY3]] (Abbreviated form)

Plot the specified edit variables using MONGO: 'mon dn tn log lin'

NEWE

Calculate new internal energies from current densities and temperatures.

NEWQNAME

Reset the names of the expected qq-file and qlib-file to reflect the current problem name.

NEWSTART

Make restart dump, put out output files, and store dumps (Obsolescent--CRAY only).

P N

Display the value of parameter name or number *N*: 'p 113'

P N VALUE

Change the value of parameter name or number *N* to *VALUE*: 'p 113 31'

P N DELTA ADD

Add *DELTA* to the value of parameter name or number *N*: 'p 1 -1.e+14 add'

PLOT N PLOT

Display plot of type *N PLOT* for the current cycle: 'plot 31'

PRINTL [N PLOT [FILENAME]]

Print landscape plot of type *N PLOT* for the current cycle: 'printl 31 k'

PL [N PLOT [FILENAME]] (Abbreviated form)

Print landscape plot of type *N PLOT* for the current cycle: 'pl 31 k'

PRINTP [N PLOT [FILENAME]]

Print portrait plot of type *N PLOT* for the current cycle: 'printp 31 k'

PP [N PLOT [FILENAME]] (Abbreviated form)

Print portrait plot of type *N PLOT* for the current cycle: 'pp 31 k'

Q N

Display the value of 'edit' parameter name or number *N*: 'q 53' or 'q teff'

S

Suspend execution, or step one cycle if suspended.

S N

Run the problem for *N* more cycles, then suspend: 's 5'

SETISO *ISOSYM1* [*ISOSYM2* ... *ISOSYM20*]

Set isotopes to be plotted in plot type 6: 'setiso he4 ne22 fe58 al26 mg 25'

SETLIB [*NAMETLIB* [*NCYCT0* [*NCYCT1* [*NCYCTDEL* [*NCYCQQT* [*LENTDMPT* [*NIYMAXT*]]]]]]]

Set '.lib' file and cycle range to be read for timeplots: 'setlib s25s2a.lib 0 18345 10 5'

SETQ [*NAMEQQLO* [*NAMEQQLI*]]

Set qq-file type and range for post-processing: 'setq s25s2a.qa s25s2a.qk'

STORE *NSDIRECT*

Store ASCII output files and labeled restart dumps in *NSDIRECT*: 'store /s1/weaver/s25s2a'

T

Make a current time edit on the terminal.

TED

Make a 'short' ASCII edit on the terminal.

TED M

Make an ASCII edit on the terminal with MEDIT (P 276) = *M*: 'ted 3'

TEST *TESTVAR J T D*

Test equation of state variable (p, e, s, or k): 'test p 1 3.E+9 2.E+7'

TIME

Display an edit of computer time usage (in seconds).

TIMEPLOT *TIMEVAR2* [*TIMEVAR3*...*TIMEVAR8*] [*AXISY2* [*AXISY3*]]

Display a timeplot of the requested variables: 'timeplot eni enk enp log same'

TIMEMAP *NAMEVAR* [*LOGFLAG* [*NCYCLO* [*NCYCLI* [*NDELCYCL*]]]]]

Display a timemap of the requested variable: 'timemap convect lin 0 18750 1'

TM *NAMEVAR* [*LOGFLAG* [*NCYCLO* [*NCYCLI* [*NDELCYCL*]]]]] (Alternate form)

Display a timemap of the requested variable: 'tm convect lin 0 18750 1'

TN

Make a nuclear reaction rate edit on the terminal (moles/s -- over the whole star).

TN REACSYM

Display the total rate of nuclear reaction *REACSYM* (moles/s): 'tn he3+he4'

TP *TIMEVAR2* [*TIMEVAR3*...*TIMEVAR8*] [*AXISY2* [*AXISY3*]] (Abbreviated form)

Display a timeplot of the requested variables: 'tp eni enk enp log same'

TQ

Make a combined time and surface edit on the terminal

TVAL N VAL1 [VAL2 VAL3 VAL10]

Set density and temperature values for EOSWRITE: 'tval 1 .1 3 1. 3. 10. 30. 100.'

V EDITVAR [JMIN [JMAX]]

Display the values of edit variable *EDITVAR* in zones *JMIN* thru *JMAX*: 'v ionye 1 100'

VED EDITVAR [JMIN [JMAX]]

Make output file edit of *EDITVAR* in zones *JMIN* thru *JMAX*: 'ved ionye 1 100'

VEDEF EDITVAR [JMIN [JMAX]]

Make 14-digit output file edit of *EDITVAR* in zones *JMIN* thru *JMAX*: 'vedf ionye 1 100'

VERSION

Display the dates on which the current code modules were last modified.

VF EDITVAR [JMIN [JMAX]]

Display 14-digit values of *EDITVAR* in zones *JMIN* thru *JMAX*: 'vf ionye 1 100'

Z EDITVAR1 [EDITVAR2....EDITVAR10] [JMIN [JMAX]]

Display an edit of the requested variables in zones *JMIN* to *JMAX*: 'z dn tn sige sigi 1 100'

ZED EDITVAR1 [EDITVAR2....EDITVAR10] [JMIN [JMAX]]

Make output file edit of requested variables in zones *JMIN* to *JMAX*: 'zed dn tn sige 1 100'

ZEDIT IZED NCYCZED EDITVAR1 [EDITVAR2....EDITVAR10] [ZEDMASS1 [ZEDMASS2]]

Edit requested variables every *NCYCZED* cycles: 'zedit 1 50 dn tn sige sigi sigr 0. 2.'

ZEROTIME

Set the problem time, *TIME* (P 2), to 0. Add the old value of *TIME* to *TOFFSET* (P 315).

Appendix B: Alphabetical Parameter List

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Name	Number	Default
ABARRATM	144	1.3
ABARRATO	143	2
ABARSEMI	324	4
ABUNLIM	128	1.D-3
ABUNLIMB	272	1.D-5
ABUNMAXB	317	1
ABUNMINB	316	0.0001
ABUNMINX	204	-1.D-5
ACCRATE	211	0
AL26MULT	266	1.0D+02
AMAGLIM	254	0
ARTV1	107	1
ARTV2	108	1
ARTV3	109	1
BACKFACQ	303	0.5
BDENMAX	237	1.D+99
BDENMIN	236	1.D-99
BTHEMT	137	0
BKUPDIV	260	10
BKUPMASS	261	1.D-13
BKUPMP	262	1.D-19
BMASSMAX	232	1.D+99
BMASSMIN	231	-1
BTEMPMAX	234	1.D+99
BTEMPMIN	233	1.D+6

Name	Number	Default
CENU	48	1
CHARSIZC	292	0.85
CHARSIZG	291	1
CHARSIZH	294	1
CHARSIZZ	293	0.85
CHIMIN	246	1.D-6
CNSEH	176	1
CONVLIM	147	1
CONVORD	133	3
COULMULT	215	1
C12AGMLT	208	1
DCHANGE	239	0.05
DDQNUM	170	1.D-4
DDSFRAC	153	0.01
DELCHI	247	0.15
DENCONV	213	1.D-7
DENSTOP	305	1.D+99
DIFIM	21	1
DNMIN	84	1.D-99
DNRATMAX	80	0.25
DNRATMIN	81	0.1
DQSELIM	203	1.D+5
DRMULT	24	0.1
DRMULTLO	325	DRMULT

Name	Number	Default
DSCALEM	297	SOLMASS
DSNUM	103	1.D-6
DTBKUP	249	0.5
DTCD	8	0.1
DTCDT	10	0.99
DTCL	72	1.D+99
DTCP	46	0.1
DTCQ	9	0.05
DTCR	6	0.05
DTCT	7	0.05
DTCUT	53	0.1
DTEDIT	17	0
DTFRAC	230	1.D-2
DTMAX	25	1.D+99
DTNEW	1	1
DTQNUM	169	1.D-4
DTSFRAC	154	0.001
DTSMULT	75	1.D+99
DYEMULT	39	200
DYMGMIN	90	1.D-10
DYPMIN	89	1.D-10
DYQMULT	40	2.5
DZERO	57	0.1
D0CORE	99	3.D+11
D0POWER	100	1

Name	Number	Default
EDMASSL	242	1.D-4
EEXPLODE	95	0
EIONMULT	196	1
ENU53	287	3
ETACONV	92	1.D-5
ETACUT	136	10
EXTRAP	3	1
E1MLTC12	227	1
E2MLTC12	228	1
FCLBU	73	1
FCLEXT	71	1.D-5
FCLMAX	70	1
FCRBU	22	0.01
FCREXT	26	10
FCRMAX	11	1.D-6
FCTBU	23	0.01
FCTEXT	27	10
FCTMAX	12	1.D-6
FDTN	248	2
FLAMERAD	214	0
FLAMVA	279	0
FLAMVB	280	1
FLAMVC	281	50
FLAMVD	282	1
FMAXM	195	1

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Name	Number	Default
FMAXMCIG	313	1
FMAX0	150	1
FMAX0CIG	314	1
FMAX1	151	1
FMAX2	152	1
FRACCORE	161	1.1
FRACDEZ	223	0.5
FRACMLIM	145	0.01
FRACNEUT	59	0.05
FRACRZ0	193	-1
FRACRZ1	138	1
FRACRZ2	139	1
FRACSZ0	218	1
FRACSZ1	219	1
FRC SOUND	146	1E+99
FUDGC	20	0.01
FYNH	178	0.05
FYPH	177	0.05
FYSIH	179	0.15
HSTATM	43	1
IAUTOOUT	159	0
IBACKGND	296	-1
IDTLOOK	302	10
IDTMAXL	301	40

Name	Number	Default
IDZONEF	87	1
IEXCITEH	171	1
IFLAGYE	167	1
IFLGABAR	160	0
IGRIDM	117	498
IGRIDT	116	370
IGRIDV	118	496
INBURN	267	0
IPIXTYPE	113	31
IPUP	28	1
IQERRFLG	207	1
IRATSTOP	258	-1
IRNET	63	0
IRTYPE	132	3
IRZOPT	216	1
ISI30BRN	202	1
ITERBARM	158	100
ITERQMH	172	1000
ITERIQE	182	10
ITVSTART	127	0
IUDFLAG	155	0
IUPDFLAG	163	1
IVPLOT	129	1
IWINLOC	45	0
IWINSIZE	42	10240750
IYTSFLAG	67	1

Name	Number	Default
IZONEF	86	1
IZONEZMS	309	1
JARTV1	110	1000
JARTV2	111	1000
JARTV3	112	1000
JFLAM	283	0
JLCALC	190	0
JMCALC	162	JMZ
JMEDITB	244	1
JMMIN	85	10
JNSE	188	0
JPAUSE	192	-1
JP0	119	1
JP1	120	0
JQSE	106	0
JSHELL0	93	1
JSHELL1	94	1000
LENQMAX	44	3000000
LENTRACK	300	16384
MAPTIME	327	2
MAXBAK	52	5
MAXIT	5	40
MAZFUL	265	1

Name	Number	Default
MEDIT	276	0
MEDITFIN	277	7
MLCOMP	226	0
NBKUP	256	0
NBKUPMAX	263	10
NCENT	251	999999
NCOMP	250	999999
NCYCQQ	299	5
NDUMP	18	10
NEDIT	16	20
NEDITA	243	10
NEDITALL	245	100
NEDITB	241	5
NEDITP	278	50
NEDITQ	180	20
NEDITQ1	198	5
NEDITZ1	274	10
NEDITZ2	275	20
NEDT	252	999999
NEGBKUP	259	0
NETMAX	240	1
NGRIDMIN	298	10
NINV	255	0
NIONDUMP	164	40
NISODUMP	165	400

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Name	Number	Default
NITERBAR	157	1
NJEDITQ	168	10
NNEWOUTF	197	2000
NOILAND	290	1
NOQSECON	210	0
NPAGE	268	53
NPFLAG	58	1
NPIXEDIT	64	50
NPLOTSYM	114	8
NSAVEB	270	10
NSAVEZ	269	24
NSDUMP	156	10
NSTOP	14	100000
NSUBCYCM	264	1
NSURFZ	217	-10
NTTY	257	6
NUMISO	318	0
NUPDATE	229	100
NZONDUMP	166	40
NZRO	253	1
O16LIM	185	0.04
O16STOP	307	-1
PBOUND	69	0
PEMULT	36	1

Name	Number	Default
PIMULT	34	1
PRMULT	35	1
PSCALEM	126	1.D-1
POCORE	98	0
QN56LIM	186	0
Q1FAC	13	0.1
Q1FACZMS	310	0.1
Q2FAC	4	4
RADIUS0	60	0
RNMAX	88	1.D+99
RNMIN	82	1.D-99
RNRATMAX	76	0.25
RNRATMIN	77	0.1
RPMAX0	122	1.D+14
RPMIN0	121	1.D+7
RSCALEM	131	1.D-5
RXXCMT	33	1
RZMULTM	194	1
RZMULT0	140	1
RZMULT1	141	1
RZMULT2	142	1
SCALEM	273	1.9892D+33
SETPARM	66	10

Name	Number	Default
SIQSELIM	189	1.D-3
SNEUTMT	101	1
SNUCMIN	235	1.D-99
SNUCMT	102	1
SNUWMULT	187	1
SSCALEM	125	1.D-3
SUMMO	61	0
TAUEXP	97	1.D-2
TAUNU	286	0
TBOUND	68	0
TCHANGE	238	0.02
TCOREFAC	104	1
TEMPCIG	311	1.D+99
TEMPSTOP	304	1.D+99
TENU	289	4
TEXPLODE	96	1.D+99
TFCLBU	74	1.D+99
TFCRBU	54	2
TFCTBU	55	2
TFCYBU	205	0.5
THICKFAC	51	1.D-3
TIME	2	0
TIMECMAX	322	0
TIMECMIN	321	0
TIMEREF	319	-1.D+99

Name	Number	Default
TIMEX0	38	-1.D+99
TIMEZMS	308	1.D+99
TMUNU	288	8
TNMIN	83	1
TNRATMAX	78	0.25
TNRATMIN	79	0.1
TNUCMIN	65	0
TOFFSET	315	0
TOSETREF	320	0
TOTM0	222	0
TQSELIM	184	1.5D+9
TQSEMIN	105	2.D+9
TRANSM	37	1
TSCALEM	115	1.D+7
TSTOP	15	1.D+30
T11CUT	200	1
T7PEEK	49	1.D+50
VINSTOP	306	1.D+99
VLIMSET	191	-1
VLOSS	271	1.D+99
VMAXMAP	329	-1.D+99
VMINMAP	328	1.D+99
VRATMAP	330	1.D-99
VSCALEM	130	1.D-5

Name	Number	Default
WIDTHTD	295	60
WILSONMT	199	-1
WOVERSHT	148	0.01
WOVERSLO	326	WOVERSHT
XFRACML	225	0.01
XIPOT	56	13.6053
XITER1QE	181	0.5
XKAPFLAM	284	0.001
XKMIN	50	1.D-10
XK1MT	29	1
XK2MT	30	1
XK3MT	31	1
XK4MT	32	1
XLTAUCON	209	0
XLUM0	62	0
XMACRETE	212	0
XMFLAM	285	0
XMIMULT	149	1
XMLEN	19	1
XMLOSSM	220	0
XMLOSS0	221	0
XMRATBAK	224	0.2
XTHRES	183	1.D-4
YEMAX	323	0.498

Name	Number	Default
YEMIN	41	0.02
YFLOORBX	206	0.001
YFLOORX	47	1.D-3
YFLRXCIG	312	0.003
YMAXTD	124	1.D+8
YMINTD	123	1
YNCONVH	174	1.D-8
YPCONVH	173	1.D-8
YPLOTMAX	135	1
YPLOTMIN	134	0
YSICONVH	175	1.D-8
Y56GESSM	201	1.D-4
ZBOUND	91	0.1

1.V.91
DRAFT

APPENDIX C

ALPHABETICAL SYNOPSIS OF ZONAL EDIT VARIABLES

This appendix lists the currently defined zonal edit variables in alphabetical order, together with a brief definition. More details are presented in Chapter 7, where they are presented by type. In the list below, only one example of each large generic classes of edit variables ('inse....', 'iso...', etc.) is listed in order to save space. Also note that edit variables are always floating point numbers even when they have integral values.

ALPHABETIC LIST OF ZONAL EDIT VARIABLES

- 3a-c12**.....Rate of the $^4\text{He}(2\alpha,\gamma)^{12}\text{C}$ reaction (moles/g/s -- APPROX only).
- abar**.....Mean atomic weight, ABAR (g/mole).
- abarnbd**..... Last calculated partial derivative of ABAR with respect to density (cc/g).
- abarnbt**..... Last calculated partial derivative of ABAR with respect to temperature (1/K).
- abarold**..... Last calculated value of ABAR
- ar36(ag)**..... Rate of the $^{36}\text{Ar}(\alpha,\gamma)^{40}\text{Ca}$ reaction (moles/g/s -- APPROX only).
- betaq**..... The ratio of the actual current abundance of ^{28}Si to its "NSE" value based on the current abundance of neutron and protons.
- bnsefe56**.....Beta (e^-) decay rate due to **fe56**, where **fe56** exemplifies any valid ISE isotope (moles/g/sec).
- c12+c12**..... Rate of the $^{12}\text{C} + ^{12}\text{C}$ reaction (moles/g/s -- APPROX only).

- c12+o16**.....Rate of the $^{12}\text{C} + ^{16}\text{O}$ reaction (moles/g/s -- APPROX only).
- c12(ag)**..... Rate of the $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$ reaction (moles/g/s -- APPROX only).
- c12(pg)**..... Rate of the $^{12}\text{C}(\text{p},\gamma)^{13}\text{N}$ reaction (moles/g/s -- APPROX only).
- ca40(ag)**..... Rate of the $^{40}\text{Ca}(\alpha,\gamma)^{44}\text{Ti}$ reaction (moles/g/s -- APPROX only).
- cnsefe56**..... Electron capture rate due to fe56, where fe56 exemplifies any valid ISE isotope (moles/g/sec).
- convect**.....Convection flag, where: 0. = 'rad', 1. = 'neut', 2. = 'osht', 3. = 'semi', 4. = 'conv'.
- cr48(ag)**..... Rate of the $^{48}\text{Cr}(\alpha,\gamma)^{52}\text{Fe}$ reaction (moles/g/s -- APPROX only).
- deriv1**.....Reserved for future derivative edit.
- deriv2**.....Reserved for future derivative edit.
- deriv3**.....Reserved for future derivative edit.
- deriv4**.....Reserved for future derivative edit.
- deriv5**.....Reserved for future derivative edit.
- difi**..... Diffusion coefficient for material mixing due to convection (cm^2/s).
- dn**..... Density (g/cc).
- dnold**..... Density at which BURN coprocessing was last done in this zone (g/cc).
- dsold**.....Density at which the energy generation rate was last calculated (g/cc).
- dtimen**..... Current timestep for BURN coprocessing in this zone (sec).
- dye**.....Total change in Y_e during the current timestep (moles/g).
- dyf**..... Total change in Y_f during the current timestep (moles/g).
- dyo16q**..... Change in the ^{16}O abundance during this timestep (moles/g)
- dyq**.....Total change in Y_q during the current timestep (moles/g).
- ebind**..... Average zonal nucleon binding energy at the end of the timestep (MeV/nucleon), including contribution from energy in excited states if IEXCITEH (P 171) > 0.
- ebind0**..... Average zonal nucleon binding energy at the beginning of the timestep (MeV/nucleon), including contribution from energy in nuclear excited states if IEXCITEH (P 171) > 0.
- ee**..... Specific electron energy including pairs (erg/g).
- ectot**.....Total zonal electron capture plus positron decay neutrino loss rate (erg/g/s).
- eed**..... Partial derivative of the electron specific energy with respect to density including pairs (erg/cc/g²).
- eedtot**..... Total zonal electron decay neutrino loss rate (erg/g/s).

eet.....	Partial derivative of the electron specific energy with respect to temperature including pairs (erg/g/K).
eexcite.....	Average zonal energy in nuclear excited states (MeV/nucleon).
ei.....	Specific ion energy (erg/g).
eid.....	Partial derivative of the ion specific energy with respect to density (erg/cc/g**2).
eit.....	Partial derivative of the ion specific energy with respect to temperature (erg/g/K).
en.....	Specific energy density (erg/g).
end.....	Partial derivative of the total specific energy with respect to density (erg/cc/g**2).
ensefe56.....	Total neutrino energy loss due to fe56, where fe56 exemplifies any valid ISE isotope (erg/g/sec).
ent.....	Partial derivative of the total specific energy with respect to temperature (erg/g/K).
eos1.....	Reserved for future EOS quantity.
eos2.....	Reserved for future EOS quantity.
eos3.....	Reserved for future EOS quantity.
ep.....	Specific positron energy (erg/g).
epd.....	Partial derivative of the positron specific energy with respect to density (erg/cc/g**2).
epdtot.....	Formerly, the total zonal positron decay neutrino loss rate (erg/g/s). This quantity is now combined into eectot, and epdtot is set = 0.
ept.....	Partial derivative of the positron specific energy with respect to temperature (erg/g/K).
er.....	Specific radiation energy (erg/g).
erd.....	Partial derivative of the radiative specific energy with respect to density (erg/cc/g**2). (Not implemented yet).
ert.....	Partial derivative of the radiative specific energy with respect to temperature (erg/g/K).
eta.....	Electron (negatron) degeneracy parameter (μ_e / kT).
etab.....	Burn neutron excess (moles/g). The corresponding BURN electron abundance is given by: $y_{\text{eburn}} = 0.5 * (1. - \text{etab})$
etabt.....	Partial derivative of the negatron degeneracy parameter with respect to temperature (1/K).
etabd.....	Partial derivative of the negatron degeneracy parameter with respect to density (cc/g).
etan.....	Electron (negatron) degeneracy parameter (μ_e / kT).
etap.....	Positron degeneracy parameter ($\mu_{\text{positron}} / kT$).

fe52:2ng..... Rate of the $^{52}\text{Fe}(2n,\gamma)^{54}\text{Fe}$ reaction (moles/g/s -- APPROX only).

fe52:a2p..... Rate of the $^{52}\text{Fe}(\alpha,2p)^{54}\text{Fe}$ reaction (moles/g/s -- APPROX only).

fe52(ag)..... Rate of the $^{52}\text{Fe}(\alpha,\gamma)^{56}\text{Ni}$ reaction (moles/g/s -- APPROX only.)

fe54:2pg..... Rate of the $^{54}\text{Fe}(2p,\gamma)^{56}\text{Ni}$ reaction (moles/g/s -- APPROX only).

gamma..... Adiabatic exponent defined by $\gamma = \rho^*(dP/d\rho)_{ad} / P = \Gamma_1$.

gammae..... Adiabatic exponent for electrons defined by $\gamma_e = \rho^*(dP_e/d\rho)_{ad} / P_e = \Gamma_{1e}$.

gammaf..... Adiabatic exponent defined by $\gamma_f = P^*(dT/dP)_{ad} / T = (\Gamma_2 - 1) / \Gamma_2$.

he3+he3..... Rate of the $^3\text{He} + ^3\text{He}$ reaction (moles/g/s -- APPROX only).

he3+he4..... Rate of the $^3\text{He} + ^4\text{He}$ reaction (moles/g/s -- APPROX only).

he4-2n2p..... Rate of the $^4\text{He}(\gamma,2p2n)$ reaction (moles/g/s -- APPROX only).

insefe56..... Isotopic mass fraction of fe56, where fe56 exemplifies any valid ISE isotope.

ionar36..... Mass fraction of ^{36}Ar in APPROX or isotopes with $36 \leq A \leq 39$ in ISE.

ionc12..... Mass fraction of ^{12}C in APPROX (= 0 in ISE).

ionca40..... Mass fraction of ^{40}Ca in APPROX or isotopes with $40 \leq A \leq 43$ in ISE.

ioncr48..... Mass fraction of ^{48}Cr in APPROX or isotopes with $48 \leq A \leq 51$ in ISE.

ioneb0..... Mean binding energy per nucleon of all ISE isotopes (MeV) (= 0 in APPROX).

ion'fe'..... Mass fraction of ISE isotopes with $A \geq 2*Z + 4$, $A > 51$, ex. ^{56}Fe (= 0 in APPROX).

ionfe52..... Mass fraction of ^{52}Fe in APPROX (= 0 in ISE).

ionfe54..... Mass fraction of ^{54}Fe in APPROX or isotopes with $A \approx 2*Z + 2$ and $A > 51$ in ISE.

ionfe56..... Mass fraction of isotope ^{56}Fe in the ISE network (= 0 in APPROX).

ionh1..... Mass fraction of unburned hydrogen in APPROX (= 0 in ISE).

ionhe3..... Mass fraction of ^3He in APPROX (= 0 in ISE).

ionhe4..... Mass fraction of ^4He in APPROX or isotopes with $2 \leq A \leq 5$ in ISE.

ionmg24..... Mass fraction of ^{24}Mg in APPROX or isotopes with $23 \leq A \leq 28$, ex. ^{28}Si , in ISE.

ionn14..... Mass fraction of ^{14}N in APPROX (= 0 in ISE).

ionne20..... Mass fraction of ^{20}Ne in APPROX (= 0 in ISE).

ionni56..... Mass fraction of ^{56}Ni in APPROX or isotopes with $A \leq 2*Z + 1$ and $A > 51$ in ISE.

ionnt1..... Mass fraction of neutrons in APPROX or ISE.

iono16..... Mass fraction of ^{16}O in APPROX or ISE.

ionpn1..... Mass fraction of photodisintegration protons in APPROX or all protons in ISE.

ions32..... Mass fraction of ^{32}S in APPROX or isotopes with $29 \leq A \leq 35$ in ISE.

ionsi28..... Mass fraction of ^{28}Si in APPROX or ISE.

- ionti44**..... Mass fraction of ^{44}Ti in APPROX or isotopes with $44 \leq A \leq 47$ in ISE.
- ionye**..... Electron abundance in all (non-BURN) networks (moles/g).
- ionyf**..... Total abundance of ISE isotopes with $A > 46$ plus ^{46}Ti (moles/g) (= 0 in APPROX).
- ionyq**..... Total abundance of ISE isotopes with $A \geq 24$ (moles/g) (= 0 in APPROX).
- iternse**..... Total number of iterations it took for ISE/NSE to converge in this zone, or to -1 if convergence was not achieved.
- isoal26**..... Isotopic mass fraction of **al26**, where **al26** exemplifies any valid BURN isotope.
- knsefe56**..... Neutrino energy loss due to e^- capture and e^+ decay due to **fe56**, where **fe56** exemplifies any valid ISE isotope (erg/g/sec).
- limnuc**..... Integer containing the Z and A of the isotope controlling the BURN timestep along with the KEPLER cycle that this zone was last burned coded in the form:

$$\text{LIMNUC} = A + 100 * Z + 10000 * \text{NCYC}$$
- mg24(ag)**..... Rate of the $^{24}\text{Mg}(\alpha, \gamma)^{28}\text{Si}$ reaction (moles/g/s -- APPROX only).
- mixlen**..... Mixing length used in calculating convection (cm).
- n(e+nu)p**..... Rate of the $n(e^+, \nu)p$ reaction (moles/g/s -- APPROX & ISE).
- n14(ag)**..... Rate of the $^{14}\text{N}(\alpha, \gamma)^{18}\text{F}$ reaction (moles/g/s -- APPROX only).
- n14(pg)**..... Rate of the $^{14}\text{N}(p, \gamma)^{15}\text{O}$ reaction (moles/g/s -- APPROX only).
- nalim**..... Atomic weight of the nucleus limiting the BURN zonal timestep.
- ncyczb**..... KEPLER cycle at which this zone was last coprocessed by BURN.
- ne20(ag)**..... Rate of the $^{20}\text{Ne}(\alpha, \gamma)^{24}\text{Mg}$ reaction (moles/g/s -- APPROX & ISE).
- netnum**..... Number of the nuclear network currently used in the zone.
- netnumb**..... Number of the BURN isotopic nuclear network used in this zone.
- nzlim**..... Atomic number of the nucleus limiting the BURN zonal timestep.
- o16+o16**..... Rate of the $^{16}\text{O} + ^{16}\text{O}$ reaction (moles/g/s -- APPROX & ISE).
- o16(ag)**..... Rate of the $^{16}\text{O}(\alpha, \gamma)^{20}\text{Ne}$ reaction (moles/g/s -- APPROX only).
- o16(pg)**..... Rate of the $^{16}\text{O}(p, \gamma)^{17}\text{F}$ reaction (moles/g/s -- APPROX only).
- p+p**..... Rate of the $p + p$ reaction (moles/g/s -- APPROX only).
- p(e-nu)n**..... Rate of the $p(e^-, \nu)n$ reaction (moles/g/s -- APPROX & ISE).
- pbuf**..... Abundance buffer (internal working array -- see CONVECTB) (moles/g).
- pe**..... Electron pressure including pairs (erg/cc).

- ped..... Partial derivative of the electron pressure with respect to density including pairs (erg/g).
- pet..... Partial derivative of the electron pressure with respect to temperature including pairs (erg/cc/K).
- pi..... Ion pressure (erg/cc).
- pid..... Partial derivative of the ion pressure with respect to density (erg/g).
- pit..... Partial derivative of the ion pressure with respect to temperature (erg/cc/K).
- pn..... Pressure (erg/cc)
- pnd..... Partial derivative of the total pressure with respect to density (erg/g).
- pnsefe56..... Positron emission rate due to fe56, where fe56 exemplifies any valid ISE isotope (moles/g/sec).
- pnt..... Partial derivative of the total pressure with respect to temperature (erg/cc/K).
- pp..... Positron pressure (erg/cc).
- ppd..... Partial derivative of the positron pressure with respect to density (erg/g).
- ppt..... Partial derivative of the positron pressure with respect to temperature (erg/cc/K).
- pr..... Radiation pressure (erg/cc).
- prd..... Partial derivative of the radiation pressure with respect to density (erg/g).
- prt..... Partial derivative of the radiation pressure with respect to temperature (erg/cc/K).
- qj..... Net photodisintegration flow downward from ^{24}Mg (moles/g/sec).
- qld..... Calculated change in converged luminosity (erg/s) -- during a cycle;
Converged luminosity at last timestep (erg/s) -- at the end of a cycle.
- qln..... Converged non-neutrino luminosity at the outer zone boundary (erg/s).
- qxc12..... Photodisintegration-flow-determined mass fraction of ^{12}C in the ISE calculation.
- qxne..... Photodisintegration-flow-determined mass fraction of ^{20}Ne in the ISE calculation.
- qxo16..... Photodisintegration-flow-determined mass fraction of ^{16}O in the ISE calculation.
- rd..... Calculated change in radius (cm) -- during a cycle;
Radius at last timestep (cm) -- at the end of a cycle.
- rectot..... Total zonal electron capture rate (mole/g/s).
- redtot..... Total zonal electron decay rate (mole/g/s).
- rhorr..... Integral of ρdr for mass exterior to the outer boundary of this zone (g/cm**2).

rn..... Radius of outer zone boundary (cm).
rnsefe56..... Total weak interaction rate due to **fe56**, where **fe56** exemplifies any valid ISE isotope (moles/g/sec).
rpdtot..... Total zonal positron decay rate (mole/g/s).

s32(ag)..... Rate of the $^{32}\text{S}(\alpha,\gamma)^{36}\text{Ar}$ reaction (moles/g/s -- APPROX only).
sburn..... BURN nuclear energy generation rate, excluding neutrino losses (erg/g/s).
sdotq..... Net ISE energy generation rate including all neutrino losses (erg/g/s).
sgain..... Maximum of the net nuclear energy generation rate and zero (erg/g/s).
si28(ag)..... Rate of the $^{28}\text{Si}(\alpha,\gamma)^{32}\text{S}$ reaction (moles/g/s -- APPROX only).
sig..... Total entropy (k/baryon).
sige..... Electron entropy (negatrons only) (k/baryon).
sigi..... Ion entropy (k/baryon).
sigion..... Ionization entropy (k/baryon).
sigp..... Positron entropy (k/baryon).
sigr..... Radiation entropy (k/baryon).
sloss..... Total energy 'loss' rate, incl. neutrino loss and net nuclear loss (if any) (erg/g/s).
sn..... Total energy generation rate -- including neutrino losses (erg/g/s).
snbd..... Last calculated partial derivative of the energy generation rate with respect to density ($\text{s*cm}^{**5}/\text{g}$).
snbt..... Last calculated partial derivative of the energy generation rate with respect to temperature (erg/g/s/K).
snd..... Partial derivative of the energy generation rate with respect to density ($\text{erg*cc}/\text{g}^{**2}$).
sneut..... Neutrino loss rate (erg/g/s), where a positive value implies net loss.
snn..... Nuclear energy generation rate -- excluding neutrino losses (erg/g/s).
snold..... Last calculated energy generation rate (erg/g/s).
snt..... Partial derivative of the energy generation rate with respect to temperature (erg/g/K).
snubps..... Specific neutrino energy loss rate due to plasma-related processes (erg/g/s).
snuc1q..... ISE nuclear energy generation rate minus plasma neutrino loss rate (erg/g/s).
snucq..... ISE nuclear energy generation rate (erg/g/s).
snuw..... Total zonal specific neutrino energy loss rate due to neutronization-related processes (erg/g/s).
stot..... Total zonal entropy (k/baryon).

taumix..... Convective mixing time (sec).

tauqse..... Timescale for the Fe and Si quasiequilibrium blocks to equilibrate (sec).

td..... Calculated change in temperature (K) -- during a cycle;
Temperature at last timestep (K) -- at the end of a cycle.

ti44(ag)..... Rate of the $^{44}\text{Ti}(\alpha,\gamma)^{48}\text{Cr}$ reaction (moles/g/s -- APPROX only).

timen..... Time to which the BURN coprocessing in this zone has been updated (sec).

tn..... Temperature (K).

tnold..... Temperature at which BURN coprocessing was last done in this zone (K).

tsold..... Temperature at which the energy generation rate was last calculated (K).

un..... Velocity of the outer zone boundary (cm/s).

weak..... Total neutronization rate (moles/g/s -- ISE only).

wnsefe56..... Isotopic statistical weight of fe56, where fe56 exemplifies any valid ISE isotope.

wrate..... Total zonal weak (i.e. neutronization) rate (mole/g/s).

xkchrsty..... Christy Rosseland mean opacity (cm^2/g).

xkcompt..... Rosseland mean opacity from Compton scattering (cm^2/g). (Not implemented yet)

xkcond..... Effective Rosseland mean opacity due to electron heat conduction (cm^2/g).

xkiben1..... IBEN1 Rosseland mean opacity (cm^2/g).

xkiben2..... IBEN2 Rosseland mean opacity (cm^2/g).

xkn..... Rosseland mean opacity (cm^2/g).

xknd..... Partial derivative of the total opacity with respect to density (cm^5/g^2).

xknt..... Partial derivative of the total opacity with respect to temperature ($\text{cm}^2/\text{g/K}$).

xkr..... Total radiative Rosseland mean opacity (cm^2/g).

xln..... Calculated non-neutrino luminosity at the outer zone boundary (erg/s).

xm..... Zonal mass (g).

xne..... Electron number density including pairs (#/cc).

xnebd..... Partial derivative of the electron number density with respect to density including pairs (#/g).

xnebt..... Partial derivative of the electron number density with respect to temperature including pairs (#/cc/K).

xnei..... Number density of ionized electrons (electrons/cc) -- not implemented yet.

xnemc..... Electron number density without contribution from pairs (#/cc).

xni..... Ion number density (#/cc).

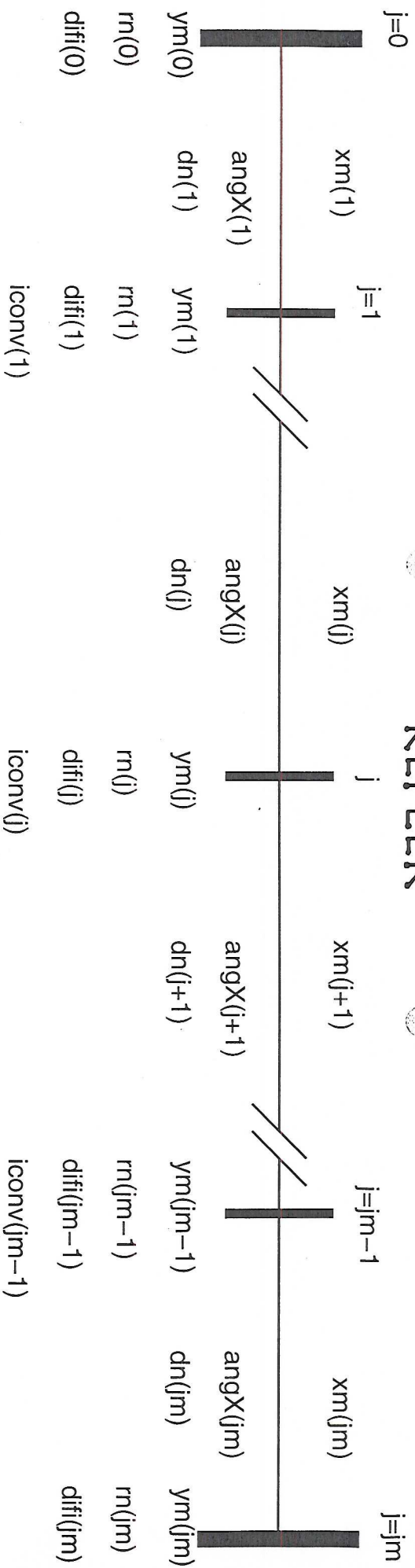
xnp..... Positron (or pair) number density (#/cc).

xnsefe56..... Energy stored in the excited states of fe56, where fe56 exemplifies any valid ISE

isotope (MeV/nucleus).

- yeburn**.....Electron abundance calculated for this zone by the BURN coprocessor (mole/g).
- yffac**..... The actual value of Y_Q is less than **yfqse** by the factor $1 / yffac$.
- yfqse**..... Quasiequilibrium value of Y_Q based on the current abundance of neutron and protons and ^{28}Si (moles/g).
- ym**..... Exterior mass coordinate (g).
- ymb**..... Mass interior to the outer boundary of this zone, as last considered by the BURN coprocessor (g).
- ynbtime**.....Last calculated total time derivative of the proton abundance (mole/g/sec).
- ypbtime**.....Last calculated total time derivative of the proton abundance (mole/g/sec).
- zbar**..... Mean atomic charge.
- zn**..... Viscous stress -- including linear and quadratic artificial viscosity (ergs).

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