SAFIRE User's Manual

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SAFIRE User's Manual

INTRODUCTION

Analytical models for scaling the cost and performance of inertial confinement fusion (ICF) electric-power plants have been developed and incorporated into the SAFIRE code. SAFIRE denotes systems analysis for ICF reactor economics. Volume 1 presents the details of the cost and performance scaling algorithms. This volume, Vol. 2, describes the subroutines, COMMON blocks, file handling, and input and output variables of the code. Appendix A in this volume presents sample input and output files. Appendix B is an alphabetical list of variables.

The original version of this code was written to calculate the parameters of fusion-fission hybrids. Although the current version of the code retains some of the hybrid-related variables and calculations, it cannot be used to analyze fusion-fission hybrids.

The SAFIRE code is available on the National Magnetic Fusion Energy Computer Center's Cray-1 and X-MP computers. The example input and output files described in Appendix A and the source code are contained in a directory called SAFIRTAK. This directory also includes a text file called README that describes the available files and provides update information. Use FILEM to retrieve files from SAFIRTAK as follows:

```
filem read .7767 .safirtak filelist
```

where filelist is the space-delimited list of file names.

SAFIRE must be compiled using RCFT. The following RCFT command line precompiles with PRECOMP, compiles with CFT, loads with LDR, and executes the resulting controllee:

```
rcft p=safire,go
```

Before typing this line, change the name of the input file to "infile." To avoid recompiling for subsequent problems, type the following:

```
xsafire infile=filename
```

where filename is the name of the input file if it has not already been changed to "infile."

SUBROUTINES AND THEIR FUNCTIONS

The SAFIRE code is written in FORTRAN 77 and can be run on any computer that accepts the NAMELIST statement as an input option. It is written in a top-down modular style as shown in Fig. 1. The main program coordinates the overall control of the program flow, while each subroutine performs a specific function. The subroutine descriptions are listed below.

ABLATE	Calculates the wall loss per pulse (ablation) of the first wall based on surface temperatures.
BLODST	Calculates the costs of buildings and structures for Account 21.
BLODIZ	Calculates the building sizes for later use in costing.
BLNKT	Calculates parameters associated with the ICF blanket and shield systems, including effective reaction rates, zonal parameters, material volumes and costs, and overall dimensions of the ICF chamber.
BOPCST	Calls the appropriate subroutines to calculate the balance-of-plant cost for Accounts 20, 21, 23, 24, and 25.
CASBOP	Calculates the power balance for the Cascade reactor.
CASCAD	Calculates the Cascade chamber radius.
CASCOS	Calculates the Cascade reactor costs for Accounts 21 to 26.
CASPLT	Calls the appropriate subroutines to calculate the Cascade balance of plant and costs.
CONHT9	Assigns values to material properties for HT-9.
CON316	Assigns values to material properties for 316 stainless steel.
COSTI	Calculates the final costs.
DELTAT	Calculates the maximum temperature difference (TMAX-T0) in the first wall based on thermal-stress and liquid-impact fatigue issues.
DRYCAV	Calculates the necessary radius and thickness for the drywall chamber designs. Also, calculates chamber lifetimes and direct operating costs for the chamber.
EAGLE	Calculates the necessary radius and thickness for the EAGLE chamber designs. Also, calculates chamber lifetimes and direct operating costs for the chamber.

EPECST	Calculates the electrical plant equipment costs for Account 25.
EXTRAC	Calculates the performance and tritium inventory associated with the molten-salt tritium-extraction process.
HANDF	Calculates the midplane packing fraction of the liquid lithium and the required lithium head for the HYLIFE chamber.
HIBALL	Calculates the necessary radius and thickness for the HIBALL chamber designs. Also, calculates chamber lifetimes and direct operating costs for the chamber.
HIBDRI	Calculates the heavy-ion-beam power requirements and direct cost.
HTSBOP	Sizes the power conversion system and computes the power balance including finding the net electric power.
HTSYM	Calculates several values for the heat exchanger system including: coolant temperatures, power balance, flow rates, size of steam generators, and costs associated with the system.
HYDRO	Computes the chamber- and blanket-flow parameters for HIBALL.
HYDRO3	Computes the chamber- and blanket-flow parameters for EAGLE.
ICFBLD	Calculates building and tunnel sizes.
ICFPLT	Calculates power requirements and calls appropriate subroutines to calculate building sizes.
INDIR	Computes parameters used to determine indirect costs and cost of electricity.
INFLAT	Uses inflation factors to inflate direct capital costs and operating costs to reference-year dollars.
INIT	Sets up the initialization of the program, including reading the input file and defining default values.
INITIA	Determines target yield, gain, driver energy, fusion power, and repetition rate per chamber.
LFLOW	Calculates the lithium-flow requirements and pumping requirements.
LIBDRI	Computes the efficiency, cost, and solid-angle parameters for the light-ion driver.
LLRCST	Calculates the cost of land and land rights for Account 20.
LMR0	Calculates the inner radius of the liquid-lithium jets to satisfy impact stress limits for the HYLIFE chamber.
LMW	Calculates the cost and lifetime parameters for lithium-wall designs for the HYLIFE chamber.

MPECST	Calculates the cost of miscellaneous plant equipment for Account 25.
OUT0	Consists of an output routine for the first half of the longer version of the output.
OUT1	Consists of an output routine for the second half of the longer version of the output.
OUT2	Consists of an output routine for the two short versions of the output.
PLANT	Calculates integrated and global plant parameters including: power flow, direct costs, operating costs, fuel production, and tritium inventory.
POWCON	Calculates gross turbine cycle efficiency.
REACPL	Calculates the liquid-metal reactor cost for Account 22.
RINNER	Calculates the inner radius of the blanket for the HIBALL reactor.
SCALE	Calculates the chamber size using various scaling relationships for HYLIFE. Also, calculates the required liquid-lithium effective thickness based on radiation damage.
SCALE2	Scales the chamber size using various scaling relationships for HIBALL such as displacement per atom (dpa) and helium production.
SCALE3	Scales the chamber radius with impact stress and dpa for EAGLE.
SHELL1	Relates the driver energy to the yield and gain of heavy-ion and laser drivers for single-shell targets.
SHELL2	Relates the driver energy to the yield and gain of heavy-ion and laser drivers for double-shell targets.
SLUG	Calculates the liquid-impact stress and is iteratively used by LMR0.
STMDOT	Calculates the steam flow rates.
STRESS	Calculates the temperature rise and stress in the first wall.
SNLDRI	Computes the short-wavelength (KrF) laser performance and cost as well as final optics and lost solid-angle parameters.
TGTFAC	Computes the direct cost, tritium inventory, and a number of parameters associated with an ICF target factory.
TPECST	Calculates the turbine plant equipment cost for Account 23.

TRITFL	Calculates tritium, deuterium, total hydrogen, and helium (fusion debris) burn, production, and flow rates in ICF targets, chambers, blankets, target factories, and the total plant. Also, computes unburned fuel and debris flows to vacuum and liquid-curtain systems (if applicable).
TUBES	Calculates the radius, number, and cost of tubes for HIBALL.
TYPHTS	Finds the character representation of the type of heat transfer system.
WALL	Calculates the wall thickness based on the maximum temperature difference.

Figure 1. Program structure of the SAFIRE code.

COMMON BLOCKS

Most of the variables used in SAFIRE are stored in COMMON blocks.
Variables that:

- End with T refer to the axial-blanket region.
- End with O refer to the radial-blanket region.
- Include 1 in the name refer to the first of two types of material.
- Include 2 in the name refer to the second of two types of material.

The COMMON blocks are listed below with the definitions of the variables and the units.

COMMON / BANDS /

CBMO	Total direct cost of fabricated radial-blanket materials (M\$).
CBMT	Total direct cost of fabricated axial-blanket materials (M\$).
DBO(6)	Array of radial-zone thicknesses (m).
DBT(6)	Array of axial-zone thicknesses (m).
EMMO	Fusion neutron energy multiplication in the radial blanket.
EMMT	Fusion neutron energy multiplication in the axial blanket.
EMO(6)	Array of radial zonal neutron-energy multiplication factors.
EMT(6)	Array of axial zonal neutron-energy multiplication factors.
FWCO	Solid-angle fraction associated with the radial blanket.
FWCT	Solid-angle fraction associated with the axial blanket.
OCBMO	Operating cost to replace radial-blanket structure (M\$/yr).
OCBMT	Operating cost to replace axial-blanket structure (M\$/yr).
PDENSO(6)	Array of zonal power densities in radial blanket (MW_t/m^3).
PDENST(6)	Array of zonal power densities in axial blanket (MW_t/m^3).
PWRBO(6)	Array of zonal powers in radial blanket (MW_t).
PWRBT(6)	Array of zonal powers in axial blanket (MW_t).
RBO	Inner radius of radial blanket (m).

RBT Inner radius of axial blanket (m).
 ROSO Outer radius of radial blanket (m).
 ROST Outer radius of axial blanket (m).
 TEMM Average neutron-energy multiplication in blanket.
 TPO Tritium production in radial blanket (kg/yr).
 TPT Tritium production in radial blanket (kg/yr).
 TRELO Tritium breeding ratio in radial blanket.
 TRELT Tritium breeding ratio in axial blanket.
 TTP Total tritium production per chamber (kg/yr).
 UCBSO(6,6) Array of unit direct costs for radial-blanket materials by zone (M\$/m³).
 UCBST(6,6) Array of unit direct costs for axial-blanket materials by zone (M\$/m³).
 VBO(6) Array of radial-blanket zone volumes (m³).
 VBT(6) Array of axial-blanket zone volumes (m³).
 VBSRO(6,6) Array of radial-blanket volumes by zone and material (m³).
 VBSRT(6,6) Array of axial-blanket volumes by zone and material (m³).
 VFBSO(6,6) Array of radial-blanket material volume fractions by zone.
 VFBST(6,6) Array of axial-blanket material volume fractions by zone.
 WCADJO Solid-angle fraction for radial blanket.
 WCADJT Solid-angle fraction for axial blanket.

COMMON / BLNKT1 /

SALREM Net available solid-angle fraction for breeding.

COMMON / BLNKT2 /

DAGO Gap between the first wall and radial blanket (cm).
 DAGT Gap thickness between the first wall and the axial blanket (cm).

DCBM	Total direct cost of blanket materials per chamber (M\$).
MCOOLO	Material number for radial-blanket coolant.
MCOOLT	Material number for axial-blanket coolant.
MSTRO1	Material number for radial-blanket structure: component 1.
MSTRO2	Material number for radial-blanket structure: component 2.
MSTRO3	Material number for radial-blanket structure: component 3.
MSTRO4	Material number for radial-blanket structure: component 4.
MSTRT1	Material number for axial-blanket structure: component 1.
MSTRT2	Material number for axial-blanket structure: component 2.
MSTRT3	Material number for axial-blanket structure: component 3.
MSTRT4	Material number for axial-blanket structure: component 4.
TIRRD0	Radial-blanket irradiation time (full power years).
TIRRO1	Axial-blanket irradiation time (full power years).
TO	Tritium atoms bred per neutron in radial blanket at 100% solid angle.
TT	Tritium atoms bred per neutron in axial blanket at 100% solid angle.
TOCBM	Total operating cost of blanket materials per chamber (M\$).

COMMON / CAVITI /

ASTRLO	Actual radial-blanket-structure lifetime for neutron damage at input plant capacity (yr).
ASTRLT	Actual axial-blanket-structure lifetime for neutron damage at input plant capacity (yr).
FWT	Actual first-wall thickness including liner (mm).
HDRATI	Height to diameter ratio for ISHAPE equa's 2.
ISHAPE	Switch for ICF chamber shape: 1 sphere 2 cylinder

COMMON / CAVIT2 /

AWLIFE	Actual first-wall lifetime (yr).
AWLIFN	Lifetime based on first-wall neutron damage (yr).
CAREA	Actual chamber front-surface area (m^2).
CVOLUM	Chamber volume (m^3).
DCFVAL	Direct cost of first wall (M\$).
FLONG	Fraction of fusion energy associated with neutrons.
FLUFW	Fluence limit for neutron damage to first wall ($MW \cdot yr/m^2$).
FLUSTO	Fluence limit for neutron damage to radial-blanket structure ($MW \cdot yr/m^2$).
FLUSTT	Fluence limit for neutron damage to axial-blanket structure ($MW \cdot yr/m^2$).
FHPWRA	Maximum first-wall power density (MW/m^2).
GASDEN	Lithium vapor density (g/cm^3).
MNWLLO	Maximum neutron wall loading including capacity factor (MW/m^2).
OCFWAL	Operating cost of ICF first wall (M\$/yr).
RADNFW	First-wall radius based on neutron-damage limit (m).
RADNSO	Radial-blanket radius based on neutron-damage limit (m).
RADNST	Axial-blanket radius based on neutron-damage limit (m).
RHOW2	First-wall-structure density (g/cm^3).
STRLFO	Desired radial-blanket-structure lifetime (yr).
STRLFT	Desired axial-blanket-structure lifetime (yr).
WCST2	Unit cost of the fabricated first wall (\$/kg).
X2	Equivalent solid thickness of first-wall structural material (mm).

COMMON / CAVIT3 /

ALPSAR	Maximum fraction of sacrificial liner allowed to ablate per shot.
AWLIFA	Lifetime based on first-wall ablation (yr).

DTPULS	Temperature rise of front surface for each pulse (K).
EFFWLS	Effective wall loss for each pulse, excluding recondensation (mm).
EFWLLM	Maximum thickness of THSACR to ablate per shot (mm).
FRECON	Fraction of ablated materials uniformly recondensed on the wall to reduce ablation loss.
FSHORT	Fraction of fusion energy absorbed on front surface of the first wall.
IRAD	Final damage-criterion-type index: 1 ablation 2 neutron damage 3 neutron damage (blanket) 4 externally input constraint
IWDSGN	Switch for first-wall-structure thickness: 1 fixed 2 calculated
MINRAD	Minimum acceptable chamber radius (m).
MLOSS	Sacrificial-liner mass loss for each pulse (g).
RADISA	Minimum chamber radius to satisfy ablation criterion (m).
T0	Maximum temperature of outside of first wall for boundary condition for ablation calculation; usually the first-wall coolant temperature (°C).
THSACR	Thickness of sacrificial ablation material (mm).
TMAX	Front surface temperature to ablate MLOSS (K).
VFFWC	First-wall-coolant volume fraction.
VFFWS	Structural volume fraction of first wall.
WLIFE	Desired first-wall lifetime at 100% capacity factor (yr).
WLOSS	Actual permissible wall loss at each pulse (mm).

COMMON / CAVIT4 /

BFUSPR	Fusion neutron power passed to blanket (MW/m ²).
FHPWR	Fusion power collected in first wall (MW _t).

COMMON / CAVITY /

C1	First coefficient for temperature calculation ($K \cdot m^{2.5}$).
C2	Second coefficient for temperature calculation ($K \cdot m^{2.5}$).
C3	First coefficient for radius calculation ($m \cdot K^{0.4}$).
C4	Second coefficient for radius calculation ($m \cdot K^{0.6}$).
C5	Normalized constant for first WLOSS(r) equation (μm).
C6	Exponentiation constant for first WLOSS(r) equation (m^{-1}).
C7	Radius at which calculation switches from first to second WLOSS(r) equation (m).
C8	Normalization constant for second WLOSS(r) equation (μm).
C9	Exponentiation constant for second WLOSS(r) equation (m^{-1}).
C10	Wall loss at which the calculation switches from the second to first r(WLOSS) equation (mm).
CC1(3)	Corresponds to C1.
CC2(3)	Corresponds to C2.
CC3(3)	Corresponds to C3.
CC4(3)	Corresponds to C4.
CC5(3)	Corresponds to C5.
CC6(3)	Corresponds to C6.
CC7(3)	Corresponds to C7.
CC8(3)	Corresponds to C8.
CC9(3)	Corresponds to C9.
CC10(3)	Corresponds to C10.
CCP(3)	Array of CP values ($K \cdot m^{2.5}/MJ$).
CCX2(3)	Array of CX2 values ($mm \cdot m/MJ$).
CP	Material constant normalized to reference design for temperature rise of sacrificial liner for each pulse ($K \cdot m^{2.5}/MJ$).
CX2	First-wall thickness normalized constant ($mm \cdot m/MJ$).

FLU(3) Array of fluence values ($\text{MW}\cdot\text{yr}/\text{m}^2$).
 K1 Thermal conductivity of sacrificial liner ($\text{MW}/\text{mm}\cdot\text{K}$).
 K2 Thermal conductivity of first-wall structure ($\text{MW}/\text{mm}\cdot\text{K}$).
 RHOM1 Sacrificial liner density (g/cm^3).
 RRHOM1(3) Array of RHOM1 values (g/cm^3).
 RRHOM2(3) Array of RHOM2 values (g/cm^3).
 WCST1 Unit cost of the fabricated sacrificial liner ($\$/\text{kg}$).
 WWCST1(3) Array of cost values ($\$/\text{kg}$).
 WWCST2(3) Array of WCST2 values ($\$/\text{kg}$).
 X1 Beginning of cycle thickness of sacrificial liner (mm).
 XK1(3) Array of K1 values ($\text{MW}/\text{mm}\cdot\text{K}$).
 XK2(3) Array of K2 values ($\text{MW}/\text{mm}\cdot\text{K}$).
 XX1(3) Array of X1 Values (mm).
 XX2(3) Array of X2 values (mm).

COMMON / CMBLDG /

ABLDG Total area of all the buildings (m^2).
 APSB Area of the power supply building (m^2).
 ARCB Area of the reactor containment building (m^2).
 VBC Volume of the control building (m^3).
 VBLDG Total volume of all the buildings (m^3).
 VMSS Volume of the miscellaneous structures (m^3).
 VPSB Volume of the power supply building (m^3).
 VRABNR Volume of the reactor auxiliary building (nonradioactive) (m^3).
 VRABR Volume of the reactor auxiliary building (radioactive) (m^3).
 VRCB Volume of the reactor containment building (m^3).
 VRSB Volume of the steam reactor service building (m^3).

VSGB	Volume of the steam generator building (m^3).
VTGB	Volume of the turbine generator building (m^3).
VTUN	Volume of the beam tunnels (m^3).

COMMON / CMBOPC /

CEPE	Cost of electric plant equipment for Account 24 (M\$).
CHRS	Cost of main heat rejection equipment for Account 26 (M\$).
CLLR	Cost of land and land rights for Account 20 (M\$).
CMPE	Cost of miscellaneous plant equipment for Account 25 (M\$).
CSSF	Cost of structures and site facilities for Account 21 (M\$).
CTPE	Cost of turbine plant equipment for Account 23 (M\$).

COMMON / CMHTS /

CTHTS	Total cost of heat-transport-system components for Account 22.02 (M\$).
DC	Pulse duty cycle.
IBCLT	Switch identifying blanket-coolant type: 1 Li 2 Na 6 PbLi
NSG	Number of steam generator units.
PB	Power generated in blanket (MW_t).
PCPP	Coolant-pumping-power requirement (MW_e).
PS	Turbine steam pressure (MPa).
PSG	Power rating for steam generators (MW_t).
QREJ	Thermal power rejected from cycle (MW_t).
TOFF	Off time between pulses (s).
TS	Turbine steam temperature ($^{\circ}C$).
TSUP	Minimum steam temperature for superheat cycle ($^{\circ}C$).
VCB	Volume of blanket coolant (m^3).
WS	Steam flow rate to the turbine (kg/s).

COMMON / CPMOWC /

ELBOP	Electric power required to run balance of plant (MW_e).
ELGENL	General type electric power requirements to run the driver (MW_e).
ELSPEC	Special power requirements for driver (MW_e).
FEGRS	Gross electric power production (MW_e).
GETA	Generator efficiency.
ICYCLE	Switch for determining the type of cycles: 1 saturated steam 2 superheated steam
NILOOP	Switch for setting the cooling loop type: 1 single loop 2 double loop
NTGU	Number of turbine generator units.
PEGRS	Gross electric power (MW_e).
PENET	Net electric power production (MW_e).
PGRSTH	Thermal power per plant (MW_t).
PTG	Power rating per turbine generator (MW_e).
TETA	Turbine cycle efficiency.

COMMON / COUTT /

ACCT	Character representation of the account names.
ATITLE	Character variable for the title of the current file.
CTYP	Character representation of the coolant type.
MATLO(6)	Material character identifiers for the radial blanket--up to six materials.
MATLI(6)	Material character identifiers for the axial blanket--up to six materials.
SCT	Character representation of the steam cycle.
TTSU	Character representation of the cooling system description.

COMMON / CURTAN /

ALPH	Thermal expansion coefficient (K^{-1}).
ALPH1	Normalized constant for impact stress.
AUXPW	Auxiliary power (MW_e).
C	Speed of sound in lithium (m/s).
CH1	Preexponential for IH scaling.
CH2	Exponential for IH scaling.
CHI1	Thermal-stress-profile constant.
CRW1	Preexponential for IRW scaling.
CRW2	Exponential for IRW scaling.
DTIHX	Constant used to calculate intermediate heat exchanger flow rate.
DTLITH	Lithium energy change per pulse (MJ).
EBLK	Total energy in blanket (MJ).
ELI	Total energy in lithium (MJ).
EN	Maximum neutron energy in lithium per pulse.
F	Calculated lithium fractional coverage.
F1	Displacement per atom (dpa) limit constant.
F2	Atomic-parts-per-million (appm) helium limit constant.
F3	Constant used for maximum impact stress calculations.
F4	Constant used for yield stress limit calculations.
FINJ	Fractional area coverage at inlet.
FLOW	Volume flow of lithium in the chamber (m^3/s).
FLWIHX	IXH lithium flow (m^3/s).
FMIN	Minimum lithium fractional midplane coverage.
GAMM	Grüneisen coefficient.
GNU	Poisson's ratio.

HEADL	Lithium head (m).
HGT	Chamber height (m).
IDPA	Damage limit designator: 0 appm is limiting 1 dpa is limiting
IH	Scaling option switch for the chamber height. 1 scales as the square root of fusion power 2 scales as the square root of target yield 3 scales as fusion power raised to the CH2
IRW	Scaling option switch for wall radius. 1,2 are the same as for IH 3 scales as fusion power raised to the CHW2
PBLIM	Evaporated mass of lithium per shot (kg).
PUMPHD	Pumping head for TFLOW (m).
RFLOW	Lithium flow in the reflector (m^3/s).
RHO	Liquid-lithium density (kg/m^3).
RØ	Inner radius of lithium jets (m).
SI(3)	Impact stress coefficients.
SIGMA	Same as SIMP.
SIMP	Calculated maximum impact stress.
STH	Calculated thermal stress.
SY(3)	Yield stress coefficients.
TCOST	Cost of the HIBALL tubes (M\$).
TLI	Liquid-lithium operating temperature (K).
TNUM	Number of HIBALL tubes.
TOTFLW	Total lithium flow (m^3/s).
TRADIS	Tube radius (m).
UU	Energy attenuation coefficient.
VELINJ	Injection velocity of lithium (m/s).
VELMP	Midplane velocity of lithium (m/s).

VOLCHB	Lithium volume in head (m^3).
WALLC	Constant multiplier for wall temperature rise.
XL	Effective lithium thickness (m).
XLAMDA	Constant used in calculating the lithium-slug size.
YOUNGM	Young's modulus (MPa).

COMMON / DRIVER /

ANOT	KrF-driver energy-scaling exponent.
BNOT	Constant used to determine the KrF-driver cost scaling with pulse rate.
CNOT	KrF-driver reference cost (\$).
DCDRIV	Direct cost of an ICF driver system (M\$).
DCHIB1	Heavy-ion-beam cost-scaling coefficient 1 (M\$).
DCHIB2	Heavy-ion-beam cost-scaling exponent.
DCLIB1	Light-ion-beam cost-scaling coefficient 1 (M\$).
DCLIB2	Light-ion-beam cost-scaling exponent.
DCTRCK	Direct cost of a T,D,A system per chamber (M\$).
DFMAG1	Distance between first wall and beam exit from final focusing magnet (m).
DFMAG2	Length of final focusing magnet (m).
DPPC	Input power to driver (MW_e).
EDNOT	KrF-driver reference energy (MJ).
EPS	Required input energy to driver per shot (MJ).
ETAD	Driver efficiency.
ETAHIB	Efficiency of the heavy-ion-beam driver.
ETANOT	KrF-driver reference efficiency.
FLUOPT	Fusion-power fluence limit for final optics ($MW\cdot yr/m^2$).
FNUM	Calculated f/number of final optics.

FNUMAX	Maximum f/number for final optics.
FOCUSL	Distance between focusing magnet and chamber (m).
HIBCRA	Distance between focusing magnet and chamber center (m).
HIBEAM	Radius of heavy-ion-beam leaving final-focusing-magnet exit (cm).
IDRIVE	Switch for driver type: 1 short wavelength laser 3 heavy-ion beam 4 light-ion beam
KDRIV	Switch to calculate driver efficiency: 1 do calculation 0 use input value
KOPTIC	Switch to calculate the radius of the final optics: 1 do calculations 0 use input value
NBEAM	Number of final beams per chamber.
NYRHIB	Year in which heavy-ion-beam cost estimates originated.
NYRLIB	Year in which light-ion-beam cost estimates originated.
NYRSWL	Year in which laser cost estimates originated.
ODL	Optical damage limit (J/cm^2).
OPTICL	Radius of final optics (m).
OPTICR	Radius of final optical focusing surface (cm).
OPTLIF	Desired lifetime of final optics (yr).
PCNOT	Constant used to determine the KrF-driver efficiency.
RDNOT	KrF-driver reference pulse rate (Hz).
RRPD	Shot repetition rate per driver (Hz).
SANGL	Solid angle associated with all beams (steradians).
TAU	KrF-driver pulse length (ns).
TAUNOT	KrF-driver reference pulse length (ns).

COMMON / EXTRAT /

GPTBRP Tritium breeding rate in total plant (g/s).
GSDUBL Deuterium breeding rate in total plant (g/s).
GSTUBL Unburned tritium flow to liquid-metal curtain (g/s).

COMMON / INDCST /

CDOM Current-dollar levelized operation and maintenance cost
 (expressed as a fraction of TOC).
CDOMR Constant-dollar levelized operation and maintenance cost
 (expressed as a fraction of TOC).
CE Current-dollar cost of electricity (mills/kW_e).
CER Constant-dollar cost of electricity (mills/kW_e).
CINVT Total investment cost (M\$/kW_e).
CLEVI Levelized cost factor.
CONDOL Switch to convert to constant-dollar fixed charge rate if CONDOL
 equals 1.
CONTIM Construction time (yr).
COSTM After tax cost of money (yr⁻¹).
DUCOST Deuterium cost (\$/kg).
ERATE Escalation rate (yr⁻¹).
FCCOMS Fraction of capital from common stock.
FCDEP Fraction of capital from debt.
FCPEFS Fraction of capital from preferred stock.
FCRATE Current-dollar fixed charge rate (yr⁻¹).
FCRATR Constant-dollar fixed charge rate (yr⁻¹).
FUELC Current-dollar fuel cost (mills/MM·h).
FUELCR Constant-dollar fuel cost (mills/MM·h).
GINF General inflation factor (yr⁻¹).

LICOST	Lithium cost (\$/kg).
NUNIT	Number of units per plant.
PCENT(7)	Interest rate during construction (yr^{-1}).
PLF	Power plant life (yr).
PTAXR	Annual property tax rate (yr^{-1}).
REALCM	Real cost of money (yr^{-1}).
RIODEP	Interest rate on debt (yr^{-1}).
RRCOMS	Rate of return on common stock (yr^{-1}).
RRPEFS	Rate of return on preferred stock (yr^{-1}).
T6BR	Tritium breeding ratio from ${}^6\text{Li}$.
TAXR	Effective income tax rate (yr^{-1}).
TOC	Total operating costs (M\$).

COMMON / INOUT /

DCEXTR	Direct cost of an extractor unit of capacity CAPEX (M\$).
IPRINT	Switch to print NAMELIST parameters if IPRINT is greater than 1.
NYRBNK	Year in which blanket materials costs originated.
NYRDCA	Year in which chamber materials costs originated.
NYREX	Year in which extractor cost estimate originated.
NYRTF	Year in which the target factory cost estimates originated.
NYRTRC	Year in which tracking, delivery, and alignment (T,D,A) system costs originated.

COMMON / OUTT /

AC COST	Costs of the various accounts (M\$).
ATUN	Area of the beam tunnels (m^2).
C2106	Total cost of Account 21.06.
CAW	Cost of air, water, and steam equipment (M\$).

CCB	Cost of the control building (M\$).
CCE	Cost of the communications equipment (M\$).
CCS	Cost of the condensing equipment (M\$).
CCSS	Cost of the cooling system structure (M\$).
CDCB	Cost of the <i>direct conversion</i> building (M\$).
CES	Cost of electrical structures and wiring (M\$).
CFE	Cost of electrical furnishing and fixtures (M\$).
CFH	Cost of the feed heating systems (M\$).
CIC	Cost of the instrumentation and control (M\$).
CI*IVD	Direct investment cost (M\$/kW _e).
CK2	Cost of the tracking and alignment system (M\$).
CK4	Cost of the first-wall system (M\$).
CK5	Cost of the tritium extraction system (M\$).
CK6	Cost of the blanket and shield (M\$).
CME	Cost of the main-heat-condenser mechanical equipment (M\$).
CMI	Cost of miscellaneous turbine plant equipment (M\$).
CMSS	Cost of miscellaneous structures building costs (M\$).
COE	Cost of electricity (¢/kW _e h).
COPER	Current-dollar operating costs (mills/kW _e h).
COPERR	Constant-dollar operating costs (mills/kW _e h).
COSHTS	An array containing the costs of the subsystems of the heat transport systems (M\$).
CPC	Cost of power and control wiring for the electric plant (M\$).
CPE	Cost of protective equipment for the electric plant (M\$).
CPSB	Building and structure power supply and energy storage building costs (M\$).
CRABNR	Cost of nonradioactive auxiliary building (M\$).
CRABR	Cost of the radioactive auxiliary building (M\$).

CRCB	Cost of the reactor containment building (M\$).
CRET	Current-dollar capital return (mills/kW _{gh}).
CRETR	Constant-dollar capital return (mills/kW _{gh}).
CRSB	Cost of the reactor service building (M\$).
CS	Cost of the main heat-condenser structures (M\$).
CSB	Cost of the switchboards (M\$).
CSGB	Cost of the steam generator building (M\$).
CSGG	Cost of the switch gear (M\$).
CSI	Cost of site improvement and facilities (M\$).
CSS	Cost of the station service equipment (M\$).
CTG	Cost of the turbine generators (M\$).
CTGB	Cost of the turbine generator building (M\$).
CTL	Cost of the transportation and lift equipment (M\$).
CTUN	Cost of the tunnels (M\$).
CWW	Cost of the waste water-treatment equipment (M\$).
DELPB	Blanket-coolant pressure drop (MPa).
DELTC	Coolant temperature rise across blanket (°C).
ENET	Net electric energy (GW _{gh}).
EXTEMP	Blanket-coolant exit temperature (°C).
FELBOP	Fraction of gross electric power needed to run the balance of plant.
I1	Used for internal tracking of coolant type.
I2	Used for internal tracking of the cooling system description.
I3	Used for internal tracking of the steam generator type.
NN	Number of heat transport systems.
PIN	Blanket-coolant inlet pressure (MPa).
PPFR	Maximum allowable fraction of gross electric power that is used for coolant pumping power.

PPTMP	Coolant pumping power (MW_e).
PSGMAX	Maximum size of the steam generators (MW_t).
PTGMAX	Maximum turbine-generator unit size (MW_e).
QELEC	Gross electric power (MW_e).
SUMT	Total capital costs (M\$).
TUNL	Length of the tunnels (m).
WPC	Primary-coolant flow rate (kg/s).
WSC	Secondary-coolant flow rate (kg/s).

COMMON / PLANT1 /

ADCBM	Direct cost of the blanket (M\$).
ADCEXR	Direct cost of the tritium extraction system (M\$).
ADCFAT	Direct cost of one target factory (M\$).
ADCRV	Direct cost of the driver (M\$).
ADCTRK	Direct cost of target/beam tracking, alignment, and delivery (T,D,A) systems for one chamber (M\$).
ADCWAL	Direct cost of the chamber first wall (M\$).
AOCWAL	Operating cost of the chamber first wall (M\$).
ATOCBM	Operating cost of one reactor blanket (M\$).
BFPWRT	Total plant fusion power passed to the blanket coolant systems (neutrons) (MW_t).
FLOOP	Fraction of total coolant outside reactor.
FPWRPT	Total plant fusion power (MW_t).
ICTRCK	T,D,A system costing switch: 0 add cost of T,D,A system for each chamber 1 add cost of T,D,A for number of chambers minus number of drivers
NADD	Number of additional T,D,A systems beyond those costed with the drivers.
RRPLT	Total plant shot-repetition rate (Hz).

TCVPC Total coolant volume per chamber (m^3).
 TCVPP Total plant primary coolant (m^3).
 TINV Total tritium inventory in plant (g).
 TINVFC Total tritium inventory in target factories (g).
 TPYPP Targets shot per year per plant.

COMMON / PLANT2 /

FMPHRT Total plant fusion power deposited in first-wall coolant systems (MW_t).
 TDCBM Direct costs of all reactor blankets (M\$).
 TDP Total electrical input power for drivers (MW_e).
 TTOCBM Operating costs of all blankets (M\$/yr).

COMMON / PLANT3 /

DPPD Input power to driver per driver system (MW_e).

COMMON / PLANT4 /

NXTRAC Number of required tritium extractor units.
 SSIT Steady-state tritium inventory in total plant (g).

COMMON / PLANT5 /

TDCDRI Adjusted direct cost of all drivers (M\$).
 TDCEXT Total direct cost of the molten-salt extraction units (M\$).
 TDCFAC Total direct cost of all target factories (M\$).
 TDCTRC Total direct cost of all T,D,A systems (M\$).
 TDCWAL Total direct cost of all first walls (M\$).
 TOCWAL Total operating costs of all first walls (M\$).

COMMON / PLANT6 /

TPWRBO Total radial-blanket power per chamber (MW_t).

TPWRBT Total axial-blanket power per chamber (MW_t).
 TTPWR Total blanket power per chamber (MW_t).
 TVCB Total coolant volume per blanket (m^3).

COMMON / PLNT /

TDCPCA Subtotal of adjusted plant costs per chamber (M\$).
 TDCPLN Subtotal of adjusted plant direct costs (M\$).
 TOCCAV Subtotal of plant operating costs (M\$).
 TOCPCA Subtotal of plant operating costs per chamber (M\$).
 TOTALC Total plant thermal power in axial blankets (MW_t).
 TOTALP Total plant thermal power in radial blankets (MW_t).
 TTPHRO Total plant power in radial blankets (MW_t).
 TTPHRT Total plant power in axial blankets (MW_t).
 TTTPRW Total plant power in blankets (MW_t).

COMMON / PLTCAS /

CTOT Total reactor plant equipment cost for Account 22 (M\$).

COMMON / POMBAL /

FPOWER Fusion power per chamber (MW_t).
 RPRATE Shot repetition rate per chamber (Hz).
 TYIELD Target yield (MJ).

COMMON / RINF /

NYEAR Current year of calculation.
 RINF75 Inflation rate for calendar year 1975.
 RINF76 Inflation rate for calendar year 1976.
 RINF77 Inflation rate for calendar year 1977.
 RINF78 Inflation rate for calendar year 1978.

RINF79 Inflation rate for calendar year 1979.
 RINF80 Inflation rate for calendar year 1980.
 RINF81 Inflation rate for calendar year 1981.
 RINF82 Inflation rate for calendar year 1982.
 RINF83 Inflation rate for calendar year 1983.
 RINF84 Inflation rate for calendar year 1984.
 RINF85 Inflation rate for calendar year 1985.

COMMON / STUFF /

CFACTR Plant capacity factor.
 CRADUS Chamber first-wall radius (m).
 DTWALL Steady-state temperature difference across wall (K).
 ICAVIT Chamber designator:
 1 graphite/stainless steel
 2 stainless steel
 3 niobium/stainless steel
 4 drywall
 5 HYLIFE
 6 HIBALL
 7 EAGLE
 9 Cascade
 NCAVIT Number of chambers per plant.
 NDRIVE Number of drivers per plant.
 PUMPPW Jet-array pumping power (MW_e).
 TTREL Adjusted tritium-breeding ratio.
 TVCFW First-wall coolant volume (m³).
 VOLHD Lithium volume in head (m³).
 VOLPIP Lithium volume in piping (m³).

COMMON / TAR1 /

ETA Switch for the target gain curve:
 -2 advanced concepts, laser driver
 -1 lower curve for current designs, laser driver
 0 upper curve for current designs, laser driver
 0.05, 0.01, 0.02, 0.04 r^{3/4}R value for heavy-ion-beam driver

SHELL Switch for the number of shells on the target (1, 2).
 TGAİN Target gain.

COMMON / TARFAC /

DCFAC0 Reference cost of a target factory (M\$).
 DCFAC1 Target-factory scaling factor.
 DCFAC2 Target-factory scaling factor.
 DCFAC3 Target-factory scaling factor.
 EPSTG1 Target-factory scaling exponent.
 EPSTG2 Target-factory scaling exponent.
 EPSTG3 Target-factory scaling exponent.
 RRFACT Target-factory production rate (Hz).
 RRFACT0 Reference target-factory production rate (Hz).
 TAUFACT Inventory of tritium-filled targets in factory production process
 (full power days).
 TPFCT Number of targets per year per factory (yr⁻¹).
 TYIEL0 Reference target yield (MJ)

COMMON / TARGET /

DCFACT Adjusted direct cost of all target factories (M\$).
 GTTGT Tritium inventory in target (g).
 INVFACT Tritium inventory in process at a target factory (g).
 NTGTFC Number of target factories per plant.

COMMON / TENER /

DRP The increment in repetition rate when solving for several
 repetition-rate situations (Hz).
 DTE The increment in driver energy when solving for net power (MJ).
 DTE0 The initial increment in driver energy when converging on net
 power (MJ).

IFLAG A flag set to 1 when an iteration to find net power is wanted.

NUM An internal counter to count the number of times through the loop.

NUMM A flag set to 0 the first time through the loop, thereafter NUMM equals 1.

PEERR The allowable relative error when converging on net power.

PEFLAG The desired net power of the plant (MW_g).

RPFLAG The maximum allowed repetition rate (Hz).

RP0 The initial repetition rate (Hz).

TEFLAG The maximum allowed driver energy (MJ).

TENERG Driver energy incident on target (MJ).

TENER0 The initial driver energy when converging on net power (MJ).

COMMON / TEXTRI /

ASSAY6 ^6Li assay in liquid lithium.

CAPEX Capacity of each extractor unit (cm^3/s).

DVEX Volumetric distribution of tritium between the lithium and the salt.

EPSEX Efficiency of tritium recovery from the salt.

ETAEX Efficiency factor that accounts for nonequilibrium tritium distribution during contacting.

ETAREM Lumped tritium extraction efficiency.

ILIINV Lithium inventory designator:
 1 = first wall + radial blanket + axial blanket
 2 = first wall + radial blanket
 3 = first wall + axial blanket
 4 = radial blanket + axial blanket
 5 = first wall
 6 = radial blanket
 7 = axial blanket
 8 = input by user

ITICAL Tritium inventory calculation designator:
 1 calculate TRCONC from input SSIT
 2 calculate SSIT from input TRCONC

LIFLOW Lithium flow rate to tritium extraction process (cm^3/s).

PRODTR Total tritium source to liquid-metal curtain (g/s).
 PWREX Power required by each extractor unit (MW_e).
 SSID Total-plant steady-state deuterium inventory in lithium (g).
 SSIH Total-plant steady-state hydrogen inventory in lithium (g).
 TLIINV Lithium inventory in total plant (g).
 TRCONC Tritium concentration in liquid lithium (appm).
 XFRAC Fraction of lithium inventory processed per unit time (Hz).

COMMON / TEXTR2 /

LIINV Lithium inventory per chamber (g), only when ILIINV equals 8.
 PXTRAC Total power required by all extractors (MW_e).

COMMON / TEXTR3 /

VCBO Total coolant volume in radial blanket (m^3).
 VCBT Axial-blanket coolant volume (m^3).

COMMON / TRIT1 /

ALPHEL Fraction of helium taken up by liquid lithium inside the chamber.
 ALPHYL Fraction of unburned hydrogen gas taken up by liquid lithium inside the chamber.
 FBURN Fraction of deuterium and tritium burned per shot.
 GDBN Deuterium burned per shot (g).
 GDBTGF Deuterium burn rate per target factory (g/s).
 GDFTGF Deuterium flow rate per target factory (g/s).
 GDTGT Deuterium charge in the target (g).
 GDUBL Unburned deuterium source to liquid-metal curtain (g/s).
 GDUBV Unburned deuterium to vacuum system per shot (g).
 GHBN Amount of hydrogen burned per shot (g).
 GHBTGF Hydrogen burn rate per target factory (g/s).

GHEPR	Helium debris produced per shot (g).
GHPERL	Helium debris to liquid-lithium system per shot (g).
GHEPRV	Helium debris to vacuum systems per shot (g).
GHFTGF	Hydrogen flow rate per target factory (g/s).
GHTGT	Tritium charge in target (g).
GHUBL	Unburned hydrogen source to liquid-metal curtain (g/s).
GHUBV	Unburned hydrogen to vacuum system per shot (g).
GPDTGT	Deuterium flow rates per chamber in targets (g/s).
GPDUBL	Deuterium flow to liquid-metal curtain per chamber (g/s).
GPDUBV	Deuterium flow to vacuum per chamber (g/s).
GPHBN	Hydrogen burn rate per chamber (g/s).
GPHEPL	Helium flow to liquid-lithium system per chamber (g/s).
GPHEPR	Helium production rate per chamber (g/s).
GPHEPV	Helium flow to vacuum system per chamber (g/s).
GPHTGT	Hydrogen flow rates per chamber in targets (g/s).
GPHUBL	Hydrogen flow to liquid-metal curtain per chamber (g/s).
GPHUBV	Hydrogen flow to vacuum per chamber (g/s).
GPSDBN	Deuterium burn rate per chamber (g/s).
GPTBN	Tritium burn rate per chamber (g/s).
GPTBR	Tritium breeding rate per chamber (g/s).
GPTTGT	Tritium flow rate per chamber in targets (g/s).
GPTUBL	Tritium flow to liquid-metal curtain per chamber (g/s).
GPTUBV	Total tritium-debris flow to vacuum (g/s).
GSDBNP	Deuterium burn rate in total plant (g/s).
GSDTGT	Deuterium flow rate in target in total plant (g/s).
GSDUBV	Unburned deuterium flow to vacuum system per chamber (g/s).
GSHBNP	Hydrogen burn rate in total plant (g/s).

GSHTGT	Hydrogen flow rate in target in total plant (g/s).
GSHUBL	Hydrogen flow to lithium in total plant (g/s).
GSHUBV	Total hydrogen debris flow to vacuum (g/s).
GSTBNP	Tritium burn rate in total plant (g/s).
GSTTGT	Tritium flow rate rate in targets in total plant (g/s).
GSTUBV	Unburned tritium flow to vacuum system per chamber (g/s).
GTBN	Tritium burned per shot (g).
GTBR	Tritium bred per shot (g).
GTBTGT	Tritium burn rate per target factory (g/s).
GTFTGT	Tritium flow rate per target factory (g/s).
GTUBL	Unburned tritium to liquid-lithium system per shot (g).
GTUBV	Unburned tritium to vacuum system per shot (g).
MOLEBN	Moles of deuterium and tritium burned per shot.

INPUT FILE

There is one input file, unit 5. This file contains both NAMELIST and formatted data. The NAMELIST variables are listed in this section with their default values in parenthesis. The formatted variables are read in after the NAMELIST variables and are described at the end of this section. A default value of zero usually indicates that the value is internally calculated.

NAMELIST Input

NAMELIST / ACCNT /

CLEVI	Interim replacement cost fraction (0.01).
CONDOL	Switch to convert to constant-dollar fixed-charge rate if CONDOL equals 1 (1).
CONTIM	Construction time (8 yr).
ERATE	Escalation rate (6%).
FCCOMS	Fraction of capital from common stock (0.38).
FCDEP	Fraction of capital from debt (0.5).
FCPEFS	Fraction of capital from preferred stock (0.12).
GINF	General inflation factor (6%).
NUNIT	Number of units per plant (1).
NYEAR	Current year of calculation (1985).
PLF	Power plant life (30 yr).
PTAXR	Annual property tax rate (0.02).
RINF75	Inflation rate for calendar year 1975 (9.3×10^{-2}).
RINF76	Inflation rate for calendar year 1976 (5.2×10^{-2}).
RINF77	Inflation rate for calendar year 1977 (5.9×10^{-2}).
RINF78	Inflation rate for calendar year 1978 (7.4×10^{-2}).
RINF79	Inflation rate for calendar year 1979 (8.6×10^{-2}).
RINF80	Inflation rate for calendar year 1980 (9.3×10^{-2}).
RINF81	Inflation rate for calendar year 1981 (9.4×10^{-2}).

RINF82 Inflation rate for calendar year 1982 (6.3×10^{-2}).
 RINF83 Inflation rate for calendar year 1983 (3.8×10^{-2}).
 RINF84 Inflation rate for calendar year 1984 (3.7×10^{-2}).
 RINF85 Inflation rate for calendar year 1985 (3.0×10^{-2}).
 RIODEP Interest rate on debt (10%).
 RRCOMS Rate of return on common stock (14%).
 RRPEFS Rate of return on preferred stock (9%).
 TAXR Effective income tax rate (0.48).

NAMELIST / CBANDS /

ALPSAR Maximum fraction of sacrificial liner allowed to ablate per shot (0.02).
 C1 First coefficient for temperature calculation ($0 \text{ K} \cdot \text{m}^{2.5}$).
 C2 Second coefficient for temperature calculation ($0 \text{ K} \cdot \text{m}^{2.5}$).
 C3 First coefficient for radius calculation ($0 \text{ m} \cdot \text{K}^{0.4}$).
 C4 Second coefficient for radius calculation ($0 \text{ m} \cdot \text{K}^{0.4}$).
 C5 Normalized constant for first WLOSS(r) equation ($0 \text{ } \mu\text{m}$).
 C6 Exponentiation constant for first WLOSS(r) equation (0 m^2).
 C7 Radius at which calculation switches from first to second WLOSS(r) (0).
 C8 Normalization constant for second WLOSS(r) equation ($0 \text{ } \mu\text{m}$).
 C9 Exponentiation constant for second WLOSS(r) equation (0 m^{-1}).
 C10 Wall loss at which calculation switch from second to first r(WLOSS) (0).
 CP Material constant normalized to reference design for temperature rise of sacrificial liner for each pulse ($0 \text{ K} \cdot \text{m}^{2.5}/\text{MJ}$).
 CX2 First-wall structure-thickness normalized constant ($0 \text{ mm} \cdot \text{m}/\text{MJ}$).
 DAGO Assembly gap between the first wall and the radial blanket (0 cm).

DAGT	Gap thickness between the first wall and the axial blanket (0 cm).
FLOOP	Fraction of total coolant outside reactor (0).
FLUFW	Fluence limit for neutron damage to first wall (6 MW·yr/m ²).
FLUSTO	Fluence limit for neutron damage to radial blanket (12 MW·yr/m ²).
FLUSTT	Fluence limit for neutron damage to axial blanket (12 MW·yr/m ²).
FRECON	Fraction of ablated materials uniformly recondensed (0).
FSHORT	Fraction of fusion energy absorbed on the front surface of the first wall (0.32).
HDRATI	Height to diameter ratio for ISHAPE equals 2 (1).
ICAVIT	Chamber designator (5): 1 graphite/stainless steel 2 stainless steel 3 niobium/stainless steel 4 drywall 5 HYLIFE 6 HIBALL 7 EAGLE 9 Cascade
ISHAPE	Switch for ICF chamber shape (2): 1 sphere 2 cylinder
IWDSGN	Switch for first-wall-structure thickness (2): 1 fixed 2 calculated
K1	Thermal conductivity of sacrificial liner (0 MW/mm·K).
K2	Thermal conductivity of first-wall structure (0 MW/mm·K).
MCOOLO	Material number for radial-blanket coolant (1).
MCOOLT	Material number for axial-blanket coolant (1).
MINRAD	Minimum acceptable chamber radius (2 m).
MSTRO1	Material number for radial-blanket structure: component 1 (0).
MSTRO2	Material number for radial-blanket structure: component 2 (0).
MSTRO3	Material number for radial-blanket structure: component 3 (0).
MSTRO4	Material number for radial-blanket structure: component 4 (0).

MSTRT1	Material number for axial-blanket structure: component 1 (0).
MSTRT2	Material number for axial-blanket structure: component 2 (0).
MSTRT3	Material number for axial-blanket structure: component 3 (0).
MSTRT4	Material number for axial-blanket structure: component 4 (0).
NCAVIT	Number of chambers per plant (1).
NYRBNK	Year in which blanket materials costs originated (1980).
NYRDCA	Year in which chamber materials costs originated (1977).
RHOW1	Sacrificial liner density (0 g/cm ³).
RHOW2	First-wall-structure density (0 g/cm ³).
STRLFO	Desired radial-blanket-structure lifetime for neutron damage (4).
STRLFT	Desired axial-blanket-structure lifetime for neutron damage (4).
T0	Maximum temperature of outside of first wall for boundary condition for ablation calculation; usually the first-wall coolant temperature (400°C).
THSACR	Thickness of sacrificial ablation material (10 mm).
TIRRD0	Radial-blanket irradiation time (0 full power years).
TIRRDT	Axial-blanket irradiation time (0 full power years).
TO	Tritium atoms bred per neutron in radial blanket at 100% solid angle (0).
TT	Tritium atoms bred per neutron in axial blanket at 100% solid angle (0).
VFFWC	First-wall coolant volume fraction (0).
VFFHS	Structural volume fraction of first wall (1).
WCST1	Unit cost for fabricated sacrificial liner (0 \$/kg).
WCST2	Unit cost for fabricated first wall (0 \$/kg).
WLIFE	Desired first-wall lifetime at 100% capacity factor for ablation and neutrons (1 yr).
X1	Beginning of cycle thickness of sacrificial liner (0 mm).
X2	Equivalent solid thickness of first-wall structural material (0 mm).

NAMelist / DSYST /

ANOT	KrF-driver energy-scaling exponent (0.74).
BNOT	Constant used to determine KrF-driver cost scaling with pulse rate (2.4×10^{-2}).
CNOT	KrF-driver reference cost (150 M\$).
DCHIB1	Heavy-ion-beam cost scaling coefficient (680 M\$).
DCHIB2	Heavy-ion-beam cost scaling exponent (0.4).
DCLIB1	Light-ion-beam cost scaling coefficient (75 M\$).
DCLIB2	Light-ion-beam cost scaling exponent (0.8).
DCTRCK	Direct cost of a T,D,A system per chamber (20 M\$).
DFMAG1	Distance between first wall and beam exit from final focusing magnet (3 m).
DFMAG2	Length of final focusing magnet (10 m).
EDNOT	KrF-driver reference energy (1 MJ).
ETAD	Driver efficiency (0).
ETANOT	KrF-driver reference efficiency (0.09).
FLUOPT	Fusion-power fluence limit for final optics ($0.1 \text{ MW}\cdot\text{yr}/\text{m}^2$).
FNUMAX	Maximum f/number for final optics (30).
HIBEAM	Radius of heavy-ion beam leaving final focusing magnet exit (0 cm).
ICTRCK	T,D,A system costing switch (0).
IDRIVE	Switch for driver type (1): 1 short-wavelength laser 3 heavy-ion beam 4 light-ion beam
NBEAM	Number of final beams per chamber (2).
NDRIVE	Number of drivers per plant (1).
NYRHIB	Year in which heavy-ion-beam cost estimates originated (1983).
NYRLIB	Year in which light-ion-beam cost estimates originated (1979).

NYRSHL Year in which laser cost estimates originated (1983).
 NYRTRC Year in which T,D,A system costs originated (1980).
 ODL Optical damage limit (4 J/cm^2).
 OPTICL Radius of final optics (0 m).
 OPTLIF Desired lifetime of final optics (1 yr).
 PCNOT Constant used to determine the KrF-driver efficiency (1.74×10^{-3}).
 RDNOT KrF-driver reference pulse rate (1 Hz).
 TAU KrF-driver pulse length (10 ns).
 TAUNOT KrF-driver reference pulse length (10 ns).

NAMelist / FUEL /

ALPHEL Fraction of helium taken up by liquid lithium inside the chamber (0).
 ALPHYL Fraction of unburned hydrogen gas taken up by liquid lithium inside the chamber (0).
 ASSAY6 ^6Li assay in liquid lithium (7.5×10^{-2}).
 CAPEX Capacity of each extractor unit ($3200 \text{ cm}^3/\text{s}$).
 DCEXTR Direct cost of an extractor unit of capacity CAPEX (1 M\$).
 DCFAC0 Reference cost of a target factory (100 M\$).
 DCFAC1 Target-factory scaling factor (0.333).
 DCFAC2 Target-factory scaling factor (0.333).
 DCFAC3 Target-factory scaling factor (0.333).
 DVEX Volumetric distribution of tritium between the lithium and the salt (2).
 EPSEX Efficiency of tritium recovery from the salt (0.9).
 EPSTG1 Target-factory scaling exponent (1.0).
 EPSTG2 Target-factory scaling exponent (0.333).
 EPSTG3 Target-factory scaling exponent (0.333).

ETAEX Efficiency factor that accounts for nonequilibrium tritium (0.3).

FBURN Fraction of deuterium and tritium burned per shot (0.3).

ILINLV Lithium inventory designator (1):
 1 = first wall + radial blanket + axial blanket
 2 = first wall + radial blanket
 3 = first wall + axial blanket
 4 = radial blanket + axial blanket
 5 = first wall
 6 = radial blanket
 7 = axial blanket
 8 = input by user

ITICAL Tritium inventory calculation designator (2):
 1 calculate TRCONC from input SSIT
 2 calculate SSIT from input TRCONC

LIINV Lithium inventory per chamber (0 g), only when ILINLV equals 8.

NTGTFC Number of target factories per plant (1).

NYREX Year in which extractor cost estimate originated (1980).

NYRTF Year in which the target-factory cost estimates originated (1983).

PWREX Power required by each extractor unit (3.73×10^{-3} MW_e).

RRFCT0 Reference target factory production rate (5 Hz).

SSIT Steady-state tritium inventory in liquid curtain in the total plant (0 g).

TAUFAC Inventory of tritium-filled targets in factory production process (2 full power days).

TRCONC Tritium concentration in liquid lithium (1.0 appm).

TYIEL0 Reference target yield (600 MJ).

NAMLIST / LMWIN /

ALPH1 Normalized constant for impact stress (0).

ALPH Thermal expansion coefficient (0 K⁻¹).

C Speed of sound in lithium (0 m/s).

CH1 Preexponential for IH scaling (0).

CH2 Exponential for IH scaling (0).

CHI1	Thermal stress profile constant (0).
CRW1	Preexponential for IRW scaling (0).
CRW2	Exponential for IRW scaling (0).
F1	The dpa limit constant (1).
F2	The appm helium limit constant (1).
F3	Constant used for maximum impact stress calculations (1).
F4	Constant used for yield stress limit calculations (1).
FINJ	Fractional area coverage at inlet (0.77).
FMIN	Minimum lithium fractional midplane coverage (0.5).
GAMM	Grüneisen coefficient (0).
GASDEN	Lithium vapor density (0 g/cm ³).
GNU	Poisson's ratio (0).
IDPA	Damage limit designator (1): 0 appm is limiting 1 dpa is limiting
IH	Scaling option switch for chamber height (1). 1 scales as the square root of fusion power 2 scales as the square root of target yield 3 scales as fusion power raised to the CH2
IRW	Scaling option switch for wall radius (1). 1,2 are the same as for IH 3 scales as fusion power raised to the CHW2
RHO	Liquid-lithium density (485 kg/m ³).
SI(3)	Impact stress coefficients (0,0,0).
SY(3)	Yield stress coefficients (0,0,0).
TLI	Liquid-lithium operating temperature (0 K).
UU	Energy attenuation coefficient (0).
WALLC	Constant multiplier for wall deuterium and tritium (0).
XLAMDA	Constant used in calculating the lithium-slug size (0).
YOUNGM	Young's modulus (0 MPa).

NAMelist / TASK /

CFACTR	Plant capacity factor (0.7).
DRP	The increment in repetition rate when solving for several repetition rates (0 Hz).
DTE	The increment in driver energy when solving for net power (0 MJ).
ETA	Switch for the target gain curve (0): -2 advanced concepts, laser driver -1 lower curve for current designs, laser driver 0 upper curve for current designs, laser driver 0.05, 0.01, 0.02, 0.04 $r^{3/2}_R$ value for heavy-ion-beam driver
FPOWER	Fusion power per chamber (0 MW _t).
IACCT	Switch to read the ACCNT NAMelist if IACCT equals 1 (1).
ICBAND	Switch to read the CBANDS NAMelist if ICBAND equals 1 (1).
IDSYST	Switch to read the DSYST NAMelist if IDSYST equals 1 (1).
IFLAG	A flag set to 1 when an iteration of find net power is wanted (0).
IFUEL	Switch to read the FUEL NAMelist if IFUEL equals 1 (1).
IPRINT	Switch to print NAMelist parameters if IPRINT is greater than 1 (3).
PEERR	The allowable relative error when converging on net power (0).
PEFLAG	The desired net power of the plant (0 MW _e).
RPFLAG	The maximum allowed repetition rate (0 Hz).
RPRATE	Shot repetition rate per chamber (0 Hz).
SHELL	Switch for the number of shells on the target (1 or 2) (0).
TEFLAG	The maximum allowed driver energy (0 MJ).
TENERG	Driver energy incident on target (0 MJ).
TGAIN	Target energy gain (0).
TYIELD	Target yield (0 MJ).

The NAMELIST variables are read in the following sequence after a one line title:

NAMELIST	Condition for reading
TASK	always
CBANDS	if ICBANDS.eq.1
LMWIN	if ICAVIT.eq.5,6,7
DSYST	if IDSYST.eq.1
FUEL	if IFUEL.eq.1
ACCNT	if IACCT.eq.1

Formatted Input

After the NAMELIST variables are read, the following formatted input variables are read. These variables are read for all cavity types except Cascade.

Variable	Format
EMO(L), L = 1,6	6E12.5
MATLO(L), L = 1,6	6A12
VFBST(L,M), M = 1,6, L = 1,6	6E12.5
DBO(L), L = 1,6	6E12.5
UCOBSO(L,M), M = 1,6, L = 1,6	6E12.5
EMT(L), L = 1,6	6E12.5
MATLT(L), L = 1,6	6A12
VFBST(L,M), M = 1,6, L = 1,6	6E12.5
DBT(L), L = 1,6	6E12.5
UCOBSO(L,M), M = 1,6, L = 1,6	6E12.5
DELTC, EXTEMP, PIN, DELPB, PPFR	5E12.5
PSGMAX, TSUP	2E12.5
IBCLT, NLOOP	2I12
PTGMAX, FELBOP	2E12.5

For the Cascade chamber, (ICAVIT = 9), there is only one formatted read statement: DELTC, EXTEMP 2E12.5

INPUT/OUTPUT (I/O) UNITS

The SAFIRE code uses five different I/O units. These units are listed below with their specific function.

Unit No.	File name	Function
<hr/>		
5	infile	All input variables are read from this file
6	outfile	The long version of the output
7	shtfil1	The one page version of the output
8	flofile	The NAMELIST reiteration and sequence of routines
9	shtfil2	The two page version of the short output

The only non-FORTRAN 77 statement in the SAFIRE code is the NAMELIST statement. The code was not revised to eliminate this statement for two reasons: most mainframe FORTRAN compilers have this option and using NAMELIST greatly simplifies the input file.

ACKNOWLEDGMENT

The authors thank Elaine Price of the Technical Information Department for her editorial assistance on this manual. Numerous errors, inconsistencies, and omissions were detected and corrected as a result of her work. We also appreciate her suggestions on the organization and layout of this manual.

APPENDIX A:
EXAMPLE INPUT AND OUTPUT FILES FOR SAFIRE

Figures A-1 through A-4 are examples of input files for the various reactor types. Figures A-5 through A-7 list example output files for the HYLIFE reactor, using the input file of Fig. A-1.

```

1  HYLIFE REACTOR; LITHIUM COOLANT; DOUBLE LOOP; FEB 1987
2  IACCT=1,
3  IFLAG=1, PEFLAG=1066.0, PEERR=1.E-2,
4  RPRATE=1.5, DRP=0.1, RPFLAG=1.5,
5  TENERG=1.0, DTE=1.0, TEFLAG=10.0,
6  SHELL=1.0, ETA=-2.0
7  $END
8  ICAVIT=5, NCAVIT=1,
9  RHOM2=7.8, MCST2=20.0, NYRDCA=1983, T0=1.75,
10 DAGO=5.E-2, MCOOLO=1, STRLFO=21., MSTR01=2,
11 DAGT=5.E-2, MCOOLT=1, STRLFT=21., MSTRT1=2, MSTRT2=3,
12 NYRBNK=1983
13 $END
14 IRH=2, IH=2,
15 ALPH1=0.28, RHO=485.0, C=4500.0, GAMM=0.9, UU=2.19, XLAMDA=0.15
16 $END
17 IDRIVE=1
18 $END
19 TRCONC=2.0
20 $END
21 NUNIT=1, NYEAR=1985
22 $END
23      1.40
24      LITHIUM      GRAPHITE
25      0.05         0.95
26
27
28
29
30
31      1.0
32      0.020         0.014
33
34
35
36
37
38      1.40          0.05
39      LITHIUM      GRAPHITE      STEEL
40      0.85         0.15
41      0.80         0.20
42
43
44
45
46      0.70          0.50
47      0.020         0.014      0.156
48      0.014         0.156
49
50
51
52
53      104.5         500.0         0.10      0.003      0.05
54      900.0         295.0
55      1           0
56      1600.0        0.030
57

```

Figure A-1. Input file for the HYLIFE reactor.

```

1  CASCADE REACTOR; JAN 1987
2  IACCT=1,
3  IFLAG=1, PEFLAG=815.0, PEERR=1.E-2,
4  RPRATE=1.0, DRP=1.0, RPFLAG=10.0,
5  TENERG=1.0, DTE=1.0, TEFLAG=10.0,
6  SHELL=1.0, ETA=-2.0
7  $END
8  ICAVIT=9, NCAVIT=1
9  $END
10 IDRIVE=1
11 $END
12 $END
13 NUNIT=2, NYEAR=1985
14 $END
15          450.          1600.

```

Figure A-2. Input file for the Cascade reactor.

```

1  HIBALL REACTOR; PBLI COOLANT; FEB 1987
2  IACCT=1,
3  IFLAG=1, PEFLAG=3250.0, PEERR=1.E-2,
4  RPRATE=5.0, DRP=0.1, RPFLAG=5.0,
5  TENERG=3.0, DTE=1.0, TEFLAG=10.0,
6  SHELL=1, ETA=0.02
7  $END
8  ICAVIT=6, NCAVIT=4,
9  RLIFE=21.0, FSHORT=0.28,
10 RHOM2=7.8, MCST2=20.0, NYRDCA=1983, TD=1.2,
11 MCOOL0=2, STRLFO=21.0, MSTROI=1, MSTRO2=2,
12 MCOOLT=2, STRLFT=21.0, MSTRT1=1, MSTRT2=2
13 $END
14 IRN=2, IH=2
15 $END
16 IDRIVE=3, NBEAM=20, ETAD=0.267, DCTRCK=3.0,
17 DFMAG1=1.5, DFMAG2=3.5, HIBEAM=33.0
18 $END
19 TRCONC=6.E-4
20 $END
21 NYEAR=1985
22 $END
23          1.28
24          HT-9          PBLI
25          0.90          0.10
26
27
28
29
30
31          0.40
32          0.156          0.059
33
34
35
36
37
38          1.28
39          HT-9          PBLI
40          0.90          0.10
41
42
43
44
45
46          0.40
47          0.156          0.059
48
49
50
51
52
53          170.0          500.0          0.20          0.02          0.05
54          900.0          295.0
55          6
56          1600.0          0.030
57

```

Figure A-3. Input file for the HIBALL reactor.


```

1  EAGLE REACTOR; FEB 1987
2  IACCT=1, IFLAG=0,
3  RPRATE=11.6, DRP=0.1, RPFLAG=11.6,
4  TENERG=4.0,
5  SHELL=1.0, ETA=0.02
6  $END
7  ICAVIT=7, NCAVIT=1,
8  WLIFE=5.0, FLUFN=20.0, X2=10.0, FSHORT=0.3, TO=500.0,
9  RHONZ=7.8, WCST2=20.0, NYRDC=1983, TO=1.16,
10 MCDOLO=1, STRLFO=5.0, MSTR01=2, MSTR02=3, FLUST0=20.0,
11 MCDOLO=1, STRLFT=5.0, MSTR11=2, MSTR12=3, FLUST1=20.0,
12 NYRBNK=1983
13 $END
14 GASDEN=50.
15 $END
16 IDRIVE=4, NBEAM=24, DCLIB1=75., DCLIB2=.8
17 $END
18 TRCONC=2.0
19 $END
20 NUNIT=1, NYEAR=1985
21 $END
22      1.16
23      LITHIUM      GRAPHITE      STEEL
24      0.65          0.33          0.02
25
26
27
28
29
30      0.9
31      0.020          0.014          0.156
32
33
34
35
36
37      1.16
38      LITHIUM      GRAPHITE      STEEL
39      0.65          0.33          0.02
40
41
42
43
44
45      0.9
46      0.020          0.014          0.156
47
48
49
50
51
52      110.0          475.0          0.2          0.02          0.5
53      900.0          295.0
54      1              2
55      1600.0          0.03

```

Figure A-4. Input file for the EAGLE reactor.

THIS FILE CONTAINS THE SHORTENED OUTPUT FROM THE SAFIRE CODE.

DRIVER TYPE : KR-F LASER
 GAIN CURVE : ADVANCED
 CHAMBER TYPE : HYLIFE
 NUMBER OF CHAMBERS PER UNIT: 1
 NUMBER OF UNITS PER PLANT: 1

F = CHAMBER PULSE RATE IN HZ.
 ED = DRIVER ENERGY IN MJ.
 G = TARGET GAIN
 PT = TOTAL THERMAL POWER OF PLANT IN MWT.
 PG = TOTAL GROSS POWER OF PLANT IN MWE.
 PD = TOTAL DRIVER POWER CONSUMPTION IN MWE.
 PN = TOTAL NET POWER IN MWE.
 CR = DIRECT COST OF ALL UNITS IN \$M.
 CD = DIRECT COST OF DRIVER IN \$M.
 CTF = DIRECT COST OF TARGET FACTORY IN \$M.
 CAP = CAPITAL PART OF COE IN C/KWEH.
 OM = O & M PART OF COE IN C/KWEH.
 COE = TOTAL COST OF ELECTRICITY IN C/KWEH.

F	ED	G	PT	PG	PD	PN	CR	CD	CTF	CURRENT\$			CONSTANT\$		
HZ	MJ		MWT		MWE			\$M		CAP	OM	COE	CAP	OM	COE
										C/KWEH			C/KWEH		
1.50	4.50	398.	3087.	1258.	74.	1061.	1230.	509.	77.	13.20	4.35	17.58	4.24	1.40	5.65

Figure A-5. Output file shtfill1 for the HYLIFE reactor.

CASE TITLE: HYLIFE REACTOR; LITHIUM COOLANT; DOUBLE LOOP; FEB 1987

DESCRIPTION:

DRIVER TYPE: KR-F LASER
GAIN CURVE: ADVANCED
CHAMBER TYPE: HYLIFE
NUMBER OF CHAMBERS PER UNIT: 1
NUMBER OF UNITS PER PLANT: 1
NUMBER OF DRIVERS: 1
NUMBER OF TARGET FACTORIES: 1

PLANT PARAMETERS:

CHAMBER PULSE RATE (HZ): 1.50
DRIVER ENERGY (MJ): 4.50
TARGET GAIN: 398.1
TARGET YIELD: 1791.5
THERMAL POWER (MWT): 3086.8
THERMAL CYCLE EFFICIENCY (%): 40.8
HEAT REJECTED (MWT): 1828.5
AVAILABILITY FACTOR (%): 70.0

ELECTRIC POWER BALANCE (MWE):

GROSS ELECTRIC POWER: 1258.3
DRIVER POWER/UNIT: 74.2
PUMPING POWER: 85.4
OTHER BOP POWER: 37.7
NET ELECTRIC POWER: 1061.0

ECONOMIC FACTORS (%):

ESCALATION RATE: 6.00
GENERAL INFLATION RATE: 6.00
AFTER-TAX COST OF MONEY: 9.00
REAL COST OF MONEY: 2.83
CURRENT DOLLAR FIXED CHARGE RATE: 16.22
CONSTANT DOLLAR FIXED CHARGE RATE: 8.32

INDIRECT AND TIME-RELATED COST FACTORS:

CONSTRUCTION SERVICES (F91): 0.200
HOME OFFICE ENG. & SERVICES (F92): 0.150
FIELD OFFICE ENG. & SERVICES (F93): 0.100
OWNERS COST (F94): 0.070
PROJECT CONTINGENCY (F95): 0.100
CONSTRUCTION TIME (YR): 8.000
ESCALATION DURING CONST. (FEDC): 0.323
INTEREST DURING CONST. (FIDC): 0.420

Figure A-6. Output file shtfil2 for the HYLIFE reactor.

ICF POWER PLANT ECONOMIC EVALUATION

ACCOUNT	ACCOUNT TITLE	\$M (1985)	
20	LAND AND LAND RIGHTS	5.0	
21	STRUCTURES AND IMPROVEMENTS	262.7	
22	REACTOR PLANT EQUIPEMENT	512.4	
23	TURBINE PLANT EQUIPEMENT	214.8	
24	ELECTRICAL PLANT EQUIPEMENT	85.1	
25	MISCELLANEOUS PLANT EQUIPEMENT	55.2	
26	MAIN HEAT REJECTION EQUIPEMENT	34.9	
27	DRIVER EQUIPEMENT	509.4	
28	TARGET FACTORY EQUIPEMENT	76.9	
	TOTAL DIRECT COST	1816.3	
91	CONSTRUCTION SERVICES	363.3	
92	HOME OFFICE ENGINEERING AND SERVICES	272.4	
93	FIELD OFFICE ENGINEERING AND SERVICES	181.6	
94	OWNERS COST	127.1	
95	PROJECT CONTINGENCY	276.1	
	TOTAL OVERNIGHT COST	3036.9	
		CURRENT \$	CONSTANT \$
96	ESCALATION DURING CONSTRUCTION	980.1	0.0
97	INTEREST DURING CONSTRUCTION	1275.6	283.7
	TOTAL CAPITAL COST	5292.5	3320.6

COST OF ELECTRICITY		CURRENT \$	CONSTANT \$
		CENTS/KWEH	CENTS/KWEH
	CAPITAL	13.20	4.24
	FUEL	0.03	0.01
	O & M	4.35	1.40
	TOTAL	17.58	5.65

Figure A-6. (Continued.)

ENTER SAFIRE: ICF SYSTEMS ANALYSIS CODE

THE SAFIRE CODE HAS MANY AUTHORS WHO HAVE CONTRIBUTED
OVER THE YEARS. THE MOST RECENT AUTHORS INCLUDE:

MAYHE MEIER - LLNL, DAVE BERWALD - TRW,
JIM GORDON - TRW, TOM MCCARVILLE - TRW,
CHRIS CARSON - TRW, BRUCE GLASGOW - TRW
LAST CHANGE FEB. 18, 1987

CASE TITLE: HYLIFE REACTOR; LITHIUM COOLANT; DOUBLE LOOP; FEB 1987

WARNING: IN POWCON PS = , 2.2296e+01 RESET TO 17
WARNING: IN MPECST, PTG = , 1.0740e+02
WARNING: IN POWCON PS = , 2.2296e+01 RESET TO 17
WARNING: IN MPECST, PTG = , 3.4541e+02
WARNING: IN POWCON PS = , 2.2296e+01 RESET TO 17
WARNING: IN POWCON PS = , 2.2296e+01 RESET TO 17
WARNING: IN POWCON PS = , 2.2296e+01 RESET TO 17
WARNING: IN MPECST, PTG = , 1.4798e+03
WARNING: IN POWCON PS = , 2.2296e+01 RESET TO 17
WARNING: IN POWCON PS = , 2.2296e+01 RESET TO 17

NOTE: - QUANTITIES DESIGNATED BY +++++ INCLUDE AVERAGE
CAPACITY FACTOR INFLUENCE.
- ALL OTHER QUANTITIES AT FULL PLANT CAPACITY
- MOST INFO IS FOR THE FIRST UNIT IN THE CASE OF
MULTI-UNIT POWER PLANTS. COST SUMMARY IS FOR
TOTAL PLANT.

.....

Figure A-7. Output file outfile for the HYLIFE reactor.

OVERALL PLANT PERFORMANCE SUMMARY:

DESCRIPTION:

DRIVER TYPE: KR-F LASER
 GAIN CURVE: ADVANCED
 CHAMBER TYPE: HYLIFE
 NUMBER OF CHAMBERS PER UNIT: 1
 NUMBER OF UNITS PER PLANT: 1
 NUMBER OF DRIVERS: 1
 NUMBER OF TARGET FACTORIES: 1

PLANT PARAMETERS:

CHAMBER PULSE RATE (HZ): 1.50
 DRIVER ENERGY (MJ): 4.50
 TARGET GAIN: 398.1
 TARGET YIELD: 1791.5
 THERMAL POWER (MWT): 3086.8
 THERMAL CYCLE EFFICIENCY (%): 40.8
 HEAT REJECTED (MWT): 1828.5
 AVAILABILITY FACTOR (%): 70.0

ELECTRIC POWER BALANCE (MWE):

GROSS ELECTRIC POWER: 1258.3
 DRIVER POWER/UNIT: 74.2
 PUMPING POWER: 85.4
 OTHER BOP POWER: 37.7
 NET ELECTRIC POWER: 1061.0

KR-F LASER DRIVER PERFORMANCE & COST INFORMATION:

DRIVER OUTPUT ENERGY= 4.50 MJ
 DRIVER EFFICIENCY=0.091
 DRIVER INPUT ELECTRICAL ENERGY PER SHOT= 49.47 MJ
 DRIVER REPETITION RATE= 1.50 SHOTS/SEC
 REQUIRED INPUT ELECTRICAL POWER PER DRIVER= 74.20 MWE

FINAL FOCUSING OPTICS (OR MAGNET) INFORMATION:

NUMBER OF BEAMS= 2
 OPTICAL DAMAGE LIMIT= 4.00 J/CM SQ
 RADIUS OF FINAL OPTICS=423.1 CM
 DISTANCE OF FINAL OPTICS FROM CHAMBER CENTER=38.7 M +++++
 - TO SATISFY THE FOLLOWING USER REQUIREMENTS:
 - DESIRED FINAL OPTICS LIFETIME= 1.0 YR
 - OPTICAL SURFACE FUSION NEUTRON DAMAGE LIMIT=0.10 MW YR/M SQ
 REQUIRED FINAL OPTICS (OR FOCUSING MAGNET) F NUMBER FOR ABOVE= 4.6
 SOLID ANGLE LOST DUE TO BEAM PENETRATIONS=0.545 OF 12.6 STERADIANS

Figure A-7. (Continued.)

CHAMBER PERFORMANCE AND COST INFORMATION:

BASIS: ONE ICF CHAMBER

CHAMBER TYPE: MYLIFE, STEEL WALL

POWER RELATED INFORMATION:

FUSION YIELD=1791.5 MJ (32.0 PCT. SHORT RANGE, 68.0 PCT. LONG RANGE)
 MICROEXPLOSION REPETITION RATE= 1.50 SHOTS/SEC
 FUSION POWER= 2687.3 MW THERMAL

.....

GEOMETRY RELATED INFORMATION:

FINAL CHAMBER RADIUS= 5.0 M
 CHAMBER GEOMETRY IS RIGHT CIRCULAR CYLINDRICAL
 HEIGHT/DIAMETER RATIO=0.8
 CHAMBER AREA= 328.7 M²
 USEFUL SOLID ANGLE FRACTION=0.957
 CHAMBER VOLUME= 623.9 M³ CUBE
 COMPUTED EQUIVALENT FIRST WALL STRUCTURE THICKNESS=42.5 MM (SOLID)
 TOTAL FIRST WALL THICKNESS (INCL. COOLANT AND VOID)=42.5 MM
 TOTAL FIRST WALL COOLANT VOLUME=0.515e+02 M³ CUBE

.....

DESIGN VALUES FOR LIQUID METAL JETS

LM BLANKET HEAD LOSS	4.57 M
JET ARRAY EFFECTIVE THICKNESS	0.86 M
INNER JET RADIUS	0.39 M
MIDPLANE PACKING FRACTION	0.56
JET ARRAY IMPACT STRESS	60.9 MPA
FIRST WALL THERMAL STRESS	164.8 MPA

JET ARRAY FLOW REQUIREMENTS

INJECTION VELOCITY	9.5 M/S
MIDPLANE VELOCITY	13.0 M/S
CHAMBER FLOW	81.1 M ³ /S
REFLECTOR FLOW	11.5 M ³ /S
INX FLOW	8.3 M ³ /S
PUMP HEAD	17.8 M
PUMPING POWER	22.4 MWE

LIQUID METAL VOLUME TALLY

VOLUME IN CHAMBER	51.5 M ³
VOLUME IN HEAD	53.8 M ³
VOLUME IN PIPING	1247.4 M ³
MERGE TO ONE LOOP (IE., THEY ARE COMPATABLE)	

.....

FIRST WALL RAD'US SELECTION INFORMATION:

JET ARRAY EFFECTIVE THICKNESS OF 0.8639 METERS GIVES A 30.00 YEAR LIFE
 FOR A FIRST WALL AT 4.99 METERS

FIRST WALL FABRICATED MATERIALS COST INFORMATION:
 FIRST WALL DIRECT COST=0.234e+07 IN 1985 DOLLARS
 FIRST WALL OPERATING COST=0.780e+05 \$/YR IN 1985 DOLLARS +++++

.....

Figure A-7. (Continued.)

BLANKET AND SHIELD PERFORMANCE AND COST INFORMATION:

BASIS: ONE ICF CHAMBER

GEOMETRY & MATERIALS COMPOSITION INFORMATION FOR STRUCTURAL COMPONENTS:

	RADIAL BLANKET	AXIAL BLANKETS
DISTANCE TO FIRST WALL SURFACE (M)	4.988	3.991
FIRST WALL THICKNESS (M)	.042	.042
GAP THICKNESS (M)	.050	.050
BLANKET INNER RADIUS (M)	5.081	4.083
ZONE 1 THICKNESS (M)	1.000	0.700
- VOLUME (M CUBE)	0.280e+03	0.109e+03
ZONE 2 THICKNESS (M)		0.500
- VOLUME (M CUBE)		0.782e+02
BLANKET OUTER RADIUS (M)	6.081	5.283
SOLID ANGLE FRACTION	.625	.375
NET AVAILABLE SOLID ANGLE FRACTION	.957	0.957
NET EFFECTIVE SOLID ANGLE FRACTION	.598	.359
BLANKET MATERIAL 1	LITHIUM	LITHIUM
BLANKET MATERIAL 2	GRAPHITE	GRAPHITE
BLANKET MATERIAL 3		STEEL
BLANKET MATERIAL 4		
BLANKET MATERIAL 5		
BLANKET MATERIAL 6		
BLANKET COOLANT	LITHIUM	LITHIUM

BLANKET MATERIAL VOLUME FRACTIONS BY ZONE:

RADIAL BLANKET		BLANKET MATERIAL					
ZONE	1	2	3	4	5	6	
1	0.050	0.950	0.000	0.000	0.000	0.000	
AXIAL BLANKETS		BLANKET MATERIAL					
ZONE	1	2	3	4	5	6	
1	0.850	0.000	0.150	0.000	0.000	0.000	
2	0.000	0.800	0.200	0.000	0.000	0.000	

BLANKET MATERIAL VOLUMES (M CUBE) BY ZONE:

RADIAL BLANKET		BLANKET MATERIAL					
ZONE	1	2	3	4	5	6	
1	0.140e+02	0.266e+03	0.	0.	0.	0.	
AXIAL BLANKETS		BLANKET MATERIAL					
ZONE	1	2	3	4	5	6	
1	0.930e+02	0.	0.164e+02	0.	0.	0.	
2	0.	0.625e+02	0.156e+02	0.	0.	0.	

Figure A-7. (Continued.)

BLANKET POWER RELATED INFORMATION:

	RADIAL BLANKET	AXIAL BLANKETS
ZONE 1 FUSION NEUT. ENERGY MULTIPLICATION	1.40	1.40
- POWER DENSITY (W/CM CUBE)	0.8	1.3
- POWER (MWT)	230.5	138.5
ZONE 2 FUSION NEUT. ENERGY MULTIPLICATION		0.05
- POWER DENSITY (W/CM CUBE)		0.1
- POWER (MWT)		4.9
TOTAL FUSION NEUT. ENERGY MULTIPLICATION	1.40	1.45
TOTAL POWER (MWT)	230.5	143.4
TOTAL COOLANT VOLUME (M CUBE)	0.140e+02	0.930e+02

BLANKET ENERGY MULTIPLICATION FOR TOTAL CHAMBER= 1.36
 BLANKET POWER FOR TOTAL CHAMBER= 374.0 MWT
 BLANKET COOLANT VOLUME FOR TOTAL CHAMBER= 0.107e+03 M CUBE

BLANKET TRITIUM BREEDING INFORMATION:

TRITIUM BREEDING IN LIQUID METAL BLANKET

	RADIAL BLANKET
TRITIUM BREEDING PER FUSION NEUTRON	1.750
- AT 100 PCT. SOLID ANGLE	
ADJUSTED TRITIUM BREEDING PER FUSION	1.750
TRITIUM PRODUCTION (KG/YR) +++++	184.5

BLANKET MATERIALS COST INFORMATION:

BLANKET MATERIALS COST (MILLION \$/M CUBE) BY ZONE:

RADIAL BLANKET		BLANKET MATERIAL					
ZONE	1	2	3	4	5	6	
1	0.200e-01	0.140e-01	0.	0.	0.	0.	

AXIAL BLANKETS		BLANKET MATERIAL					
ZONE	1	2	3	4	5	6	
1	0.200e-01	0.	0.156e+00	0.	0.	0.	
2	0.	0.140e-01	0.156e+00	0.	0.	0.	

TOTAL BLANKET DIRECT COST=0.576e+08 IN 1985 DOLLARS
 TOTAL BLANKET OPERATING COST=0.714e+06 IN 1985 DOLLARS +++++

Figure A-7. (Continued.)

PER ICF TARGET FACTORY PERFORMANCE AND COST INFORMATION:

TARGET PRODUCTION RATE= 1.50 ICF TARGETS/SEC
 TARGETS PRODUCED PER YEAR=0.351e+08 +++++
 TARGET FACTORY DIRECT COST=0.769e+08 DOLLARS

MOLTEN SALT TRITIUM EXTRACTION SYSTEM INFORMATION:

LIQUID METAL INVENTORY PER UNIT=0.752e+09 GM
 TOTAL TRITIUM SOURCE TO LIQ. MET. BLANKET=0.832e-02 GM/SEC
 TRITIUM CONCENTRATION IN LIQ. MET. BLANKET=0.200e+01 APPM
 LUMPED EXTRACTION EFFICIENCY OF 0.351 DERIVED FROM
 - EFFICIENCY OF TRITIUM RECOVERY FROM THE SALT=0.900
 - VOLUMETRIC DISTR. COEFF. BETWEEN LI AND SALT=2.000
 - NONEQUILIBRIUM TRIT. DISTR. EFFIC. FACTOR=0.300
 REQUIRED PROCESS RATE= 1/0.275e+05 OF TOTAL LI PER SEC
 ABOVE LI FLOW CORRESPONDS TO 0.565e+05 CM CUBE/SEC
 ABOVE REQUIRES 18 EXTRACTOR UNITS OF 0.320e+04 CM CUBE/SEC EACH
 EACH EXTRACTOR UNIT REQUIRES 0.00373 MWE
 EXTRACTOR UNIT COST=0.137e+01 M\$

FUSION FUEL FLOW AND INVENTORY INFORMATION:

D-T BURN FRACTION=0.30
 MOLES OF D-T FUEL BURNED PER SHOT=0.106e-02
 TRITIUM BREEDING RATIO=1.75

PER SHOT INFORMATION (ALL GM)

TRITIUM DEUTERIUM HYDROGEN

AMOUNT BURNED PER SHOT	0.317e-02	0.211e-02	0.528e-02
AMOUNT BRED PER SHOT	0.555e-02	NA	NA
CHARGE IN TARGET	0.106e-01	0.704e-02	0.176e-01
UNBURNED DEBRIS TO VACUUM SYSTEMS	0.740e-02	0.493e-02	0.123e-01

PER SHOT INFORMATION (ALL GM/SEC)

BURN RATE PER CHAMBER	0.475e-02	0.317e-02	0.792e-02
BREEDING RATE PER CHAMBER	0.832e-02	NA	NA
FLOW RATE IN TARGETS PER CHAMBER	0.158e-01	0.106e-01	0.264e-01
DEBRIS FLOW TO VACUUM PER CHAMBER	0.111e-01	0.740e-02	0.185e-01
BURN RATE PER UNIT	0.475e-02	0.317e-02	0.792e-02
BREEDING RATE PER UNIT	0.832e-02	NA	NA
FLOW RATE IN TARGETS PER UNIT	0.158e-01	0.106e-01	0.264e-01
DEBRIS FLOW TO VACUUM PER UNIT	0.111e-01	0.740e-02	0.185e-01
BURN RATE PER TARGET FACTORY	0.475e-02	0.317e-02	0.792e-02
FLOW RATE IN TARGETS PER TARGET FACTORY	0.158e-01	0.106e-01	0.264e-01

TRITIUM INVENTORY INFORMATION (ALL GM)

INVENTORY IN TARGET	1.056e-02
INVENTORY IN LIQ. MET. BLANKET	6.513e+02
INVENTORY IN A TARGET FACTORY	2.738e+03
INVENTORY IN ALL TARGET FACTORIES	2.738e+03
INVENTORY IN ALL TRITIUM BREEDING SYST.	6.513e+02
TOTAL TRITIUM INVENTORY IN PLANT	3.390e+03

HELIUM (DEBRIS) GENERATION INFORMATION

GENERATION PER SHOT= 0.423e-02 GM
 AMOUNT PASSED TO VACUUM SYSTEM PER SHOT= 0.423e-02 GM
 HELIUM GENERATION RATE PER CHAMBER= 0.634e-02 GM/SEC
 FLOW TO VACUUM PER CHAMBER= 0.634e-02 GM/SEC

Figure A-7. (Continued.)

HEAT TRANSPORT SYSTEM INPUT PARAMETERS

```

1.0450e+02 DELTC, BLANKET COOLANT DELTA T (C)
5.0000e+02 BLANKET COOLANT EXIT TEMP (C)
1.0000e-01 BLANKET COOLANT INLET PRESS (MPA)
3.0000e-03 BLANKET COOLANT PRESS DROP (MPA)
5.0000e-02 MAX FRAC OF GROSS PHR FOR PUMPING POWER
9.0000e+02 MAX SIZE OF STM GENERATOR (MWT)
2.9500e+02 SUPERHEAT CYCLE TEMP POINT (C)

```

BLANKET COOLANT IS LITHIUM

RESULTS OF HEAT TRANSPORT SYSTEM(HTS) CALCULATION

NHTS = 1 LI COOLANT, SUPERHEATED STEAM CYCLE.

```

PS, STEAM PRESSURE (MPA)          17.0
TS, STEAM TEMPERATURE (C)         480.0
HS, STEAM FLOW RATE (KG/S)         1641.8
PB, THERMAL POWER (MWT)            3086.8
HPC, PRIMARY COOL FLOW (KG/S)      11183.9
HSC, SECONDARY COOL FLOW (KG/S)    35941.5
PCPP, COOLANT PUMP POWER(MWE)       62.9
QELEC, GRS ELECTRIC POWER(MWE)     1258.3
NSG, NO. OF STEAM GENERATORS       4
PSG, SIZE OF STM GENER. (MWT)      771.7

```

COSTS FOR THE HTS COMPONENTS (M\$).....

```

1 - RECIRCULATING JET ARRAY SYSTEM      137.7
2 - INTERMEDIATE HEAT EXCHANGER         38.9
3 - PRIMARY LOOP PIPING                 43.3
4 - PRIMARY COOLANT CLEANUP PLANT       14.5
5 - PRIMARY COOLANT PUMPS + MOTORS      38.0
6 - SECONDARY LOOP PIPING               23.0
7 - STEAM GENERATOR                     44.8
8 - SECONDARY COOLANT PUMPS + MOTORS    53.3
9 - SECONDARY COOLANT CLEANUP PLANT     21.7
10 - STEAM SEPARATOR                    10.0
11 - WATER LOOP PIPING                  0.1
12 - FLASH BOILER ACCUMULATOR          0.0
13 - STEAM SUPERHEATER                  35.2
TOTAL HEAT TRANSPORT SYSTEM COST.... 460.5

```

INPUT TO POWER CONVERSION MODEL....

```

PTGMAX, MAX TG UNIT SIZE,MWE          1600.0
FELBOP, FRACTION OF GROSS MWE TO RUN BOP 0.0

```

OUTPUT FROM POWER CONVERSION MODEL....

```

PEGRS, GROSS ELECTRIC POWER (MWE)      1258.3
NTGU, NUMBER OF TG UNITS                 1
PTG, CAPACITY OF EACH TG UNIT(MWE)      1258.3
TEYA, TURBINE CYCLE EFFICIENCY           0.41
GEYA, GENERATOR EFFICIENCY               0.98
ELBOP, BOP ELECTRICAL LOAD(MWE)         37.7

```

SUPERHEAT CYCLE SELECTED

ELECTRIC POWER (MWE) BALANCE....

```

GROSS ELECTRIC POWER          1258.3
GENL POWER CONSUMED           85.4
DRIVER POWER CONSUMED          74.2
NON-PUMP BOP POWER CONSUMED    37.7
NET ELECTRIC POWER             1061.0

```

HEAT REJECTED FROM TURBINE CYCLE (MWT) = 1828.5

Figure A-7. (Continued.)

VOLUME OF BUILDINGS AND STRUCTURES

VOLUME OF RCB(M**3)	139284.3
AREA OF RCB(M**2)	2360.8
AREA OF TUNNELS(M**2)	56.2
LENGTH OF TUNNELS(M)	8.7
NUMBER OF TUNNELS	2
VOL OF TUNNELS(M**3)	980.3
VOL OF TURBINE GEN BLDG =	110802.4
VOL OF REAC AUX BLDG-R =	67669.6
VOL OF REAC AUX BLDG-NR =	5514.1
VOL OF REAC SERV BLDG =	83414.5
VOL OF STEAM GENER BLDG =	51957.8
VOL OF CONTROL BUILDING =	55592.8
VOL OF MISC. STRUCTURES =	75000.0
TOTAL VOL OF BUILDINGS =	589235.4
TOTAL AREA OF BUILDINGS =	9255.1

.....

COST OF LAND AND LAND RIGHTS (\$M)	5.0
STRUCTURES & IMPROVEMENTS COSTS (M\$)....	
21.01 SITE IMPROV. AND FACILITIES	23.9
21.02 REACTOR CONTAINMENT BUILDING	110.7
21.03 TURBINE GENERATOR BUILDING	22.3
21.04 COOLING SYSTEM STRUCTURE	4.9
21.05 PWR SUPP + ENER STORAGE BLDG	0.0
21.06 OTHER PLANT BUILDINGS	100.8
21.00 TOTAL S&I COST	262.7

INDIVIDUAL COSTS IN ACCOUNT 21.06 (M\$)....	
REAC AUX BLDG.R	21.2
REAC AUX BLDG.NR	2.7
REAC SERV BLDG	23.6
STEAM GEN BLDG	12.9
CONTROL BLDG	20.3
DIRECT CONV BLDG	0.0
MISC STRUCTURES	17.5
TUNNELS	2.6
TOTAL IN 21.06...	100.8

REACTOR PLANT EQUIPMENT COSTS (M\$)	
TRACKING, ALIGN SYSTEMS	27.4
FIRST WALL SYSTEMS	2.3
T EXTRACTION SYSTEMS	24.6
BLANKET AND SHIELD	57.6
HEAT TRANSPORT SYSTEM	460.5
22.00 TOTAL RPE COST	572.4

TURBINE PLANT EQUIPMENT COSTS (M\$)....	
23.01 TURBINE GENERATORS	124.3
23.02 NOT CURRENTLY USED	
23.03 CONDENSING SYSTEMS	32.2
23.04 FEED HEATING SYSTEMS	22.7
23.05 OTHER TP EQUIPMENT	22.7
23.06 INSTRUMENT. AND CONTROL	5.9
23.07 MISCELLANEOUS ITEMS	7.0
23.00 TOTAL TPE COST	214.8

Figure A-7. (Continued.)

ELECTRIC PLANT EQUIPMENT COSTS (M\$)....		
24.01	SWITCHGEAR	12.3
24.02	STATION SERVICE EQUIP	18.5
24.03	SWITCHBOARDS	1.8
24.04	PROTECTIVE EQUIPMENT	3.1
24.05	ELECT STRUCTS + WIRING	26.5
24.06	POWER + CONTRL WIRING	22.9
24.00	TOTAL EPE COST	85.1
MISCELLANEOUS PLANT EQUIPMENT COSTS (M\$)....		
25.01	TRANSP. + LIFT EQUIP	6.0
25.02	AIR, WATER AND STEAM	35.2
25.03	COMMUNICATIONS EQUIP	4.0
25.04	FURNISHINGS + FIXTURES	2.9
25.05	WASTE WATER TREATMENT	3.2
25.00	TOTAL MPE COSTS	55.2
MAIN HEAT REJECTION SYSTEM COSTS (M\$)...		
26.01	COST OF STRUCTURES	2.8
26.02	MECHANICAL EQUIPMENT	32.1
26.00	TOTAL MHRE COST	34.9
ECONOMIC FACTORS (%):		
	ESCALATION RATE:	6.00
	GENERAL INFLATION RATE:	6.00
	AFTER-TAX COST OF MONEY:	9.00
	REAL COST OF MONEY:	2.83
	CURRENT DOLLAR FIXED CHARGE RATE:	16.22
	CONSTANT DOLLAR FIXED CHARGE RATE:	8.32
INDIRECT AND TIME-RELATED COST FACTORS:		
	CONSTRUCTION SERVICES (F91):	0.200
	HOME OFFICE ENG. & SERVICES (F92):	0.150
	FIELD OFFICE ENG. & SERVICES (F93):	0.100
	OWNERS COST (F94):	0.070
	PROJECT CONTINGENCY (F95):	0.100
	CONSTRUCTION TIME (YR):	8.000
	ESCALATION DURING CONST. (FEDC):	0.323
	INTEREST DURING CONST. (FIDC):	0.420

Figure A-7. (Continued.)

ICF ECONOMIC EVALUATION FOR 1 UNIT POWER PLANT

ACCOUNT	ACCOUNT TITLE	M\$	
20	LAND AND LAND RIGHTS	5.0	
21	STRUCTURES AND IMPROVEMENTS	262.7	
22	REACTOR PLANT EQUIPMENT	572.4	
23	TURBINE PLANT EQUIPMENT	214.8	
24	ELECTRIC PLANT EQUIPMENT	85.1	
25	MISCELLANEOUS PLANT EQUIPMENT	55.2	
26	MAIN HEAT REJECTION EQUIPMENT	34.9	
27	DRIVER EQUIPMENT	509.4	
28	TARGET FACTORY EQUIPMENT	76.9	
	TOTAL DIRECT COST	1816.3	
91	CONSTRUCTION SERVICES	363.3	
92	HOME OFFICE ENGINEERING AND SERVICES	272.4	
93	FIELD OFFICE ENGINEERING AND SERVICES	181.6	
94	OWNER'S COST	127.1	
95	PROJECT CONTINGENCY	276.1	
	TOTAL OVERNIGHT COST	3056.9	
		CURRENT\$	CONSTANT\$
96	ESCALATION DURING CONSTRUCTION	980.1	0.0
97	INTEREST DURING CONSTRUCTION	1275.6	283.7
	TOTAL CAPITAL COST	5292.5	3320.6
	COST OF ELECTRICITY		
	CAPITAL	13.20	4.24
	FUEL	0.03	0.01
	OM	4.35	1.40
	TOTAL	17.58	5.65

CONSTANT \$ RESULTS IN 1985 DOLLARS
CURRENT \$ RESULTS IN 1993 DOLLARS

Figure A-7. (Continued.)

APPENDIX B:
ALPHABETICAL LIST OF VARIABLES

This Appendix lists all variables used by SAFIRE in the COMMON blocks and the NAMELIST statements and the associated page numbers in this User's Manual.

LIST OF VARIABLES

VARIABLE	COMMON BLOCK	NAMELIST	PAGE
ABLDG	CMBLDG		13
ACOST	OUTT		21
ACCT	COU1T		15
ADCBM	PLANT1		24
ADCEXR	PLANT1		24
ADCFAT	PLANT1		24
ADCRV	PLANT1		24
ADCTRK	PLANT1		24
ADCHAL	PLANT1		24
ALPH	CURTAN	LMWIN	16, 39
ALPH1	CURTAN	LMWIN	16, 39
ALPHEL	TRIT1	FUEL	30, 38
ALPHYL	TRIT1	FUEL	30, 38
ALPSAR	CAVIT3	CBANDS	10, 34
ANOT	DRIVER	DSYST	18, 37
AOCWAL	PLANT1		24
APSB	CMBLDG		13
ARCB	CMBLDG		13
ASSAY6	TEXTR1	FUEL	29, 38
ASTRLO	CAVIT1		9
ASTRLT	CAVIT1		9
ATITLE	COU1T		15
ATOCBM	PLANT1		24
ATUN	OUTT		21
AUXPW	CURTAN		16
AWLIFA	CAVIT3		10
AWLIFE	CAVIT2		10
AWLIFN	CAVIT2		10
BFPWRT	PLANT1		24
BFUSPR	CAVIT4		11
BNOT	DRIVER	DSYST	18, 37
C1	CAVITY	CBANDS	12, 34
C2	CAVITY	CBANDS	12, 34
C3	CAVITY	CBANDS	12, 34
C4	CAVITY	CBANDS	12, 34
C5	CAVITY	CBANDS	12, 34
C6	CAVITY	CBANDS	12, 34
C7	CAVITY	CBANDS	12, 34

LIST OF VARIABLES (continued).

VARIABLE	COMMON BLOCK	NAMELIST	PAGE
C8	CAVITY	CBANDS	12, 34
C9	CAVITY	CBANDS	12, 34
C10	CAVITY	CBANDS	12, 34
C2106	OUTT		21
CAPEX	TEXTRI		29, 38
CAREA	CAVIT2		10
CAW	OUTT	FUEL	21
CBMO	BANDS		7
CBMT	BANDS		7
CCB	OUTT		22
CCE	OUTT		22
CCP	CAVITY		12
CCS	OUTT		22
CCSS	OUTT		22
CC1	CAVITY		12
CC2	CAVITY		12
CC3	CAVITY		12
CC4	CAVITY		12
CC5	CAVITY		12
CC6	CAVITY		12
CC7	CAVITY		12
CC8	CAVITY		12
CC9	CAVITY		12
CC10	CAVITY		12
CCX2	CAVITY		12
CDCB	OUTT		22
CDOM	INDCST		20
CDOMR	INDCST		20
CE	INDCST		20
CEPE	OMBOPC		14
CER	INDCST		20
CES	OUTT		22
CFACR	STUFF	TASK	27, 41
CFF	OUTT		22
CFH	OUTT		22
CH1	CURTAN	LHAIN	16, 39
CH2	CURTAN	LHAIN	16, 39
CHI1	CURTAN	LHAIN	16, 40
CHRS	OMBOPC		14
CIC	OUTT		22
CINVO	OUTT		22
CINVT	INDCST		20
CK2	OUTT		22
CK4	OUTT		22
CK5	OUTT		22
CK6	OUTT		22
CLEVI	INDCST	ACCNT	22
CLLR	OMBOPC		20, 33

LIST OF VARIABLES (continued).

VARIABLE	COMMON BLOCK	NAMELIST	PAGE
CME	OUTT		22
CMI	OUTT		22
CMPE	CHBOPC		14
CMSS	OUTT		22
CNOT	DRIVER	DSYST	18, 37
COE	OUTT		22
CONDOL	INDCST	ACCNT	20, 33
CONTIM	INDCST	ACCNT	20, 33
COPER	OUTT		22
COPERR	OUTT		22
COSHTS	OUTT		22
COSTM	OUTT		20
CP	INDCST		22
CPC	CAVITY	CBANDS	12, 34
CPE	OUTT		22
CPSB	OUTT		22
CRABNR	OUTT		22
CRABR	OUTT		22
CRADUS	STUFF		27
CRCB	OUTT		23
CRET	OUTT		23
CRETR	OUTT		23
CRS8	OUTT		23
CRM1	CURTAN	LMWIN	16, 40
CRM2	CURTAN	LMWIN	16, 40
CS	OUTT		23
CSB	OUTT		23
CSGB	OUTT		23
CSG6	OUTT		23
CSI	OUTT		23
CSS	OUTT		23
CSSF	CHBOPC		14
CTG	OUTT		23
CTGB	OUTT		23
CTHTS	OUTT		14
CTL	OUTT		23
CTOT	PLTCAS		26
CTPE	CHBOPC		14
CTUN	OUTT		23
CTYP	COUIT		15
CVOLUM	CAVITY		10
CW4	OUTT		23
CX2	CAVITY	CBANDS	12, 34
DAGO	BLNK12	CBANDS	8, 34
DAGT	BLNK12	CBANDS	8, 35
DBO	BANDS		7
DBT	BANDS		7
DC	CHHTS		14

LIST OF VARIABLES (continued).

VARIABLE	COMMON BLOCK	NAMELIST	PAGE
DCBM	BLNKT2		9
DCDRIV	DRIVER		18
DCEXTR	INOUT	FUEL	21, 38
DCFACT	TARGET		28
DCFAC0	TARFAC	FUEL	28, 38
DCFAC1	TARFAC	FUEL	28, 38
DCFAC2	TARFAC	FUEL	28, 38
DCFAC3	TARFAC	FUEL	28, 38
DCFVAL	CAVIT2		10
DCHIB1	DRIVER	DSYST	18, 37
DCHIB2	DRIVER	DSYST	18, 37
DCLIB1	DRIVER	DSYST	18, 37
DCLIB2	DRIVER	DSYST	18, 37
DCTRCK	DRIVER	DSYST	18, 37
DELPB	OUTT		23
DELTC	OUTT		23
DFMAG1	DRIVER	DSYST	18, 37
DFMAG2	DRIVER	DSYST	18, 37
DPPC	DRIVER		18
DPPD	PLANT3		25
DRP	TENER	TASK	28, 41
DTE	TENER	TASK	28, 41
DTE0	TENER		28
DTIHx	CURTAN		16
DTLITH	CURTAN		16
DTPULS	CAVIT3		11
DTWALL	STUFF		27
DUCCOST	INDCST		20
DVEX	TEXTRI	FUEL	29, 38
EBLK	CURTAN		16
EDNOT	DRIVER	DSYST	18, 37
EFFWLS	CAVIT3		11
EFWLLM	CAVIT3		11
ELBOP	CMPOWC		15
ELGENL	CMPOWC		15
ELI	CURTAN		16
ELSPEC	CMPOWC		15
EMMO	BANDS		7
EMMT	BANDS		7
EMO	BANDS		7
EMT	BANDS		7
EN	CURTAN		16
ENET	OUTT		23
EPS	DRIVER		18
EPSEX	TEXTRI	FUEL	29, 38
EPSTG1	TARFAC	FUEL	28, 38
EPSTG2	TARFAC	FUEL	28, 38
EPSTG3	TARFAC	FUEL	28, 38

LIST OF VARIABLES (continued).

VARIABLE	COMMON BLOCK	NAMELIST	PAGE
ERATE	INDCST	ACCNT	20, 33
ETA	TAR1	TASK	27, 41
ETAD	DRIVER	DSYST	18, 37
ETAEX	TEXTR1	FUEL	29, 39
ETAHIB	DRIVER		18
ETANOT	DRIVER	DSYST	18, 37
ETAREM	TEXTR1		29
EXTEMP	OUTT		23
F	CURTAN		16
FBURN	TRIT1	FUEL	30, 39
FCCOMS	INDCST	ACCNT	20, 33
FCDEP	INDCST	ACCNT	20, 33
FCPEFS	INDCST	ACCNT	20, 33
FCRATE	INDCST		20
FCRATR	INDCST		20
FEGRS	CMPOWC		15
FELBOP	OUTT		23
FINJ	CURTAN	LMWIN	16, 40
FLONG	CAVIT2		10
FLOOP	PLANT1	CBANDS	24, 35
FLOW	CURTAN		16
FLU	CAVITY		13
FLUFW	CAVIT2	CBANDS	10, 35
FLUOPT	DRIVER	DSYST	18, 37
FLUSTO	CAVIT2	CBANDS	10, 35
FLUSTT	CAVIT2	CBANDS	10, 35
FLWIHX	CURTAN		16
FMIN	CURTAN	LMWIN	16, 40
FNUM	DRIVER		18
FNUMAX	DRIVER	DSYST	19, 37
FOCUSL	DRIVER		19
FPOWER	POMBAL	TASK	26, 41
FPHRPT	PLANT1		24
FRECON	CAVIT3	CBANDS	11, 35
FSHORT	CAVIT3	CBANDS	11, 35
FUELC	INDCST		20
FUELCR	INDCST		20
FWCO	BANDS		7
FWCT	BANDS		7
FWPWR	CAVIT4		11
FWPWRA	CAVIT2		10
FWPWR7	PLANT2		25
FWT	CAVIT1		9
F1	CURTAN	LMWIN	16, 40
F2	CURTAN	LMWIN	16, 40
F3	CURTAN	LMWIN	16, 40
F4	CURTAN	LMWIN	16, 40

LIST OF VARIABLES (continued).

VARIABLE	COMMON BLOCK	NAMLIST	PAGE
GAMM	CURTAN	LMWIN	16, 40
GASDEN	CAVIT2	LMWIN	10, 40
GDBN	TRIT1		30
GDBTGF	TRIT1		30
GDFTGF	TRIT1		30
GDTGT	TRIT1		30
GDUBL	TRIT1		30
GDUBV	TRIT1		30
GETA	CMPOWC		15
GHBN	TRIT1		30
GHBTF	TRIT1		30
GHEPR	TRIT1		31
GHEPRL	TRIT1		31
GHEPRV	TRIT1		31
GHFTGF	TRIT1		31
GHTGT	TRIT1		31
GHUBL	TRIT1		31
GHUBV	TRIT1		31
GINF	INDCST	ACCNT	20, 33
GNU	CURTAN	LMWIN	16, 40
GPDGT	TRIT1		31
GPUBL	TRIT1		31
GPUBV	TRIT1		31
GPHBN	TRIT1		31
GPHEPL	TRIT1		31
GPHEPR	TRIT1		31
GPHEPV	TRIT1		31
GPHTGT	TRIT1		31
GPHUBL	TRIT1		31
GPHUBV	TRIT1		31
GPSDBN	TRIT1		31
GPTBN	TRIT1		31
GPTBR	TRIT1		31
GPTBRP	EXTRAT		20
GPTTGT	TRIT1		31
GPTUBL	TRIT1		31
GPTUBV	TRIT1		31
GSDBNP	TRIT1		31
GSDTGT	TRIT1		31
GSDUBL	EXTRAT		20
GSDUBV	TRIT1		31
GSHBNP	TRIT1		31
GSHGTGT	TRIT1		32
GSHUBL	TRIT1		32
GSHUBV	TRIT1		32
GSTBNP	TRIT1		32
GSTTGT	TRIT1		32
GSTUBL	EXTRAT		20

LIST OF VARIABLES (continued).

VARIABLE	COMMON BLOCK	NAMelist	PAGE
GSTUBV	TRITI		32
GTBN	TRITI		32
GTBR	TRITI		32
GTBTGT	TRITI		32
GTFTGT	TRITI		32
GTTGT	TARGET		28
GTUBL	TRITI		32
GTUBV	TRITI		32
HDRATI	CAVITI	CBANDS	9, 35
HEADL	CURTAN		17
HGT	CURTAN		17
HIBCRA	DRIVER		19
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ICAVIT	STUFF	CBANDS	27, 35
ICBAND		TASK	41
ICTRCK	PLANT1	DSYST	24, 37
ICYCLE	CMPOWC		15
IDPA	CURTAN	LMWIN	17, 40
IDRIVE	DRIVER	DSYST	19, 37
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IFLAG	TENER	TASK	29, 41
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IH	CURTAN	LMWIN	17, 40
ILIINV	TEXTRI	FUEL	29, 39
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IRAD	CAVIT3		11
IRW	CURTAN	LMWIN	17, 40
ISHAPE	CAVITI	CBANDS	9, 35
ITICAL	TEXTRI	FUEL	29, 39
IWDSGN	CAVIT3	CBANDS	11, 35
K1	CAVITY	CBANDS	13, 35
K2	CAVITY	CBANDS	13, 35
KDRIV	DRIVER		19
KOPTIC	DRIVER		19
LICOST	INDCST		21
LIFLOW	TEXTRI		29
LIINV	TEXTRI	FUEL	30, 39
MATLO	COUtt		15, 42
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MCOOLT	BLNKT2	CBANDS	9, 35

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MLOSS	CAVIT3		11
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MOLEBN	TRIT1		32
MSTRO1	BLNKT2	CBANDS	9, 35
MSTRO2	BLNKT2	CBANDS	9, 35
MSTRO3	BLNKT2	CBANDS	9, 35
MSTRO4	BLNKT2	CBANDS	9, 35
MSTRT1	BLNKT2	CBANDS	9, 36
MSTRT2	BLNKT2	CBANDS	9, 36
MSTRT3	BLNKT2	CBANDS	9, 36
MSTRT4	BLNKT2	CBANDS	9, 36
NADD	PLANT1		24
NBEAM	DRIVER	DSYST	19, 37
NCAVIT	STUFF	CBANDS	27, 36
NDRIVE	STUFF	DSYST	27, 37
NLOOP	CMPOWC		15
NN	OUTT		23
NSG	CMHTS		14
NTGTFC	TARGET	FUEL	28, 39
NTGU	CMPOWC		15
NUM	TENER		29
NUMM	TENER		29
NUNIT	INDCST	ACCNT	21, 33
NXTRAC	PLANT4		25
NYEAR	RINF	ACCNT	26, 33
NYRBNK	INOUT	CBANDS	21, 36
NYRDCA	INOUT	CBANDS	21, 36
NYREX	INOUT	FUEL	21, 39
NYRHIB	DRIVER	DSYST	19, 37
NYRLIB	DRIVER	DSYST	19, 37
NYRSWL	DRIVER	DSYST	19, 38
NYRTF	INOUT	FUEL	21, 39
NYRTRC	INOUT	DSYST	21, 38
OCBMO	BANDS		7
OCBMT	BANDS		7
OCFWAL	CAVIT2		10
ODL	DRIVER	DSYST	19, 38
OPTICL	DRIVER	DSYST	19, 38
OPTICR	DRIVER		19
OPTLIF	DRIVER	DSYST	19, 38
PB	CMHTS		14
PBLIM	CURTAN		17
PCENT	INDCST		21
PCNOT	DRIVER	DSYST	19, 38
PCPP	CMHTS		14
PDENSO	BANDS		7
PDENST	BANDS		7

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PEFLAG	TENER	TASK	29, 41
PEGRS	CMPOWC		15
PENET	CMPOWC		15
PGRSTH	CMPOWC		15
PIN	CUTT		23
PLF	INDCST	ACCNT	21, 33
PPFR	OUTT		23
PPTEMP	OUTT		24
PRODTR	TEXTR1		30
PS	CMHTS		14
PSG	CMHTS		14
PSGMAX	OUTT		24
PTAXR	INDCST	ACCNT	21, 33
PTG	CMPOWC		15
PTGMAX	OUTT		24
PUMPHD	CURTAN		17
PUMPPW	STUFF		27
PWRBO	BANDS		7
PWRBT	BANDS		7
PWREX	TEXTR1	FUEL	30, 39
PXTRAC	TEXTR2		30
QELC	OUTT		24
QREJ	CMHTS		14
RADISA	CAVIT3		11
RADNFW	CAVIT2		10
RADNSO	CAVIT2		10
RADNST	CAVIT2		10
RBO	BANDS		7
RBT	BANDS		8
RDNOT	DRIVER	DSYST	19, 38
REALCM	INDCST		21
RFLOW	CURTAN		17
RHO	CURTAN	LMWIN	17, 40
RHOW1	CAVITY	CBANDS	13, 36
RHOW2	CAVIT2	CBANDS	10, 36
RINF75	RINF	ACCNT	26, 33
RINF76	RINF	ACCNT	26, 33
RINF77	RINF	ACCNT	26, 33
RINF78	RINF	ACCNT	26, 33
RINF79	RINF	ACCNT	27, 33
RINF80	RINF	ACCNT	27, 33
RINF81	RINF	ACCNT	27, 33
RINF82	RINF	ACCNT	27, 34
RINF83	RINF	ACCNT	27, 34
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RPFLAG	TENER	TASK	29, 41
RP0	TENER		29
RPRATE	PONBAL	TASK	26, 41
RRCOMS	INDCST	ACCNT	21, 34
RRFCT	TARFAC		28
RRFCT0	TARFAC	FUEL	28, 39
RRHOW1	CAVITY		13
RRHOW2	CAVITY		13
RRPD	DRIVER		19
RRPEFS	INDCST	ACCNT	21, 34
RRPLT	PLANT1		24
SALREM	BLNKT1		8
SANGL	DRIVER		19
SCT	COUTT		15
SHELL	TAR1	TASK	28, 41
SI	CURTAN	LMWIN	17, 40
SIGMA	CURTAN		17
SIMP	CURTAN		17
SSID	TEXTR1		30
SSIH	TEXTR1		30
SSIT	PLANT4	FUEL	25, 39
STH	CURTAN		17
STRLFO	CAVIT2	CBANDS	10, 36
STRLFT	CAVIT2	CBANDS	10, 36
SUMT	OUTT		24
SY	CURTAN	LMWIN	17, 40
T0	CAVIT3	CBANDS	11, 36
TAU	DRIVER	DSYST	19, 38
TAUFAC	TARFAC	FUEL	28, 39
TAUNOT	DRIVER	DSYST	19, 38
TAXR	INDCST	ACCNT	21, 34
TCOST	CURTAN		17
TCVPC	PLANT1		25
TCVPP	PLANT1		25
TDCBM	PLANT2		25
TDCDRI	PLANT5		25
TDCEXT	PLANT5		25
TDCFAC	PLANT5		25
TDCPCA	PLNT		26
TDCPLN	PLNT		26
TDCTRC	PLANT5		25
TDCHAL	PLANT5		25
TDP	PLANT2		25
TEFLAG	TENER	TASK	29, 41
TEMM	BANDS		8

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TENERØ	TENER		29
TETA	CMPOWC		15
TGAIN	TAR1	TASK	28, 41
THSACR	CAVIT3	CBANDS	11, 36
TINV	PLANT1		25
TINVFC	PLANT1		25
TIRDO	BLNK12	CBANDS	9, 36
TIRDT	BLNK12	CBANDS	9, 36
TLI	CURTAN	LMWIN	17, 40
TLINV	TEXTRI		30
TMAX	CAVIT3		2, 11
TNUM	CURTAN		17
TO	BLNK12	CBANDS	9, 36
TOC	INDCST		21
TOCBM	BLNK12		9
TOCCAV	PLNT		26
TOCPA	PLNT		26
TOCNAL	PLANT5		25
TOFF	CMHTS		14
TOTALC	PLNT		26
TOTALP	PLNT		26
TOTFLW	CURTAN		17
TPO	BANDS		8
TPT	BANDS		8
TMRBO	PLANT6		25
TPWRBT	PLANT6		26
TPVFCT	TARFAC		28
TPYPP	PLANT1		25
TRADIS	CURTAN		17
TRCONC	TEXTRI	FUEL	30, 39
TRELO	BANDS		8
TRELT	BANDS		8
TS	CMHTS		14
TSUP	CMHTS		14
TT	BLNK12	CBANDS	9, 36
TTOCBM	PLANT2		25
TTP	BANDS		8
TPWR	PLANT6		26
TPWRO	PLNT		26
TPWRT	PLNT		26
TTREL	STUFF		27
TTSU	COUTT		15
TTTPRM	PLNT		26
TUNL	COUTT		24
TVCB	PLANT6		26
TVCFW	STUFF		27
TYIELØ	TARFAC	FUEL	28, 39

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TYIELD	POWBAL	TASK	26, 41
T6BR	INDCST		21
UU	CURTAN	LMWIN	17, 40
UCOBSO	BANDS		8
UCOBST	BANDS		8
VBC	CMBLDG		13
VBLDG	CMBLDG		13
VBO	BANDS		8
VBSRO	BANDS		8
VBSRT	BANDS		8
VBT	BANDS		8
VCB	CMHTS		14
VCBO	TEXTR3		30
VCBT	TEXTR3		30
VELINJ	CURTAN		17
VELMP	CURTAN		17
VFBSO	BANDS		8
VFBST	BANDS		8
VFFWC	CAVIT3	CBANDS	11, 36
VFFWS	CAVIT3	CBANDS	11, 36
VMSS	CMBLDG		13
VOLCHB	CURTAN		18
VOLHD	STUFF		27
VOLPIP	STUFF		27
VPSB	CMBLDG		13
VRABNR	CMBLDG		13
VRABR	CMBLDG		13
VRCB	CMBLDG		13
VRSB	CMBLDG		13
VSGB	CMBLDG		14
VTGB	CMBLDG		14
VTUN	CMBLDG		14
WALLC	CURTAN	LMWIN	18, 40
WCADJO	BANDS		8
WCADJT	BANDS		8
WCST1	CAVITY	CBANDS	13, 36
WCST2	CAVIT2	CBANDS	10, 36
WLIFE	CAVIT3	CBANDS	11, 36
WLOSS	CAVIT3		11
WPC	OUTT		24
WS	CMHTS		14
WSC	OUTT		24
WWCST1	CAVITY		13
WWCST2	CAVITY		13
XFRAC	TEXTR1		30
XK1	CAVITY		13
XK2	CAVITY		13

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XLAMDA	CURTAN	LMWIN	18, 40
X1	CAVITY	CBANDS	13, 36
X2	CAVIT2	CBANDS	10, 36
XX1	CAVITY		13
XX2	CAVITY		13
YOUNGM	CURTAN	LMWIN	18, 40