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Fusion Energy Division

NUFACE: AN INTERFACE CODE FOR THE CALCULATION OF NUCLEAR RESPONSES

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ABSTRACT

The NUFACE interface code computes nuclear responses for use in the nuclear analysis of a given tokamak reactor design. The NUFACE code operates on the neutron and gamma fluxes provided by the one-dimensional neutral-particle transport code ONEDANT. Zonewise and zone-boundary responses are computed to obtain both zone-integrated values and maximum surface values. Information on each material mixture within a zone and on each element or isotope constituent of each material is computed. This feature allows for a detailed analysis of the reactor whereby one can easily identify the fractional contribution to the response of interest from each material and each element or isotope.

1. INTRODUCTION

The NUFACE interface code calculates nuclear responses, such as the first-wall and toroidal field coil irradiation damage limits, the tritium breeding ratio, the helium and hydrogen production rates, and the fast neutron fluence for a given tokamak fusion reactor. These responses are used for the sizing and costing optimization process of the reactor and in the design of shielding for the protection of critical components. The interface code can facilitate and simplify the optimization process of a given reactor configuration where multiple calculations are required to span and parameterize the reactor geometric and material domains of interest.

The interface code has several features that enhance and assist the nuclear analysis process of a given fusion reactor. Besides the standard nuclear analysis response output option of the code, zonewise and zone-boundary responses are computed to obtain zone-integrated values and maximum surface values. In addition, zonewise material mixture and element or isotope responses are calculated which allow for detailed analysis of the reactor whereby one can easily determine the material and element or isotope fractional contributions to the total value of the response of interest.

Section 2 briefly outlines the calculational procedure and the formulas used to compute the nuclear responses and describes the response function library used and its group structure. The input data requirements for the NUFACE code are given in Sect. 3. A sample problem and its description, input, and output are provided in the Appendix.

2. CALCULATIONAL PROCEDURE AND DATA

2.1 CALCULATIONAL PROCEDURE

The calculation of nuclear response rates for a magnetic fusion device is composed of the following two steps. The first step is the determination of the steady-state neutron and gamma fluxes throughout the reactor by using the one-dimensional neutral-particle transport code ONEDANT.¹ The input to ONEDANT consists of the neutron source in the plasma region, the material compositions and spatial zoning of the fusion reactor, and the neutron and gamma energy transfer cross-section matrices. The second step involves the use of the NUFACE code to compute the nuclear response rates. The calculation of the zone-integrated response rates is performed by multiplying the neutron (gamma) flux at a position, r , by the response function [neutron (gamma) heating kerma, (n,2n) reaction, tritium breeding, etc.] of interest and summing over all constituents and fine-mesh cells within the zone. In general, the volume-integrated response rates [R.Rate] are given by

$$[\text{R.Rate}]_j = \sum_i [\text{R.Rate}]_{ij} = \int_{V_j} \sum_{\ell} N_{\ell}(r) \int_0^{\infty} K_i^{\ell}(E) \phi_{n,g}(r, E) dE dV_j, \quad (1)$$

where N_{ℓ} is the number density for element ℓ , K_i^{ℓ} is the i th kerma or response function of interest for isotope ℓ , V_j is the j th zone volume, E is energy, and $\phi_{n,g}$ is either the neutron (n) or the gamma (g) flux. Zone-integrated individual isotopic constituent and material response information is also printed by the NUFACE code. The zone-boundary responses having the units of [R.Rate]/cm³ are computed by multiplying the zone-boundary flux (the angular, integrated boundary flux), $\psi(r_b, E)$, by the response functions. The zone-boundary values are necessary for the computation of the maximum heating rates (maximum coil winding heat etc.).

Certain nuclear responses are required for use in the analysis and optimization process [shielding requirements, displacements per atom (DPA), tritium breeding ratio (TBR), etc.] of a given reactor design. This information is extracted from the preceding computed zone-integrated, boundary, isotopic, and material mixture information. The various responses, their units, and the formulas used to compute them are given in this section. The responses are normalized to 1 MW/m², as required for the TETRA systems code.² The variable names used for the nuclear responses follow the nomenclature found in the TETRA systems code nuclear analysis module. Parameters common to the formulas are listed and defined here:

WLOAD	The number of neutrons equivalent to 1 MW/m ² of neutron wall loading [4.43×10^{13} n/(cm ² ·s)]
FPYR	The number of seconds equal to 1 full-power year (FPY) of operation (3.156×10^7 s)

RJPLS	Outboard first-wall loading {currently equal to $1/[2\pi(R_o + R_i)]$, where R_o is the outboard first-wall radius (cm) and R_i is the inboard first-wall radius (cm)}
RJMNS	Inboard first-wall loading {currently equal to $1/[2\pi(R_o + R_i)]$ }
$\Phi_g(r, E)$	Gamma photon cell-centered scalar flux
$\Phi_n(r, E)$	Neutron cell-centered scalar flux
$\Psi_g(r_b, E)$	Gamma photon angular, integrated boundary flux
$\Psi_n(r_b, E)$	Neutron angular, integrated boundary flux
EVS	MeV to MW-s conversion factor ($1 \text{ MW-s} = 6.242 \times 10^{18} \text{ MeV}$)
RAD	Rads to eV/erg conversion factor ($1 \text{ rad} = 6.242 \times 10^{13} \text{ eV/erg}$)

- **Tritium breeding ratio.** Tritium is produced from the following nuclear reactions on lithium:

The TBR is the summation of all neutron interactions on ${}^6\text{Li}$ and ${}^7\text{Li}$ which produce triton atoms integrated over the total volume of the fusion machine. The TBR rate is given by

$$\text{TBR} = \int_V [N_{{}^6\text{Li}}(r) K_{\text{T Prod.}}^{{}^6\text{Li}}(E) + N_{{}^7\text{Li}}(r) K_{\text{T Prod.}}^{{}^7\text{Li}}(E)] \phi_n(r, E) dE dV . \quad (2)$$

- **Outboard first-wall atomic displacement.** The outboard first-wall atomic displacement (OFWAD) response is calculated from the outboard first-wall steel DPA interaction rate integrated over the outboard first-wall volume and normalized to a first-wall loading of 1 MW/m^2 and 1 full-power year of operation. The OFWAD response is given by

$$\begin{aligned} \text{OFWAD} &= \frac{\text{WLOAD} \times \text{FPYR}}{\text{fwvol} \times \text{nfwl} \times \text{RJPLS}} \\ &\times \int_V \sum_i N_i(r) \int_0^\infty K_{\text{DPA}}^i(E) \phi_n(r, E) dE dV_j , \end{aligned} \quad (3)$$

where fwvol is the first-wall volume, nfwl is the first-wall steel atom density, and the OFWAD response is in units of $\text{DPA} \cdot \text{FPY}^{-1} \cdot (\text{MW/m}^2)^{-1}$.

- **Outboard first-wall helium production.** The outboard first-wall helium production (OFWHEP) response is calculated from the outboard first-wall steel helium production rate integrated over the outboard first-wall volume and

normalized to a first-wall loading of 1 MW/m^2 and 1 full-power year of operation. The OFWHEP response is given by

$$\text{OFWHEP} = \frac{\text{WLOAD} \times \text{FPYR} \times 10^6}{\text{fwvol} \times \text{nfwl} \times \text{RJPLS}} \times \int_{V_j} \sum_{\ell} N_{\ell}(r) \int_0^{\infty} K_{\text{He Prod.}}^{\ell}(E) \phi_n(r, E) dE dV_j; \quad (4)$$

in units of $\text{appm} \cdot \text{FPY}^{-1} \cdot (\text{MW/m}^2)^{-1}$, where appm is atomic parts per million.

- **Outboard first-wall hydrogen production.** The outboard first-wall hydrogen production (OFWHP) response is calculated from the outboard first-wall steel hydrogen production rate integrated over the outboard first-wall volume and normalized to a first-wall loading of 1 MW/m^2 and 1 full-power year of operation. The OFWHP response is given by

$$\text{OFWHP} = \frac{\text{WLOAD} \times \text{FPYR} \times 10^6}{\text{fwvol} \times \text{nfwl} \times \text{RJPLS}} \int_{V_j} \sum_{\ell} N_{\ell}(r) \times \int_0^{\infty} K_{\text{H Prod.}}^{\ell}(E) \phi_n(r, E) dE dV_j; \quad (5)$$

in units of $\text{appm} \cdot \text{FPY}^{-1} \cdot (\text{MW/m}^2)^{-1}$.

- **Outboard first-wall fast neutron fluence.** The outboard first-wall fast neutron fluence (OFWFNF) response is obtained from the maximum fast neutron fluence value found within the first wall by using the cell-centered scalar-flux values. The fast neutron fluence is the energy-integrated neutron fluence above 0.1 MeV. The fast neutron fluence response is normalized to a first-wall loading of 1 MW/m^2 and 1 full-power year of operation. The OFWFNF response is given by

$$\text{OFWFNF} = \frac{\text{WLOAD} \times \text{FPYR}}{\text{RJPLS}} \times \max \left[\int_{0.1 \text{ MeV}}^{\infty} \phi_n(r, E) dE \right]_{V_j}; \quad (6)$$

in units of $\text{n}/(\text{cm}^2 \cdot \text{s}) \cdot \text{FPY}^{-1} \cdot (\text{MW/m}^2)^{-1}$.

- **Outboard first-wall total neutron fluence.** The outboard first-wall total neutron fluence (OFWTNF) response is obtained from the maximum total neutron fluence value found within the first wall by using the cell-centered scalar flux values. The total neutron fluence is the total energy-integrated neutron

fluence. The total fluence response is normalized to a first-wall loading of 1 MW/m² and 1 full-power year of operation. The OFWTNF response is given by

$$\text{OFWTNF} = \frac{\text{WLOAD} \times \text{FPYR}}{\text{RJPLS}} \times \max \left[\int_0^\infty \phi_n(r, E) dE \right]_{V_j} \quad (7)$$

in units of n/(cm²·s)·FPY⁻¹·(MW/m²)⁻¹.

- **Outboard first-wall nuclear heating.** The outboard first-wall nuclear heating (OFWNH) response is calculated from the neutron and gamma photon heating rates integrated over the outboard first-wall volume and normalized to a first-wall loading of 1 MW/m². The OFWNH response is given by

$$\begin{aligned} \text{OFWNH} = & \frac{\text{WLOAD}}{\text{fwvol} \times \text{RJPLS} \times \text{EVS}} \int_{V_j} \sum_{\ell} N_{\ell}(r) \\ & \times \left(\int_0^\infty K_{n \text{ Heat}}^{\ell}(E) \phi_n(r, E) dE + \int_0^\infty K_{g \text{ Heat}}^{\ell}(E) \phi_g(r, E) dE \right) dV_j, \end{aligned} \quad (8)$$

in units of (MW/m³)·(MW/m²)⁻¹.

- **Tile nuclear heating.** The tile nuclear heating (TNH) response is calculated from the neutron and gamma photon heating rates integrated over the outboard tile volume and normalized to a first-wall loading of 1 MW/m². The TNH response is given by

$$\begin{aligned} \text{TNH} = & \frac{\text{WLOAD}}{\text{tvol} \times \text{RJMNS} \times \text{EVS}} \int_{V_j} \sum_{\ell} N_{\ell}(r) \\ & \times \left(\int_0^\infty K_{n \text{ Heat}}^{\ell}(E) \phi_n(r, E) dE + \int_0^\infty K_{g \text{ Heat}}^{\ell}(E) \phi_g(r, E) dE \right) dV_j, \end{aligned} \quad (9)$$

where tvol is the tile volume and the TNH response is in units of (MW/m³)·(MW/m²)⁻¹.

- **Maximum coil case heating.** The maximum coil case heating (MCCH) response is calculated from the neutron and gamma photon heating rates at the coil case surface by using the fine-mesh boundary flux values. The MCCH

response is normalized to a first-wall loading of 1 MW/m². The MCCH response is given by

$$\begin{aligned} \text{MCCH} = & \frac{\text{WLOAD}}{\text{RJMNS} \times \text{EVS}} \sum_{\ell} N_{\ell}(r) \\ & \times \left(\int_0^{\infty} K_{\text{n Heat}}^{\ell}(E) \psi_{\text{n}}(r_b, E) dE + \int_0^{\infty} K_{\text{g Heat}}^{\ell}(E) \psi_{\text{g}}(r_b, E) dE \right) \end{aligned} \quad (10)$$

in units of (W/cm³).(MW/m²)⁻¹.

- **Total coil case heating.** The total coil case heating (TCCH) response is calculated from the neutron and gamma photon heating rates integrated over the coil case volume and normalized to a first-wall loading of 1 MW/m². The TCCH response is given by

$$\begin{aligned} \text{TCCH} = & \frac{\text{WLOAD}}{\text{RJMNS} \times \text{EVS}} \int_{V_j} \sum_{\ell} N_{\ell}(r) \\ & \times \left(\int_0^{\infty} K_{\text{n Heat}}^{\ell}(E) \phi_{\text{n}}(r, E) dE + \int_0^{\infty} K_{\text{g Heat}}^{\ell}(E) \phi_{\text{g}}(r, E) dE \right) dV_j \end{aligned} \quad (11)$$

in units of W.(MW/m²)⁻¹.

- **Maximum coil winding heating.** The maximum coil winding heating (MCWH) response is calculated from the neutron and gamma photon heating rates at the coil winding surface by using the fine-mesh boundary flux values. The MCWH response is normalized to a first-wall loading of 1 MW/m². The MCWH response is given by

$$\begin{aligned} \text{MCWH} = & \frac{\text{WLOAD}}{\text{RJMNS} \times \text{EVS}} \sum_{\ell} N_{\ell}(r) \\ & \times \left(\int_0^{\infty} K_{\text{n Heat}}^{\ell}(E) \psi_{\text{n}}(r_b, E) dE + \int_0^{\infty} K_{\text{g Heat}}^{\ell}(E) \psi_{\text{g}}(r_b, E) dE \right) \end{aligned} \quad (12)$$

in units of (W/cm³).(MW/m²)⁻¹.

- **Total coil winding heating.** The total coil winding heating (TCWH) response is calculated from the neutron and gamma photon heating rates integrated over

the coil winding volume and normalized to a first-wall loading of 1 MW/m². The TCWH response is given by

$$\text{TCWH} = \frac{\text{WLOAD}}{\text{RJMNS} \times \text{EVS}} \sum_{\ell} N_{\ell}(r) \times \left(\int_0^{\infty} K_{\text{n Heat}}^{\ell}(E) \phi_{\text{n}}(r, E) dE + \int_0^{\infty} K_{\text{g Heat}}^{\ell}(E) \phi_{\text{g}}(r, E) dE \right) dV, \quad (13)$$

in units of W·(MW/m²)⁻¹.

- **Maximum fast neutron fluence in coil windings.** The maximum coil winding fast neutron fluence (MCWFNF) response is obtained from the fast neutron fluence at the surface of the coil winding. The fast neutron fluence is the energy-integrated neutron fluence above 0.1 MeV. The fast neutron response is normalized to a first-wall loading of 1 MW/m² and 1 full-power year of operation. The MCWFNF response is given by

$$\text{MCWFNF} = \frac{\text{WLOAD} \times \text{FPYR}}{\text{RJMNS}} \int_{0.1 \text{ MeV}}^{\infty} \psi_{\text{n}}(r_{\text{b}}, E) dE \quad (14)$$

in units of n/(cm²·s)·FPY⁻¹·(MW/m²)⁻¹.

- **Maximum electrical insulator dose.** The maximum electrical insulator dose (MEID) response is obtained from the neutron and gamma heating rates at the electrical insulator surface by using the fine-mesh boundary flux values. The MEID response is normalized to a first-wall loading of 1 MW/m² and 1 full-power year of operation and is given by

$$\text{MEID} = \frac{\text{WLOAD} \times \text{FPYR}}{\text{RJMNS} \times \text{dinsul} \times \text{RAD}} \sum_{\ell} N_{\ell}(r) \times \left(\int_0^{\infty} K_{\text{n Heat}}^{\ell}(E) \psi_{\text{n}}(r_{\text{b}}, E) dE + \int_0^{\infty} K_{\text{g Heat}}^{\ell}(E) \psi_{\text{g}}(r_{\text{b}}, E) dE \right), \quad (15)$$

where dinsul is the insulator density given in units of g/cm³ and the MEID response is in units of rads·FPY⁻¹·(MW/m²)⁻¹.

- **Maximum atomic displacement in copper stabilizers.** The maximum copper stabilizer atomic displacement (MCUAD) response is obtained from the copper stabilizer DPA interaction rate at the copper stabilizer surface by using

the fine-mesh boundary flux values. The MCUAD response is normalized to a first-wall loading of 1 MW/m^2 and 1 full-power year of operation and is given by

$$\text{MCUAD} = \frac{\text{WLOAD} \times \text{FPYR}}{\text{RJMNS} \cdot \text{ncu}} \sum_l N_l(\tau) \int_0^\infty K_{\text{DPA}}^l(E) \psi_n(r_b, E) dE, \quad (16)$$

where ncu is the copper stabilizer atom density and MCUAD response is in units of $\text{DPA} \cdot \text{FPY}^{-1} \cdot (\text{MW/m}^2)^{-1}$.

- **Maximum Induced Resistivity in Copper Stabilizers.** The maximum copper stabilizer induced resistivity (MCUIR) response is obtained from the formula³

$$\text{MCUIR} = 300.0 \times [1.0 - \exp(-240.0 \times \text{MCUAD})], \quad (17)$$

where MCUAD is the maximum copper stabilizer atomic displacement response and the MCUIR response is in units of $\text{n}\Omega\text{-cm}$.

2.2 RESPONSE FUNCTION DATA LIBRARY

The data required for the nuclear response calculations are taken from the MACKLIB-IV⁴ nuclear response function library, which is based on the ENDF/B-IV basic nuclear data file. The data are given in a coupled 46-neutron, 21-gamma photon group structure format. The group boundaries for both neutron and gamma photon data sets are given in Table 2.1. Both group structures are compatible with the corresponding energy transfer cross-section matrix group structures used in the neutron and photon transport calculations.

The data library is called RESPLIB and contains 52 element and isotope entries arranged in the order presented in Table 2.2. For each energy group of a given element or isotope, there are 34 nuclear response function entries, arranged according to the cross-section positions listed in Table 2.3.

Table 2.1. Neutron 46 and gamma photon 21 multigroup structures in eV group boundaries

Group	Neutron upper energy (eV) ^a	Gamma upper energy (eV) ^b
1	1.4918E+7	1.40E+7
2	1.3499E+7	1.20E+7
3	1.2214E+7	1.00E+7
4	1.1052E+7	8.00E+6
5	1.0000E+7	7.50E+6
6	9.0484E+6	7.00E+6
7	8.1873E+6	6.50E+6
8	7.4082E+6	6.00E+6
9	6.7032E+6	5.50E+6
10	6.0653E+6	5.00E+6
11	5.4881E+6	4.50E+6
12	4.9659E+6	4.00E+6
13	4.4933E+6	3.50E+6
14	4.0657E+6	3.00E+6
15	3.6788E+6	2.50E+6
16	3.3287E+6	2.00E+6
17	3.0119E+6	1.50E+6
18	2.7253E+6	1.00E+6
19	2.4660E+6	4.00E+5
20	1.8268E+6	2.00E+5
21	1.3534E+6	1.00E+5
22	1.0026E+6	
23	7.4274E+5	
24	5.5023E+5	
25	4.0762E+5	
26	3.0197E+5	
27	2.2371E+5	
28	1.6573E+5	
29	1.2277E+5	
30	6.7379E+4	
31	3.1828E+4	
32	1.5034E+4	
33	7.1017E+3	
34	3.3546E+3	
35	1.5346E+3	
36	7.4027E+2	
37	3.3137E+2	
38	1.6751E+2	
39	7.8893E+1	
40	3.7267E+1	
41	1.7603E+1	
42	8.3153E+0	
43	3.9379E+0	
44	1.8554E+0	
45	8.7643E-1	
46	4.1399E-1	

^aThe lower energy boundary of the 46th group is 2.2000E-2 eV.

^bThe lower energy boundary of the 21st gamma group is 1.0E+4 eV.

**Table 2.2. Order of element and isotope entries
contained in RESPLIB**

Entry	Element or isotope	Entry	Element or isotope
1	H	27	Cu
2	D	28	Zr
3	He	29	Nb
4	⁶ Li	30	Mo
5	⁷ Li	31	Sn
6	Be	32	Ta
7	¹⁰ B	33	¹⁸² W
8	¹¹ B	34	¹⁸³ W
9	¹² C	35	¹⁸⁴ W
10	N	36	¹⁸⁶ W
11	O	37	Pb
12	F	38	²³² Th
13	Na	39	²³³ Pa
14	Mg	40	²³³ U
15	Al	41	²³⁴ U
16	Si	42	²³⁵ U
17	Cl	43	²³⁶ U
18	K	44	²³⁸ U
19	Ca	45	²³⁷ Np
20	Ti	46	²³⁸ Pu
21	V	47	²³⁹ Pu
22	Cr	48	²⁴⁰ Pu
23	Mn	49	²⁴¹ Pu
24	Fe	50	²⁴² Pu
25	Co	51	²⁴¹ Am
26	Ni	52	²⁴³ Am

Table 2.3. Nuclear response function cross-section set format
 (for each element or isotope, for each energy group, there
 are MEDIT entries arranged according to this table)

Position	Content	Code variable
1	Neutron and gamma kerma factors	NG-KERMA
2	Neutron kerma factor	N.-KERMA
3	Gamma kerma factor	G.-KERMA
4	Displacement cross section - A	DPA-XS-A
5	Displacement cross section - B	DPA-XS-B
6	Total hydrogen production cross section	TOT-H1-P
7	Total tritium production cross section	TOT-H3-P
8	Total helium production cross section	TOT-He-P
9	Total cross section	SIG-TOT
10	Elastic cross section	SIG-ELST
11	Total inelastic cross section	TOT-INEL
12	(n,2n) cross section	(N,2N)
13	(n,3n) cross section	(N,3N)
14	Total fission cross section	TOT-FISS
15	(n,n't) cross section	(N,N*T)
16	(n,n') cross section	(N,N*)CT
17	(n, γ) cross section	(N,GAM)
18	(n,p) cross section	(N,P)
19	(n,d) cross section	(N,D)
20	(n,t) cross section	(N,T)
21	(n, ^3He) cross section	(N,He3)
22	(n, α) cross section	N,ALPHA
23	Elastic scattering kerma factor	EL-KERMA
24	(n,n') charged particles kerma factor	(N,N*)KM
25	Inelastic-level scattering kerma factor	IN-KERMA
26	(n,charged particles) kerma factor	(N,CP)KM
27	(n,2n) kerma factor	(N,2N)KM
28	(n,3n) kerma factor	(N,3N)KM
29	Fission kerma factor	FISS-KMA
30	Inelastic continuum kerma factor	INCT-KMA
31	Radiative capture kerma factor	RADC-KMA
32	Group midenergy for neutron and gamma	GMPE-NG.
33	Group midenergy for neutron only	GMPE-N.
34	Group midenergy for gamma only	GMPE-G.

3. DESCRIPTION OF INPUT

This section gives a brief description of the input data. It is intended to serve as a guide for the preparation of the input data. The read statements required for reading the formatted input given here have been converted to free format read statements by using the default read option supported by Fortran 77 on the Lawrence Livermore National Laboratory Cray computers (specifically the d- and e-machines). Thus, the user should ignore the formats given next to the card number. (Some additional guidance for the user is included in the notes at the end of the discussion on the input parameters.)

Card 1 (A72)

Title Card

Card 2 (A8)

CARDINP Type: 'cardinp='

Card 3 (12I6)

Note: The ANISN-formatted flux read option is not complete; thus, use only LTH=2.

LID	Identification number
LTH	Flux read option 1: ANISN-formatted flux read 2: ONEDANT-formatted flux read
LGE	Geometry 1: Slab (x for one dimension and x-y for two dimensions) 2: Cylinder (r for one dimension and r-z for two dimensions) 3: Sphere
NGRP	Number of energy groups in the problem 46: Neutron calculation only 67: Neutron + gamma calculation
IZN	Number of zones
IMIX	Number of material mixtures (H ₂ O, SS316, PCA, Nb ₃ Sn, Cu, etc.)
ICMP	Number of structure compositions (magnet, first wall, coil case, outboard blanket shield, etc.)
INTVAL	Number of fine-mesh cells (intervals)
IDT	Number of material response function edits

LFLU **Energy group cutoff for fast fluence calculation**

Card 4 (12I6)

LVCLPRT **Print option for fine-mesh volumes**
 0: No effect
 1: Print fine-mesh volumes

LSYS **Print option for nuclear analysis response**
 information
 0: No effect
 1: Print nuclear analysis response information

LZNPRT **Print option for zonewise nuclear response information**
 0: No effect
 1: Print zonewise information

Card 5 (6F10.3)

RJMNS **Inboard current normalization value for normalization**
 of inboard nuclear responses

RJPLS **Outboard current normalization value for normalization**
 of outboard nuclear responses

DINSUL **Insulator density (g/cm³)**

Card 6 (A8)

DIMENS **Type: 'dimens='**

Card 7 (I4)

Note: Two-dimensional option is not complete; thus, use only IDIM=1.

IDIM **Geometry dimension option**
 1: One-dimensional geometry calculation
 2: Two-dimensional geometry calculation

Card 8 (A8)

RZONE **Type: 'rzone='**

Card No. 9 (I4)

IRMSH **Number of x- or r-dimension zones**

Card 10 (A8)

RMESH **Type: 'rmesh='**

Card 11 (6E12.3)

RAD(1)	First x- or r-dimension zone boundary
RAD(2)	Second x- or r-dimension zone boundary
.	.
.	.
RAD(IRMSH+1)	Last x- or r-dimension zone boundary

Card 12 (A8)

RINT Type: 'rint='

Card 13 (12I6)

NINT(1)	Number of intervals/zone for first x- or r-zone
NINT(2)	Number of intervals/zone for second x- or r-zone
.	.
.	.
NINT(IRMSH)	Number of intervals/zone for last x- or r-zone

Card 14a (A8) — Note: Required only if IDIM is 2.

ZZONE Type: 'zzone='

Card 14b (I4) — Note: Required only if IDIM is 2.

IZMSH Number of y- or z-dimension zones

Card 14c (A8) — Note: Required only if IDIM is 2.

ZMESH Type: 'zmesh='

Card 14d (6E12.3) — Note: Required only if IDIM is 2.

ZZZ(1)	First y- or z-dimension zone boundary
ZZZ(2)	Second y- or z-dimension zone boundary
.	.
.	.
ZZZ(IZMSH+1)	Last y- or z-dimension zone boundary

Card 14e (A8) — Note: Required only if IDIM is 2.

ZINT Type: 'zint='

Card 14f (12I6) — Note: Required only if IDIM is 2.

IZZZ(1)	Number of intervals/zone for first y- or z-zone
IZZZ(2)	Number of intervals/zone for second y- or z-zone
.	.

.....
 IZZZ(IZMSH) Number of intervals/zone for last y- or z-zone

Card 15 (A8)

MIXTURE Type: 'mixture='

Card 16 (12I6)

MIX(1) Number of elements in first material mixture
 MIX(2) Number of elements in second material mixture

 MIX(IMIX) Number of elements in last material mixture

Card 17 (A8,5(I3,F9.3)); then (8X,5(I3,F9.3))

Note: As many cards as IMIX are required.

Card 17a Material(I=1)

AMIX(I) Material alphanumeric
 ISOTP(I,1) Response library id for first element constituent of
 material I
 DEN(I,1) Atom density for first element constituent of material I
 ISOTP(I,2) Response library id for second element constituent of
 material I
 DEN(I,2) Atom density for second element constituent of material I

 ISOTP(I,MIX(I)) Response library id for last element constituent of
 material I
 DEN(I,MIX(I)) Atom density for last element constituent of material I

Card 17b Material(I=2)

AMIX(I) Material alphanumeric
 ISOTP(I,1) Response library id for first element constituent of
 material I
 DEN(I,1) Atom density for first element constituent of material I
 ISOTP(I,2) Response library id for second element constituent of
 material I
 DEN(I,2) Atom density for second element constituent of material I

ISOTP(I,MIX(I)) Response library id for last element constituent of material I
 DEN(I,MIX(I)) Atom density for last element constituent of material I

Card 18 (A8)

MATLS Type: 'assign='

Card 19 (12I6)

IMATL(1) Number of materials in first structure
 IMATL(2) Number of materials in second structure

 IMATL(ICMP) Number of materials in last structure

Card 20 (A8,5(A8,F4.2)); then (8X,5(A8,F4.2))

Note: As many cards as ICMP are required.

Card 20a

AMATL(1) Structure 1 alphanumeric
 ATEMP(1) Material alphanumeric for first material constituent of structure 1
 TEMP(1) Material volume fraction for first material constituent of structure 1
 ATEMP(2) Material alphanumeric for second material constituent of structure 1
 TEMP(2) Material volume fraction for second material constituent of structure 1

 ATEMP(IMATL(1)) Material alphanumeric for last material constituent of structure 1
 TEMP(IMATL(1)) Material volume fraction for last material constituent of structure 1

Card 20b

AMATL(2) Structure 2 alphanumeric
 ATEMP(1) Material alphanumeric for first material constituent of structure 2
 TEMP(1) Material volume fraction for first material constituent of structure 2

ATEMP(2)	Material alphanumeric for second material constituent of structure 2
TEMP(2)	Material volume fraction for second material constituent of structure 2
.	.
.	.
ATEMP(IMATL(2))	Material alphanumeric for last material constituent of structure 2
TEMP(IMATL(2))	Material volume fraction for last material constituent of structure 2

Card 21 (A8)

ZNMAT Type: 'zone-str'

Card 22 (12I6)

MTZN(1) **Zone 1 structure assignment**
MTZN(2) **Zone 2 structure assignment**

.

MTZN(IZN) **Last zone structure assignment**

Note: The input "0" for the structure assignment indicates a void region.

Card 23 (A8)

EDIT Type: 'edit='

Card 24 (12I6)

MEDIT(1) **Position of first response function edit in response function library**
MEDIT(2) **Position of second response function edit in response function library**

.

MEDIT(IDT) **Position of last response function edit in response function library**

Card 25 (A8)

ASYSTM Type: 'system='

Card 26 (I4)

ISZN Number of zones for which nuclear analysis responses
are to be calculated

Card 27 (12I6)

Note: Input zone numbers in ascending order.

ISYSZN(1) Zone number of first zone for which nuclear analysis
responses are to be computed

ISYSZN(2) Zone number of second zone for which nuclear analysis
reponses are to be computed

.

.

ISYSZN(ISZN) Zone number of last zone for which nuclear analysis
reponses are to be computed

Card 28 (A8)

Note: As many cards as ISZN are required. The following alphanumeric are
required to initiate calculation of specific nuclear responses within the ISYSZN(I)
zones.

Type: 'coilcase' - for calculation of coilcase responses;
'windings' - for calculation of magnet windings responses;
'insulate' - for calculation of insulator responses;
'tileheat' - for calculation of tile heat responses;
'obfirstw' - for calculation of outboard first-wall responses.

ASYS(1) Alphanumeric for nuclear response computation in ISYSZN(1)

ASYS(2) Alphanumeric for nuclear response computation in ISYSZN(2)

.

.

ASYS(ISZN) Alphanumeric for nuclear response computation in ISYSZN(ISZN)

Card 29 (A8,2X,A8)

AFWL First-wall structure alphanumeric to specifically
extract first-wall information

ASTEEL First-wall material alphanumeric to specifically
extract material information

Card 30 (A8,2X,A8)

AMAG Magnet structure alphanumeric to specifically extract
magnet information

ACOPPER Magnet material alphanumeric to specifically extract material information

Notes

- There are two input options for which the coding is not complete. These are the ANISN-formatted flux read option and the two-dimensional calculation option. Therefore, one should use the option given in the brief note accompanying the card input description.
- The atom density input for the DEN array should be given in units of barns.
- The input to the NUFACE code has been styled or modeled (structured) after the ONEDANT code. Thus, the users who are familiar with the ONEDANT-formatted input should have minimal difficulty in preparing the input.
- The parameter variables used as dimension limits for arrays are given in Table 3.1. The dimensions can be easily changed within the code to suit specific problem-dependent needs.
- The logical units required for the NUFACE code are given in Table 3.2.

Table 3.1. Dimensions

Code parameter	Description	Value
MINT	Number of mesh intervals	500
MZN	Number of structural zones	30
MNG	Number of neutron groups	46
MGG	Number of gamma groups	21
NMIX	Number of material mixtures	10
NCMP	Number of structural materials	10
NELMT	Maximum number of element entries per material mixture	20
NMAT	Maximum number of material mixtures per structural material	10
NEDT	Number of response function edits	12
NBFLU	Number of boundary flux values required	20
NRSPD	Length of response function cross-section table (see Table 2.3)	34
NISO	Number of elements or isotopes for which data are given in RESPLIB	52
NADIR	Number of angular directions used in the transport calculations (see ONEDANT input)	50

Table 3.2. I/O units for NUFACE code

I/O unit	Description
N5 (5)	Standard input unit from which basic data cards are read
N6 (6)	Standard output unit for printing
N8 (8)	Response function cross-section file unit; name: RESPLIB
N9 (9)	ONEDANT or ANISN scalar-flux file unit; ONEDANT name: RTFLUX
N13 (13)	ONEDANT Sn angular quadrature file unit; name: SNCONS
N14 (14)	ONEDANT angular flux file unit; name: RAFLUX

REFERENCES

1. R. D. O'Dell, F. W. Brinkley, Jr., and D. R. Marr, *User's Manual for ONEDANT: A Code Package for One-Dimensional, Diffusion-Accelerated, Neutral-Particle Transport*, LA-9184-MS, Los Alamos Natl. Lab., February 1982.
2. R. L. Reid, ed., *ETR/ITER Systems Code*, ORNL/FEDC-87/7, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., April 1988, Sect. 4.5.
3. L. A. El-Guebaly and M. E. Sawan, "Advanced Inboard Shielding Design for Tokamak Fusion Reactors," *Fusion Technol.* 8, 1037 (July 1985).
4. Y. Gohar and M. A. Abdou, *MACKLIB-IV: A Library of Nuclear Response Functions Generated with MACK-IV Computer Program from ENDF/B-IV*, ANL/FPP/TM-106, Argonne Natl. Lab., 1978.

APPENDIX

The sample problem consists of a 3-m major-radius tokamak reactor based on the TIBER reactor design² using cylindrical toroidal geometry. The reactor has an inboard thickness of 80 cm, comprising 78 cm of inboard shield, 1 cm of inboard first wall, and 1 cm of beryllium tile. The outboard side is composed of 1 cm of outboard first wall, 20 cm of beryllium neutron multiplier, and 79 cm of outboard shield, for a total outboard thickness of 100 cm. The plasma region has a minor radius of 86 cm. The first-wall steel and the bulk of the shielding material are composed of PCA (prime candidate alloy) steel. The blanket and first walls are cooled by an aqueous solution of lithium nitrate (LiNO_3), which also serves as the tritium breeding material. Table A.1 presents the inboard and outboard first-wall, blanket, and shield zone thicknesses, along with the zone material compositions. The superconducting magnet, coil case, and insulator geometric and material composition parameters are given in Table A.2. The mesh zoning and nuclide atom densities (given in units of barns) for the problem can be gleaned from the input listing to the NUFACE code given in Table A.3.

Table A.3 lists the input for the sample problem. Following the description for the input data given in Sect. 3.1, one notes that the nuclear analysis response and the zonewise nuclear response print options have been chosen. The fine-mesh volume print option has been suppressed. One may also note that the inboard and outboard first-wall current normalization parameters are identical as the results are normalized to the total machine first-wall loading of 1 MW/m^2 .

Table A.1. First-wall, blanket, and shield parameters

Zone description	Zone thickness (cm)	Zone composition (vol %)		
		PCA steel	H_2O^a	Be
Inboard blanket and shield	78	80	20	
Inboard first wall	1	50	50	
Inboard tile	1			100
Inboard scrape-off layer	6			
Plasma	172			
Outboard scrape-off layer	11			
Outboard first wall	1	50	50	
Outboard blanket and shield	79	65	35	
Neutron multiplier	20	5	35	60

^aWith 16 g of LiNO_3 per 100 cm^3 . A 90% ^6Li enrichment is used.

Table A.2. Parameters for insulator, coil case, and superconducting magnet

Zone description	Zone thickness (cm)	Zone composition (vol %)			
		Helium (liquid)	Polyimide	Type 304 stainless steel	Nb ₃ Sn OFHC ^a copper
Coil case	4.9	5		95	
GFF polyimide	0.5		100		
Superconducting winding pack	37.6	25	5	37	14.2 18.8
GFF polyimide	0.5		100		
Coil case	5.5	5		95	
Clearance	2.0				

^aOFHC = oxygen-free high-conductivity.

Table A.4 presents a listing of the output to the NUFACE code. The first section is an editing of the input data in a form in which input errors are easily identifiable. The number of zones, the number of materials, the number of mesh intervals, the print options, and other parameters relating to the general setup of the problem are given first. The zone boundaries, the fine-mesh divisions per zone, and the zone or coarse-mesh volumes follow. Next, four tables presenting information on structural material vs zone, material composition vs structure, isotope vs material composition, and response function edits requested are listed. This listing is followed by various parameters required for the nuclear analysis response calculations, such as inboard and outboard current normalization, insulator density, and zones in which nuclear responses are to be computed. The last three lines in the edit section of the printout are specific file read completion messages indicating successful file reads. The atom density and material volume fraction data underlined in this section of the table are used to compute specific responses for the reactor design nuclear analysis calculations (see Sect. 2.1).

The second section lists the volume-integrated and the left- and right-boundary responses for the nuclear responses requested and the neutron fluences for each non-void zone in the problem. One can easily discern that not only is the total volume-integrated response computed but also information on each material mixture in the zone and on each element or isotope composing each material is provided. This allows for a detailed analysis of the reactor whereby one can easily identify the material and the element or isotope fractional contribution to the specific response of interest. The response results underlined in the zonewise listing are used to compute the nuclear analyses responses.

Table A.3. Input to the NUFACE code sample problem

```

1  TEST INPUT FOR TIBER-II PROBLEM - stainless steel case
2  cardinp=
3      0      2      2      67      19      9      8      .37      7      29
4      1
5      2.6307-4  2.6307-4      1.70
6  dimens=
7      1
8  rzone=
9      19
10 rmesh=
11      0.0  76.0  77.0  81.9  82.4  120.0
12      120.5  126.0  128.0  167.0  206.0  207.0
13      208.0  214.0  386.0  397.0  398.0  418.0
14      497.0  498.0
15 rint=
16      38      1      5      1      37      1      5      2      40      40      1      1
17      6      86      1      1      20      40      1
18 mixture=
19      1
20      he      6      11      4      2      8      5      4      1
21      ss304      9      3.1842-4      16      1.7210-3      22      1.7660-2      23      1.1438-3      24      6.0199-2
22      poly      26      7.4126-3
23      1      1.5847-2      9      2.4040-2      10      2.2880-3      11      2.2431-2      12      3.5570-5
24      13      1.3094-4      14      7.5408-4      15      1.8557-3      16      6.0883-3      19      2.1026-3
25      24      1.6501-5
26      cuofhc      24      2.4102-7      26      5.5042-7      27      8.4724-2      37      1.2992-7
27      nb3sn      29      4.0686-2      31      1.3562-2
28      pca      30      1.0043-3      24      5.5968-2      21      9.4570-5      22      1.2971-2      26      1.3129-2
29      23      1.7530-3      16      8.5765-4      20      3.0173-4
30      h2olno      1      6.6852-2      10      1.4144-3      5      1.4144-4      4      1.2730-3      11      3.7667-2
31      w      33      1.6641-2      34      9.0554-3      35      1.9423-2      36      1.8095-2
32      be      6      1.2361-1
33 assign=
34      2
35      cocase      1      he      5      2      ss304      2      1      3      2
36      gfpoly      poly      i
37      magnet      ss304      .37      poly      .05      he      .25      cuofhc      .188      nb3sn      .142
38      ibkshd      pca      0.8      h2olno      0.2
39      frstwl      pca      0.5      h2olno      0.5
40      itile      be      1.0
41      nmult      pca      .05      h2olno      .35      be      0.6
42      obkshd      pca      .65      h2olno      .35
43 zone-str
44      0      0      1      2      3      2      1      0      4      4      5      6
45      0      0      0      5      7      8      0
46 edit=
47      1      2      3      4      6      7      8
48 system=
49      6
50      3      5      6      7      12      16
51 coilcase
52 windings
53 insulate
54 coilcase
55 tileheat
56 obfirstw
57 frstwl      pca
58 magnet      cuofhc

```

The third section listed shows the responses required for the nuclear analysis of the tokamak reactor design. Section 2.1 presents information on the calculation and normalization of the nuclear responses.

Not shown on the output is the fourth and last section, which lists the fine-mesh volumes for each fine-mesh cell.

REFERENCE

1. J. D. Lee, tech. ed., *TIBER II/ETR Final Design Report*, UCID-21150 (Vols. 1-3), Lawrence Livermore Natl. Lab., September 1987.

Table A.4. Output listing to the NUFACE code sample problem

TEST INPUT FOR TIBER-II PROBLEM - stainless steel case

identification number - "lid"
 flux read option - "lth" 1/2; anis/onedant
 geometry option - "lge" 1/2/3; slab/cylinder/sphere
 number of energy groups - "ngrp" 67/46/21; n.+g./neutron/gamma
 number of zones - "lzn"
 number of materials - "lmix"
 number of compositions - "lcmp"
 number of mesh intervals - "lntval"
 number of material edits - "ldt"
 group cutoff for fast fluence comp. - "lflu"
 print fine mesh volumes - "lvolprt" 0/1; no/yes
 compute nuclear analysis parameters - "lsys" 0/1; no/yes
 print zonewise response infor. - "lznprt" 0/1; no/yes

1
2
2
67
19
9
8
337
7
29
0
1
1

r-mesh(i)
 0 760.0e-01 770.0e-01 819.0e-01 824.0e-01 120.0e+00 120.5e+00 126.0e+00 128.0e+00 167.0e+00
 206.0e+00 207.0e+00 208.0e+00 214.0e+00 386.0e+00 397.0e+00 398.0e+00 418.0e+00 497.0e+00 498.0e+00

r-int(i)
 38 1 5 1 37 1 5 2 40 40 1 1 6 86 11 1 20 40 1

Zone (coarse-mesh) Volumes

Zone 1 1.8146e+04 CM##3
 Zone 2 4.8066e+02 CM##3
 Zone 3 4.4461e+01 CM##3
 Zone 4 5.5808e+02 CM##3
 Zone 5 5.5908e+04 CM##3
 Zone 6 7.7778e+02 CM##3
 Zone 7 2.2592e+01 CM##3
 Zone 8 1.5959e+01 CM##3
 Zone 9 6.1444e+04 CM##3
 Zone 10 4.5701e+04 CM##3
 Zone 11 1.2497e+01 CM##3
 Zone 12 1.5038e+01 CM##3
 Zone 13 7.9549e+01 CM##3
 Zone 14 7.059e+01 CM##3
 Zone 15 4.974e+01 CM##3
 Zone 16 1.271e+04 CM##3
 Zone 17 2.709e+05 CM##3
 Zone 18 5.1259e+05 CM##3

Structural Material-Zone Index Table

void	zone>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
cocase		*		*				*												*
gfpoly					*		*													
magnet						*														
ibkshd										*	*									
frstwl												*					*			
itile													*							
nmult																		*		
obkshd																			*	

Table A.4 (continued)

Structural Material-Composition Table

material	cocase	gfpoly	magnet	ibkshd	frstwl	itle	nmult	obkshd
he	0.050	0.000	0.250	0.000	0.000	0.000	0.000	0.000
ss304	0.950	0.000	0.370	0.000	0.000	0.000	0.000	0.000
poly	0.000	1.000	0.050	0.000	0.000	0.000	0.000	0.000
cuofhc	0.000	0.000	0.188	0.000	0.000	0.000	0.000	0.000
nb3sn	0.000	0.000	0.142	0.000	0.000	0.000	0.000	0.000
pca	0.000	0.000	0.000	0.300	0.500	0.000	0.050	0.450
h2olno	0.000	0.000	0.000	0.200	0.500	0.000	0.550	0.350
w	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
be	0.000	0.000	0.000	0.000	0.000	1.000	0.600	0.000

Isotope-Material Composition Index Table

material	isot	density	isot	density	isot	density	isot	density	isot	density	isot	density	isot	density
he	3	1.0581e-02												
ss304	9	3.1842e-04	16	1.7210e-03	22	1.7660e-02	23	1.1438e-03	24	6.0199e-02	26	7.4126e-03		
poly	1	1.5847e-02	9	2.4040e-02	10	2.2880e-03	11	2.2431e-02	12	3.5570e-03	13	1.3094e-04	14	7.5408e-04
	15	1.8557e-03	16	6.0883e-03	19	2.1026e-03	24	1.6501e-05						
cuofhc	24	2.4102e-07	26	5.5042e-07	27	8.4724e-02	37	1.2992e-07						
nb3sn	29	4.0686e-02	31	1.3562e-02										
pca	30	1.0043e-03	24	5.5968e-02	21	9.4570e-05	22	1.2971e-02	26	1.3129e-02	23	1.7538e-03	16	8.5765e-04
	20	1.0173e-04												
h2olno	1	4.6852e-02	10	1.4144e-03	5	1.4144e-04	4	1.2730e-03	11	3.7667e-02				
w	33	1.6641e-02	34	9.0554e-03	35	1.9423e-02	36	1.8095e-02						
be	6	1.2361e-01												

Edits Requested

- 1 NG-KERMA
- 2 N.-KERMA
- 3 G.-KERMA
- 4 DPA-XS-A
- 6 TOT-H1 P
- 7 TOT-H3 P
- 8 TOT-He P

Neutron Fluence, Insulator Density and Normalization Information

Insulator Density = 1.7000e+00 [g/cm**3]

Inboard Current Normalization = 2.6307e-04

Outboard Current Normalization = 2.6307e-04

Energy group cutoff for fast fluence = 29

Zones for which nuclear analysis parameters are computed

3-coilcase 5-windings 6-insulate 7-coilcase 12-tileheat 16-obfirstw

The number density of the first wall steel is 4.304e+22 [atoms/cm**3]The number density of the copper stabilizer is 1.593e+22 [atoms/cm**3]

ONEDANT FORWARD CASE SCALAR FLUX FILE READ

ONEDANT ANGULAR FLUX FILE READ

MACKLIB-IV RESPONSE FUNCTION LIBRARY READ

Table A.4 (continued)

TEST INPUT FOR TIBER-II PROBLEM - stainless steel case

Edit Printout For Zone 3 Containing cocase [R.Rate] = R.xs(iso,jg)*Flux(int,jg)*Vol(int)

Material he With Density Fraction 0.050

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
He-4	1.175e-03	8.533e-04	3.216e-04	0.	0.	0.	0.
Total	1.175e-03	8.533e-04	3.216e-04	0.	0.	0.	0.
Zone Boundary Values [R.Rate/cm**3]							
Right	5.315e-07	3.658e-07	1.657e-07	0.	0.	0.	0.
Left	4.553e-07	3.385e-07	1.168e-07	0.	0.	0.	0.

Material ss304 With Density Fraction 0.950

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
C	8.796e-04	2.968e-04	5.829e-04	0.	0.	0.	6.562e-12
Si	9.009e-03	8.351e-04	8.174e-03	0.	2.075e-11	0.	1.180e-11
Cr	1.719e-01	5.740e-03	1.661e-01	3.085e-05	6.616e-11	2.370e-13	1.921e-11
Mn-55	1.947e-02	8.090e-03	1.138e-02	0.	4.918e-12	0.	1.087e-12
Fe	6.494e-01	1.756e-02	6.318e-01	8.865e-05	3.584e-10	3.083e-13	7.945e-11
Ni	9.073e-02	4.279e-03	8.645e-02	1.467e-05	1.785e-10	0.	4.253e-11
Total	9.413e-01	3.680e-02	9.045e-01	1.342e-04	6.287e-10	5.453e-13	1.606e-10
Zone Boundary Values [R.Rate/cm**3]							
Right	4.784e-04	1.662e-05	4.618e-04	5.680e-08	3.000e-13	2.622e-16	7.703e-14
Left	3.444e-04	1.440e-05	3.300e-04	5.355e-08	2.387e-13	2.070e-16	6.096e-14

Zone Summary

Total 9.425e-01 3.766e-02 9.048e-01 1.342e-04 6.287e-10 5.453e-13 1.606e-10

Zone Boundary Values [R.Rate/cm**3]

Right 4.789e-04 1.698e-05 4.619e-04 5.680e-08 3.000e-13 2.622e-16 7.703e-14
Left 3.448e-04 1.474e-05 3.301e-04 5.355e-08 2.387e-13 2.070e-16 6.096e-14

Neutron Fluence Summary [n/cm**2-s]

Maximum Zone Cell-Centered Fluences

Fast 2.220e-09
Total 6.134e-09

Zone Boundary Fluences

Left Fast 2.183e-09 Right Fast 2.203e-09
Left Total 5.754e-09 Right Total 6.240e-09

Table A.4 (continued)

TEST INPUT FOR TIBER-II PROBLEM - stainless steel case

Edit Printout For Zone 4 Containing gfpoly [R.Rate] = R.xs(imo,jg)*Flux(int,jg)*Vol(int)

Material poly With Density Fraction 1.000

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
H-1	1.253e-02	1.189e-02	6.386e-04	0.	0.	0.	0.
C-12	8.823e-03	2.617e-03	6.206e-03	0.	0.	0.	6.327e-11
O-16	1.021e-03	3.229e-04	6.979e-04	0.	1.494e-10	3.322e-13	4.882e-12
F-19	1.023e-02	2.315e-03	7.919e-03	0.	4.430e-10	0.	2.940e-11
Ne-23	1.873e-05	4.421e-06	1.431e-05	0.	8.934e-14	1.008e-15	1.997e-14
Na-23	7.966e-05	1.364e-05	6.602e-05	0.	5.782e-14	0.	7.999e-14
Mg	4.894e-04	6.935e-05	4.200e-04	0.	5.663e-14	0.	9.929e-14
Al-27	1.292e-03	1.572e-04	1.135e-03	8.891e-07	1.888e-12	4.832e-16	5.999e-12
Si	4.413e-03	3.535e-04	4.060e-03	0.	9.640e-12	0.	1.479e-12
Fe	2.309e-03	1.350e-04	2.174e-03	0.	1.100e-11	2.270e-17	1.224e-11
	2.479e-05	5.821e-07	2.421e-05	2.1e-09	1.289e-14	1.117e-17	2.866e-15

Total 4.123e-02 1.788e-02 2.335e-02 8.920e-07 1.770e-10 3.337e-13 1.189e-10

Zone Boundary Values [R.Rate/cm**3]

Right	1.613e-04	6.988e-05	9.140e-05	3.486e-09	6.919e-13	1.305e-15	4.632e-13
Left	1.582e-04	6.865e-05	8.959e-05	3.426e-09	6.795e-13	1.281e-15	4.566e-13

Zone Summary

Total 4.123e-02 1.788e-02 2.335e-02 8.920e-07 1.770e-10 3.337e-13 1.189e-10

Zone Boundary Values [R.Rate/cm**3]

Right	1.613e-04	6.988e-05	9.140e-05	3.486e-09	6.919e-13	1.305e-15	4.632e-13
Left	1.582e-04	6.865e-05	8.959e-05	3.426e-09	6.795e-13	1.281e-15	4.566e-13

Neutron Fluence Summary [n/cm**2-s]

Maximum Zone Cell-Centered Fluences

Fast 2.219e-09
Total 6.262e-09

Zone Boundary Fluences

Left Fast	2.203e-09	Right Fast	2.235e-09
Left Total	6.240e-09	Right Total	6.283e-09

Table A.4 (continued)

TEST INPUT FOR TIDER-II PROBLEM - stainless steel case

Edit Printout For Zone 5 Containing magnet [R.Rate] = R.Xs(iso,jg)*Flux(int,jg)*Vol(int)

Material he With Density Fraction 0.250

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
He-4	5.017e-01	4.003e-01	1.014e-01	0.	0.	0.	0.
Total	5.017e-01	4.003e-01	1.014e-01	0.	0.	0.	0.
Zone Boundary Values [R.Rate/cm**3]							
Right	6.678e-05	5.466e-05	1.212e-05	0.	0.	0.	0.
Left	2.717e-06	1.871e-06	8.460e-07	0.	0.	0.	0.

Material ss304 With Density Fraction 0.370

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
C	2.341e-02	9.208e-03	1.418e-02	0.	0.	0.	4.271e-10
Si	4.263e-01	3.108e-02	1.418e-02	0.	1.349e-09	0.	7.624e-10
Cr	4.074e+00	1.968e-01	3.957e+00	8.366e-04	2.295e-09	1.603e-11	7.022e-09
Mn-55	3.620e-01	9.703e-02	2.650e-01	0.	1.49e-10	0.	5.031e-11
Fe	1.537e+01	6.872e-01	1.468e+01	2.456e-03	1.321e-08	2.097e-11	2.146e-09
Ni	2.195e+00	1.959e-01	1.999e+00	3.780e-04	1.130e-08	0.	2.746e-09
Total	2.225e+01	1.217e+00	2.103e+01	3.671e-03	4.047e-08	3.701e-11	1.040e-08
Zone Boundary Values [R.Rate/cm**3]							
Right	2.768e-03	1.764e-04	2.591e-03	4.543e-07	6.590e-12	5.964e-15	1.685e-12
Left	1.893e-04	6.555e-06	1.827e-04	2.250e-08	1.190e-13	1.045e-16	3.058e-14

Material poly With Density Fraction 0.050

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
H-1	3.645e-01	3.495e-01	1.502e-02	0.	0.	0.	0.
C	2.389e-01	9.421e-02	1.447e-01	0.	0.	0.	4.358e-09
N	2.666e-02	1.042e-02	1.624e-02	0.	2.344e-09	2.209e-11	3.159e-10
O	2.702e-01	8.621e-02	1.840e-01	0.	9.58e-10	0.	1.966e-09
F-19	5.010e-04	1.692e-04	3.318e-04	0.	9.63e-14	6.679e-14	1.602e-13
Na-23	1.029e-03	5.027e-04	1.526e-03	0.	3.508e-14	0.	5.194e-13
Mg	1.237e-02	2.674e-03	9.692e-03	0.	3.769e-11	0.	3.951e-11
Al-27	3.196e-02	9.830e-03	2.613e-02	2.612e-05	1.262e-10	3.351e-14	4.498e-11
Si	1.082e-01	1.482e-02	9.334e-02	0.	6.447e-10	0.	3.645e-10
S	6.631e-02	6.891e-03	4.942e-02	0.	7.297e-10	1.573e-15	4.062e-10
Ca	5.692e-04	2.549e-05	3.437e-04	9.899e-08	8.996e-13	7.768e-16	1.986e-13
Total	1.112e+00	5.712e-01	5.409e-01	2.621e-05	4.182e-09	2.220e-11	7.520e-09

Table A.4 (continued)

Zone Boundary Values (R.Rate/cm**3)

Right	1.356e-04	7.058e-05	6.503e-05	3.050e-09	6.862e-13	3.616e-15	1.207e-12
Left	8.064e-06	3.494e-06	4.570e-06	1.743e-10	3.459e-14	6.523e-17	2.326e-14

Material cuofhc With Density Fraction 0.188

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
Fe	3.126e-05	1.398e-06	2.986e-05	4.997e-09	4.721e-14	4.266e-17	1.047e-14
Ni	8.282e-05	7.392e-06	7.543e-05	1.426e-08	4.264e-13	0.	1.036e-13
Cu	1.346e+01	1.247e+00	1.222e+01	2.737e-03	2.264e-08	0.	3.571e-09
Pb	1.508e-04	2.336e-07	1.506e-04	2.690e-09	0.	0.	0.
Total	1.346e+01	1.247e+00	1.222e+01	2.737e-03	2.264e-08	4.266e-17	3.571e-09

Zone Boundary Values (R.Rate/cm**3)

Right	1.695e-03	1.770e-04	1.518e-03	3.322e-07	3.672e-12	6.878e-21	5.782e-13
Left	1.202e-04	1.337e-05	1.068e-04	1.727e-08	6.743e-14	1.202e-22	1.053e-14

Material nb3sn With Density Fraction 0.142

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
Nb-93	7.723e+00	1.229e-01	7.600e+00	4.917e-04	1.335e-09	0.	3.410e-10
Sn	3.682e+00	2.276e-02	3.659e+00	0.	0.	0.	0.
Total	1.140e+01	1.456e-01	1.126e+01	4.917e-04	1.335e-09	0.	3.410e-10

Zone Boundary Values (R.Rate/cm**3)

Right	1.470e-03	1.897e-05	1.451e-03	6.002e-08	2.163e-13	0.	5.38e-14
Left	1.012e-04	8.015e-07	1.004e-04	3.025e-09	3.926e-15	0.	1.001e-15

Zone Summary

Total	<u>4.873e+01</u>	3.581e+00	4.515e+01	6.926e-03	6.862e-08	5.920e-11	2.184e-08
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Zone Boundary Values (R.Rate/cm**3)

Right	6.136e-03	4.977e-04	5.438e-03	8.496e-07	1.116e-11	9.580e-15	3.526e-12
Left	4.214e-04	2.609e-05	3.953e-04	4.297e-08	2.250e-13	1.697e-16	6.536e-14

Neutron Fluence Summary (n/cm**2-s)

Maximum Zone Cell-Centered Fluences

Fast	3.135e-08
Total	6.423e-08

Zone Boundary Fluences

Left Fast	2.235e-09	Right Fast	<u>3.215e-08</u>
Left Total	6.283e-09	Right Total	6.681e-08

Table A.4 (continued)

TEST INPUT FOR TIBER-II PROBLEM - stainless steel case

Edit Printout For Zone 6 Containing gfpoly [R.Rate] = R.xs(iso.jg)*Flux(int.jg)*Vol(int)

Material poly With Density Fraction 1.000

Nuclide	MG-KERMA	M.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-Ha P
H-1	3.298e-01	3.163e-01	1.357e-02	0.	0.	0.	0.
C	2.262e-01	9.504e-02	1.312e-01	0.	0.	0.	5.396e-09
N	2.603e-02	1.129e-02	1.474e-02	0.	2.935e-09	2.765e-11	5.945e-10
O	2.549e-01	8.779e-02	1.671e-01	0.	5.650e-10	0.	2.452e-09
F-19	4.791e-04	1.775e-04	3.016e-04	0.	7.470e-13	8.253e-14	2.038e-12
Na-23	1.935e-03	5.455e-04	1.389e-03	0.	3.146e-12	0.	6.440e-13
Mo	1.163e-02	2.800e-03	8.833e-03	0.	4.637e-11	0.	4.889e-11
Al-27	3.011e-02	6.262e-03	2.384e-02	2.344e-05	1.571e-10	4.158e-14	8.068e-11
Si	1.013e-01	1.601e-02	8.527e-02	0.	8.073e-10	0.	4.556e-10
Ca	5.375e-02	8.157e-03	4.559e-02	0.	9.190e-10	1.952e-15	4.451e-10
Fe	5.366e-04	2.813e-05	5.084e-04	8.738e-08	1.073e-12	9.644e-16	2.368e-13

Total 1.037e+00 5.444e-01 4.923e-01 2.353e-05 5.235e-09 2.777e-11 9.280e-09

Zone Boundary Values [R.Rate/cm**3]

Right	2.776e-03	1.470e-03	1.306e-03	6.357e-08	1.399e-11	7.472e-14	2.498e-11
Left	2.712e-03	1.412e-03	1.301e-03	6.099e-08	1.372e-11	7.231e-14	2.415e-11

Zone Summary

Total 1.037e+00 5.444e-01 4.923e-01 2.353e-05 5.235e-09 2.777e-11 9.280e-09

Zone Boundary Values [R.Rate/cm**3]

Right	2.776e-03	1.470e-03	1.306e-03	6.357e-08	1.399e-11	7.472e-14	2.498e-11
Left	2.712e-03	1.412e-03	1.301e-03	6.099e-08	1.372e-11	7.231e-14	2.415e-11

Neutron Fluence Summary [n/cm**2-s]

Maximum Zone Cell-Centered Fluences

Fast 3.277e-08
Total 6.773e-08

Zone Boundary Fluences

Left Fast	3.215e-08	Right Fast	3.340e-08
Left Total	6.681e-08	Right Total	6.865e-08

Table A.4 (continued)

TEST INPUT FOR TIBER-II PROBLEM - stainless steel case

Edit Printout For Zone 7 Containing cocase [R.Rate] = R.xs(iso,jg)*Flux(int,jg)*Vol(int)

Material he With Density Fraction 0.050

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
He-4	8.382e-02	6.870e-02	1.512e-02	0.	0.	0.	0.
Total	8.382e-02	6.870e-02	1.512e-02	0.	0.	0.	0.
Zone Boundary Values [R.Rate/cm**3]							
Right	2.616e-05	2.074e-05	5.421e-06	0.	0.	0.	0.
Left	1.394e-05	1.151e-05	2.433e-06	0.	0.	0.	0.

Material ss304 With Density Fraction 0.950

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
C	4.655e-02	1.932e-02	2.723e-02	0.	0.	0.	1.223e-09
Si	4.500e-01	7.189e-02	3.781e-01	0.	3.910e-09	0.	2.204e-19
Cr	8.095e+00	4.490e-01	7.646e+00	1.596e-03	1.236e-08	4.623e-11	3.582e-07
Mn-55	7.417e-01	2.180e-01	5.237e-01	0.	8.983e-10	0.	2.019e-10
Fe	3.073e+01	1.659e+00	2.907e+01	4.742e-03	6.700e-08	6.056e-11	1.477e-08
Ni	4.490e+00	5.120e-01	3.978e+00	6.902e-04	3.300e-08	0.	7.943e-09
Total	4.455e+01	2.930e+00	4.162e+01	7.049e-03	1.172e-07	1.068e-10	2.993e-08
Zone Boundary Values [R.Rate/cm**3]							
Right	1.592e-02	9.657e-04	1.495e-02	2.106e-06	4.040e-11	3.696e-14	1.035e-11
Left	7.172e-03	4.692e-04	6.703e-03	1.215e-06	1.751e-11	1.590e-14	4.473e-12

Zone Summary

Total	4.463e+01	2.998e+00	4.164e+01	7.049e-03	1.172e-07	1.068e-10	2.993e-08
Zone Boundary Values [R.Rate/cm**3]							
Right	1.595e-02	9.864e-04	1.496e-02	2.106e-06	4.040e-11	3.696e-14	1.035e-11
Left	7.186e-03	4.807e-04	6.706e-03	1.215e-06	1.751e-11	1.590e-14	4.473e-12

Neutron Fluence Summary [n/cm**2-s]

Maximum Zone Cell-Centered Fluences
Fast 4.758e-08
Total 1.014e-07

Zone Boundary Fluences

Left Fast	3.340e-08	Right Fast	4.851e-08
Left Total	6.865e-08	Right Total	1.058e-07

Table A.4 (continued)

TEST INPUT FOR TIBER-II PROBLEM - stainless steel case

Edit Printout For Zone 9 Containing ibkshd [R.Rate] = R.xs(iso,jg)*Flux(int,jg)*Vol(int)

Material pca With Density Fraction 0.800

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
Mo	4.962e+02	3.233e+01	4.639e+02	1.999e-02	0.	0.	0.
Fe	1.248e+04	6.941e+02	1.179e+04	1.584e+00	3.175e-05	3.235e-08	7.024e-06
V	1.958e+01	2.728e+00	1.686e+01	3.250e-03	2.573e-08	2.329e-09	4.443e-09
Cr	2.593e+03	1.432e+02	2.450e+03	4.107e-01	4.641e-06	1.913e-08	1.378e-06
Ni	3.498e+03	4.257e+02	3.072e+03	4.205e-01	2.830e-05	0.	7.044e-06
Mn-55	4.902e+02	1.398e+02	3.503e+02	0.	6.908e-07	0.	1.601e-07
Si	9.748e+01	1.521e+01	8.223e+01	0.	9.886e-07	0.	5.307e-07
Ti	5.362e+01	2.916e+00	5.070e+01	0.	5.210e-08	0.	3.433e-08
Total	1.973e+04	1.456e+03	1.827e+04	2.438e+00	6.647e-05	5.400e-08	1.620e-05
Zone Boundary Values [R.Rate/cm**3]							
Right	2.615e+00	2.043e-01	2.411e+00	3.385e-04	9.425e-09	7.886e-12	2.302e-09
Left	1.352e-02	8.957e-04	1.263e-02	1.714e-06	3.792e-11	2.689e-14	9.098e-12

Material h2olno With Density Fraction 0.200

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
H-1	1.628e+03	1.531e+03	9.762e+01	0.	0.	0.	0.
H	2.706e+01	1.149e+01	1.552e+01	0.	2.958e-06	3.684e-08	4.860e-07
Li-7	1.678e+00	1.042e+00	6.358e-01	0.	5.839e-08	3.544e-08	1.703e-08
Li-6	5.060e+03	5.055e+03	5.720e+00	0.	1.054e-03	1.053e-03	1.034e-03
O	7.024e+02	2.226e+02	4.798e+02	0.	1.387e-06	0.	9.080e-06
Total	7.420e+03	6.820e+03	5.993e+02	0.	1.059e-03	1.053e-03	1.064e-03
Zone Boundary Values [R.Rate/cm**3]							
Right	9.942e-01	9.149e-01	7.924e-02	0.	1.406e-07	1.398e-07	1.413e-07
Left	4.784e-03	4.370e-03	4.138e-04	0.	6.417e-10	6.386e-10	6.445e-10

Zone Summary

Total	2.715e+04	8.276e+03	1.887e+04	2.438e+00	1.125e-03	1.053e-03	1.080e-03
Zone Boundary Values [R.Rate/cm**3]							
Right	3.609e+00	1.119e+00	2.490e+00	3.385e-04	1.500e-07	1.398e-07	1.436e-07
Left	1.831e-02	5.266e-03	1.304e-02	1.714e-06	6.796e-10	6.386e-10	6.536e-10

Neutron Fluence Summary [n/cm**2-s]

Maximum Zone Cell-Centered Fluences
Fast 7.383e-06
Total 1.610e-05

Zone Boundary Fluences
Left Fast 4.820e-08 Right Fast 7.869e-06
Left Total 1.055e-07 Right Total 1.714e-05

Table A.4 (continued)

TEST INPUT FOR TIBER-II PROBLEM - stainless steel case

Edit Printout For Zone 10 Containing ibkshd (R.Rate) = R.xs(iso,jg)*Flux(int,jg)*Vol(int)

Material pca With Density Fraction 0.800

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
Mo	6.895e+04	4.840e+03	6.411e+04	5.321e+00	0.	0.	0.
Fe	1.918e+06	2.983e+05	1.620e+06	4.376e+02	1.549e-01	1.495e-05	5.512e-03
V	2.823e+03	5.013e+02	3.322e+03	8.355e-01	1.421e-04	2.42e-08	4.424e-06
Cr	3.951e+05	5.789e+04	3.372e+05	1.131e+03	1.323e-01	2.32e-05	3.383e-04
Ni	6.027e+05	1.809e+05	4.217e+05	1.166e+02	1.127e-01	0.	4.424e-06
Mn-55	6.817e+04	1.999e+04	4.818e+04	0.	3.299e-04	0.	4.401e-06
Si	1.735e+04	5.891e+03	1.146e+04	0.	2.719e-04	0.	1.793e-06
Ti	8.020e+03	1.031e+03	6.989e+03	0.	2.679e-05	0.	1.793e-06

Total 3.081e+06 5.694e+05 2.512e+06 6.935e+02 2.995e-02 3.470e-05 7.855e-03

Zone Boundary Values [R.Rate/cm**3]

Right	2.846e+02	8.958e+01	1.950e+02	9.035e-02	4.833e-06	6.317e-09	1.320e-06
Left	2.615e+00	2.043e-01	2.411e+00	3.385e-04	9.425e-09	7.886e-12	2.302e-09

Material h2olno With Density Fraction 0.200

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
H-1	3.706e+05	3.566e+05	1.399e+04	0.	0.	0.	0.
N	6.205e+03	4.005e+03	2.200e+03	0.	4.959e-04	1.723e-05	1.757e-04
Li-7	4.438e+02	3.532e+02	9.062e+01	0.	2.581e-05	2.185e-08	2.433e-05
Li-6	5.589e+05	5.581e+05	8.156e+02	0.	1.161e-01	1.57e-01	1.161e-01
O	1.494e+05	8.178e+04	6.762e+04	0.	7.689e-04	0.	4.567e-03

Total 1.086e+06 1.001e+06 8.472e+04 0. 1.174e-01 1.158e-01 1.209e-01

Zone Boundary Values [R.Rate/cm**3]

Right	1.054e+02	9.872e+01	6.643e+00	0.	9.548e-06	9.296e-06	1.013e-05
Left	9.942e-01	9.149e-01	7.924e-02	0.	1.406e-07	1.398e-07	1.413e-07

Zone Summary

Total 4.167e+06 1.570e+06 2.597e+06 6.935e+02 1.474e-01 1.158e-01 1.288e-01

Zone Boundary Values [R.Rate/cm**3]

Right	3.900e+02	1.883e+02	2.017e+02	9.035e-02	1.438e-05	9.102e-06	1.147e-05
Left	3.609e+00	1.119e+00	2.490e+00	3.385e-04	1.500e-07	1.398e-07	1.436e-07

Neutron Fluence Summary [n/cm**2-s]

Maximum Zone Cell-Centered Fluences

Fast 9.222e-04

Total 1.467e-03

Zone Boundary Fluences

Left Fast 7.869e-06 Right Fast 9.747e-04

Left Total 1.714e-05 Right Total 1.540e-03

Table A.4 (continued)

TEST INPUT FOR TIDER-II PROBLEM - stainless steel case

Edit Printout For Zone 11 Containing frstwl [R.Rate] = R.Xs(iso,jg)*Flux(int,jg)*Vol(int)

Material pca With Density Fraction 0.500

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
Mo	4.433e+03	4.249e+02	4.009e+03	6.110e-01	0.	0.	0.
Fe	1.454e+05	4.539e+04	1.001e+05	5.495e-01	2.463e-03	3.694e-06	3.688e-04
V	2.007e+02	5.746e+01	1.433e+02	9.314e-02	5.159e-04	3.489e-07	4.121e-07
Cr	2.945e+04	8.637e+03	2.082e+04	1.312e+01	5.793e-04	3.162e-06	1.230e-04
Ni	5.311e+04	2.704e+04	2.607e+04	1.385e+01	1.571e-03	0.	5.037e-04
Mn-55	4.809e+03	1.834e+03	2.975e+03	0.	5.267e-08	0.	1.826e-05
Si	1.561e+03	8.538e+02	7.069e+02	0.	7.440e-08	0.	3.996e-05
Ti	5.782e+02	1.470e+02	4.312e+02	0.	4.392e-06	0.	2.957e-06
Total	2.396e+05	8.438e+04	1.552e+05	8.262e+01	4.547e-03	6.105e-06	1.253e-03
Zone Boundary Values [R.Rate/cm**3]							
Right	1.978e+02	7.409e+01	1.237e+02	7.089e-02	3.989e-06	5.462e-09	1.106e-06
Left	1.779e+02	5.599e+01	1.219e+02	5.647e-02	3.021e-06	3.948e-09	8.251e-07

Material h2olno With Density Fraction 0.500

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
H-1	1.491e+05	1.456e+05	3.472e+03	0.	0.	0.	0.
H	2.792e+03	2.248e+03	5.441e+02	0.	2.192e-04	1.078e-05	8.846e-05
Li-7	2.101e+02	1.876e+02	2.246e+01	0.	1.548e-05	1.418e-05	1.549e-05
Li-6	1.803e+05	1.801e+05	2.022e+02	0.	3.741e-02	3.719e-02	3.741e-02
O	6.342e+04	4.670e+04	1.672e+04	0.	5.196e-04	0.	2.945e-03
Total	3.558e+05	3.748e+05	2.096e+04	0.	3.817e-02	3.721e-02	4.046e-02
Zone Boundary Values [R.Rate/cm**3]							
Right	3.467e+02	3.310e+02	1.572e+01	0.	3.497e-05	3.412e-05	3.698e-05
Left	2.634e+02	2.468e+02	1.661e+01	0.	2.387e-05	2.324e-05	2.538e-05

Zone Summary

Total	6.354e+05	4.592e+05	1.762e+05	8.262e+01	4.272e-02	3.722e-02	4.171e-02
Zone Boundary Values [R.Rate/cm**3]							
Right	5.445e+02	4.051e+02	1.394e+02	7.089e-02	3.895e-05	3.412e-05	3.809e-05
Left	4.413e+02	3.028e+02	1.385e+02	5.647e-02	2.689e-05	2.324e-05	2.621e-05

Neutron Fluence Summary [n/cm**2-s]

Maximum Zone Cell-Centered Fluences
Fast 1.050e-03
Total 1.645e-03

Zone Boundary Fluences

Left Fast	9.747e-04	Right Fast	1.125e-03
Left Total	1.540e-03	Right Total	1.750e-03

Table A.4 (continued)

TEST INPUT FOR TIBER-II PROBLEM - stainless steel case

Edit Printout For Zone 12 Containing title (R.Rate) = R.xs(iso,jg)*Flux(int,jg)*Vol(int)

Material be With Density Fraction 1.000

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-Ho P
Be-9	3.590e+05	3.081e+05	5.087e+04	0.	1.954e-03	1.949e-03	1.145e-01
Total	3.590e+05	3.081e+05	5.087e+04	0.	1.954e-03	1.949e-03	1.145e-01
Zone Boundary Values (R.Rate/cm**3)							
Right	3.070e+02	2.685e+02	3.845e+01	0.	1.783e-06	1.778e-06	9.937e-05
Left	2.437e+02	2.041e+02	3.959e+01	0.	1.215e-06	1.212e-06	7.628e-05

Zone Summary

Total	<u>3.590e+05</u>	3.081e+05	5.087e+04	0.	1.954e-03	1.949e-03	1.145e-01
Zone Boundary Values (R.Rate/cm**3)							
Right	3.070e+02	2.685e+02	3.845e+01	0.	1.783e-06	1.778e-06	9.937e-05
Left	2.437e+02	2.041e+02	3.959e+01	0.	1.215e-06	1.212e-06	7.628e-05

Neutron Fluence Summary (n/cm**2-s)

Maximum Zone Cell-Centered Fluences
Fast 1.208e-03
Total 1.840e-03

Zone Boundary Fluences
Left Fast 1.125e-03 Right Fast 1.291e-03
Left Total 1.750e-03 Right Total 1.930e-03

Table A.4 (continued)

TEST INPUT FOR TIBER-II PROBLEM - stainless steel case

[Edit Printout For Zone 16 Containing frstwl] [R.Rate] = R.xs(iso,jg)*Flux(int,jg)*Vol(int)

Material pca With Density Fraction 0.500

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H1 P	TOT-He P
Mo	9.394e+03	1.145e+03	8.248e+03	1.824e+00	0.	0.	0.
Fe	3.565e+05	1.502e+05	2.063e+05	1.664e+02	8.268e-03	1.337e-05	1.916e-03
V	4.654e+02	1.701e+02	2.951e+02	2.743e-01	7.338e-06	8.875e-06	1.425e-06
Cr	7.143e+04	2.852e+04	4.291e+04	3.916e+01	1.282e-03	7.789e-06	4.222e-04
Ni	1.417e+05	8.790e+04	5.375e+04	4.184e+01	4.931e-03	0.	1.657e-03
Mn-55	1.107e+04	4.941e+03	6.133e+03	0.	1.733e-04	0.	4.643e-05
Si	4.219e+03	2.763e+03	1.456e+03	0.	2.487e-04	0.	1.321e-04
Ti	1.368e+03	4.789e+02	8.887e+02	0.	1.490e-05	0.	1.008e-05

Total 5.961e+05 2.761e+05 3.200e+05 2.497e+02 1.493e-02 2.204e-05 4.185e-03

Zone Boundary Values [R.Rate/cm**3]

Right	2.208e+02	9.730e+01	1.235e+02	9.019e-02	5.284e-06	7.442e-09	1.465e-06
Left	2.589e+02	1.258e+02	1.351e+02	1.098e-01	6.669e-06	1.021e-08	1.886e-06

Material h2olno With Density Fraction 0.500

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
H-1	4.187e+05	4.116e+05	7.126e+03	0.	0.	0.	0.
N	8.366e+03	7.248e+03	1.119e+03	0.	6.325e-04	3.557e-05	2.706e-04
Li-7	6.338e+02	5.876e+02	4.613e+01	0.	5.019e-03	4.558e-05	4.983e-05
Li-6	4.109e+05	4.105e+05	4.152e+02	0.	8.515e-02	8.448e-02	8.513e-02
O	1.873e+05	1.529e+05	3.438e+04	0.	1.796e-03	0.	9.959e-03

Total 1.026e+06 9.829e+05 4.308e+04 0. 8.763e-02 8.451e-02 9.541e-02

Zone Boundary Values [R.Rate/cm**3]

Right	3.955e+02	3.791e+02	1.646e+01	0.	3.650e-05	3.540e-05	3.921e-05
Left	4.260e+02	4.080e+02	1.805e+01	0.	3.367e-05	3.227e-05	3.719e-05

Zone Summary

Total 1.622e+06 1.259e+06 3.630e+05 2.497e+02 1.026e-01 8.454e-02 9.960e-02

Zone Boundary Values [R.Rate/cm**3]

Right	6.164e+02	4.764e+02	1.400e+02	9.019e-02	4.179e-05	3.541e-05	4.068e-05
Left	6.849e+02	5.318e+02	1.531e+02	1.098e-01	4.033e-05	3.228e-05	3.908e-05

Neutron Fluence Summary [n/cm**2-s]

Maximum Zone Cell-Centered Fluences

Fast 1.372e-03
Total 2.011e-03

Zone Boundary Fluences

Left Fast	1.457e-03	Right Fast	1.287e-03
Left Total	2.089e-03	Right Total	1.934e-03

Table A.4 (continued)

TEST INPUT FOR TIBER-II PROBLEM - stainless steel case

Edit Printout For Zone 17 Containing nmult

(R.Ratr) = R.xs(iso,jg)*Flux(int,jg)*Vol(int)

Material pca With Density Fraction 0.050

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
Mo	1.133e+04	9.807e+02	1.035e+04	1.259e+00	0.	0.	0.
Fe	3.244e+05	8.454e+04	2.399e+05	1.140e+02	3.572e-03	5.418e-06	1.035e-03
V	4.744e+02	1.352e+02	2.392e+02	1.946e-01	3.837e-06	3.776e-07	6.827e-07
Cr	6.546e+04	1.596e+04	4.951e+04	2.748e+01	6.844e-04	3.204e-06	1.092e-04
Ni	1.177e+05	5.468e+04	6.305e+04	2.877e+01	3.536e-03	0.	1.001e-03
Mn-55	1.177e+04	4.665e+03	7.103e+03	0.	9.948e-05	0.	2.392e-05
Si	3.306e+03	1.679e+03	1.628e+03	0.	1.424e-04	0.	2.843e-05
Ti	1.294e+03	2.770e+02	1.017e+03	0.	7.760e-06	0.	5.148e-06
Total	5.358e+05	1.629e+05	3.729e+05	1.717e+02	9.048e-03	9.000e-06	2.353e-03
Zone Boundary Values (R.Rate/cm**3)							
Right	4.933e+00	7.277e-01	4.205e+00	8.980e-04	4.134e-08	2.385e-11	9.939e-09
Left	2.208e+01	9.730e+00	1.235e+01	9.019e-03	5.284e-07	7.442e-10	1.465e-07

Material h2olno With Density Fraction 0.350

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
H-1	2.234e+06	2.179e+06	5.502e+04	0.	0.	0.	0.
H	3.915e+04	3.048e+04	8.675e+03	0.	3.786e-03	1.482e-04	1.361e-03
Li-7	3.107e+03	2.750e+03	3.566e+02	0.	2.300e-04	2.150e-04	2.343e-04
Li-6	4.483e+06	4.479e+06	3.210e+03	0.	9.331e-01	9.294e-01	9.330e-01
O	8.641e+05	5.973e+05	2.668e+05	0.	5.991e-03	0.	3.748e-02
Total	7.623e+06	7.289e+06	3.341e+05	0.	9.431e-01	9.298e-01	9.721e-01
Zone Boundary Values (R.Rate/cm**3)							
Right	4.737e+01	4.354e+01	3.830e+00	0.	5.975e-06	5.915e-06	6.092e-06
Left	2.769e+02	2.654e+02	1.152e+01	0.	2.555e-05	2.478e-05	2.745e-05

Material be With Density Fraction 0.600

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
Be-9	3.550e+06	2.831e+06	7.199e+05	0.	1.288e-02	1.285e-02	1.179e+00
Total	3.550e+06	2.831e+06	7.199e+05	0.	1.288e-02	1.285e-02	1.179e+00
Zone Boundary Values (R.Rate/cm**3)							
Right	2.242e+01	1.417e+01	8.252e+00	0.	4.062e-08	4.054e-08	6.138e-06
Left	1.818e+02	1.570e+02	2.487e+01	0.	9.758e-07	9.733e-07	6.036e-05

Table A.4 (continued)

Zone Summary

Total 1.171e+07 1.028e+07 1.427e+06 1.717e+02 9.650e-01 9.426e-01 2.154e+00

Zone Boundary Values [R.Rate/cm**3]

Right 7.472e+01 5.844e+01 1.629e+01 8.980e-04 6.057e-06 5.955e-06 1.224e-05
Left 4.808e+02 4.321e+02 4.874e+01 9.019e-03 2.704e-05 2.576e-05 8.796e-05

Neutron Fluence Summary [n/cm**2-s]

Maximum Zone Cell-Centered Fluences

Fast 1.230e-03
Total 1.884e-03

Zone Boundary Fluences

Left Fast 1.287e-03 Right Fast 1.797e-04
Left Total 1.934e-03 Right Total 3.268e-04

Table A.4 (continued)

TEST INPUT FOR TIBER-II PROBLEM - stainless steel case

Edit Printout For Zone 18 Containing obkshd [R.Rate] = R.XS(iso,jg)*Flux(int,jg)*Vol(int)

Material pca With Density Fraction 0.650

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
Mo	3.164e+04	1.477e+03	3.017e+04	1.667e+00	0.	0.	0.
Fe	8.389e+05	8.319e+04	7.557e+05	1.462e+02	4.286e-03	3.222e-06	9.399e-04
V	1.245e+03	1.628e+02	1.082e+03	2.663e-01	3.368e-06	2.472e-07	5.389e-07
Cr	1.731e+05	1.585e+04	1.572e+05	3.644e+01	6.190e-04	1.965e-06	1.724e-04
Ni	2.545e+05	5.766e+04	1.969e+05	3.701e+01	4.173e-03	0.	1.010e-03
Mn-55	2.893e+04	6.462e+03	2.247e+04	0.	9.672e-05	0.	2.966e-05
Si	7.118e+03	1.789e+03	5.330e+03	0.	1.374e-04	0.	7.793e-05
Ti	3.544e+03	2.880e+02	3.256e+03	0.	6.779e-06	0.	4.401e-06

Total 1.339e+06 1.669e+05 1.172e+06 2.216e+02 9.323e-03 5.434e-06 2.226e-03

Zone Boundary Values [R.Rate/cm**3]

	Right	Left
1.030e-03	1.149e-04	9.146e-04
6.413e+01	9.459e+00	5.467e+01
1.474e-07	1.167e-02	5.374e-07
6.558e-12	3.434e-15	1.610e-12
3.101e-10	1.292e-07	

Material h2olno With Density Fraction 0.350

Nuclide	NG-KERMA	N.-KERMA	G.-KERMA	DPA-XS-A	TOT-H1 P	TOT-H3 P	TOT-He P
H-1	2.528e+05	2.458e+05	1.400e+04	0.	0.	0.	0.
N	4.724e+03	2.522e+03	2.202e+03	0.	3.568e-04	1.136e-05	1.348e-04
Li-7	3.408e+02	2.501e+02	9.070e+01	0.	1.900e-05	1.814e-05	1.963e-05
Li-6	4.742e+05	4.734e+05	8.163e+02	0.	9.861e-02	9.827e-02	9.861e-02
O	1.149e+05	4.722e+04	6.770e+04	0.	3.627e-04	0.	2.612e-03

Total 8.540e+05 7.692e+05 8.481e+04 0. 9.935e-02 9.830e-02 1.014e-01

Zone Boundary Values [R.Rate/cm**3]

	Right	Left
3.748e-04	3.071e-04	6.763e-05
4.737e+01	4.354e+01	3.830e+00
2.389e-11	2.326e-11	2.540e-11
5.975e-06	5.915e-06	6.092e-06

Zone Summary

Total 2.193e+06 9.361e+05 1.257e+06 2.216e+02 1.087e-01 9.831e-02 1.036e-01

Zone Boundary Values [R.Rate/cm**3]

	Right	Left
1.404e-03	4.221e-04	9.822e-04
1.115e+02	5.300e+01	5.850e+01
1.474e-07	1.167e-02	5.312e-06
3.045e-11	2.326e-11	2.701e-11
5.915e-06	6.221e-06	

Neutron Fluence Summary [n/cm**2-s]

Maximum Zone Cell-Centered Fluences

Fast 1.406e-04
Total 2.865e-04

Zone Boundary Fluences

	Left Fast	Right Fast
1.797e-04	2.392e-09	
3.268e-04	3.196e-09	

Table A.4 (continued)

TEST INPUT FOR TIBER-II PROBLEM - stainless steel case

NUCLEAR ANALYSIS RESPONSES

Overall Tritium Breeding Ratio.....	1.266	
Outboard First Wall Atomic Displacement..	12.338	[DPA]/[FPY]/[MW/m**2]
Outboard First Wall Helium Production....	206.763	[APPM]/[FPY]/[MW/m**2]
Outboard First Wall Hydrogen Production..	737.419	[APPM]/[FPY]/[MW/m**2]
Outboard First Wall Fast Neutron Fluence..	7.287e+21	[n/cm**2]/[FPY]/[MW/m**2]
Outboard First Wall Total Neutron Fluence	1.068e+22	[n/cm**2]/[FPY]/[MW/m**2]
Outboard First Wall Nuclear Heating.....	17.509	[MW/m**3]/[MW/m**2]
Tile Nuclear Heating.....	7.423	[MW/m**3]/[MW/m**2]
Maximum Coil Case Heating.....	4.299e-04	[N/cm**3]/[MW/m**2]
Total Coil Case Heating.....	1.229	[N]/[MW/m**2]
Maximum Coil Winding Heating.....	1.654e-04	[N/cm**3]/[MW/m**2]
Total Coil Winding Heating.....	1.314	[N]/[MW/m**2]
Maximum Fast Neutron Fluence in Coil Wdng	1.707e+17	[n/cm**2]/[FPY]/[MW/m**2]
Maximum Electrical Insulator Dose.....	1.389e+08	[RADS]/[FPY]/[MW/m**2]
Maximum Atomic Displacement In Cu Stabili	1.108e-04	[DPA]/[FPY]/[MW/m**2]
Maximum Induced Resistivity In Cu Stabili	7.870	[nohm-cm]

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