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A Comprehensive Neutron Cross-Section and Secondary Energy Distribution Uncertainty Analysis for a Fusion Reactor

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A COMPREHENSIVE NEUTRON CROSS-SECTION AND SECONDARY ENERGY DISTRIBUTION UNCERTAINTY ANALYSIS FOR A FUSION REACTOR

by

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ABSTRACT

On the example of General Atomic's well-documented Power Generating Fusion Reactor (PGFR) design, this report exercises a comprehensive neutron cross-section and secondary energy distribution (SED) uncertainty analysis. The LASL sensitivity and uncertainty analysis code SENSIT is used to calculate reaction cross-section sensitivity profiles and integral SED sensitivity coefficients. These are then folded with covariance matrices and integral SED uncertainties to obtain the resulting uncertainties of three calculated neutronics design parameters: two critical radiation damage rates and a nuclear heating rate. The report documents the first sensitivity-based data uncertainty analysis, which incorporates a quantitative treatment of the effects of SED uncertainties. The results demonstrate quantitatively that the ENDF/B-V cross-section data files for C, H, and O, including their SED data, are fully adequate for this design application, while the data for Fe and Ni are at best marginally adequate because they give rise to response uncertainties up to 25%. Much higher response uncertainties are caused by cross-section and SED data uncertainties in Cu (26 to 45%), tungsten (24 to 54%), and Cr (up to 98%). Specific recommendations are given for re-evaluations of certain reaction cross-sections, secondary energy distributions, and uncertainty estimates.

I. INTRODUCTION

One of the first steps in any new fusion reactor design is a neutronic analysis to determine adequate tritium breeding, nuclear heating in blankets and coils, acceptable radiation damage rates, etc. In an early phase it is usually sufficient to perform radiation transport calculations with a one-dimensional conceptual design model and allow for multi-dimensional streaming effects by estimated "streaming factors" which assure the 1-D model to be conservative. However, uncertainties in calculated neutronics design parameters due to cross-section uncertainties will be present in both 1-D as well as multi-dimensional analyses. These latter uncertainties can be conveniently estimated by performing a cross-section sensitivity and uncertainty analysis[(1)] based on the one-dimensional model.

Such quantitative data assessments have been performed in the past for various different fusion reactor designs, cf. e.g. Refs. (1) through (3). However, none of these analyses considers the effects of all nuclear data uncertainties simultaneously. Specifically, the effects of uncertainties in secondary energy and angular distributions have not been incorporated in the past, primarily due to the lack of a consistent methodology and the lack of uncertainty data for secondary distributions. Only recently such methodology has been developed[(4)] and relevant uncertainty data are being made available.

This uncertainty analysis includes the effects of uncertainties in all neutron reaction cross-sections relevant to the model, including correlations, and the effects of estimated uncertainties in the neutron secondary energy distributions (SED's). Effects of uncertainties in secondary angular distributions are not incorporated for the lack of uncertainty data. Also, any uncertainties in gamma ray cross sections are neglected for two reasons: (1) generally, gamma ray interaction cross-sections are known to a much higher degree of accuracy (at least an order of magnitude) than neutron interaction cross-sections, and (2) only one of the three critical nuclear design parameters in our design depends at all on the gamma ray distribution.

II. THEORY

The theoretical expressions underlying any sensitivity-based cross-section uncertainty analysis have been developed previously, cf. e.g. Refs. (1) and (2), and are given here only for completeness. The variance of any calculated integral design parameter R_k due to correlated uncertainties in given multigroup cross-section sets $\{\Sigma_i^g\}$ and $\{\Sigma_j^g\}$ can be calculated from

$$\left(\frac{\Delta R_k}{R_k}\right)^2_{i,j} = \sum_{g,g'} P^g_{i,k} \, P^{g'}_{j,k} \, \mathrm{Cov}\,(\Sigma_i^g, \Sigma_j^{g'}) \quad , \tag{1}$$

where

Σ_i^g = neutron interaction cross-section for reaction i in energy group g,

$\mathrm{Cov}(\Sigma_i^g, \Sigma_j^{g'})$ = relative covariance matrix element for the multigroup cross-sections Σ_i^g and $\Sigma_j^{g'}$,

$P^g_{i,k}$ = cross-section sensitivity profile for Σ_i^g with respect to the integral response R_k.

All cross-section uncertainty information about reaction cross-sections is contained in the relative covariance matrix which is independent of the specific reactor design. All sensitivity information about reaction cross-sections enters Eq. (1) through the product of the sensitivity profiles which, of course, are highly problem-dependent and specific for a particular reactor design and for the particular design parameter considered[1].

If the total response uncertainty due to many cross-section uncertainties is desired, then the relative standard deviation of the response R_k due to all reaction cross-section uncertainties considered for a particular material is given by

$$\left(\frac{\Delta R_k}{R_k}\right)_{MAT-XS} = \left(\sum_{i,j} \left(\frac{\Delta R_k}{R_k}\right)^2_{i,j}\right)^{\frac{1}{2}} \quad , \tag{2}$$

assuming that the variances due to individual (partial) cross-section uncertainties are uncorrelated.

The theory for the consistent incorporation of the effects of uncertainties in secondary energy distributions (SED's) has only recently been developed(5). The concept of hot/cold integral SED-sensitivities, which requires the specification of integral SED-uncertainty parameters, is adopted and applied here. As derived in Ref. 5, the relative standard deviation of an integral response R_k due to SED-uncertainties for a specific reaction, ℓ, that generates secondaries, is given by

$$\left(\frac{\Delta R_k}{R_k}\right)_\ell = \sum_{g'} \left|S^{SED}_{\ell,g'}\right| \cdot f_{\ell,g'} \quad , \tag{3}$$

where

$f_{\ell,g'}$ = integral SED-uncertainty for neutron interaction ℓ at the incident energy group g'; f is also called the spectral shape uncertainty parameter,

$S^{SED}_{\ell,g'}$ = integral SED-sensitivity for the neutron interaction ℓ at the incident energy group g'.

As noted in Ref. 5 the integral SED-sensitivity may be positive or negative, indicating whether the response R_k is more sensitive to the hot portion of the SED or its cold part:

$$S^{SED} = S^{SED}_{HOT} - S^{SED}_{COLD} \quad , \tag{4}$$

where the hot and cold portions of the integral SED-sensitivity are defined with respect to the median energy of the secondary distribution, cf. Ref. 5.

Equation (3) is valid for the sum of all SED-uncertainties pertaining to a single type of neutron interaction, identified by the subscript ℓ. If the effects of SED-uncertainties from all possible neutron interactions with one material are to be considered, then we may assume that their effects on the responses R_k are uncorrelated. With this assumption, the relative standard deviation of the response R_k due to all SED-uncertainties considered for a particular material is given by

$$\left(\frac{\Delta R_k}{R_k}\right)_{\text{MAT-SED}} = \left(\sum_{\ell} \left(\frac{\Delta R_k}{R_k}\right)_{\ell}^{2}\right)^{\frac{1}{2}} . \tag{5}$$

Under the same assumption of independent, and therefore uncorrelated, effects on R_k due to both all SED uncertainties and all reaction cross-section uncertainties per material, the total relative standard deviation of R_k per material is given by

$$\left(\frac{\Delta R_k}{R_k}\right)_{\text{MAT}} = \sqrt{\left(\frac{\Delta R_k}{R_k}\right)^{2}_{\text{MAT-XS}} + \left(\frac{\Delta R_k}{R_k}\right)^{2}_{\text{MAT-SED}}} , \tag{6}$$

which results from the quadratic sum of Eqs. (2) and (5). However, before any of the relative standard deviations defined in Eqs. (2), (3), (5), and (6) may be evaluated quantitatively, the data uncertainties in the form of covariance matrices and integral SED uncertainties, as well as the sensitivity profiles and integral SED-sensitivities must be quantified. In section III we describe how the required data uncertainties were obtained. In order to obtain the required sensitivity information a complete neutronics design analysis of the reactor system must be performed which is described in section IV.

III. CROSS-SECTION AND SECONDARY ENERGY DISTRIBUTION (SED) UNCERTAINTY DATA

One of the more important aspects of nuclear data is that the uncertainties tend to be highly correlated through the measurement processes and the corrections made to the observable quantities to obtain the microscopic cross sections. In many applications, the correlations of the uncertainties in the nuclear data play a crucial role in uncertainties in calculated results.

A. Cross-Section Covariance Data

Several versions of the reference cross-section data library known as ENDF/B (Evaluated Neutron Data Files-B) have been issued over the past 13 years, but only the latest version, ENDF/B-V, contains formats[14] and sufficient covariance data for an application such as is described in this report. Covariance data are given for 25 important nuclides in ENDF/B-V, which includes data for all nuclides needed in this analysis except Cu and W. For these elements we used the covariance files from Fe and Pb, respectively, assuming that the cross sections of Cu are as well known as those for Fe and the cross sections of W are as well known as those of Pb. Note that both these assumptions are probably optimistic. It is planned, however, that covariance data for Cu and W will be included in ENDF in the future, and the present calculations will be repeated when such data become available.

The covariance data in ENDF/B-V were processed with the NJOY code[15] to transform the data into the 30-group multigroup format needed in this study. Data from the various runs with the NJOY code were collected to form a 30-group covariance data library. The contents of this library, which is in an ENDF-like format, are shown in Table I.

B. Secondary-Energy-Distribution Covariances

It should be noted that ENDF/B-V does not contain data uncertainties and their correlations for secondary energy distribution (SED) data, and at the time of this writing, formats have yet to be specified. Hence, for the purpose of estimating the magnitude of these effects, we have generated SED covariance matrices using the very simple "hot-cold" concept outlined in Ref. 5.

The angle-averaged median energies of the composite elastic plus nonelastic neutron emission spectra were calculated for each material as functions of incident neutron energy. Relative errors were then estimated for the portions of the emission spectra lying above and below the median energies. If $\bar{\sigma}$ designates the integrated neutron emission cross section for a given incident energy and $\sigma_H = \bar{\sigma}/2$ is the integrated spectrum for $E' > E'_{median}$, then the relative uncertainties of the hot (denoted by subscript "H") and cold (subscript "C") regions can be specified by the quantity $f = \Delta\sigma_H/\bar{\sigma} = - \Delta\sigma_C/\bar{\sigma}$. For the purposes of this study, we have assumed no correlation in the SED uncertainties with incident neutron energy.

Table II lists the median energies and the relative errors assumed in the

TABLE I

ENDF/B-V COVARIANCE DATA (MF=33) PROCESSED WITH NJOY CODE

MAT	Nuclide	Ref.	MT-Nos. Processed	Reaction Cross Sections
1301	H-1	16	1,2	Total, elastic
1305	B-10	17	1,2,107,780,781	Total, elastic, (n,α), (n,α_0), and (n,α_1)
1306	C	18	1,2,4,51-68,91,102, 104,107	Total, elastic, toal inelastic, inelastic levels 1-18, inelastic continuum, (n,γ), (n,d), (n,α)
1324	Cr	19	1,2,3,4,16,17,22,28, 102,103,104,105,106	Total, elastic, nonelastic, total inelastic, (n,2n), (n,3n), (n,n'α), (n,n'p), (n,γ), (n,p), (n,t), (n,d), (n,^{3}He), (n,α)
1326	Fe	20	1,2,3,4,16,22,28,102, 103,104,105,106,107	Total, elastic, nonelastic, total inelastic, (n,2n), (n,n'α), (n,n'p), (n,γ), (n,p), (n,d), (n,t), (n,^{3}He), (n,α)
1328	Ni	21	1,2,4,16,22,28,51-76, 91,102,103,104,107, 111	Total, elastic, total inelastic, (n,2n), (n,n'α), (n,n'p), inelastic levels 1-26, inelastic continuum, (n,γ), (n,p), (n,d), (n,α), (n,2p)
1326	Cu(Fe)	20	1,2,3,4,16,17,22,28, 102,103,104,106,107	Total, elastic, nonelastic, total inelastic, (n,2n), (n,3n), (n,n'α), (n,n'p), (n,γ), (n,p), (n,d), (n,^{3}He), (n,α)
1382	W(Pb)	22	1,2,3,4,16,17,51,52, 64,102	Total, elastic, nonelastic, total inelastic, (n,2n), (n,3n), inelastic levels 1, 2, and 14, (n,γ)

TABLE II

MEDIAN ENERGIES (E'_M, IN MEV) AND FRACTIONAL UNCERTAINTIES (F) FOR SECONDARY ENERGY DISTRIBUTIONS AT INCIDENT NEUTRON ENERGIES E_0

E_o	^{12}C		^{16}O		Cr		Fe		Ni		Cu		W	
	E'_m	F	E'_m	F	E'_m	F	E'_m	F	E'_m	F	E'_m	F	E'_m	F
16.0	14.71	0.071	14.62	0.088	3.27	0.17	4.49	0.11	14.95	0.13	3.42	0.11	1.86	0.12
14.25	13.00	0.059	13.33	0.072	8.65	0.15	5.99	0.10	13.97	0.11	3.51	0.10	2.17	0.10
12.75	11.71	0.054	11.93	0.062	11.42	0.13	11.17	0.10	12.67	0.11	4.30	1.10	1.91	0.10
11.00	9.77	0.060	9.82	0.057	10.48	0.11	10.57	0.09	10.91	1.10	10.42	0.09	1.57	0.09
8.90	7.35	0.048	7.90	0.050	8.79	0.09	8.77	0.08	8.85	0.09	8.81	0.08	1.24	0.08
6.93	5.96	0.035	6.04	0.030	6.83	0.08	6.86	0.07	6.88	0.08	6.86	0.07	6.66	0.07
4.88	4.46	0.010	4.57	0.010	4.81	0.07	4.81	0.07	4.83	0.07	4.82	0.07	4.83	0.07
3.27	2.63	0.010	3.09	0.010	3.21	0.06	3.21	0.06	3.24	0.06	3.22	0.06	3.25	0.06
2.55	2.16	0.010	2.31	0.010	2.48	0.05	2.49	0.06	2.49	0.05	2.50	0.06	2.51	0.06
1.99	1.73	0.005	1.79	0.010	1.93	0.04	1.93	0.06	1.94	0.04	1.94	0.06	1.96	0.05
1.55	1.34	0.005	1.35	0.010	1.50	0.03	1.51	0.05	1.50	0.03	1.51	0.05	1.51	0.05
1.09	0.95	0.005	0.94	0.010	1.05	0.02	1.06	0.03	1.06	0.02	1.06	0.03	1.06	0.05
0.66	0.57	0.005	0.60	0.010	0.64	0.02	0.63	0.02			0.64	0.02	0.66	0.04
0.40	0.35	0.005	0.34	0.010			0.39	0.02			0.39	0.02	0.38	0.03
0.24	0.21	0.005	0.22	0.010							0.24	0.02	0.22	0.02
0.13	0.12	0.005	0.12	0.010							0.12	0.02	0.12	0.01

total neutron emission spectra for each of the elements present. The relative errors were determined by adding in quadrature separate error components due to elastic and nonelastic neutron reactions.

The elastic scattering components are based upon the evaluated errors given in the ENDF/B-V files for ^{12}C, ^{16}O, and Fe, and upon our estimates of these errors for the other materials. Typically, the elastic uncertainty is approximately 8% near 14 MeV and gradually reduces to a few percent near the inelastic threshold. These errors are significantly smaller in the case of ^{12}C, which is used as a standard in neutron scattering experiments.

The nonelastic neutron spectrum errors were determined by combining quadratically a 15% component assumed to exist for all materials at all energies and a second component based on comparisons with the 14-MeV spectrum measurements of Hermsdorf et al[23] and Clayeux and Voignier.[24] This latter component was included to roughly account for variations in the accuracy of the individual evaluations. Only in the cases of Cr and Ni did the addition of the second component significantly change the total SED uncertainty. It should be mentioned that significant differences also exist between the measured and calculated spectra for W, as has been shown by Hetrick et al.[25] In averaging over the "hot" (or "cold") portions of the 14-MeV spectrum for W, however, a significant fraction of this spectrum difference disappears. This cancellation indicates one of the problems inherent in using such a coarse representation of SED errors.

IV. NUCLEONICS ANALYSIS FOR GA'S TNS REACTOR CONCEPT (PGFR)

General Atomic's TNS ("The Next Step") reactor design, also labelled Power Generating Fusion Reactor[(6)], has been selected as a representative model for all TNS reactor concepts; Fig. 1 shows a cut-away view of the PGFR. A nuclear analysis for this reactor has been performed by General Atomic (GA) and is documented in Ref. 7, which has been issued as Vol. IV of Ref. 6. In this analysis GA identifies as the three most critical nuclear design parameters (1) the radiation damage to the superconducting TF-coil's stabilizing matrix, (2) the radiation damage to the alumina insulator in the F-coil, and (3) the nuclear heating in the superconducting TF-coil. Two one-dimensional models have been employed in the GA nucleonic analysis, an inboard and an outboard model. However, the inboard calculations were sufficient to identify the above three most critical parameters. Therefore, we selected for our data assessment task the PGFR inboard nucleonics

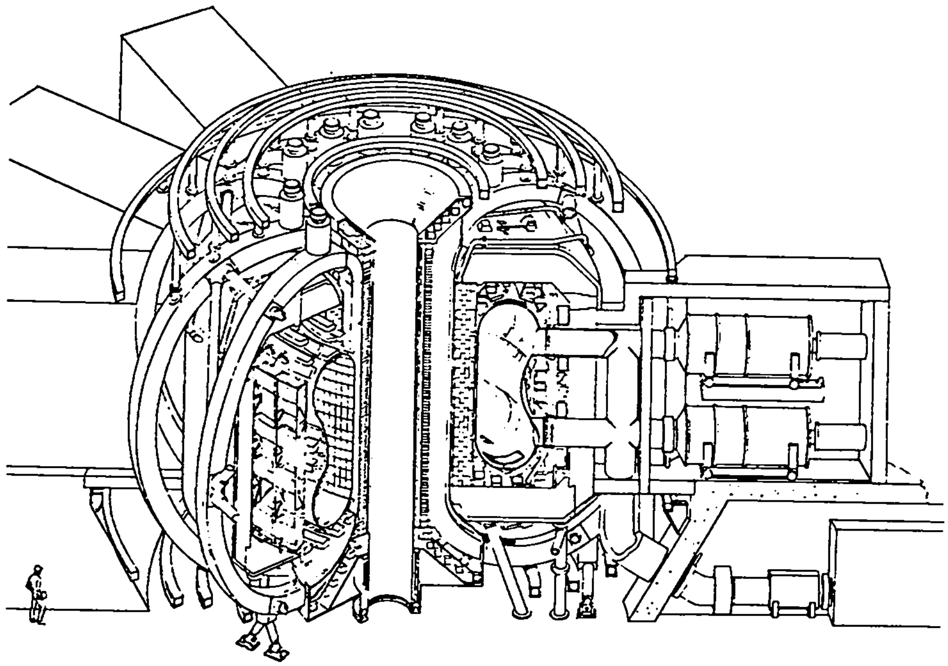

Fig. 1. General Atomic's Power Generating Fusion Reactor (PGFR)

ZONE	INSULATION	SUPPORT	E COILS	He COOLANT	TF COIL	GAP	TANK WALL	SHIELD		F-COIL / COOLANT CHANNEL		TANK WALL	GAP	1ST WALL	GAP	GRAPHITE TILES	PLASMA AND VACUUM
					$\mathcal{R}_{1,3}$					$\mathcal{R}_2$							Q
ZONE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
DENSITY FACTOR	0.2	1.0	0.8	1.0	0.8	—	1.0	1.0	1.0	0.96	1.0	1.0	—	1.0	—	1.0	—
COMPOSITION	316 SS	316 SS	60% Cu + 40% SS	He	60% Cu + 40% 316SS	VOID	316SS	63% W + 37% H_2O	H_2O	Cu	H_2O	316SS	VOID	INC. + H_2O	VOID	C	VOID
THICKNESS (CM)	7	18	31	2	27	2	1	41	2	10	4	1	5	2	1	2	97

R (CM): 47, 54, 72, 103, 105, 132, 194, 195, 236, 238, 248, 252, 253, 258, 260, 261, 263, 360

Fig. 2. PGFR inboard nucleonics model.

model which is reproduced from Ref. 7 and shown in Fig. 2. The symbol Q represents the 14-MeV neutron source at the plasma location while the $R_{1,2,3}$ indicate the locations where the 3 critical responses are calculated for which the following response functions were chosen:

R_1 = Cu dpa in the toroidal field coil (TF-coil)
$\hat{=}$ radiation damage to the superconducting TF-coil's stabilizing Cu matrix,
R_2 = Aluminum dpa in the field-shaping coil (F-coil)
$\hat{=}$ radiation damage to the Al_2O_3 insulator in the F-coil,
R_3 = Kerma in the TF-coil
$\hat{=}$ nuclear heating in the superconducting TF-coil.

All data for the response functions as well as the multigroup cross-section sets used in the analysis, were derived from ENDF/B-V [8,9] and processed with the NJOY code system[10] into coupled neutron/gamma-ray multigroup sets with 30 neutron and 12 gamma-ray groups[11]. The resulting multigroup data library has been applied successfully at LASL to several other fusion nucleonics analyses and is therefore considered a well tested and reliable cross-section data base.

The nuclear analysis of the PGFR was performed with the LASL discrete-ordinates code ONETRAN[12] in S_8 approximation and with P_2 coupled neutron and gamma-ray cross-sections. The angular flux distributions from the forward ONETRAN run and the three adjoint runs (one for each of the above response functions) were then used in the LASL sensitivity and uncertainty analysis code SENSIT[13] to compute the relevant sensitivity profiles and response uncertainties.

V. QUANTITATIVE RESULTS

Uncertainties in the three critical design parameters $R_{1,2,3}$ were calculated with SENSIT in two independent stages. First the response uncertainties due to uncertainties in neutron reaction cross-sections were calculated via Eqs. (1) and (2), and then, in a second stage, the additional response uncertainties due to estimated SED uncertainties were computed via Eqs. (3) through (5).

TABLE III

TABLE FOR DEFINITION OF ID-NOS IN TERMS OF SPECIFICATION OF CROSS SECTION COVARIANCES. NOTE IN THIS VERSION,MAT1=MAT2

ID-NO	MAT1	MAT2	MT1	MT2	CROSS SECTION COVARIANCE
1	1305	1305	1	1	B10 TOTAL WITH B10 TOTAL
2	1305	1305	1	2	B10 TOTAL WITH B10 ELASTIC
3	1305	1305	1	107	B10 TOTAL WITH B10 (N,ALPHA)
4	1305	1305	2	2	B10 ELASTIC WITH B10 ELASTIC
5	1305	1305	2	107	B10 ELASTIC WITH B10 (N,ALPHA)
6	1305	1305	107	107	B10 (N,ALPHA) WITH B10 (N,ALPHA)
7	1306	1306	1	1	C TOTAL WITH C TOTAL
8	1306	1306	1	2	C TOTAL WITH C ELASTIC
9	1306	1306	2	2	C ELASTIC WITH C ELASTIC
10	1306	1306	4	4	C INELASTIC WITH C INELASTIC
11	1306	1306	107	107	C (N,ALPHA) WITH C (N,ALPHA)
12	1324	1324	1	1	CR TOTAL WITH CR TOTAL
13	1324	1324	1	2	CR TOTAL WITH CR ELASTIC
14	1324	1324	2	2	CR ELASTIC WITH CR ELASTIC
15	1324	1324	2	4	CR ELASTIC WITH CR INELASTIC
16	1324	1324	4	4	CR INELASTIC WITH CR INELASTIC
17	1324	1324	4	102	CR INELASTIC WITH CR CAPTURE
18	1324	1324	102	102	CR CAPTURE WITH CR CAPTURE
19	1326	1326	1	1	FE TOTAL WITH FE TOTAL
20	1326	1326	1	2	FE TOTAL WITH FE ELASTIC
21	1326	1326	1	102	FE TOTAL WITH FE CAPTURE
22	1326	1326	2	2	FE ELASTIC WITH FE ELASTIC
23	1326	1326	2	4	FE ELASTIC WITH FE INELASTIC
24	1326	1326	2	102	FE ELASTIC WITH FE CAPTURE
25	1326	1326	4	4	FE INELASTIC WITH FE INELASTIC
26	1326	1326	4	102	FE INELASTIC WITH FE CAPTURE
27	1326	1326	4	103	FE INELASTIC WITH FE (N,P)
28	1326	1326	4	107	FE INELASTIC WITH FE (N,ALPHA)
29	1326	1326	102	102	FE CAPTURE WITH FE CAPTURE
30	1326	1326	103	103	FE (N,P) WITH FE (N,P)
31	1326	1326	107	107	FE (N,ALPHA) WITH FE (N,ALPHA)
32	1328	1328	1	1	NI TOTAL WITH NI TOTAL
33	1328	1328	2	2	NI ELASTIC WITH NI ELASTIC
34	1328	1328	4	4	NI INELASTIC WITH NI INELASTIC
35	1328	1328	102	102	NI CAPTURE WITH NI CAPTURE
36	1328	1328	103	103	NI (N,P) WITH NI (N,P)
37	1329	1329	1	1	CU TOTAL WITH CU TOTAL
38	1329	1329	1	2	CU TOTAL WITH CU ELASTIC
39	1329	1329	2	2	CU ELASTIC WITH CU ELASTIC
40	1329	1329	2	4	CU ELASTIC WITH CU INELASTIC
41	1329	1329	4	4	CU INELASTIC WITH CU INELASTIC
42	1329	1329	4	102	CU INELASTIC WITH CU CAPTURE
43	1329	1329	4	103	CU INELASTIC WITH CU (N,P)
44	1329	1329	4	107	CU INELASTIC WITH CU (N,ALPHA)
45	1329	1329	102	102	CU CAPTURE WITH CU CAPTURE
46	1329	1329	103	103	CU (N,P) WITH CU (N,P)
47	1329	1329	107	107	CU (N,ALPHA) WITH CU (N,ALPHA)
48	1382	1382	1	1	PB TOTAL WITH PB TOTAL
49	1382	1382	1	2	PB TOTAL WITH PB ELASTIC
50	1382	1382	1	102	PB TOTAL WITH PB CAPTURE
51	1382	1382	2	2	PB ELASTIC WITH PB ELASTIC
52	1382	1382	2	4	PB ELASTIC WITH PB INELASTIC
53	1382	1382	4	4	PB INELASTIC WITH PB INELASTIC
54	1382	1382	4	102	PB INELASTIC WITH PB CAPTURE
55	1382	1382	102	102	PB CAPTURE WITH PB CAPTURE
56	1301	1301	1	1	H TOTAL WITH H TOTAL
57	1301	1301	1	2	H TOTAL WITH H ELASTIC
58	1301	1301	2	2	H ELASTIC WITH H ELASTIC

A. Response Uncertainties caused by Reaction Cross-Section Uncertainties

A total of 24 SENSIT runs were performed to compute $\Delta R_k/R_k$ cause by reaction cross-section uncertainties which are given as relative covariance matrices for pairs of partial reaction cross-sections. Table III gives a listing of these covariance matrices and identifies the relevant pairs of partial cross-sections by ID-numbers. Partial cross-sections for one material were only paired with partials for the same material because it is assumed that the cross-section uncertainties for one material are uncorrelated with those for another material.

However, certain materials are present in more than one spatial zone of the PGFR design; cf. Fig. 2. For example, chromium is present in the first wall, in all stainless steel structural walls and in the TF and E coils, but with a different number density in each zone. Therefore, to simplify the interpretation of our results, we report contributions to response uncertainties due to cross-section uncertainties by material zones as defined by their operational function, like Cr in the first wall, or in all SS walls, or in all coil structures, etc.

Appendix A gives detailed results of our cross-section uncertainty analysis for those response uncertainty components which exceed a 10% standard deviation. The sensitivity profiles for each of the two partial cross-sections of each pair are also given in these tables. A summary of all calculated response uncertainties due to all cross-section uncertainties is given in Table IV. All standard deviations in Table IV per material (i) and zone (j) are obtained by quadratically summing the standard deviations caused by all partial cross-sections for that material according to Eq. (2). The overall response uncertainties for $R_{1,2,3}$ due to all reaction cross-section uncertainties are given in the bottom line of Table IV. Large standard deviations of 71.9% and 125.2% are predicted for the responses R_1 and R_3, respectively. In both cases the largest contributions originate from cross-section uncertainties in Cr, W, Cu, and Ni. However, due to the unavailability of evaluated cross-section uncertainty data for Cu and W we substituted the covariance data for these materials with those for Fe and Pb, as was explained in Section IIIA. These substitutions are thought to be optimistic in the sense that the Fe and Pb covariances are probably generally smaller than such data would be for Cu and W. Therefore, we feel these substitutions do not seriously weaken our conclusions that the Cu and W cross section data are serious sources of uncertainty in the R_1 and R_3 responses.

TABLE IV

PREDICTED RESPONSE UNCERTAINTIES (STANDARD DEVIATION)
DUE TO ESTIMATED CROSS-SECTION UNCERTAINTIES

CROSS SECT.		Response Uncertainties, in percent					
MAT. (i)	ZONE (j)	100x $\left(\frac{\Delta R_1}{R_1}\right)_{i,j}$	$\left(\frac{\Delta R_1}{R_1}\right)^*_i$	100x $\left(\frac{\Delta R_2}{R_2}\right)_{i,j}$	$\left(\frac{\Delta R_2}{R_2}\right)^*_i$	100x $\left(\frac{\Delta R_3}{R_3}\right)_{i,j}$	$\left(\frac{\Delta R_3}{R_3}\right)^*_i$
C	TILES	1.69	1.69	2.05	2.05	1.70	1.70
Cr	FIRST WALL	0.38		0.47		0.38	
	SS WALLS	0.13	28.7	0.04	0.47	5.3	98.3
	TF+E COILS	28.7		$6x10^{-10}$		98.2	
Ni	FIRST WALL	1.79		2.21		1.79	
	SS WALLS	1.81	6.91	0.78	2.34	1.5	24.9
	TF+E COILS	6.43		$9x10^{-9}$		24.8	
Fe	FIRST WALL	0.18		0.22		0.18	
	SS WALLS	2.61	14.1	1.67	1.68	2.46	15.99
	TF+E COILS	13.9		$2x10^{-8}$		15.8	
Cu	F-COIL	3.68	33.0	4.80	4.80	3.66	45.3
	TF+E COILS	32.8		$8x10^{-9}$		45.1	
W	SHIELD	54.0	54.0	0.196	0.196	54.3	54.3
H	FIRST WALL	0.07		1.11		0.073	
	H_2O COOLT.	0.49	5.74	0.76	0.77	0.50	8.71
	SHIELD	5.72		0.066		8.7	
O	FIRST WALL	0.25		0.28		0.25	
	H_2O COOLT.	1.51	7.67	1.01	1.05	1.50	7.65
	SHIELD	7.52		0.014		7.5	
ALL*			71.9		6.12		125.1

*) quadratic sums

B. Response Uncertainties caused by SED Uncertainties

In a second series of 24 computer runs with SENSIT (in SED anaylsis mode ITYP = 3)[13], the additional response uncertainties $\Delta R_k/R_k$ due to estimated uncertainties in secondary energy distributions were evaluated according to Eqs. (3) and (5). Integral SED uncertainties $f_{\ell,g'}$ between 0.5% and 17% were used as input, as specified in Table II, for incident neutron energies between 16 and 0.13 MeV.

Appendix B gives the detailed results of our SED uncertainty analysis for those calculated response uncertainties which exceed a 10% standard deviation. Integral SED-sensitivity coefficients S^{SED}, together with S^{SED}_{HOT} and S^{SED}_{COLD} according to Eq. (4), are also given in Appendix B for each incident energy group. All calculated response uncertainties due to all SED uncertainties are summarized in Table V by material (i) and zone (j). It should be noted that in this case no substitutions of cross-section or uncertainty files were performed as was necessary for the copper and tungsten reaction cross-section uncertainty analysis. The largest response uncertainties due to SED uncertainties are calculated for R_1 (33.1%) and R_3(37.1%) which are both mainly due to Cu and W SED uncertainties, each contributing between 23 and 28% in $\Delta R/R$.

A note of caution must be added here, which should be taken into consideration when the results of this SED uncertainty analysis are interpreted. As mentioned in Section III.B, the integral SED uncertainties were estimated for the composite secondary energy distributions of elastic and nonelastic reactions, which resulted in the fairly low spectral shape uncertainty parameters $f_{\ell,g'}$ listed in Table II. In addition, such composite SED's often exhibit two distinctly separated peaks, one due to the elastically scattered secondaries peaking fairly close to the incident neutron energy, and the second at much lower energies due to nonelastic emission neutrons. In these situations it is questionable how adequate the SED uncertainties can be realistically described by the simple hot/cold concept which is the basis for our anaylsis[(5)]. Quite possibly this concept may result in too coarse a representation and may therefore underestimate the real response uncertainties due to SED uncertainties. This potential inadequacy could be remedied, however, if SED uncertainties were treated separately for individual partial cross-sections.

C. Total Response Uncertainties due to all Data Uncertainties

Summary Tables IV and V give the calculated response uncertainties by material as defined in Eqs. (2) and (5), respectively. In Table VI we compare the

TABLE V

PREDICTED RESPONSE UNCERTAINTIES (STANDARD DEVIATION)
DUE TO ESTIMATED SED UNCERTAINTIES

CROSS SECT.		Response Uncertainties, in percent					
MAT. (i)	ZONE (j)	100x $\left(\frac{\Delta R_1}{R_1}\right)_{i,j}$	$\left(\frac{\Delta R_1}{R_1}\right)^*_i$	100x $\left(\frac{\Delta R_2}{R_2}\right)_{i,j}$	$\left(\frac{\Delta R_2}{R_2}\right)^*_i$	100x $\left(\frac{\Delta R_3}{R_3}\right)_{i,j}$	$\left(\frac{\Delta R_3}{R_3}\right)^*_i$
C	TILES	0.41	0.41	0.26	0.26	0.41	0.41
Cr	FIRST WALL	0.24		0.27		0.24	
	SS WALLS	0.33	1.17	0.23	0.35	0.31	0.86
	TF+E COILS	1.10		$2x10^{-10}$		0.76	
Ni	FIRST WALL	0.79		0.74		0.79	
	SS WALLS	0.31	0.86	0.08	0.75	0.13	0.85
	TF+E COILS	0.31		$1x10^{-10}$		0.28	
Fe	FIRST WALL	0.06		0.07		0.06	
	SS WALLS	0.94	6.57	0.51	0.52	0.84	4.58
	TF+E COILS	6.50		$6x10^{-10}$		4.50	
Cu	F-COIL	5.2	26.1	10.1	10.1	5.2	28.0
	TF+E COILS	25.6		$1x10^{-9}$		27.5	
W	SHIELD	23.5	23.5	0.37	0.37	23.9	23.9
H	FIRST WALL	0.10		0.07		0.09	
	H_2O COOLT.	0.39	0.99	0.36	0.37	0.39	1.03
	SHIELD	0.90		0.01		0.95	
O	FIRST WALL	0.11		0.10		0.11	
	H_2O COOLT.	0.45	1.05	0.46	0.47	0.46	1.13
	SHIELD	0.94		0.02		1.03	
ALL*			33.1		10.2		37.1

*) quadratic sums

TABLE VI

TOTAL RESPONSE UNCERTAINTIES (STANDARD DEVIATION)
DUE TO ALL DATA UNCERTAINTIES

Input Cross-Section Data	Response Uncertainties in precent		
	$\frac{\Delta R_1}{R_1} x\ 100$	$\frac{\Delta R_1}{R_2} x\ 100$	$\frac{\Delta R_1}{R_3} x100$
All C due to XS-Uncert.	1.69	2.05	1.70
due to SED-Uncert.	0.41	0.26	0.41
All Cr due to XS-Uncert.	28.7	0.46	98.3
due SED-Uncert.	1.17	0.35	0.86
All Ni due to XS-Uncert.	6.91	2.34	24.9
due to SED-Uncert.	0.86	0.75	0.85
All Fe due to XS-Uncert.	14.1	1.68	15.99
due to SED-Uncert.	6.57	0.52	4.58
All Cu due to XS-Uncert.	33.0	4.80	45.3
due to SED-Uncert.	26.1	10.1	28.0
All W due to XS-Uncert.	54.0	0.20	54.3
due to SED-Uncert.	23.5	0.37	23.9
All H due to XS-Uncert.	5.74	0.77	8.71
due to SED-Uncert.	0.99	0.37	1.03
All O due to XS-Uncert.	7.67	1.05	7.65
due to SED-Uncert.	1.05	0.47	1.13
All*	79.2	11.9	130.6

*) quadratic sums

calculated response uncertainties due to cross-section uncertainties with those due to SED uncertainties per material. We note that in almost all cases the response uncertainties due to SED uncertainties are smaller than those due to reaction cross-section uncertainties.

The total response uncertainties due to all data uncertainties were calculated using Eq. (6), which assumes all individual results summarized in Table VI are uncorrelated and may be summed quadratically by column. The large total response uncertainties of 79% for R_1 and 130% for R_3 are reasons for concern in a real design environment. In our conclusion we recommend, therefore, that certain cross-section files including the SED data, and certain covariance files, be re-evaluated. However, if such re-evaluations or re-measurements should result in only insignificantly lower response uncertainties, then some additional conservatism might have to be built into future blanket and shield designs.

VI. CONCLUSIONS AND RECOMMENDATIONS

In general, when a cross-section uncertainty analysis is performed with presently available codes and data, some care must be taken in the interpretation of the results. Specifically, it must be recognized that considerable uncertainty generally exists in the covariance files with the result that fairly large errors are possible in the calculated response uncertainties themselves. Additionally, any conclusions regarding the adequacy of nuclear data for a particular application requires a statement as to what errors are tolerable in the calculated responses. For the conclusions below we have assumed that response uncertainties greater than $\sim$ 25% are not acceptable.

With these qualifications in mind, the main conclusions drawn from this PGFR cross-section and SED uncertainty analysis are the following:

1. The quadratic combination of the worst case response uncertainties (R_3) for H, C, and O results in a combined uncertainty of less than 13%. Therefore, the existing ENDF/B-V neutron cross-section files for these materials, including SED data, appear to be fully adequate for this application.
2. The calculated R_3 response uncertainties for Ni and Fe are 25% and 17%, respectively, with the major components resulting from cross-section

uncertainties. The data for these materials therefore appear to be marginally adequate for the present application, although some further reduction in uncertainty would probably be desirable.

3. The W cross-section data are probably inadequate, as indicated by a calculated response uncertainty of 54% for both R_1 and R_3. This conclusion must be qualified somewhat because Pb covariance data were used in the W analysis. However, an examination of the Pb covariance file suggests strongly that this qualitative conclusion would stand even if W covariances were available. Additionally, the calculated 24% response uncertainties in R_1 and R_3 due to tungsten SED uncertainties alone indicate a need for improved data. It is recommended, therefore, that as a first step the cross-section and uncertainty files for W be re-evaluated to include the most recent experimental results.

4. For Cu the cross-section as well as the SED data appear inadequate because they produce response uncertainties in R_1 and R_3 between 26 and 45%. Specifically, large sensitivities are obtained for the elastic and total copper cross-sections (see Appendix A) and SED's (see Appendix B) in the energy range from 1.3 keV to 1.3 MeV. These cross-sections and secondary energy distributions are recommended for re-evaluation and possibly re-measurement. Again, these conclusions are subject to a similar qualification as was given for the W results in that Fe covariance data were used in the absense of such data for Cu. As with tungsten, however, we believe the qualitative conclusions for Cu are valid.

5. The cross-section data for Cr appear grossly inadequate because they produce an almost 100% uncertainty in R_3, while the SED data are found fully adequate. The main contribution to the 98% standard deviation is from the Cr total and elastic cross-sections (compare Appendix A). While the sensitivity of R_3 to the Cr total and elastic cross-sections is roughly a factor of 10 lower than the sensitivity of R_3 to the copper cross-sections, the uncertainty estimates for Cr are much larger than those for Cu. We recommend, therefore, first a re-evaluation of the covariance files for the total and elastic chromium cross-sections, and secondly, if the new uncertainty estimates are not substantially lower, a re-evaluation of the Cr cross-sections themselves.

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APPENDIX A

In this appendix we reproduce 24 tables from the detailed SENSIT printouts for those cases of our reaction cross-section uncertainty analysis where response uncertainties greater than 10% have been obtained. The ID-numbers at the top of the tables identify the cross-section pair for which correlated uncertainties in the form of a covariance matrix have been used in the uncertainty analysis, as listed in Table III. The sensitivity profiles for each of the two reaction cross-sections of each pair are also given as P1(G) and P2(G), which are printed per lethargy interval width DELTA-U.

TNS(PGFR) XS-SENS.ANAL. FOR R1-DPA ADJ. * TF+E COILS * I56:CR,NI,FE,CU

Cr(tot, tot)

************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 12 **************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 4.80458E+00
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 5.02000E-03 AND NDEN2 = 5.02000E-03

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-3.604E-01	-3.604E-01
3	1.350E+07	1.18E-01	-1.123E-01	-1.123E-01
4	1.200E+07	1.82E-01	-3.654E-02	-3.654E-02
5	1.000E+07	2.50E-01	-3.007E-02	-3.007E-02
6	7.790E+06	2.49E-01	-2.975E-02	-2.975E-02
7	6.070E+06	5.00E-01	-2.936E-02	-2.936E-02
8	3.680E+06	2.50E-01	-4.754E-02	-4.754E-02
9	2.865E+06	2.50E-01	-6.988E-02	-6.988E-02
10	2.232E+06	2.50E-01	-8.550E-02	-8.550E-02
11	1.738E+06	2.50E-01	-1.105E-01	-1.105E-01
12	1.353E+06	4.97E-01	-2.340E-01	-2.340E-01
13	8.230E+05	4.98E-01	-6.011E-01	-6.011E-01
14	5.000E+05	5.01E-01	-6.642E-01	-6.642E-01
15	3.030E+05	4.99E-01	-2.841E-01	-2.841E-01
16	1.840E+05	1.00E+00	-3.680E-01	-3.680E-01
17	6.760E+04	1.00E+00	-5.192E-02	-5.192E-02
18	2.480E+04	1.00E+00	-1.367E-02	-1.367E-02
19	9.120E+03	1.00E+00	-3.582E-02	-3.582E-02
20	3.350E+03	9.98E-01	-4.791E-03	-4.791E-03
21	1.235E+03	1.00E+00	-1.343E-04	-1.343E-04
22	4.540E+02	1.00E+00	-8.179E-05	-8.179E-05
23	1.670E+02	1.00E+00	-5.581E-05	-5.581E-05
24	6.140E+01	9.99E-01	-4.326E-05	-4.326E-05
25	2.260E+01	9.99E-01	-2.666E-05	-2.666E-05
26	8.320E+00	1.00E+00	-1.344E-05	-1.344E-05
27	3.060E+00	9.96E-01	-6.471E-06	-6.471E-06
28	1.130E+00	1.00E+00	-2.949E-06	-2.949E-06
29	4.140E-01	1.00E+00	-1.404E-06	-1.404E-06
30	1.520E-01	1.11E+00	-1.399E-07	-1.399E-07
			----------	----------
INTEGRAL			-1.531E+00	-1.531E+00

*********************** AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ***********************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 2.749E-02
RELATIVE STANDARD DEVIATION = DR/R = 1.658E-01
= 1.658E+01 PER CENT

TNS(PGFR) XS-SENS.ANAL. FOR R1-DPA ADJ. * TF+E COILS * I56: CR,NI,FE,CU

Cr(tot, el.)

************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 13 **************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 4.80458E+00
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 5.02000E-03 AND NDEN2 = 5.02000E-03

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-3.604E-01	-1.639E-01
3	1.350E+07	1.18E-01	-1.123E-01	-5.424E-02
4	1.200E+07	1.82E-01	-3.654E-02	-1.873E-02
5	1.000E+07	2.50E-01	-3.007E-02	-1.678E-02
6	7.790E+06	2.49E-01	-2.975E-02	-1.743E-02
7	6.070E+06	5.00E-01	-2.936E-02	-1.783E-02
8	3.680E+06	2.50E-01	-4.754E-02	-3.379E-02
9	2.865E+06	2.50E-01	-6.988E-02	-5.268E-02
10	2.232E+06	2.50E-01	-8.550E-02	-7.058E-02
11	1.738E+06	2.50E-01	-1.105E-01	-1.006E-01
12	1.353E+06	4.97E-01	-2.340E-01	-2.202E-01
13	8.230E+05	4.98E-01	-6.011E-01	-5.975E-01
14	5.000E+05	5.01E-01	-6.642E-01	-6.635E-01
15	3.030E+05	4.99E-01	-2.841E-01	-2.838E-01
16	1.840E+05	1.00E+00	-3.680E-01	-3.675E-01
17	6.760E+04	1.00E+00	-5.192E-02	-5.173E-02
18	2.480E+04	1.00E+00	-1.367E-02	-1.356E-02
19	9.120E+03	1.00E+00	-3.582E-02	-3.571E-02
20	3.350E+03	9.98E-01	-4.791E-03	-4.734E-03
21	1.235E+03	1.00E+00	-1.343E-04	-1.338E-04
22	4.540E+02	1.00E+00	-8.179E-05	-8.125E-05
23	1.670E+02	1.00E+00	-5.581E-05	-5.523E-05
24	6.140E+01	9.99E-01	-4.326E-05	-4.253E-05
25	2.260E+01	9.99E-01	-2.666E-05	-2.593E-05
26	8.320E+00	1.00E+00	-1.344E-05	-1.284E-05
27	3.060E+00	9.96E-01	-6.471E-06	-6.011E-06
28	1.130E+00	1.00E+00	-2.949E-06	-2.619E-06
29	4.140E-01	1.00E+00	-1.404E-06	-1.162E-06
30	1.520E-01	1.11E+00	-1.399E-07	-9.143E-08
INTEGRAL			-1.531E+00	-1.468E+00

********************** AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING **********************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 2.749E-02
RELATIVE STANDARD DEVIATION = DR/R = 1.658E-01
= 1.658E+01 PER CENT

TNS(PGFR) XS-SENS.ANAL. FOR R1-DPA ADJ. * TF+E COILS * I56:CR,NI.FE.CU

Cr(el, el.)

****************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 14 ******************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 4.89458E+00
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 5.02000E-03 AND NDEN2 = 5.02000E-03

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-1.639E-01	-1.639E-01
3	1.350E+07	1.18E-01	-5.424E-02	-5.424E-02
4	1.200E+07	1.82E-01	-1.873E-02	-1.873E-02
5	1.000E+07	2.50E-01	-1.678E-02	-1.678E-02
6	7.790E+06	2.49E-01	-1.743E-02	-1.743E-02
7	6.070E+06	5.00E-01	-1.783E-02	-1.783E-02
8	3.680E+06	2.50E-01	-3.379E-02	-3.379E-02
9	2.865E+06	2.50E-01	-5.268E-02	-5.268E-02
10	2.232E+06	2.50E-01	-7.058E-02	-7.058E-02
11	1.738E+06	2.50E-01	-1.006E-01	-1.006E-01
12	1.353E+06	4.97E-01	-2.282E-01	-2.282E-01
13	8.230E+05	4.98E-01	-5.975E-01	-5.975E-01
14	5.000E+05	5.01E-01	-6.635E-01	-6.635E-01
15	3.030E+05	4.99E-01	-2.838E-01	-2.838E-01
16	1.840E+05	1.00E+00	-3.675E-01	-3.675E-01
17	6.760E+04	1.00E+00	-5.173E-02	-5.173E-02
18	2.480E+04	1.00E+00	-1.356E-02	-1.356E-02
19	9.120E+03	1.00E+00	-3.571E-02	-3.571E-02
20	3.350E+03	9.98E-01	-4.734E-03	-4.734E-03
21	1.235E+03	1.00E+00	-1.338E-04	-1.338E-04
22	4.540E+02	1.00E+00	-8.125E-05	-8.125E-05
23	1.670E+02	1.00E+00	-5.523E-05	-5.523E-05
24	6.140E+01	9.99E-01	-4.253E-05	-4.253E-05
25	2.260E+01	9.99E-01	-2.593E-05	-2.593E-05
26	8.320E+00	1.00E+00	-1.284E-05	-1.284E-05
27	3.060E+00	9.96E-01	-6.011E-06	-6.011E-06
28	1.130E+00	1.00E+00	-2.619E-06	-2.619E-06
29	4.140E-01	1.00E+00	-1.162E-06	-1.162E-06
30	1.520E-01	1.11E+00	-9.143E-08	-9.143E-08
INTEGRAL			-1.468E+00	-1.468E+00

*********************** AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ***********************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 2.750E-02
RELATIVE STANDARD DEVIATION = DR/R = 1.658E-01
= 1.658E+01 PER CENT

TNS(PGFR) XS-SENS.ANAL. FOR P1-DPA ADJ. * TF+E COILS * 156: CR,NI,FE,CU

Cu(tot,tot)

****************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 37 ******************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 4.80458E+00
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL .
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 4.07000E-02 AND NDEN2 = 4.07000E-02

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-3.570E+00	-3.570E+00
3	1.350E+07	1.18E-01	-1.111E+00	-1.111E+00
4	1.200E+07	1.82E-01	-3.610E-01	-3.610E-01
5	1.000E+07	2.50E-01	-2.835E-01	-2.835E-01
6	7.790E+06	2.49E-01	-2.619E-01	-2.619E-01
7	6.070E+06	5.00E-01	-2.386E-01	-2.386E-01
8	3.680E+06	2.50E-01	-3.476E-01	-3.476E-01
9	2.865E+06	2.50E-01	-4.860E-01	-4.860E-01
10	2.232E+06	2.50E-01	-6.373E-01	-6.373E-01
11	1.738E+06	2.50E-01	-8.260E-01	-8.260E-01
12	1.353E+06	4.97E-01	-1.955E+00	-1.955E+00
13	8.230E+05	4.98E-01	-5.624E+00	-5.624E+00
14	5.000E+05	5.01E-01	-6.517E+00	-6.517E+00
15	3.030E+05	4.99E-01	-2.767E+00	-2.767E+00
16	1.840E+05	1.00E+00	-2.730E+00	-2.730E+00
17	6.760E+04	1.00E+00	-6.749E-01	-6.749E-01
18	2.480E+04	1.00E+00	-3.693E-01	-3.693E-01
19	9.120E+03	1.00E+00	-1.703E-01	-1.703E-01
20	3.350E+03	9.98E-01	-8.924E-02	-8.924E-02
21	1.235E+03	1.00E+00	-2.053E-03	-2.053E-03
22	4.540E+02	1.00E+00	-1.011E-03	-1.011E-03
23	1.670E+02	1.00E+00	-7.841E-04	-7.841E-04
24	6.140E+01	9.99E-01	-6.518E-04	-6.518E-04
25	2.260E+01	9.99E-01	-4.101E-04	-4.101E-04
26	8.320E+00	1.00E+00	-1.997E-04	-1.997E-04
27	3.060E+00	9.96E-01	-9.568E-05	-9.568E-05
28	1.130E+00	1.00E+00	-4.305E-05	-4.305E-05
29	4.140E-01	1.00E+00	-2.005E-05	-2.005E-05
30	1.520E-01	1.11E+00	-1.869E-06	-1.869E-06
INTEGRAL			-1.387E+01	-1.387E+01

************************** AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING **************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 3.530E-02
RELATIVE STANDARD DEVIATION = DR/R = 1.879E-01
= 1.879E+01 PER CENT

TNS(PSTD) XS-SENS.ANAL. FOR R1-DPA ADJ. * TF+E COILS * I56: CR,NI,FE,CU

Cu(tot,el)

****************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 38 ******************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 4.80458E+00
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 4.0700E-02 AND NDEN2 = 4.9700E-02

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-3.570E+00	-1.672E+00
3	1.350E+07	1.10E-01	-1.111E+00	-5.309E-01
4	1.200E+07	1.82E-01	-3.610E-01	-1.821E-01
5	1.000E+07	2.50E-01	-2.835E-01	-1.539E-01
6	7.790E+06	2.49E-01	-2.619E-01	-1.408E-01
7	6.070E+06	5.00E-01	-2.386E-01	-1.366E-01
8	3.680E+06	2.50E-01	-3.476E-01	-2.024E-01
9	2.865E+06	2.50E-01	-4.860E-01	-2.993E-01
10	2.232E+06	2.50E-01	-6.373E-01	-4.276E-01
11	1.738E+06	2.50E-01	-8.260E-01	-6.147E-01
12	1.353E+06	4.97E-01	-1.955E+00	-1.771E+00
13	8.230E+05	4.98E-01	-5.624E+00	-5.572E+00
14	5.000E+05	5.01E-01	-6.517E+00	-6.496E+00
15	3.030E+05	4.99E-01	-2.767E+00	-2.757E+00
16	1.840E+05	1.00E+00	-2.730E+00	-2.719E+00
17	6.760E+04	1.00E+00	-6.749E-01	-6.714E-01
18	2.480E+04	1.00E+00	-3.693E-01	-3.664E-01
19	9.120E+03	1.00E+00	-1.703E-01	-1.678E-01
20	3.350E+03	9.98E-01	-8.924E-02	-8.756E-02
21	1.235E+03	1.00E+00	-2.053E-03	-1.743E-03
22	4.540E+02	1.00E+00	-1.011E-03	-9.792E-04
23	1.670E+02	1.00E+00	-7.841E-04	-7.790E-04
24	6.140E+01	9.99E-01	-6.518E-04	-6.452E-04
25	2.260E+01	9.99E-01	-4.101E-04	-4.032E-04
26	8.320E+00	1.00E+00	-1.997E-04	-1.939E-04
27	3.060E+00	9.96E-01	-9.568E-05	-9.118E-05
28	1.130E+00	1.00E+00	-4.305E-05	-3.979E-05
29	4.140E-01	1.00E+00	-2.005E-05	-1.766E-05
30	1.520E-01	1.11E+00	-1.869E-06	-1.388E-06
INTEGRAL			-1.387E+01	-1.311E+01

****************************** AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ******************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 3.529E-02
RELATIVE STANDARD DEVIATION = DR/R = 1.879E-01
= 1.879E+01 PER CENT

TNS(PGFR) XS-SENS.ANAL. FOR R1-DPA ADJ. * TF+E COILS * I56: CR,NI,FE,CU

Cu(el., el.)

****************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 39 ******************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 4.80458E+00
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 4.07000E-02 AND NDEN2 = 4.07000E-02

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-1.672E+00	-1.672E+00
3	1.350E+07	1.18E-01	-5.389E-01	-5.389E-01
4	1.200E+07	1.82E-01	-1.821E-01	-1.821E-01
5	1.000E+07	2.50E-01	-1.539E-01	-1.539E-01
6	7.790E+06	2.49E-01	-1.480E-01	-1.480E-01
7	6.070E+06	5.00E-01	-1.366E-01	-1.366E-01
8	3.680E+06	2.50E-01	-2.024E-01	-2.024E-01
9	2.865E+06	2.50E-01	-2.993E-01	-2.993E-01
10	2.232E+06	2.50E-01	-4.276E-01	-4.276E-01
11	1.738E+06	2.50E-01	-6.147E-01	-6.147E-01
12	1.353E+06	4.97E-01	-1.771E+00	-1.771E+00
13	8.230E+05	4.98E-01	-5.572E+00	-5.572E+00
14	5.000E+05	5.01E-01	-6.496E+00	-6.496E+00
15	3.030E+05	4.99E-01	-2.757E+00	-2.757E+00
16	1.840E+05	1.00E+00	-2.719E+00	-2.719E+00
17	6.760E+04	1.00E+00	-6.714E-01	-6.714E-01
18	2.480E+04	1.00E+00	-3.664E-01	-3.664E-01
19	9.120E+03	1.00E+00	-1.678E-01	-1.678E-01
20	3.350E+03	9.98E-01	-8.756E-02	-8.756E-02
21	1.235E+03	1.00E+00	-1.743E-03	-1.743E-03
22	4.540E+02	1.00E+00	-9.792E-04	-9.792E-04
23	1.670E+02	1.00E+00	-7.790E-04	-7.790E-04
24	6.140E+01	9.99E-01	-6.452E-04	-6.452E-04
25	2.260E+01	9.99E-01	-4.032E-04	-4.032E-04
26	8.320E+00	1.00E+00	-1.939E-04	-1.939E-04
27	3.060E+00	9.96E-01	-9.118E-05	-9.118E-05
28	1.130E+00	1.00E+00	-3.979E-05	-3.979E-05
29	4.140E-01	1.00E+00	-1.766E-05	-1.766E-05
30	1.520E-01	1.11E+00	-1.389E-06	-1.388E-06
INTEGRAL			-1.311E+01	-1.311E+01

************************** AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 3.609E-02
RELATIVE STANDARD DEVIATION = DR/R = 1.900E-01
= 1.900E+01 PER CENT

TNS(PGFP) XS-SENS.ANAL. FOR R1-DPA ADJ. * TF+E COILS * I56: CP,NI,FE,CU

Fe (tot, tot)

************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 19 ******************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 4.80458E+00
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 1.89090E-02 AND NDEN2 = 1.89090E-02

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-1.454E+00	-1.454E+00
3	1.350E+07	1.18E-01	-4.512E-01	-4.512E-01
4	1.200E+07	1.82E-01	-1.491E-01	-1.491E-01
5	1.000E+07	2.50E-01	-1.203E-01	-1.203E-01
6	7.790E+06	2.49E-01	-1.156E-01	-1.156E-01
7	6.070E+06	5.00E-01	-1.089E-01	-1.089E-01
8	3.680E+06	2.50E-01	-1.632E-01	-1.632E-01
9	2.865E+06	2.50E-01	-2.398E-01	-2.398E-01
10	2.232E+06	2.50E-01	-2.979E-01	-2.979E-01
11	1.738E+06	2.50E-01	-3.803E-01	-3.803E-01
12	1.353E+06	4.97E-01	-7.603E-01	-7.603E-01
13	8.230E+05	4.98E-01	-2.182E+00	-2.182E+00
14	5.000E+05	5.01E-01	-2.779E+00	-2.779E+00
15	3.030E+05	4.99E-01	-1.028E+00	-1.028E+00
16	1.840E+05	1.00E+00	-9.157E-01	-9.157E-01
17	6.760E+04	1.00E+00	-3.388E-01	-3.388E-01
18	2.480E+04	1.00E+00	-2.913E-02	-2.913E-02
19	9.120E+03	1.00E+00	-5.571E-02	-5.571E-02
20	3.350E+03	9.98E-01	-1.565E-02	-1.565E-02
21	1.235E+03	1.00E+00	-1.011E-03	-1.011E-03
22	4.540E+02	1.00E+00	-7.138E-04	-7.138E-04
23	1.670E+02	1.00E+00	-5.138E-04	-5.138E-04
24	6.140E+01	9.99E-01	-3.988E-04	-3.988E-04
25	2.260E+01	9.99E-01	-2.445E-04	-2.445E-04
26	8.320E+00	1.00E+00	-1.219E-04	-1.219E-04
27	3.060E+00	9.96E-01	-5.763E-05	-5.763E-05
28	1.130E+00	1.00E+00	-2.551E-05	-2.551E-05
29	4.140E-01	1.00E+00	-1.162E-05	-1.162E-05
30	1.520E-01	1.11E+00	-1.005E-06	-1.005E-06
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INTEGRAL			-5.340E+00	-5.340E+00

************************ AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 6.317E-03
RELATIVE STANDARD DEVIATION = DR/R = 7.948E-02
= 7.948E+00 PER CENT

TNS(PGFP) XS-SENS.ANAL. FOR R1-DPA ADJ. * TF+E COILS * I56: CR,NI,FE,CU

Fe(tot, el)

****************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 20 ******************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R.PHI) = 4.80458E+00
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 1.89[illegible]E-02 AND NDEN2 = 1.8[illegible]E-02

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-1.454E+00	-6.624E-01
3	1.350E+07	1.18E-01	-4.512E-01	-2.154E-01
4	1.200E+07	1.82E-01	-1.491E-01	-7.494E-02
5	1.000E+07	2.50E-01	-1.203E-01	-6.497E-02
6	7.790E+06	2.49E-01	-1.156E-01	-6.591E-02
7	6.070E+06	5.00E-01	-1.089E-01	-6.351E-02
8	3.680E+06	2.50E-01	-1.632E-01	-1.058E-01
9	2.865E+06	2.50E-01	-2.398E-01	-1.745E-01
10	2.232E+06	2.50E-01	-2.979E-01	-2.163E-01
11	1.738E+06	2.50E-01	-3.803E-01	-2.911E-01
12	1.353E+06	4.97E-01	-7.603E-01	-6.694E-01
13	8.230E+05	4.98E-01	-2.182E+00	-2.177E+00
14	5.000E+05	5.01E-01	-2.779E+00	-2.776E+00
15	3.030E+05	4.99E-01	-1.028E+00	-1.026E+00
16	1.840E+05	1.00E+00	-9.157E-01	-9.136E-01
17	6.760E+04	1.00E+00	-3.388E-01	-3.383E-01
18	2.480E+04	1.00E+00	-2.913E-02	-2.904E-02
19	9.120E+03	1.00E+00	-5.571E-02	-5.562E-02
20	3.350E+03	9.98E-01	-1.565E-02	-1.564E-02
21	1.235E+03	1.00E+00	-1.011E-03	-9.859E-04
22	4.540E+02	1.00E+00	-7.138E-04	-7.122E-04
23	1.670E+02	1.00E+00	-5.138E-04	-5.121E-04
24	6.140E+01	9.99E-01	-3.988E-04	-3.966E-04
25	2.260E+01	9.99E-01	-2.445E-04	-2.422E-04
26	8.320E+00	1.00E+00	-1.219E-04	-1.201E-04
27	3.060E+00	9.96E-01	-5.763E-05	-5.620E-05
28	1.130E+00	1.00E+00	-2.551E-05	-2.449E-05
29	4.140E-01	1.00E+00	-1.162E-05	-1.086E-05
30	1.520E-01	1.11E+00	-1.005E-06	-8.544E-07
INTEGRAL			-5.348E+00	-5.048E+00

************************ AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 6.317E-03
RELATIVE STANDARD DEVIATION = DR/R = 7.948E-02
= 7.948E+00 PER CENT

TNS(PGFR) XS-SENS.ANAL. FOR R1-DPA ADJ. * TF+E COILS *·I56: CR,NI,FE,CU

Fe(inel, el.)

****************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 22 ******************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 4.80458E+00
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 1.89000E-02 AND NDEN2 = 1.89000E-02

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-6.624E-01	-6.624E-01
3	1.350E+07	1.18E-01	-2.154E-01	-2.154E-01
4	1.200E+07	1.82E-01	-7.494E-02	-7.494E-02
5	1.000E+07	2.50E-01	-6.497E-02	-6.497E-02
6	7.790E+06	2.49E-01	-6.591E-02	-6.591E-02
7	6.070E+06	5.00E-01	-6.351E-02	-6.351E-02
8	3.680E+06	2.50E-01	-1.058E-01	-1.058E-01
9	2.865E+06	2.50E-01	-1.745E-01	-1.745E-01
10	2.232E+06	2.50E-01	-2.163E-01	-2.163E-01
11	1.738E+06	2.50E-01	-2.911E-01	-2.911E-01
12	1.353E+06	4.97E-01	-6.694E-01	-6.694E-01
13	8.230E+05	4.98E-01	-2.177E+00	-2.177E+00
14	5.000E+05	5.01E-01	-2.776E+00	-2.776E+00
15	3.030E+05	4.99E-01	-1.026E+00	-1.026E+00
16	1.840E+05	1.00E+00	-9.136E-01	-9.136E-01
17	6.760E+04	1.00E+00	-3.383E-01	-3.383E-01
18	2.480E+04	1.00E+00	-2.904E-02	-2.904E-02
19	9.120E+03	1.00E+00	-5.562E-02	-5.562E-02
20	3.350E+03	9.98E-01	-1.564E-02	-1.564E-02
21	1.235E+03	1.00E+00	-9.859E-04	-9.859E-04
22	4.540E+02	1.00E+00	-7.122E-04	-7.122E-04
23	1.670E+02	1.00E+00	-5.121E-04	-5.121E-04
24	6.140E+01	9.99E-01	-3.966E-04	-3.966E-04
25	2.260E+01	9.99E-01	-2.422E-04	-2.422E-04
26	8.320E+00	1.00E+00	-1.201E-04	-1.201E-04
27	3.060E+00	9.96E-01	-5.620E-05	-5.620E-05
28	1.130E+00	1.00E+00	-2.449E-05	-2.449E-05
29	4.140E-01	1.00E+00	-1.086E-05	-1.086E-05
30	1.520E-01	1.11E+00	-8.544E-07	-8.544E-07
INTEGRAL			-5.048E+00	-5.048E+00

************************ AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 6.478E-03
RELATIVE STANDARD DEVIATION = DR/R = 8.049E-02
= 8.049E+00 PER CENT

SENSIT SAMPLE 8. *FUSION REACTOR*VECTOR-XS.SEN+UNCERT.*RUN76: CR, NI, FE, CU

Cr (tot, tot)

****************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 12 ******************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R.PHI) = 1.12278E+04
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 5.02000E-03 AND NDEN2 = 5.02000E-03

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-3.186E-01	-3.186E-01
3	1.350E+07	1.18E-01	-1.071E-01	-1.071E-01
4	1.200E+07	1.82E-01	-3.735E-02	-3.735E-02
5	1.000E+07	2.50E-01	-2.811E-02	-2.811E-02
6	7.790E+06	2.49E-01	-2.522E-02	-2.522E-02
7	6.070E+06	5.00E-01	-2.191E-02	-2.191E-02
8	3.680E+06	2.50E-01	-3.254E-02	-3.254E-02
9	2.865E+06	2.50E-01	-4.448E-02	-4.448E-02
10	2.232E+06	2.50E-01	-5.191E-02	-5.191E-02
11	1.738E+06	2.50E-01	-6.916E-02	-6.916E-02
12	1.353E+06	4.97E-01	-1.403E-01	-1.403E-01
13	8.230E+05	4.98E-01	-3.153E-01	-3.153E-01
14	5.000E+05	5.01E-01	-5.170E-01	-5.170E-01
15	3.030E+05	4.99E-01	-4.105E-01	-4.105E-01
16	1.840E+05	1.00E+00	-8.189E-01	-8.189E-01
17	6.760E+04	1.00E+00	-3.433E-01	-3.433E-01
18	2.480E+04	1.00E+00	-1.914E-01	-1.914E-01
19	9.120E+03	1.00E+00	-1.415E+00	-1.415E+00
20	3.350E+03	9.98E-01	-3.159E-01	-3.159E-01
21	1.235E+03	1.00E+00	-4.703E-02	-4.703E-02
22	4.540E+02	1.00E+00	-3.094E-02	-3.094E-02
23	1.670E+02	1.00E+00	-2.874E-02	-2.874E-02
24	6.140E+01	9.99E-01	-2.356E-02	-2.356E-02
25	2.260E+01	9.99E-01	-1.575E-02	-1.575E-02
26	8.320E+00	1.00E+00	-8.983E-03	-8.983E-03
27	3.060E+00	9.96E-01	-4.271E-03	-4.271E-03
28	1.130E+00	1.00E+00	-1.592E-03	-1.592E-03
29	4.140E-01	1.00E+00	-4.703E-04	-4.703E-04
30	1.520E-01	1.11E+00	-1.088E-04	-1.088E-04
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INTEGRAL			-4.067E+00	-4.067E+00

************************** AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING **************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 3.216E-01
RELATIVE STANDARD DEVIATION = DR/R = 5.671E-01
= 5.671E+01 PER CENT

SENSIT SAMPLE 8. *FUSION REACTOR*VECTOR-XS.SEN+UNCERT.*RUN76: CR, NI, FE, CU

Cr(tot, el.)

****************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 13 ******************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R.PHI) = 1.12270E+04
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 5.02000E-03 AND NDEN2 = 5.02000E-03

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-3.186E-01	-1.449E-01
3	1.350E+07	1.18E-01	-1.071E-01	-5.174E-02
4	1.200E+07	1.82E-01	-3.735E-02	-1.915E-02
5	1.000E+07	2.50E-01	-2.811E-02	-1.569E-02
6	7.790E+06	2.49E-01	-2.522E-02	-1.477E-02
7	6.070E+06	5.00E-01	-2.191E-02	-1.331E-02
8	3.680E+06	2.50E-01	-3.254E-02	-2.313E-02
9	2.865E+06	2.50E-01	-4.448E-02	-3.354E-02
10	2.232E+06	2.50E-01	-5.191E-02	-4.286E-02
11	1.738E+06	2.50E-01	-6.916E-02	-6.298E-02
12	1.353E+06	4.97E-01	-1.403E-01	-1.368E-01
13	8.230E+05	4.98E-01	-3.153E-01	-3.134E-01
14	5.000E+05	5.01E-01	-5.170E-01	-5.164E-01
15	3.030E+05	4.99E-01	-4.105E-01	-4.101E-01
16	1.840E+05	1.00E+00	-8.189E-01	-8.179E-01
17	6.760E+04	1.00E+00	-3.433E-01	-3.420E-01
18	2.480E+04	1.00E+00	-1.914E-01	-1.898E-01
19	9.120E+03	1.00E+00	-1.415E+00	-1.411E+00
20	3.350E+03	9.98E-01	-3.159E-01	-3.122E-01
21	1.235E+03	1.00E+00	-4.703E-02	-4.683E-02
22	4.540E+02	1.00E+00	-3.094E-02	-3.074E-02
23	1.670E+02	1.00E+00	-2.874E-02	-2.844E-02
24	6.140E+01	9.99E-01	-2.356E-02	-2.316E-02
25	2.260E+01	9.99E-01	-1.575E-02	-1.532E-02
26	8.320E+00	1.00E+00	-8.983E-03	-8.584E-03
27	3.060E+00	9.96E-01	-4.271E-03	-3.967E-03
28	1.130E+00	1.00E+00	-1.592E-03	-1.414E-03
29	4.140E-01	1.00E+00	-4.703E-04	-3.892E-04
30	1.520E-01	1.11E+00	-1.088E-04	-7.107E-05
INTEGRAL			-4.067E+00	-4.003E+00

************************ AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 3.216E-01
RELATIVE STANDARD DEVIATION = DR/R = 5.671E-01
= 5.671E+01 PER CENT

SENSIT SAMPLE 5, *FUSION REACTOR*VECTOR-XS.SEN+UNCERT.*RUN76: CR, NI, FE, CU

Cr(el., el.)

****************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 14 ******************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R.PHI) = 1.12278E+04
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 5.02000E-03 AND NDEN2 = 5.02000E-03

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-1.449E-01	-1.449E-01
3	1.350E+07	1.18E-01	-5.174E-02	-5.174E-02
4	1.200E+07	1.82E-01	-1.915E-02	-1.915E-02
5	1.000E+07	2.50E-01	-1.569E-02	-1.569E-02
6	7.790E+06	2.49E-01	-1.477E-02	-1.477E-02
7	6.070E+06	5.00E-01	-1.331E-02	-1.331E-02
8	3.680E+06	2.50E-01	-2.313E-02	-2.313E-02
9	2.865E+06	2.50E-01	-3.354E-02	-3.354E-02
10	2.232E+06	2.50E-01	-4.286E-02	-4.286E-02
11	1.738E+06	2.50E-01	-6.298E-02	-6.298E-02
12	1.353E+06	4.97E-01	-1.368E-01	-1.368E-01
13	8.230E+05	4.98E-01	-3.134E-01	-3.134E-01
14	5.000E+05	5.01E-01	-5.164E-01	-5.164E-01
15	3.030E+05	4.99E-01	-4.101E-01	-4.101E-01
16	1.840E+05	1.00E+00	-8.179E-01	-8.179E-01
17	6.760E+04	1.00E+00	-3.420E-01	-3.420E-01
18	2.480E+04	1.00E+00	-1.898E-01	-1.898E-01
19	9.120E+03	1.00E+00	-1.411E+00	-1.411E+00
20	3.350E+03	9.98E-01	-3.122E-01	-3.122E-01
21	1.235E+03	1.00E+00	-4.683E-02	-4.683E-02
22	4.540E+02	1.00E+00	-3.074E-02	-3.074E-02
23	1.670E+02	1.00E+00	-2.844E-02	-2.844E-02
24	6.140E+01	9.99E-01	-2.316E-02	-2.316E-02
25	2.260E+01	9.99E-01	-1.532E-02	-1.532E-02
26	8.320E+00	1.00E+00	-8.584E-03	-8.584E-03
27	3.060E+00	9.96E-01	-3.967E-03	-3.967E-03
28	1.130E+00	1.00E+00	-1.414E-03	-1.414E-03
29	4.140E-01	1.00E+00	-3.892E-04	-3.892E-04
30	1.520E-01	1.11E+00	-7.107E-05	-7.107E-05
INTEGRAL			-4.003E+00	-4.003E+00

****************************** AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ******************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 3.216E-01
RELATIVE STANDARD DEVIATION = DR/R = 5.671E-01
= 5.671E+01 PER CENT

SENSIT SAMPLE 8. *FUSION REACTOR*VECTOR-XS.SEN+UNCERT.*RUN76: CR. NI. FE. CU

Ni (tot, tot)

************************ SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 32 ***************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R.PHI) = 1.12276E+04
FOR THE SUM OVER ALL PERTURBED ZONES. WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 3.20000E-03 AND NDEN2 = 3.20000E-03

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-2.299E-01	-2.299E-01
3	1.350E+07	1.10E-01	-7.793E-02	-7.793E-02
4	1.200E+07	1.02E-01	-2.722E-02	-2.722E-02
5	1.000E+07	2.50E-01	-1.980E-02	-1.980E-02
6	7.790E+06	2.49E-01	-1.692E-02	-1.692E-02
7	6.070E+06	5.00E-01	-1.376E-02	-1.376E-02
8	3.680E+06	2.50E-01	-1.883E-02	-1.883E-02
9	2.865E+06	2.50E-01	-2.472E-02	-2.472E-02
10	2.232E+06	2.50E-01	-3.000E-02	-3.000E-02
11	1.738E+06	2.50E-01	-4.301E-02	-4.301E-02
12	1.353E+06	4.97E-01	-9.005E-02	-9.005E-02
13	8.230E+05	4.98E-01	-1.995E-01	-1.995E-01
14	5.000E+05	5.01E-01	-4.126E-01	-4.126E-01
15	3.030E+05	4.99E-01	-4.239E-01	-4.239E-01
16	1.840E+05	1.00E+00	-4.970E-01	-4.970E-01
17	6.760E+04	1.00E+00	-3.614E-01	-3.614E-01
18	2.480E+04	1.00E+00	-1.054E+00	-1.054E+00
19	9.120E+03	1.00E+00	-6.409E-01	-6.409E-01
20	3.350E+03	9.98E-01	-3.949E-01	-3.949E-01
21	1.235E+03	1.00E+00	-1.056E-01	-1.056E-01
22	4.540E+02	1.00E+00	-7.560E-02	-7.560E-02
23	1.670E+02	1.00E+00	-7.180E-02	-7.180E-02
24	6.140E+01	9.99E-01	-5.908E-02	-5.908E-02
25	2.260E+01	9.99E-01	-3.936E-02	-3.936E-02
26	8.320E+00	1.00E+00	-2.222E-02	-2.222E-02
27	3.060E+00	9.96E-01	-1.039E-02	-1.039E-02
28	1.130E+00	1.00E+00	-3.768E-03	-3.768E-03
29	4.140E-01	1.00E+00	-1.067E-03	-1.067E-03
30	1.520E-01	1.11E+00	-2.162E-04	-2.162E-04
INTEGRAL			-3.985E+00	-3.985E+00

************************ AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 3.454E-02
RELATIVE STANDARD DEVIATION = DR/R = 1.858E-01
= 1.858E+01 PER CENT

35

SENSIT SAMPLE 8. *FUSION REACTOR*VECTOR-XS.SEN+UNCERT.*RUN76: CR, NI, FE, CU

*************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 33 ****************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 1.12278E+04
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 3.20000E-03 AND NDEN2 = 3.20000E-03

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-1.132E-01	-1.132E-01
3	1.350E+07	1.18E-01	-4.053E-02	-4.053E-02
4	1.200E+07	1.82E-01	-1.493E-02	-1.493E-02
5	1.000E+07	2.50E-01	-1.149E-02	-1.149E-02
6	7.790E+06	2.49E-01	-9.998E-03	-9.998E-03
7	6.070E+06	5.60E-01	-8.011E-03	-8.011E-03
8	3.680E+06	2.50E-01	-1.150E-02	-1.150E-02
9	2.865E+06	2.50E-01	-1.812E-02	-1.812E-02
10	2.232E+06	2.50E-01	-2.415E-02	-2.415E-02
11	1.738E+06	2.50E-01	-3.890E-02	-3.890E-02
12	1.353E+06	4.97E-01	-8.933E-02	-8.933E-02
13	8.230E+05	4.98E-01	-1.984E-01	-1.984E-01
14	5.690E+05	5.01E-01	-4.111E-01	-4.111E-01
15	3.030E+05	4.99E-01	-4.229E-01	-4.229E-01
16	1.840E+05	1.00E+00	-4.954E-01	-4.954E-01
17	6.760E+04	1.00E+00	-3.602E-01	-3.602E-01
18	2.480E+04	1.00E+00	-1.051E+00	-1.051E+00
19	9.120E+03	1.00E+00	-6.490E-01	-6.490E-01
20	3.350E+03	9.98E-01	-3.941E-01	-3.941E-01
21	1.235E+03	1.00E+00	-1.054E-01	-1.054E-01
22	4.540E+02	1.00E+00	-7.541E-02	-7.541E-02
23	1.670E+02	1.00E+00	-7.152E-02	-7.152E-02
24	6.140E+01	9.99E-01	-5.871E-02	-5.871E-02
25	2.260E+01	9.99E-01	-3.895E-02	-3.895E-02
26	8.320E+00	1.00E+00	-2.185E-02	-2.185E-02
27	3.060E+00	9.96E-01	-1.010E-02	-1.010E-02
28	1.130E+00	1.00E+00	-3.601E-03	-3.601E-03
29	4.140E-01	1.00E+00	-9.911E-04	-9.911E-04
30	1.520E-01	1.11E+00	-1.808E-04	-1.808E-04
INTEGRAL			-3.942E+00	-3.942E+00

*************************** AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ***************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 2.697E-02
RELATIVE STANDARD DEVIATION = DR/R = 1.642E-01
= 1.642E+01 PER CENT

SENSIT SAMPLE 8, *FUSION REACTOR*VECTOR-XS.SEN+UNCERT.*RUN76: CR, NI, FE, CU

Fe(tot, tot)

****************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 19 ******************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 1.12278E+04
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 1.89000E-02 AND NDEN2 = 1.89000E-02

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-1.285E+00	-1.285E+00
3	1.350E+07	1.18E-01	-4.305E-01	-4.305E-01
4	1.200E+07	1.82E-01	-1.524E-01	-1.524E-01
5	1.000E+07	2.50E-01	-1.125E-01	-1.125E-01
6	7.790E+06	2.49E-01	-9.801E-02	-9.801E-02
7	6.070E+06	5.00E-01	-8.128E-02	-8.128E-02
8	3.680E+06	2.50E-01	-1.117E-01	-1.117E-01
9	2.865E+06	2.50E-01	-1.527E-01	-1.527E-01
10	2.232E+06	2.50E-01	-1.809E-01	-1.809E-01
11	1.738E+06	2.50E-01	-2.381E-01	-2.381E-01
12	1.353E+06	4.97E-01	-4.558E-01	-4.558E-01
13	8.230E+05	4.98E-01	-1.144E+00	-1.144E+00
14	5.000E+05	5.01E-01	-2.163E+00	-2.163E+00
15	3.030E+05	4.99E-01	-1.485E+00	-1.485E+00
16	1.840E+05	1.00E+00	-2.038E+00	-2.038E+00
17	6.760E+04	1.00E+00	-2.240E+00	-2.240E+00
18	2.480E+04	1.00E+00	-4.077E-01	-4.077E-01
19	9.120E+03	1.00E+00	-2.201E+00	-2.201E+00
20	3.350E+03	9.98E-01	-1.032E+00	-1.032E+00
21	1.235E+03	1.00E+00	-3.539E-01	-3.539E-01
22	4.540E+02	1.00E+00	-2.700E-01	-2.700E-01
23	1.670E+02	1.00E+00	-2.646E-01	-2.646E-01
24	6.140E+01	9.99E-01	-2.171E-01	-2.171E-01
25	2.260E+01	9.99E-01	-1.445E-01	-1.445E-01
26	8.320E+00	1.00E+00	-8.148E-02	-8.148E-02
27	3.060E+00	9.96E-01	-3.803E-02	-3.803E-02
28	1.130E+00	1.00E+00	-1.378E-02	-1.378E-02
29	4.140E-01	1.00E+00	-3.891E-03	-3.891E-03
30	1.520E-01	1.11E+00	-7.813E-04	-7.813E-04
INTEGRAL			-1.242E+01	-1.242E+01

************************* AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 8.177E-03
RELATIVE STANDARD DEVIATION = DR/R = 9.043E-02
= 9.043E+00 PER CENT

SENSIT SAMPLE 8, *FUSION REACTOR*VECTOR-XS.SEN+UNCERT.*RUN76: CR, NI, FE, CU

Fe(tot,el)

****************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 20 ******************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 1.12278E+04
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 1.89000E-02 AND NDEN2 = 1.83000E-02

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-1.285E+00	-5.857E-01
3	1.350E+07	1.18E-01	-4.305E-01	-2.055E-01
4	1.200E+07	1.82E-01	-1.524E-01	-7.660E-02
5	1.000E+07	2.50E-01	-1.125E-01	-6.074E-02
6	7.790E+06	2.49E-01	-9.801E-02	-5.586E-02
7	6.070E+06	5.00E-01	-8.128E-02	-4.740E-02
8	3.680E+06	2.50E-01	-1.117E-01	-7.245E-02
9	2.865E+06	2.50E-01	-1.527E-01	-1.111E-01
10	2.232E+06	2.50E-01	-1.809E-01	-1.313E-01
11	1.738E+06	2.50E-01	-2.381E-01	-1.823E-01
12	1.353E+06	4.97E-01	-4.558E-01	-4.013E-01
13	8.230E+05	4.98E-01	-1.144E+00	-1.142E+00
14	5.000E+05	5.01E-01	-2.163E+00	-2.161E+00
15	3.030E+05	4.99E-01	-1.485E+00	-1.483E+00
16	1.840E+05	1.00E+00	-2.038E+00	-2.033E+00
17	6.760E+04	1.00E+00	-2.240E+00	-2.236E+00
18	2.480E+04	1.00E+00	-4.077E-01	-4.065E-01
19	9.120E+03	1.00E+00	-2.201E+00	-2.198E+00
20	3.350E+03	9.98E-01	-1.032E+00	-1.031E+00
21	1.235E+03	1.00E+00	-3.539E-01	-3.451E-01
22	4.540E+02	1.00E+00	-2.700E-01	-2.694E-01
23	1.670E+02	1.00E+00	-2.646E-01	-2.638E-01
24	6.140E+01	9.99E-01	-2.171E-01	-2.160E-01
25	2.260E+01	9.99E-01	-1.445E-01	-1.431E-01
26	8.320E+00	1.00E+00	-8.148E-02	-8.024E-02
27	3.060E+00	9.96E-01	-3.803E-02	-3.709E-02
28	1.130E+00	1.00E+00	-1.378E-02	-1.322E-02
29	4.140E-01	1.00E+00	-3.891E-03	-3.639E-03
30	1.520E-01	1.11E+00	-7.813E-04	-6.641E-04
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INTEGRAL			-1.242E+01	-1.216E+01

*************************** AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ***************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 8.175E-03
RELATIVE STANDARD DEVIATION = DR/R = 9.042E-02
= 9.042E+00 PER CENT

SENSIT SAMPLE 8. *FUSION REACTOR*VECTOR-XS.SEN+UNCERT.*RUN76: CR, NI, FE, CU

Fe(el.,el.)

************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 22 ***************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 1.12278E+04
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 1.89000E-02 AND NDEN2 = 1.89000E-02

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-5.857E-01	-5.857E-01
3	1.350E+07	1.18E-01	-2.055E-01	-2.055E-01
4	1.200E+07	1.82E-01	-7.660E-02	-7.660E-02
5	1.000E+07	2.50E-01	-6.074E-02	-6.074E-02
6	7.790E+06	2.49E-01	-5.586E-02	-5.586E-02
7	6.070E+06	5.00E-01	-4.740E-02	-4.740E-02
8	3.680E+06	2.50E-01	-7.245E-02	-7.245E-02
9	2.865E+06	2.50E-01	-1.111E-01	-1.111E-01
10	2.232E+06	2.50E-01	-1.313E-01	-1.313E-01
11	1.738E+06	2.50E-01	-1.823E-01	-1.823E-01
12	1.353E+06	4.97E-01	-4.013E-01	-4.013E-01
13	8.230E+05	4.98E-01	-1.142E+00	-1.142E+00
14	5.000E+05	5.01E-01	-2.161E+00	-2.161E+00
15	3.030E+05	4.99E-01	-1.483E+00	-1.483E+00
16	1.840E+05	1.00E+00	-2.033E+00	-2.033E+00
17	6.760E+04	1.00E+00	-2.236E+00	-2.236E+00
18	2.480E+04	1.00E+00	-4.065E-01	-4.065E-01
19	9.120E+03	1.00E+00	-2.198E+00	-2.198E+00
20	3.350E+03	9.98E-01	-1.031E+00	-1.031E+00
21	1.235E+03	1.00E+00	-3.451E-01	-3.451E-01
22	4.540E+02	1.00E+00	-2.694E-01	-2.694E-01
23	1.670E+02	1.00E+00	-2.630E-01	-2.630E-01
24	6.140E+01	9.99E-01	-2.160E-01	-2.160E-01
25	2.260E+01	9.99E-01	-1.431E-01	-1.431E-01
26	8.320E+00	1.00E+00	-8.024E-02	-8.024E-02
27	3.060E+00	9.96E-01	-3.709E-02	-3.709E-02
28	1.130E+00	1.00E+00	-1.322E-02	-1.322E-02
29	4.140E-01	1.00E+00	-3.639E-03	-3.639E-03
30	1.520E-01	1.11E+00	-6.641E-04	-6.641E-04
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INTEGRAL			-1.216E+01	-1.216E+01

********************** AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING **********************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 8.258E-03
RELATIVE STANDARD DEVIATION = DR/R = 9.087E-02
= 9.087E+00 PER CENT

SENSIT SAMPLE 8, *FUSION REACTOR*VECTOR-XS.SEN+UNCERT.*RUN76: CR, NI, FE, CU

Cu (tot, tot)

**************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 37 ****************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 1.12278E+04
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 4.07000E-02 AND NDEN2 = 4.07000E-02

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-3.156E+00	-3.156E+00
3	1.350E+07	1.18E-01	-1.060E+00	-1.060E+00
4	1.200E+07	1.82E-01	-3.690E-01	-3.690E-01
5	1.000E+07	2.50E-01	-2.651E-01	-2.651E-01
6	7.790E+06	2.49E-01	-2.220E-01	-2.220E-01
7	6.070E+06	5.00E-01	-1.781E-01	-1.781E-01
8	3.680E+06	2.50E-01	-2.379E-01	-2.379E-01
9	2.865E+06	2.50E-01	-3.094E-01	-3.094E-01
10	2.232E+06	2.50E-01	-3.870E-01	-3.870E-01
11	1.738E+06	2.50E-01	-5.172E-01	-5.172E-01
12	1.353E+06	4.97E-01	-1.172E+00	-1.172E+00
13	8.230E+05	4.98E-01	-2.950E+00	-2.950E+00
14	5.000E+05	5.01E-01	-5.073E+00	-5.073E+00
15	3.030E+05	4.99E-01	-3.998E+00	-3.998E+00
16	1.840E+05	1.00E+00	-6.075E+00	-6.075E+00
17	6.760E+04	1.00E+00	-4.462E+00	-4.462E+00
18	2.480E+04	1.00E+00	-5.170E+00	-5.170E+00
19	9.120E+03	1.00E+00	-6.729E+00	-6.729E+00
20	3.350E+03	9.98E-01	-5.885E+00	-5.885E+00
21	1.235E+03	1.00E+00	-7.186E-01	-7.186E-01
22	4.540E+02	1.00E+00	-3.826E-01	-3.826E-01
23	1.670E+02	1.00E+00	-4.038E-01	-4.038E-01
24	6.140E+01	9.99E-01	-3.549E-01	-3.549E-01
25	2.260E+01	9.99E-01	-2.423E-01	-2.423E-01
26	8.320E+00	1.00E+00	-1.335E-01	-1.335E-01
27	3.060E+00	9.96E-01	-6.314E-02	-6.314E-02
28	1.130E+00	1.00E+00	-2.324E-02	-2.324E-02
29	4.140E-01	1.00E+00	-6.719E-03	-6.719E-03
30	1.520E-01	1.11E+00	-1.452E-03	-1.452E-03
INTEGRAL			-3.836E+01	-3.836E+01

************************ AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 6.769E-02
RELATIVE STANDARD DEVIATION = DR/R = 2.602E-01
= 2.602E+01 PER CENT

SENSIT SAMPLE 8. *FUSION REACTOR*VECTOR-XS.SEN+UNCERT.*RUN76: CR, NI, FE, CU

Cu (tot, el)

************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 38 **************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 1.12278E+04
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 4.07000E-02 AND NDEN2 = 4.07000E-02

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-3.156E+00	-1.478E+00
3	1.350E+07	1.18E-01	-1.060E+00	-5.142E-01
4	1.200E+07	1.82E-01	-3.690E-01	-1.861E-01
5	1.000E+07	2.50E-01	-2.651E-01	-1.439E-01
6	7.790E+06	2.49E-01	-2.220E-01	-1.261E-01
7	6.070E+06	5.00E-01	-1.781E-01	-1.019E-01
8	3.680E+06	2.50E-01	-2.379E-01	-1.385E-01
9	2.865E+06	2.50E-01	-3.094E-01	-1.905E-01
10	2.232E+06	2.50E-01	-3.870E-01	-2.596E-01
11	1.738E+06	2.50E-01	-5.172E-01	-3.849E-01
12	1.353E+06	4.97E-01	-1.172E+00	-1.062E+00
13	8.230E+05	4.98E-01	-2.950E+00	-2.923E+00
14	5.000E+05	5.01E-01	-5.073E+00	-5.056E+00
15	3.030E+05	4.99E-01	-3.998E+00	-3.983E+00
16	1.840E+05	1.00E+00	-6.075E+00	-6.050E+00
17	6.760E+04	1.00E+00	-4.462E+00	-4.439E+00
18	2.480E+04	1.00E+00	-5.170E+00	-5.129E+00
19	9.120E+03	1.00E+00	-6.729E+00	-6.629E+00
20	3.350E+03	9.98E-01	-5.885E+00	-5.773E+00
21	1.235E+03	1.00E+00	-7.186E-01	-6.102E-01
22	4.540E+02	1.00E+00	-3.826E-01	-3.704E-01
23	1.670E+02	1.00E+00	-4.038E-01	-4.012E-01
24	6.140E+01	9.99E-01	-3.549E-01	-3.513E-01
25	2.260E+01	9.99E-01	-2.423E-01	-2.382E-01
26	8.320E+00	1.00E+00	-1.335E-01	-1.296E-01
27	3.060E+00	9.96E-01	-6.314E-02	-6.017E-02
28	1.130E+00	1.00E+00	-2.324E-02	-2.148E-02
29	4.140E-01	1.00E+00	-6.719E-03	-5.916E-03
30	1.520E-01	1.11E+00	-1.452E-03	-1.079E-03
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INTEGRAL			-3.836E+01	-3.735E+01

*********************** AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ***********************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 6.682E-02
RELATIVE STANDARD DEVIATION = DR/R = 2.585E-01
= 2.585E+01 PER CENT

SENSIT SAMPLE 8, *FUSION REACTOR*VECTOR-XS.SEN+UNCERT.*RUN76: CR, NI, FE, CU

Cu(el,el)

**************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 39 *****************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 1.12278E+04
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 4.07000E-02 AND NDEN2 = 4.07000E-02

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-1.478E+00	-1.478E+00
3	1.350E+07	1.18E-01	-5.142E-01	-5.142E-01
4	1.200E+07	1.82E-01	-1.861E-01	-1.861E-01
5	1.000E+07	2.50E-01	-1.439E-01	-1.439E-01
6	7.790E+06	2.49E-01	-1.261E-01	-1.261E-01
7	6.070E+06	5.00E-01	-1.019E-01	-1.019E-01
8	3.680E+06	2.50E-01	-1.385E-01	-1.385E-01
9	2.865E+06	2.50E-01	-1.905E-01	-1.905E-01
10	2.232E+06	2.50E-01	-2.596E-01	-2.596E-01
11	1.738E+06	2.50E-01	-3.849E-01	-3.849E-01
12	1.353E+06	4.97E-01	-1.062E+00	-1.062E+00
13	8.230E+05	4.98E-01	-2.923E+00	-2.923E+00
14	5.000E+05	5.01E-01	-5.056E+00	-5.056E+00
15	3.030E+05	4.99E-01	-3.983E+00	-3.983E+00
16	1.840E+05	1.00E+00	-6.050E+00	-6.050E+00
17	6.760E+04	1.00E+00	-4.439E+00	-4.439E+00
18	2.480E+04	1.00E+00	-5.129E+00	-5.129E+00
19	9.120E+03	1.00E+00	-6.629E+00	-6.629E+00
20	3.350E+03	9.98E-01	-5.773E+00	-5.773E+00
21	1.235E+03	1.00E+00	-6.102E-01	-6.102E-01
22	4.540E+02	1.00E+00	-3.704E-01	-3.704E-01
23	1.670E+02	1.00E+00	-4.012E-01	-4.012E-01
24	6.140E+01	9.99E-01	-3.513E-01	-3.513E-01
25	2.260E+01	9.99E-01	-2.382E-01	-2.382E-01
26	8.320E+00	1.00E+00	-1.296E-01	-1.296E-01
27	3.060E+00	9.96E-01	-6.017E-02	-6.017E-02
28	1.130E+00	1.00E+00	-2.148E-02	-2.148E-02
29	4.140E-01	1.00E+00	-5.916E-03	-5.916E-03
30	1.520E-01	1.11E+00	-1.079E-03	-1.079E-03
INTEGRAL			-3.735E+01	-3.735E+01

************************** AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING **************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 6.626E-02
RELATIVE STANDARD DEVIATION = DR/R = 2.574E-01
= 2.574E+01 PER CENT

TNS(PGFR) XS-SENS.-ANALYSIS FOR R3=TF-COIL KERMA *** SHIELD * 175: H,O(W)

P6 (tot, tot)

******************************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 48 ********************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 1.12278E+04
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 3.93000E-02 AND NDEN2 = 3.93000E-02

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-5.691E+01	-5.691E+01
3	1.350E+07	1.18E-01	-1.060E+01	-1.060E+01
4	1.200E+07	1.82E-01	-2.945E+00	-2.945E+00
5	1.000E+07	2.50E-01	-1.725E+00	-1.725E+00
6	7.790E+06	2.49E-01	-1.388E+00	-1.388E+00
7	6.070E+06	5.00E-01	-9.193E-01	-9.193E-01
8	3.680E+06	2.50E-01	-1.078E+00	-1.078E+00
9	2.865E+06	2.50E-01	-1.206E+00	-1.206E+00
10	2.232E+06	2.50E-01	-9.907E-01	-9.907E-01
11	1.738E+06	2.50E-01	-9.497E-01	-9.497E-01
12	1.353E+06	4.97E-01	-1.027E+00	-1.027E+00
13	8.230E+05	4.98E-01	-1.151E+00	-1.151E+00
14	5.000E+05	5.01E-01	-7.689E-01	-7.689E-01
15	3.030E+05	4.99E-01	-6.793E-01	-6.793E-01
16	1.840E+05	1.00E+00	-4.932E-01	-4.932E-01
17	6.760E+04	1.00E+00	-3.103E-01	-3.103E-01
18	2.480E+04	1.00E+00	-2.152E-01	-2.152E-01
19	9.120E+03	1.00E+00	-1.691E-01	-1.691E-01
20	3.350E+03	9.98E-01	-1.358E-01	-1.358E-01
21	1.235E+03	1.00E+00	-7.506E-02	-7.506E-02
22	4.540E+02	1.00E+00	-3.312E-02	-3.312E-02
23	1.670E+02	1.00E+00	-2.624E-02	-2.624E-02
24	6.140E+01	9.99E-01	-6.665E-03	-6.665E-03
25	2.260E+01	9.99E-01	-6.052E-04	-6.052E-04
26	8.320E+00	1.00E+00	-4.239E-04	-4.239E-04
27	3.060E+00	9.96E-01	-2.883E-03	-2.883E-03
28	1.130E+00	1.00E+00	-2.035E-03	-2.035E-03
29	4.140E-01	1.00E+00	-1.150E-03	-1.150E-03
30	1.520E-01	1.11E+00	-7.773E-04	-7.773E-04
			----------	----------
INTEGRAL			-1.336E+01	-1.336E+01

************************ AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 7.489E-02
RELATIVE STANDARD DEVIATION = DR/R = 2.737E-01
= 2.737E+01 PER CENT

TNS(PGFR) XS-SENS.-ANALYSIS FOR R3=TF-COIL KERMA *** SHIELD * 175: H,O(W)

Pb(tot, el)

************************ SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 49 *************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 1.12278E+04
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 3.93000E-02 AND NDEN2 = 3.93000E-02

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.760E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-5.691E+01	-3.056E+01
3	1.350E+07	1.18E-01	-1.060E+01	-5.565E+00
4	1.200E+07	1.82E-01	-2.945E+00	-1.533E+00
5	1.000E+07	2.50E-01	-1.725E+00	-9.106E-01
6	7.790E+06	2.49E-01	-1.386E+00	-8.129E-01
7	6.070E+06	5.00E-01	-9.193E-01	-6.331E-01
8	3.630E+06	2.50E-01	-1.079E+00	-8.885E-01
9	2.865E+06	2.50E-01	-1.206E+00	-1.072E+00
10	2.232E+06	2.50E-01	-9.907E-01	-8.953E-01
11	1.738E+06	2.50E-01	-9.497E-01	-8.784E-01
12	1.353E+06	4.97E-01	-1.027E+00	-9.787E-01
13	8.230E+05	4.98E-01	-1.151E+00	-1.143E+00
14	5.000E+05	5.01E-01	-7.689E-01	-7.683E-01
15	3.030E+05	4.99E-01	-6.793E-01	-6.790E-01
16	1.840E+05	1.00E+00	-4.932E-01	-4.930E-01
17	6.760E+04	1.00E+00	-3.103E-01	-3.101E-01
18	2.480E+04	1.00E+00	-2.152E-01	-2.151E-01
19	9.120E+03	1.00E+00	-1.691E-01	-1.691E-01
20	3.350E+03	9.98E-01	-1.350E-01	-1.341E-01
21	1.235E+03	1.00E+00	-7.506E-02	-7.505E-02
22	4.540E+02	1.00E+00	-3.312E-02	-3.311E-02
23	1.670E+02	1.00E+00	-2.624E-02	-2.623E-02
24	6.140E+01	9.99E-01	-6.665E-03	-6.663E-03
25	2.260E+01	9.99E-01	-6.052E-04	-6.048E-04
26	8.320E+00	1.00E+00	-4.239E-04	-4.234E-04
27	3.060E+00	9.96E-01	-2.883E-03	-2.877E-03
28	1.130E+00	1.00E+00	-2.035E-03	-2.029E-03
29	4.140E-01	1.00E+00	-1.150E-03	-1.145E-03
30	1.520E-01	1.11E+00	-7.773E-04	-7.676E-04
			----------	----------
INTEGRAL			-1.336E+01	-9.037E+00

************************ AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING *******************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 7.489E-02
RELATIVE STANDARD DEVIATION = DR/R = 2.737E-01
= 2.737E+01 PER CENT

TNS(PGFR) XS-SENS.-ANALYSIS FOR R3=TF-COIL KERMA *** SHIELD * 175: H,O(W)

Pb(el.,el.)

********************** SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 51 ******************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 1.12278E+04
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 3.93000E-02 AND NDEN2 = 3.93000E-02

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-3.056E+01	-3.056E+01
3	1.350E+07	1.18E-01	-5.565E+00	-5.565E+00
4	1.200E+07	1.82E-01	-1.533E+00	-1.533E+00
5	1.000E+07	2.50E-01	-9.106E-01	-9.106E-01
6	7.790E+06	2.49E-01	-8.129E-01	-8.129E-01
7	6.070E+06	5.00E-01	-6.331E-01	-6.331E-01
8	3.680E+06	2.50E-01	-8.885E-01	-8.885E-01
9	2.865E+06	2.50E-01	-1.072E+00	-1.072E+00
10	2.232E+06	2.50E-01	-8.953E-01	-8.953E-01
11	1.738E+06	2.50E-01	-8.784E-01	-8.784E-01
12	1.353E+06	4.97E-01	-9.787E-01	-9.787E-01
13	8.230E+05	4.99E-01	-1.143E+00	-1.143E+00
14	5.000E+05	5.01E-01	-7.683E-01	-7.683E-01
15	3.030E+05	4.99E-01	-6.790E-01	-6.790E-01
16	1.840E+05	1.00E+00	-4.930E-01	-4.930E-01
17	6.760E+04	1.00E+00	-3.101E-01	-3.101E-01
18	2.480E+04	1.00E+00	-2.151E-01	-2.151E-01
19	9.120E+03	1.00E+00	-1.691E-01	-1.691E-01
20	3.350E+03	9.98E-01	-1.341E-01	-1.341E-01
21	1.235E+03	1.00E+00	-7.505E-02	-7.505E-02
22	4.540E+02	1.00E+00	-3.311E-02	-3.311E-02
23	1.670E+02	1.00E+00	-2.623E-02	-2.623E-02
24	6.140E+01	9.99E-01	-6.663E-03	-6.663E-03
25	2.260E+01	9.99E-01	-6.048E-04	-6.048E-04
26	8.320E+00	1.00E+00	-4.234E-04	-4.234E-04
27	3.060E+00	9.96E-01	-2.877E-03	-2.877E-03
28	1.130E+00	1.00E+00	-2.029E-03	-2.029E-03
29	4.140E-01	1.00E+00	-1.145E-03	-1.145E-03
30	1.520E-01	1.11E+00	-7.676E-04	-7.676E-04
INTEGRAL			-9.087E+00	-9.087E+00

******************** AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ******************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 1.161E-01
RELATIVE STANDARD DEVIATION = DR/R = 3.407E-01
= 3.407E+01 PER CENT

TNS(PGFR) XS-SENS.-ANALYSIS FOR RS=TF-COIL KERMA *** SHIELD * 175: H.D(W)

Pb(inel, inel)

************************ SENSITIVITY PROFILES FOR CROSS-SECTION PAIRS WITH ID = 53 ************************
P1(G) AND P2(G) ARE PER LETHARGY WIDTH DELTA-U AND NORMALIZED TO THE RESPONSE I1PHI = (R,PHI) = 1.12278E+04
FOR THE SUM OVER ALL PERTURBED ZONES, WHERE BOTH CROSS SECTIONS WITH THIS ID ARE PRESENT IN THE MODEL
THE NUMBER DENSITIES FOR THIS XS-PAIR ARE NDEN1 = 3.93000E-02 AND NDEN2 = 3.93000E-02

GROUP	UPPER-E(EV)	DELTA-U	P1(G)	P2(G)
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-3.727E+00	-3.727E+00
3	1.350E+07	1.18E-01	-9.481E-01	-9.481E-01
4	1.200E+07	1.82E-01	-5.141E-01	-5.141E-01
5	1.000E+07	2.50E-01	-6.059E-01	-6.059E-01
6	7.790E+06	2.49E-01	-5.673E-01	-5.673E-01
7	6.070E+06	5.00E-01	-2.861E-01	-2.861E-01
8	3.680E+06	2.50E-01	-1.898E-01	-1.898E-01
9	2.865E+06	2.50E-01	-1.343E-01	-1.343E-01
10	2.232E+06	2.50E-01	-9.527E-02	-9.527E-02
11	1.738E+06	2.50E-01	-7.105E-02	-7.105E-02
12	1.353E+06	4.97E-01	-4.814E-02	-4.814E-02
13	8.230E+05	4.99E-01	-7.494E-03	-7.494E-03
14	5.000E+05	5.01E-01	0.	0.
15	3.030E+05	4.99E-01	0.	0.
16	1.840E+05	1.00E+00	0.	0.
17	6.760E+04	1.00E+00	0.	0.
18	2.480E+04	1.00E+00	0.	0.
19	9.120E+03	1.00E+00	0.	0.
20	3.350E+03	9.99E-01	0.	0.
21	1.235E+03	1.00E+00	0.	0.
22	4.540E+02	1.00E+00	0.	0.
23	1.670E+02	1.00E+00	0.	0.
24	6.140E+01	9.99E-01	0.	0.
25	2.260E+01	9.99E-01	0.	0.
26	8.320E+00	1.00E+00	0.	0.
27	3.060E+00	9.96E-01	0.	0.
28	1.130E+00	1.00E+00	0.	0.
29	4.140E-01	1.00E+00	0.	0.
30	1.520E-01	1.11E+00	0.	0.
INTEGRAL			-1.184E+00	-1.184E+00

************************ AN UNCERTAINTY ANALYSIS FOR THIS CROSS-SECTION PAIR YIELDS THE FOLLOWING ************************
FRACTIONAL RESPONSE UNCERTAINTY DUE TO XS-UNCERTAINTIES SPECIFIED IN THE COVARIANCE MATRIX FOR THIS ID:

VARIANCE, (DELTA-R OVER R)-SQUARE = (DR/R)SQ. = 2.792E-02
RELATIVE STANDARD DEVIATION = DR/R = 1.671E-01
= 1.671E+01 PER CENT

APPENDIX B

The following 11 tables are reproduced from the SENSIT printout of our SED uncertainty analysis for those cases where the response uncertainties exceed 10%. The title lines are self expalanatory and the nomenclature coincides with that used in the theory section (Sec. II) of the text. Only for the first case (Cu in TF+F coils for response function R_1) the detailed neutron cross-section and SED sensitivity profiles are also reproduced. The gamma ray sensitivity profiles are all zero for this case because R_1 is a dpa cross-section which has no gamma ray component.

TNS(PGFR) XS-SENS.-ANAL. FOR DPA-ADJOINT *TF+E COILS* 156SED: CR,NI,FE,CU

** SED UNCERTAINTY ANALYSIS **

G-IN	MEDIAN G-OUT OF SED (FROM INPUT)	INTEGRAL SED-UNCERT. F (FROM INPUT)	HOT INTEGRAL SENS. COEFF. S-HOT	COLD INTEGRAL SENS. COEFF. S-COLD	NET INTEGRAL SED SENS.-COEFF. S (SHOT - SCOLD)	RESPONSE UNCERT. DR/R DUE TO SED-UNCERT. (F * S)
1	8	.1100	0.	0.	0.	0.
2	8	.1000	1.810E-01	7.677E-02	1.042E-01	1.042E-02
3	7	.1000	6.258E-02	2.933E-02	3.325E-02	3.325E-03
4	4	.0900	2.808E-02	1.814E-02	9.933E-03	8.939E-04
5	5	.0800	3.235E-02	2.005E-02	1.230E-02	9.840E-04
6	6	.0700	3.093E-02	1.911E-02	1.183E-02	8.279E-04
7	7	.0700	5.977E-02	3.645E-02	2.332E-02	1.632E-03
8	8	.0600	4.297E-02	2.942E-02	1.355E-02	8.129E-04
9	9	.0600	6.331E-02	3.907E-02	2.424E-02	1.454E-03
10	10	.0600	9.101E-02	4.832E-02	4.269E-02	2.561E-03
11	11	.0500	1.352E-01	5.366E-02	8.151E-02	4.075E-03
12	12	.0400	8.612E-01	1.071E-01	7.541E-01	3.016E-02
13	13	.0200	2.792E+00	1.159E-01	2.676E+00	5.352E-02
14	14	.0200	3.297E+00	1.094E-01	3.188E+00	6.375E-02
15	15	.0200	1.469E+00	6.204E-02	1.407E+00	2.814E-02
16	16	.0200	2.716E+00	3.045E-02	2.685E+00	5.370E-02
17	0	0.0000	0.	0.	0.	0.
18	0	0.0000	0.	0.	0.	0.
19	0	0.0000	0.	0.	0.	0.
20	0	0.0000	0.	0.	0.	0.
21	0	0.0000	0.	0.	0.	0.
22	0	0.0000	0.	0.	0.	0.
23	0	0.0000	0.	0.	0.	0.
24	0	0.0000	0.	0.	0.	0.
25	0	0.0000	0.	0.	0.	0.
26	0	0.0000	0.	0.	0.	0.
27	0	0.0000	0.	0.	0.	0.
28	0	0.0000	0.	0.	0.	0.
29	0	0.0000	0.	0.	0.	0.
30	0	0.0000	0.	0.	0.	0.
TOTAL INTEGRAL			1.186E+01	7.952E-01	1.107E+01	2.563E-01 = 25.626 PER CENT

DEFINITIONS OF SENSIT SENSITIVITY PROFILE NOMENCLATURE

AXS = SENSITIVITY PROFILE PER DELTA-U FOR THE ABSORPTION CROSS-SECTION (TAKEN FROM POSITION IHA IN INPUT CROSS-SECTION TABLES), PURE LOSS TERM

NU-FISS = SENSITIVITY PROFILE PER DELTA-U FOR THE CROSS SECTION IN POSITION IHA+1 IN INPUT XS-TABLES, WHICH IS USUALLY NU-TIMES THE FISSION CROSS SECTION. PURE LOSS TERM

SXS = PARTIAL SENSITIVITY PROFILE PER DELTA-U FOR THE SCATTERING CROSS-SECTION (COMPUTED FOR EACH ENERGY GROUP AS A DIAGONAL SUM FROM INPUT XS-TABLES), LOSS TERM ONLY

TXS = SENSITIVITY PROFILE PER DELTA-U FOR THE TOTAL CROSS SECTION (AS GIVEN IN POSITION IHT IN INPUT CROSS-SECTION TABLES), PURE LOSS TERM

N-GAIN = PARTIAL SENSITIVITY PROFILE PER DELTA-U FOR THE NEUTRON SCATTERING CROSS-SECTION. GAIN TERM FOR SENSITIVITY GAINS DUE TO SCATTERING OUT OF ENERGY GROUP G INTO ALL LOWER NEUTRON ENERGY GROUPS, COMPUTED FROM FORWARD DIFFERENCE FORMULATION.

G-GAIN = PARTIAL SENSITIVITY PROFILE PER DELTA-U FOR THE GAMMA SCATTERING CROSS-SECTION. GAIN TERM FOR SENSITIVITY GAINS DUE TO SCATTERING OUT OF GAMMA ENERGY GROUP G INTO ALL LOWER GAMMA ENERGY GROUPS, COMPUTED FROM FORWARD DIFFERENCE FORMULATION.

N-GAIN(SED) = RE-ORDERED PARTIAL SENSITIVITY PROFILE PER DELTA-U FOR SCATTERING CROSS-SECTION. GAIN TERM FOR SENSITIVITY GAINS DUE TO SCATTERING INTO GROUP G FROM ALL HIGHER NEUTRON ENERGY GROUPS, COMPUTED FROM ADJOINT DIFFERNCE FORMULATION.
CORRESPONDS TO SINGLE-DIFFERENTIAL SED SENSITIVITY PROFILE, PSED(G-OUT) PER DELU-OUT, INTEGRATED OVER ALL INCIDENT ENERGY GROUPS.

NG-GAIN = PARTIAL SENSITIVITY PROFILE PER DELTA-U FOR THE GAMMA PRODUCTION CROSS-SECTION AT NEUTRON ENERGY GROUP G. PURE GAIN TERM FOR SENSITIVITY GAINS DUE TO TRANSFER FROM NEUTRON GROUP G INTO ALL GAMMA GROUPS.

SEN = NET SENSITIVITY PROFILE PER DELTA-U FOR THE SCATTERING CROSS-SECTION (SEN=SXS+NGAIN)

SENT = NET SENSITIVITY PROFILE PER DELTA-U FOR THE TOTAL CROSS-SECTION (SENT=TXS+NGAIN)

SENR = SENSITIVITY PROFILE PER DELTA-U FOR THE DETECTOR RESPONSE FUNCTION R(G)

SENQ = SENSITIVITY PROFILE PER DELTA-U FOR THE SOURCE DISTRIBUTION FUNCTION Q(G)

TNS(PGFR) XS-SENS.-ANAL. FOR DPA-ADJOINT *TF+E COILS* I56SED: CR.NI.FE.CU

************************************ NEUTRON CROSS SECTION SENSITIVITY PROFILES ************************************
************************************ SUMMED OVER ALL PERTURBED ZONES ************************************
PARTIAL AND NET SENSITIVITY PROFILES PER DELTA-U. NORMALIZED TO I1PHI = (R,PHI) = 4.00458E+00
FOR NEUTRON INTERACTION CROSS SECTIONS: (N-N) AND (N-GAMMA)

GROUP	UPPER-E(EV)	DELTA-U	****** P U R E L O S S AXS	NU-FISS	T E R M S SXS	******** TXS	******** PURE GAIN TERMS N-GAIN	N-GAIN(SED)	******** NG-GAIN
1	1.700E+07	1.25E-01	0.	0.	0.	0.	0.	0.	0.
2	1.500E+07	1.05E-01	8.406E+00	0.	-4.182E+00	-3.509E+00	2.447E+00	1.341E+00	0.
3	1.350E+07	1.18E-01	2.174E+00	0.	-1.201E+00	-1.102E+00	7.804E-01	5.408E-01	0.
4	1.200E+07	1.82E-01	5.880E-01	0.	-3.536E-01	-3.597E-01	2.535E-01	1.707E-01	0.
5	1.000E+07	2.50E-01	3.887E-01	0.	-2.770E-01	-2.852E-01	2.098E-01	1.450E-01	0.
6	7.790E+06	2.49E-01	3.140E-01	0.	-2.573E-01	-2.632E-01	2.006E-01	1.499E-01	0.
7	6.070E+06	5.00E-01	2.262E-01	0.	-2.322E-01	-2.360E-01	1.923E-01	1.719E-01	0.
8	3.680E+06	2.50E-01	2.712E-01	0.	-3.410E-01	-3.454E-01	2.892E-01	2.689E-01	0.
9	2.865E+06	2.50E-01	3.053E-01	0.	-4.796E-01	-4.840E-01	4.101E-01	3.771E-01	0.
10	2.232E+06	2.50E-01	3.164E-01	0.	-6.327E-01	-6.364E-01	5.570E-01	5.170E-01	0.
11	1.738E+06	2.50E-01	3.120E-01	0.	-8.454E-01	-8.488E-01	7.540E-01	7.182E-01	0.
12	1.353E+06	4.97E-01	1.996E-01	0.	-2.070E+00	-2.078E+00	1.940E+00	1.932E+00	0.
13	8.230E+05	4.98E-01	5.086E-02	0.	-6.032E+00	-6.049E+00	5.835E+00	5.908E+00	0.
14	5.000E+05	5.01E-01	2.261E-02	0.	-6.996E+00	-7.017E+00	6.801E+00	6.920E+00	0.
15	3.030E+05	4.99E-01	1.064E-02	0.	-3.139E+00	-3.149E+00	3.069E+00	3.205E+00	0.
16	1.840E+05	1.00E+00	1.163E-02	0.	-2.799E+00	-2.811E+00	2.742E+00	2.786E+00	0.
17	6.760E+04	1.00E+00	3.448E-03	0.	-6.797E-01	-6.833E-01	6.594E-01	6.724E-01	0.
18	2.480E+04	1.00E+00	2.492E-03	0.	-3.205E-01	-3.231E-01	3.112E-01	3.247E-01	0.
19	9.120E+03	1.00E+00	1.849E-03	0.	-1.351E-01	-1.370E-01	1.342E-01	1.381E-01	0.
20	3.350E+03	9.98E-01	1.192E-03	0.	-8.073E-02	-8.198E-02	8.008E-02	8.120E-02	0.
21	1.235E+03	1.00E+00	2.409E-04	0.	-1.663E-03	-1.915E-03	1.649E-03	1.754E-03	0.
22	4.540E+02	1.00E+00	2.321E-05	0.	-9.174E-04	-9.418E-04	9.062E-04	9.197E-04	0.
23	1.670E+02	1.00E+00	3.583E-06	0.	-6.817E-04	-6.855E-04	6.795E-04	6.800E-04	0.
24	6.140E+01	9.99E-01	4.296E-06	0.	-5.476E-04	-5.521E-04	5.465E-04	5.515E-04	0.
25	2.260E+01	9.99E-01	4.924E-06	0.	-3.480E-04	-3.540E-04	3.480E-04	3.534E-04	0.
26	8.320E+00	1.00E+00	5.724E-06	0.	-1.941E-04	-2.001E-04	1.944E-04	1.993E-04	0.
27	3.060E+00	9.96E-01	4.480E-06	0.	-9.122E-05	-9.591E-05	9.185E-05	9.460E-05	0.
28	1.130E+00	1.00E+00	3.249E-06	0.	-3.980E-05	-4.320E-05	4.047E-05	4.198E-05	0.
29	4.140E-01	1.00E+00	2.381E-06	0.	-1.766E-05	-2.016E-05	1.722E-05	1.900E-05	0.
30	1.520E-01	1.11E+00	5.257E-07	0.	-1.387E-06	-1.938E-06	1.356E-06	1.567E-06	0.
INTEGRAL			2.001E+00	0.	-1.460E+01	-1.459E+01	1.385E+01	1.385E+01	0.

GROUP	UPPER-E(EV)	DELTA-U	**** NET PROFILES **** SEN	SENT
1	1.700E+07	1.25E-01	0.	0.
2	1.500E+07	1.05E-01	-1.736E+00	-1.142E+00
3	1.350E+07	1.18E-01	-4.210E-01	-3.219E-01
4	1.200E+07	1.82E-01	-1.001E-01	-1.062E-01
5	1.000E+07	2.50E-01	-6.715E-02	-7.537E-02
6	7.790E+06	2.49E-01	-5.670E-02	-6.267E-02
7	6.070E+06	5.00E-01	-3.989E-02	-4.377E-02
8	3.680E+06	2.50E-01	-5.180E-02	-5.621E-02
9	2.865E+06	2.50E-01	-6.950E-02	-7.393E-02
10	2.232E+06	2.50E-01	-7.572E-02	-7.945E-02
11	1.738E+06	2.50E-01	-9.130E-02	-9.480E-02
12	1.353E+06	4.97E-01	-1.226E-01	-1.298E-01
13	8.230E+05	4.98E-01	-1.972E-01	-2.147E-01
14	5.000E+05	5.01E-01	-1.950E-01	-2.164E-01
15	3.030E+05	4.99E-01	-6.909E-02	-8.027E-02

16	1.840E+05	1.00E+00	-5.639E-02	-6.822E-02
17	6.760E+04	1.00E+00	-2.028E-02	-2.385E-02
18	2.400E+04	1.00E+00	-9.258E-03	-1.186E-02
19	9.120E+03	1.00E+00	-8.526E-04	-2.787E-03
20	3.350E+03	9.90E-01	-6.466E-04	-1.894E-03
21	1.235E+03	1.00E+00	-1.320E-05	-2.656E-04
22	4.540E+02	1.00E+00	-1.118E-05	-3.551E-05
23	1.670E+02	1.00E+00	-2.229E-06	-5.984E-06
24	6.140E+01	9.99E-01	-1.088E-06	-5.591E-06
25	2.260E+01	9.99E-01	-8.321E-07	-5.993E-06
26	8.320E+00	1.00E+00	3.661E-07	-5.633E-06
27	3.060E+00	9.96E-01	6.374E-07	-4.058E-06
28	1.130E+00	1.00E+00	6.676E-07	-2.737E-06
29	4.140E-01	1.00E+00	-4.462E-07	-2.942E-06
30	1.520E-01	1.11E+00	-3.104E-08	-5.820E-07
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INTEGRAL			-7.530E-01	-7.392E-01

*****************************DOUBLE-DIFFERENTIAL SED SENSITIVITY PROFILES*****************************
*****************************FOR THE SUM OVER ALL SPECIFIED PERTURBED ZONES*****************************
DOUBLE-DIFFERENTIAL PROFILES PER DELTA-U-IN AND PER DELTA-U-OUT, NORMALIZED TO I1PHI=(R,PHI)= 4.80458E+03
FOR NEUTRON GROUPS ONLY

*****************************PSED(G-IN,G-OUT) PER (DELU-IN)(DELU-OUT)I1PHI*****************************

G-OUT	DELU-OUT	G-IN = 1	G-IN = 2	G-IN = 3	G-IN = 4	G-IN = 5	G-IN = 6	G-IN = 7	G-IN = 8	G-IN = 9	G-IN =10
1	.125163	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	.105361	0.	1.27E+01	0.	0.	0.	0.	0.	0.	0.	0.
3	.117783	0.	8.29E-01	3.85E+00	0.	0.	0.	0.	0.	0.	0.
4	.182322	0.	2.58E-02	1.18E-01	8.45E-01	0.	0.	0.	0.	0.	0.
5	.249744	0.	7.19E-02	2.60E-02	2.67E-02	5.19E-01	0.	0.	0.	0.	0.
6	.249482	0.	1.17E-01	4.14E-02	8.38E-03	2.87E-02	4.97E-01	0.	0.	0.	0.
7	.500446	0.	2.64E-01	7.89E-02	2.59E-02	1.79E-02	2.46E-02	2.39E-01	0.	0.	0.
8	.250344	0.	3.79E-01	1.24E-01	4.33E-02	3.43E-02	2.78E-02	3.86E-02	6.86E-01	0.	0.
9	.249670	0.	3.92E-01	1.31E-01	5.03E-02	4.19E-02	3.71E-02	3.34E-02	8.46E-02	1.02E+00	0.
10	.250163	0.	3.79E-01	1.21E-01	5.10E-02	4.28E-02	4.08E-02	3.40E-02	7.53E-02	1.32E-01	1.45E+00
11	.250411	0.	3.64E-01	1.06E-01	4.21E-02	3.65E-02	3.73E-02	3.64E-02	6.78E-02	1.02E-01	1.63E-01
12	.497123	0.	3.41E-01	9.21E-02	2.98E-02	2.74E-02	2.99E-02	3.60E-02	4.33E-02	1.10E-01	1.27E-01
13	.498348	0.	3.12E-01	9.00E-02	1.99E-02	1.60E-02	1.86E-02	2.57E-02	4.55E-02	3.63E-02	1.19E-01
14	.500875	0.	1.55E-01	4.71E-02	8.18E-03	5.42E-03	6.48E-03	9.55E-03	2.38E-02	3.71E-02	4.83E-02
15	.498797	0.	5.56E-02	1.79E-02	2.82E-03	1.41E-03	1.64E-03	2.51E-03	6.50E-03	9.02E-03	9.30E-03
16	1.001328	0.	1.34E-02	4.84E-03	7.45E-04	2.68E-04	2.87E-04	4.59E-04	1.21E-03	1.75E-03	1.33E-03
17	1.002764	0.	6.26E-04	3.55E-04	6.80E-05	7.19E-06	9.91E-07	8.66E-06	2.23E-05	3.46E-05	6.14E-05
18	1.000374	0.	1.11E-04	6.35E-05	1.22E-05	1.29E-06	1.79E-07	1.56E-06	4.02E-06	6.22E-06	4.72E-06
19	1.001509	0.	1.48E-05	8.43E-06	1.62E-06	1.71E-07	2.30E-08	2.08E-07	5.35E-07	8.20E-07	2.81E-07
20	.997899	0.	3.35E-06	1.91E-06	3.67E-07	3.89E-08	5.42E-09	4.72E-08	1.21E-07	1.88E-07	3.09E-08
21	1.000729	0.	2.42E-07	1.38E-07	2.65E-08	2.81E-09	3.91E-10	3.40E-09	8.71E-09	1.35E-08	1.14E-09
22	1.000103	0.	6.93E-08	3.98E-08	7.62E-09	8.07E-10	1.12E-10	9.83E-10	2.53E-09	3.93E-09	0.
23	1.000584	0.	1.79E-08	1.03E-08	1.97E-09	2.08E-10	2.90E-11	2.55E-10	6.59E-10	1.02E-09	0.
24	.999460	0.	6.57E-09	3.78E-09	7.22E-10	7.65E-11	1.06E-11	9.33E-11	2.41E-10	3.74E-10	0.
25	.999288	0.	2.36E-09	1.36E-09	2.29E-10	0.	0.	0.	0.	0.	0.
26	1.000247	0.	8.16E-10	4.68E-10	7.93E-11	0.	0.	0.	0.	0.	0.
27	.996197	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	1.004107	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	1.001995	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	1.111858	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

1	.125163	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	.105361	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	.117783	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	.182322	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	.249744	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	.249482	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	.500446	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	.250344	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	.249670	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10	.250163	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	.250411	2.16E+00	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	.497123	1.81E-01	3.48E+00	0.	0.	0.	0.	0.	0.	0.	0.
13	.498348	1.51E-01	2.99E-01	1.12E+01	0.	0.	0.	0.	0.	0.	0.
14	.500875	6.54E-02	7.48E-02	4.52E-01	1.31E+01	0.	0.	0.	0.	0.	0.
15	.498797	1.96E-02	3.87E-02	0.	4.38E-01	5.90E+00	0.	0.	0.	0.	0.
16	1.001328	5.74E-03	8.75E-03	5.30E-03	0.	1.24E-01	2.71E+00	0.	0.	0.	0.
17	1.002764	5.88E-04	6.51E-04	8.96E-04	0.	0.	3.03E-02	6.39E-01	0.	0.	0.

18	1.000374	4.98E-05	6.02E-05	8.91E-05	0.	0.	0.	1.84E-02	3.06E-01	0.	0.
19	1.001509	2.44E-06	3.75E-06	5.16E-06	0.	0.	0.	0.	5.08E-03	1.33E-01	0.
20	.997889	1.77E-07	3.97E-07	4.74E-07	0.	0.	0.	0.	0.	1.25E-03	8.01E-02
21	1.000729	4.78E-09	1.10E-08	9.62E-09	0.	0.	0.	0.	0.	0.	1.40E-04
22	1.000103	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	1.000584	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	.999460	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	.999288	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	1.000247	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	.996197	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	1.004107	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	1.001985	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	1.111858	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

1	.125163	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	.105361	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	.117783	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	.102322	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	.249744	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	.249482	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	.500446	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	.250344	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	.249670	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10	.250163	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	.250411	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	.497123	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	.498348	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	.500875	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	.498797	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	1.001328	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	1.002764	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	1.000374	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	1.001509	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	.997889	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	1.000729	1.61E-03	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	1.000103	3.54E-05	8.84E-04	0.	0.	0.	0.	0.	0.	0.	0.
23	1.000584	0.	2.19E-05	6.58E-04	0.	0.	0.	0.	0.	0.	0.
24	.999460	0.	0.	2.14E-05	5.30E-04	0.	0.	0.	0.	0.	0.
25	.999288	0.	0.	0.	1.65E-05	3.37E-04	0.	0.	0.	0.	0.
26	1.000247	0.	0.	0.	0.	1.11E-05	1.88E-04	0.	0.	0.	0.
27	.996197	0.	0.	0.	0.	0.	6.30E-06	8.86E-05	0.	0.	0.
28	1.004107	0.	0.	0.	0.	0.	0.	3.54E-06	3.83E-05	0.	0.
29	1.001985	0.	0.	0.	0.	0.	0.	0.	2.01E-06	1.70E-05	0.
30	1.111858	0.	0.	0.	0.	0.	0.	0.	0.	2.10E-07	1.22E-06

*** SINGLE-DIFFERENTIAL PROFILES, PSED ***

G-IN OR G-OUT	PSED(G-OUT) PER DELU-OUT	PSED(G-IN) PER DELU-IN
1	0.	0.
2	1.341E+00	2.447E+00
3	5.400E-01	7.804E-01
4	1.707E-01	2.535E-01
5	1.450E-01	2.093E-01
6	1.439E-01	2.006E-01
7	1.719E-01	1.923E-01
8	2.683E-01	2.892E-01
9	3.771E-01	4.101E-01

10	5.170E-01	5.570E-01
11	7.182E-01	7.540E-01
12	1.932E+00	1.948E+00
13	5.908E+00	5.835E+00
14	6.920E+00	6.801E+00
15	3.205E+00	3.069E+00
16	2.786E+00	2.742E+00
17	6.724E-01	6.594E-01
18	3.247E-01	3.112E-01
19	1.381E-01	1.342E-01
20	8.120E-02	8.008E-02
21	1.754E-03	1.649E-03
22	9.197E-04	9.062E-04
23	6.800E-04	6.795E-04
24	5.515E-04	5.465E-04
25	3.534E-04	3.480E-04
26	1.993E-04	1.944E-04
27	9.460E-05	9.185E-05
28	4.198E-05	4.047E-05
29	1.900E-05	1.722E-05
30	1.567E-06	1.356E-06
TOTAL INTEGRAL	1.385E+01	1.385E+01

TNS(PGFR) XS-SENS.-ANALYSIS FOR DPA-ADJOINT *** SHIELD * I55SED: H.O.W

*** SED UNCERTAINTY ANALYSIS ***

G-IN	MEDIAN G-OUT OF SED (FROM INPUT)	INTEGRAL SED-UNCERT. F (FROM INPUT)	HOT INTEGRAL SENS. COEFF. S-HOT	COLD INTEGRAL SENS. COEFF. S-COLD	NET INTEGRAL SED SENS.-COEFF. S (SHOT - SCOLD)	RESPONSE UNCERT. DR/R DUE TO SED-UNCERT. (F * S)
1	10	.1200	0.	0.	0.	0.
2	10	.1000	1.252E+00	1.257E-01	1.126E+00	1.126E-01
3	10	.1000	2.890E-01	3.861E-02	2.504E-01	2.504E-02
4	11	.0900	1.219E-01	1.629E-02	1.056E-01	9.505E-03
5	12	.0800	9.572E-02	6.247E-03	8.947E-02	7.158E-03
6	6	.0600	7.111E-02	2.197E-02	4.913E-02	2.948E-03
7	7	.0700	1.320E-01	3.368E-02	9.827E-02	6.879E-03
8	8	.0600	9.907E-02	2.593E-02	7.314E-02	4.388E-03
9	9	.0600	1.377E-01	3.586E-02	1.010E-01	6.110E-03
10	10	.0500	1.536E-01	3.951E-02	1.141E-01	5.705E-03
11	11	.0500	1.740E-01	3.584E-02	1.382E-01	6.910E-03
12	12	.0500	4.951E-01	4.560E-02	4.495E-01	2.248E-02
13	13	.0400	4.598E-01	2.531E-02	4.345E-01	1.738E-02
14	14	.0300	1.951E-01	9.968E-03	1.852E-01	5.555E-03
15	15	.0200	7.416E-02	3.836E-03	7.032E-02	1.406E-03
16	16	.0100	6.958E-02	3.665E-04	6.921E-02	6.921E-04
17	0	0.0000	0.	0.	0.	0.
18	0	0.0000	0.	0.	0.	0.
19	0	0.0000	0.	0.	0.	0.
20	0	0.0000	0.	0.	0.	0.
21	0	0.0000	0.	0.	0.	0.
22	0	0.0000	0.	0.	0.	0.
23	0	0.0000	0.	0.	0.	0.
24	0	0.0000	0.	0.	0.	0.
25	0	0.0000	0.	0.	0.	0.
26	0	0.0000	0.	0.	0.	0.
27	0	0.0000	0.	0.	0.	0.
28	0	0.0000	0.	0.	0.	0.
29	0	0.0000	0.	0.	0.	0.
30	0	0.0000	0.	0.	0.	0.
TOTAL INTEGRAL			3.820E+00	4.647E-01	3.355E+00	2.340E-01
						23.478 PER CENT

TNS(PGFR) XS-SENS.-ANALYSIS FOR AL-DPA-ADJ. *** F-COIL * I64SED (CU)

** SED UNCERTAINTY ANALYSIS **

G-IN	MEDIAN G-OUT OF SED (FROM INPUT)	INTEGRAL SED-UNCERT. F (FROM INPUT)	HOT INTEGRAL SENS. COEFF. S-HOT	COLD INTEGRAL SENS. COEFF. S-COLD	NET INTEGRAL SED SENS.-COEFF. S (SHOT - SCOLD)	RESPONSE UNCERT. DR/R DUE TO SED-UNCERT. (F * S)
1	8	.1100	0.	0.	0.	0.
2	8	.1000	4.630E-01	2.241E-01	2.389E-01	2.389E-02
3	7	.1000	8.145E-02	4.331E-02	3.814E-02	3.814E-03
4	4	.0900	3.699E-02	2.668E-02	1.031E-02	9.279E-04
5	5	.0800	4.943E-02	3.407E-02	1.537E-02	1.229E-03
6	6	.0700	4.910E-02	3.237E-02	1.672E-02	1.171E-03
7	7	.0700	9.737E-02	6.140E-02	3.597E-02	2.518E-03
8	8	.0600	6.392E-02	4.361E-02	2.031E-02	1.219E-03
9	9	.0600	7.844E-02	4.855E-02	2.989E-02	1.794E-03
10	10	.0600	9.387E-02	4.856E-02	4.531E-02	2.719E-03
11	11	.0500	1.183E-01	4.640E-02	7.194E-02	3.597E-03
12	12	.0300	4.948E-01	5.801E-02	4.368E-01	1.310E-02
13	13	.0200	7.551E-01	3.824E-02	7.169E-01	1.434E-02
14	14	.0200	6.642E-01	2.711E-02	6.371E-01	1.274E-02
15	15	.0200	4.016E-01	2.210E-02	3.795E-01	7.589E-03
16	16	.0200	5.085E-01	4.352E-03	5.042E-01	1.008E-02
17	0	0.0000	0.	0.	0.	0.
18	0	0.0000	0.	0.	0.	0.
19	0	0.0000	0.	0.	0.	0.
20	0	0.0000	0.	0.	0.	0.
21	0	0.0000	0.	0.	0.	0.
22	0	0.0000	0.	0.	0.	0.
23	0	0.0000	0.	0.	0.	0.
24	0	0.0000	0.	0.	0.	0.
25	0	0.0000	0.	0.	0.	0.
26	0	0.0000	0.	0.	0.	0.
27	0	0.0000	0.	0.	0.	0.
28	0	0.0000	0.	0.	0.	0.
29	0	0.0000	0.	0.	0.	0.
30	0	0.0000	0.	0.	0.	0.
TOTAL INTEGRAL			3.956E+00	7.588E-01	3.197E+00	1.007E-01
						10.074 PER CENT

TNS(PGFR) XS-SENS.-ANAL. FOR TF-KERMA *TF+E COILS* 176SED: CR,NI,FE,CU

** SED UNCERTAINTY ANALYSIS **

G-IN	MEDIAN G-OUT OF SED (FROM INPUT)	INTEGRAL SED-UNCERT. F (FROM INPUT)	HOT INTEGRAL SENS. COEFF. S-HOT	COLD INTEGRAL SENS. COEFF. S-COLD	NET INTEGRAL SED SENS.-COEFF. S (SHOT - SCOLD)	RESPONSE UNCERT. DR/R DUE TO SED-UNCERT. (F * S)
1	8	.1100	0.	0.	0.	0.
2	8	.1000	1.576E-01	5.179E-02	1.058E-01	1.058E-02
3	7	.1000	5.899E-02	2.028E-02	3.871E-02	3.871E-03
4	4	.0900	2.884E-02	1.257E-02	1.628E-02	1.465E-03
5	5	.0800	3.048E-02	1.337E-02	1.711E-02	1.369E-03
6	6	.0700	2.641E-02	1.244E-02	1.398E-02	9.783E-04
7	7	.0700	4.481E-02	2.331E-02	2.150E-02	1.505E-03
8	8	.0600	2.950E-02	1.917E-02	1.033E-02	6.198E-04
9	9	.0600	4.038E-02	2.566E-02	1.472E-02	8.829E-04
10	10	.0600	5.538E-02	3.054E-02	2.484E-02	1.490E-03
11	11	.0500	8.475E-02	3.717E-02	4.758E-02	2.379E-03
12	12	.0400	5.164E-01	7.853E-02	4.378E-01	1.751E-02
13	13	.0200	1.464E+00	9.655E-02	1.368E+00	2.736E-02
14	14	.0200	2.565E+00	1.578E-01	2.407E+00	4.814E-02
15	15	.0200	2.122E+00	1.374E-01	1.984E+00	3.969E-02
16	16	.0200	6.042E+00	2.017E-01	5.840E+00	1.168E-01
17	0	0.0000	0.	0.	0.	0.
18	0	0.0000	0.	0.	0.	0.
19	0	0.0000	0.	0.	0.	0.
20	0	0.0000	0.	0.	0.	0.
21	0	0.0000	0.	0.	0.	0.
22	0	0.0000	0.	0.	0.	0.
23	0	0.0000	0.	0.	0.	0.
24	0	0.0000	0.	0.	0.	0.
25	0	0.0000	0.	0.	0.	0.
26	0	0.0000	0.	0.	0.	0.
27	0	0.0000	0.	0.	0.	0.
28	0	0.0000	0.	0.	0.	0.
29	0	0.0000	0.	0.	0.	0.
30	0	0.0000	0.	0.	0.	0.
TOTAL INTEGRAL			1.327E+01	9.183E-01	1.235E+01	2.746E-01
						= 27.464 PER CENT

TNS(PGFR) XS-SENS.-ANALYSIS FOR TF-COIL KERMA * SHIELD * I75SED: H_2O (W)

** SED UNCERTAINTY ANALYSIS **

G-IN	MEDIAN G-OUT OF SED (FROM INPUT)	INTEGRAL SED-UNCERT. F (FROM INPUT)	HOT INTEGRAL SENS. COEFF. S-HOT	COLD INTEGRAL SENS. COEFF. S-COLD	NET INTEGRAL SED SENS.-COEFF. S (SHOT - SCOLD)	RESPONSE UNCERT. DR/R DUE TO SED-UNCERT. (F * S)
1	10	.1200	0.	0.	0.	0.
2	10	.1000	1.224E+00	1.453E-01	1.079E+00	1.079E-01
3	10	.1000	2.917E-01	4.449E-02	2.472E-01	2.472E-02
4	11	.0900	1.276E-01	2.044E-02	1.071E-01	9.643E-03
5	12	.0800	9.860E-02	1.011E-02	8.850E-02	7.080E-03
6	6	.0600	6.959E-02	2.326E-02	4.633E-02	2.780E-03
7	7	.0700	1.251E-01	3.726E-02	8.785E-02	6.149E-03
8	8	.0600	9.328E-02	2.913E-02	6.415E-02	3.849E-03
9	9	.0600	1.285E-01	4.040E-02	8.811E-02	5.287E-03
10	10	.0500	1.461E-01	4.521E-02	1.009E-01	5.047E-03
11	11	.0500	1.742E-01	4.535E-02	1.289E-01	6.443E-03
12	12	.0500	5.100E-01	6.094E-02	4.491E-01	2.246E-02
13	13	.0400	5.293E-01	4.853E-02	4.808E-01	1.923E-02
14	14	.0300	3.584E-01	3.331E-02	3.251E-01	9.752E-03
15	15	.0200	2.487E-01	2.224E-02	2.265E-01	4.52[illegible]E-03
16	16	.0100	3.976E-01	6.827E-03	3.908E-01	3.908E-03
17	0	0.0000	0.	0.	0.	0.
18	0	0.0000	0.	0.	0.	0.
19	0	0.0000	0.	0.	0.	0.
20	0	0.0000	0.	0.	0.	0.
21	0	0.0000	0.	0.	0.	0.
22	0	0.0000	0.	0.	0.	0.
23	0	0.0000	0.	0.	0.	0.
24	0	0.0000	0.	0.	0.	0.
25	0	0.0000	0.	0.	0.	0.
26	0	0.0000	0.	0.	0.	0.
27	0	0.0000	0.	0.	0.	0.
28	0	0.0000	0.	0.	0.	0.
29	0	0.0000	0.	0.	0.	0.
30	0	0.0000	0.	0.	0.	0.
TOTAL INTEGRAL			4.523E+00	6.127E-01	3.910E+00	2.388E-01
						= 23.877 PER CENT

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