DOCUMENT CONTENT AND FORMAT GUIDE

for the

International Criticality Safety Benchmark Evaluation Project (ICSBEP)

(Critical and Subcritical Measurements)

General Format Guidelines

Final formatting, in terms of the document, including text, table and graphics, will be done by the publication staff. Evaluators are encouraged to follow the standard formatting guidelines outlined below, but should allow the publication staff to perform final formatting, to ensure consistency in evaluations contained within the Handbook. Publication templates will be used to ensure this consistency. Evaluations containing special/individual formatting functions, such as auto table/figure numbering, may interfere with the template styles and capabilities. Such special formatting functions should be avoided.

General presentation guidelines that evaluators should follow are given below:

- *Paper size can be either 'A4' or 'Letter'.*
- *Use 11-point, Times New Roman font for main text.*
- *Main text should be left-justified.*
- *Margins should be set as follows: top and bottom margins - .3 inches; left-hand margins – 1 inch; and right-hand margins - .8 inches.*

DOCUMENT CONTENT AND FORMAT GUIDE
(Critical and Subcritical Measurements)

Identification Number

EXPERIMENT TITLE

IDENTIFICATION NUMBER:

Each experiment has a unique identifier. The elements of the identifier correspond to the categories and subcategories named in the organization section of this report. The identifier takes the following form:

(Fissile Material)-(Physical Form)-(Spectrum)-(Three-Digit Numerical Identifier)

Identifier elements and their meanings for each category and subcategory are given below.

Fissile Material		Physical Form		Spectrum	
Plutonium	PU	Metal	MET	Fast	FAST
Highly Enriched Uranium	HEU	Compound	COMP	Intermediate-Energy	INTER
Intermediate Enriched Uranium	IEU	Solution	SOL	Thermal	THERM
Low Enriched Uranium	LEU	Miscellaneous	MISC	Mixed	MIXED
Uranium-233	U233				
Mixed Plutonium - Uranium	MIX				
Special Isotope	SPEC				

Subcritical measurements are denoted by including the letters “SUB” at the beginning of the identifier.

Examples of identifiers are: IEU-COMP-THERM-001 for thermal, intermediate enriched uranium system in which the fissile material is in the form of a compound; HEU-SOL-THERM-001 for highly enriched uranium solution; SUB-HEU-SOL-THERM-001 for subcritical measurements on highly enriched uranium solution systems.

KEY WORDS:

A list of words that describe key features of the experiment is provided.

1.0 DETAILED DESCRIPTION

Section 1 General Guidelines

A detailed description of the experiments and all relevant experimental data are provided in the appropriate subsections within this section. The detailed description includes the measurement methods used and the results obtained for the parameters of interest, as well as methods used to obtain the experimental data. Experimental data are values of parameters that are needed to completely describe the experiment and that have been directly measured. Examples are dimensions obtained from tightly controlled specifications or with calibrated measuring devices, masses obtained from weighing, and temperatures from thermometer readings. It is recommended that only experimental data that are taken directly from the references be included in Section 1. However, values derived from experimental data, such as density derived from masses and dimensions, or compositions normalized to 100 wt.%, may be included if clearly noted as derived with the method of derivation given.

In order to clarify the description of the experiment and to not prejudge the evaluation, there should be no mention of models, calculated results, or evaluative statements in this section. Only the physical description of the actual experiment is given.

Uncertainties in the data that were assigned by the experimenters, either in published or unpublished (e.g., logbook) sources, should be given. How the uncertainties were determined and what they represent (e.g., standard deviation, specification tolerance, estimated bounds), if known, should be noted.

Any inconsistencies in the data from different sources are mentioned. In addition to enough information that the derivation of benchmark-model specifications in Section 3 is evident, it is recommended that more experimental data, which might be useful for more detailed modeling or for justification of sufficiency of the model, be provided. The source of each datum should be clear. Sources of data include published reports, logbooks, chemical-laboratory analyses, handbooks or standards of material compositions, photographs, memos or other records provided by experimenters, and discussions with experimenters.

In general, modeling (idealization, simplification) of the experiment is not discussed here. However, if the exact experimental configuration is unknown (e.g., perhaps it was not reported because it was thought to be too complicated to describe in detail) and an idealization was provided by the experimenters, then the idealized experiment may be described here. Evaluation (Sections 2 and 3.1) of an idealized experiment includes an explanation of the assumptions used in going from the real experimental configuration to the idealization.

1.1 Overview of Experiment

The overview of the experiment includes a summary description of the experiment, its original purpose, the parameters that vary in a series of configurations, and mention of significant relationships to other ICSBEP-evaluated experiments. It should include the name of the facility, when the experiments were performed, the organization that performed the experiments, and perhaps the names of the experimenters if available. The conclusions of the Evaluation of Experimental Data section, Section 2, should be briefly stated. (e.g., "Twenty experiments were evaluated, but only 12 were judged to be acceptable critical benchmark experiments.")

1.2 Description of Experimental Configuration

This section contains the detailed description of the physical arrangement and dimensions of the experiment. The method of determining the critical condition and, if applicable, the method of determining the measured reactivity are stated. For ease of accurate transcription and checking, data and uncertainties are simply copied from the references, in their original units and to the precision that was recorded. However, if original units are not SI, evaluators are encouraged to parenthetically provide SI units immediately following the original units.

Subcritical measurements may require more detailed information about the source and detectors than is typically required for critical assemblies.

1.3 Description of Material Data

This section contains the detailed description of all materials used in the experiment as well as significant materials in the surroundings. Measured temperature is given. Whether compositions are from physical or chemical analyses of the materials actually used in the experiments or are from material handbooks when only the type of material was specified (e.g., stainless steel 304L) should be clear. Details of the methods of analysis and uncertainties, if known, are also given. When isotopic buildup and decay are important, dates of the experiment, of the chemical analysis, and of isotopic analysis or purification should be provided.

1.4 Temperature Data

The temperature at which the experiments were performed should be given and discussed in this section.

1.5 Supplemental Experimental Measurements

This section contains additional experimental data (e.g., flux distributions, spectral indices, β_{eff}, reactivity data, etc.) not necessarily relevant to the derivation of the benchmark model. Additional information that is not used in the evaluation may be included by reference to readily available documents. If such documents are not available, the additional data may be included in this section or by reference to an appendix. If there is no such additional data, it is so stated.

Evaluations of subcritical measurements include a description of the measurement technology and a discussion on the interpretation of the measurements as well as the measured data.

2.0 EVALUATION OF EXPERIMENTAL DATA

Section 2 General Guidelines

Evaluation of the experimental data is documented in this section and conclusions are stated and justified. Missing data or weaknesses and inconsistencies in published data are discussed and resolved in appropriate subsections of this section. Uncertainties of k_{eff} due to uncertainties of the experimental data are discussed and quantified. Codes and modeling methods used for calculations of the effects should be specified. Use of data with large uncertainties or data that require questionable assumptions on the part of the evaluator is justified.

Besides effects of reported uncertainties, sensitivity of k_{eff} to variation in each parameter whose uncertainty was not reported is calculated or otherwise estimated and provided. If the sensitivity shows that the effect of a rough but reasonable estimate of the uncertainty is negligible, the effect may be evaluated simply as 'negligible.' (The meaning of 'negligible' should be quantified.) Otherwise, a standard uncertainty (i.e., approximate standard deviation[a]) of the parameter is estimated based on whatever information is obtainable, such as typical uncertainty of the parameter at the experimental facility at the time of the experiments, information from the manufacturer of the component or of the measuring device, and personal experience. The basis of the uncertainty estimate should be explained.

Differences between code input specifications whose calculated results are subtracted to obtain effects, if not obvious, should be made clear. It is not necessary to use the exact benchmark-model specifications for sensitivity calculations; however, any large discrepancies from the benchmark model should be noted.

At the end of Section 2, a summary table showing effects on k_{eff} of the standard uncertainties is presented. It is recommended to also show sensitivities of k_{eff} to the various parameters per unit measure or per 100% and with the sign (+ or -), to preserve in convenient form this outcome of the evaluation. The table concludes with the total combined uncertainty in k_{eff}, which is defined as the individual uncertainty effects combined with the measurement uncertainty of the experimentally measured value of k_{eff}.

If all or some of the configurations are found to be unacceptable for use as benchmark data, this fact is noted in this section, and the reasons are summarized. The evaluation process for the unacceptable configurations is terminated at this point (i.e., unacceptable data are not included in Sections 3, 4, and Appendix A).

A decision made by the ICSBEP Working Group that a particular experiment is not acceptable for use as a "Criticality Safety Benchmark Experiment" is not intended to imply that the data, if properly interpreted and applied, cannot be used for validation efforts. In particular, experiments for which the combined uncertainty in the benchmark k_{eff} value exceeds 1% are often judged to be unacceptable. This is especially true when the data are not required to fill gaps in existing data. However, if the large uncertainty is properly taken into account, the data may be used in validation efforts.

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[a] See the *ICSBEP Guide to the Expression of Uncertainties.* Uncertainties specified in evaluations published after 2001 correspond to one standard deviation, 1σ. Uncertainties published prior to that date often do not adhere to that convention.

3.0 BENCHMARK SPECIFICATIONS

Section 3 General Guidelines

In general, the benchmark specifications provide the information necessary to justify and construct calculational models that best represent the experiment. The benchmark-model specifications should retain as much detail as necessary to preserve all important aspects of the actual experiment. When it is necessary or desirable to simplify the representation of the experiment for the benchmark model, this section must include description of the transformation from the measured values to the benchmark-model values and must provide the effect of the transformation on k_{eff} and the effects of the uncertainties associated with the transformation on k_{eff}.

Benchmark specifications include a description of simplifications (Section 3.1) and the benchmark-model specifications: geometry description and dimensions (Section 3.2); material data (Section 3.3); temperature data (Section 3.4); and the benchmark-model value of k_{eff} and its evaluated uncertainty (Section 3.5).

Section 3.1 describes simplifications of the model compared to the experiment and estimates, from calculations or reactivity measurements, the effect of simplifications on the value of k_{eff}. The effect is applied as an adjustment (i.e., correction, bias) to the expected value of k_{eff} to be calculated. (This expected value is called the 'benchmark-model k_{eff}'.) Uncertainty (1σ estimate) of the k_{eff} adjustment is also given, to be combined with the total uncertainty from the end of Section 2 to obtain the final evaluated uncertainty of k_{eff} in Section 3.5.

Section 3.2 is the complete and concise description of the benchmark-model geometry. Schematics of the benchmark–model geometry should always be included in Section 3.2.

Values that define the benchmark model (Sections 3.2, 3.3, and 3.4) are, in general, derived from experimental data without rounding and are, thus, given with more digits than uncertainty of the experimental data implies. This is to maintain consistency between the benchmark model and the "best values" obtainable from the evaluation of the experimental data. ("Best values" are those most likely to have been the actual values, based on the evaluation.) Uncertainties of values are given explicitly in other sections of the evaluation, namely in Sections 1, 2, 3.1, and 3.5.

3.1 Description of Model

This section begins with a general description of the main physical features of the benchmark model(s). Any simplifications and approximations made to geometric configurations or material compositions are described and justified and any resulting biases and additional uncertainties in k_{eff} are quantified. All codes and data used for calculations of biases and their uncertainties should be noted. Discussion of the model(s) includes an explanation of all assumptions used in going from the real experimental configuration to the benchmark-model configuration.

Justification for omitting any constituents of the materials used in the experiment description is provided. Materials that are not included are, in most cases, replaced with void; i.e., their effect is truly negligible. Substitution of other material is discouraged because of the effect on the spectrum, thereby changing the basic nature of the configuration to an unknown extent.

3.2 Dimensions

All required dimensions and information needed to completely describe the geometry of the benchmark model(s) are included in this section. Specifications are derived from reported values given in previous sections and should not be rounded, i.e., all additional digits that result from unit conversions should be retained. Sketches, including dimensions and labels, of the benchmark model(s) should always be included.

3.3 Material Data

Atom densities for all materials specified for the model(s) are derived from the reported compositions and masses or densities given in the previous sections and are concisely listed here. Lists are broken into subheadings such as core, structural, and reflector materials. If the method of deriving of atom densities from reported data is not obvious, it is explained. Unique or complicated formulas for deriving atom densities are provided. Atom densities are listed in scientific notation with five significant digits.

3.4 Temperature Data

Temperature of the model is provided in this section.

3.5 Experimental and Benchmark-Model k_{eff} and/or Subcritical Parameters

The experimental k_{eff} and its reported uncertainty, if it is available, are given in this section. If the experimenters simply indicated that the system was critical, a k_{eff} of 1.0 is assumed for the experiment. (For replacement measurements, Δk_{eff} is provided. If Δk_{eff} is given as ¢, β_{eff} is also provided.)

If the experiment description is simplified (as described in Section 3.1) in the benchmark-model specifications, the effect on k_{eff} of this transformation, carefully quantified either from measurements or calculations, may result in an adjustment of the experimental k_{eff} to obtain k_{eff} of the benchmark model. Simplifications should have only a relatively small effect on the uncertainty in the adjusted benchmark-model k_{eff}. Generally, simplifications that have a significant effect on k_{eff} or the neutron spectrum are not made.

Uncertainty of the adjustment of k_{eff} due to simplification of the model (from Section 3.1) is combined with the uncertainty of k_{eff} due to uncertainties in experimental data (from the end of Section 2) to obtain the final combined uncertainty of k_{eff} of the benchmark model.

The adjusted benchmark-model k_{eff} and its uncertainty are given. The benchmark-model k_{eff} is the expected value of k_{eff} from a calculation using the benchmark model, which is completely described in Sections 3.2, 3.3 and 3.4. It is also the expected value of k_{eff} measured for an experiment with materials and geometry exactly as described by the benchmark model.

Additional benchmark-model parameters of interest, such as spectral ratio, variance-to-mean, decay constant, or count-rate ratio values and their uncertainties, in general, should be included for subcritical measurements, as well as the interpreted benchmark-model k_{eff} values.

4.0 RESULTS OF SAMPLE CALCULATIONS

Section 4 General Guidelines

Calculated results obtained with the benchmark-model specification data given in Section 3 are tabulated in this section. These are regarded as only "sample calculations" because codes often have several options available for representing the same benchmark-model configuration, and because details of input listings are not thoroughly reviewed. Choice of appropriate code input to represent the benchmark model described in Section 3 is the responsibility of the user of the evaluation.

Codes and cross section data sets used for the sample calculations are indicated in Section 4, but details about the calculations and input listings are given in Appendix A. Results should be tabulated in the following format.

Table X. Sample Calculation Results

Code Name→ (Cross Section Set)→ Case Number ↓	Code Name (Cross Section Name)	Code Name (Cross Section Name)	Code Name (Cross Section Name)

The case numbers must be sequential. Other identifiers or identifying information such as experiment IDs, density or reflector material may also be included in the table.

Originally results using specific codes and cross section data were required. Beginning with the 1997 edition of the handbook, selection of appropriate cross section data is left to the discretion of the evaluator. However, cross section data sets should be clearly identified and, for cases in which less well-known cross section data are used, a brief history discussing the development and intended use for the cross section data set should be added to the appropriate section of Appendix A. Code versions are also discussed briefly in an introductory paragraph that precedes the input listings.

Exceptions to isotopes from the specified cross section data set shall be noted in footnotes to the table in which the results are presented. The person or persons who created the sample input listings or provided the calculation results, if not the evaluators, should also be acknowledged in a footnote to the results table.

Sample calculations for which exact representation of the benchmark model (Section 3) was not possible because of code limitations should be discussed in Section 4.

Calculated results that differ from the benchmark-model values (Section 3.5) by more than 1% or 3σ (whichever is smaller) should be noted and may be explained if the reasons are thought to be known.

Calculated results for replacement measurements are reported in terms of Δk_{eff}, rather than k_{eff}.

The other benchmark model parameters given in Section 3.5 should be included for subcritical measurements as well as sample calculated eigenvalue results.

5.0 REFERENCES

All formally published documents referenced in the evaluation that contain relevant information about the experiments are listed. (References to handbooks, logbooks, code manuals, textbooks, personal communications with experts, etc. are not included in this section but are given in footnotes.)

APPENDICES

Supplemental information that is useful, but is not essential, to the derivation of the benchmark specification is provided in appendices. Appendices are labeled using letters (e.g., Appendix A). Appendix A always provides typical input listings of the sample calculations.

APPENDIX A: TYPICAL INPUT LISTINGS

Brief comments about options chosen for calculations are included in an introductory paragraph. Any small differences from the benchmark-model specifications in Section 3 are noted. This paragraph states the version of the code (e.g., KENO-IV, KENO-V.a, MONK6B, etc.) that was used for the calculations and additional information including:

S_N Codes

Quadrature order (i.e., N)

Scattering order for cross sections (P_1, P_2, P_3, etc.; corrected or not corrected for higher-order effects)

Convergence criteria for eigenvalue and flux

Representative mesh size (cm)

Monte Carlo Codes

Number of active generations

Number of skipped generations

Number of histories per generation or total number of histories

Unique and/or important features regarding the input may also be discussed just prior to the input listings. Listing titles refer to the case number and number of the table in Section 4.0 that gives the calculated result.

For countries in which multiple code systems are used, input listings are grouped by code system in the order established by that country (e.g., A.1 **KENO Input Listings**, A.2 **MCNP Input Listings**, and A.3 **ONEDANT/TWODANT Input Listings**).

NUCLEAR CONSTANTS

Atomic densities are based on a consistent set of basic nuclear constants. Unless specifically stated otherwise, all nuclear constants are taken from "Nuclides and Isotopes," Fourteenth Edition, General Electric Nuclear Energy Operations, 1989. Where atomic densities are provided in an experimental report, and the values of Avogadro's Number and the atomic weights that were used by the experimenters to determine the atomic densities are known, reported atomic densities are adjusted to be consistent with the nuclear constants given in this section. Values from the consistent set that are used in the evaluations are given below.

Avogadro's Number = $6.0221 \times 10^{23} \frac{\text{atoms}}{\text{mole}}$

TABLE 1. Atomic Weights.

Nuclide or Isotope	Atomic Weight
^{1}H	1.0079
^{2}H	2.0141
^{3}He	3.0160
He	4.0026
^{6}Li	6.0151
Li	6.941
Be	9.0122
B	10.811
^{10}B	10.0129
^{11}B	11.0093
C	12.011
N	14.0067
O	15.9994
F	18.9984
Na	22.9898
Mg	24.305
Al	26.9815
Si	28.0855
P	30.9738
S	32.07
Cl	35.453
K	39.0983
Ar	39.948
Ca	40.078
Sc	44.9559
Ti	47.88
V	50.9415
Cr	51.996
Mn	54.9380
Fe	55.847
Ni	58.69
Co	58.93320
Cu	63.546

TABLE 1. Continued.

Nuclide or Isotope	Atomic Weight
Zn	65.39
Ga	69.723
Ge	72.61
As	74.9216
Se	78.96
Br	79.904
Rb	85.4678
Sr	87.62
Y	88.9059
Zr	91.224
Nb	92.9064
Mo	95.94
Ru	101.07
Rh	102.9055
Pd	106.42
Ag	107.8682
^{107}Ag	106.9051
^{109}Ag	108.9048
Cd	112.41
^{106}Cd	105.9065
^{108}Cd	107.9042
^{110}Cd	109.9030
^{111}Cd	110.9042
^{112}Cd	111.9028
^{114}Cd	113.9034
^{116}Cd	115.9048
In	114.82
Sn	118.71
Sb	121.75
Te	127.60
I	126.9045
Cs	132.9054
Ba	137.327
La	138.9055
Ce	140.115
Pr	140.9076
Nd	144.24
Sm	150.36
^{144}Sm	143.9120
^{147}Sm	146.9149
^{148}Sm	147.9148
^{149}Sm	148.9172
^{150}Sm	149.9173
^{152}Sm	151.9197
^{154}Sm	153.9222
Eu	151.96
^{151}Eu	150.9198
^{153}Eu	152.9212

TABLE 1. Continued.

Nuclide or Isotope	Atomic Weight
Gd	157.25
^{152}Gd	151.9198
^{154}Gd	153.9209
^{155}Gd	154.9226
^{156}Gd	155.9221
^{157}Gd	156.9240
^{158}Gd	157.9241
Tb	158.9253
^{160}Gd	159.9270
Dy	162.50
^{156}Dy	155.9243
^{158}Dy	157.9244
^{160}Dy	159.9252
^{161}Dy	160.9269
^{162}Dy	161.9268
^{163}Dy	162.9287
^{164}Dy	163.9292
Ho	164.9303
Er	167.26
^{162}Er	161.9288
^{164}Er	163.9292
^{166}Er	165.9303
^{167}Er	166.9320
^{168}Er	167.9324
^{170}Er	169.9355
Tm	168.9342
Yb	173.04
Lu	174.967
Hf	178.49
^{174}Hf	173.9400
^{176}Hf	175.9414
^{177}Hf	176.9432
^{178}Hf	177.9437
^{179}Hf	178.9458
^{180}Hf	179.9465
Ta	180.9479
^{180}Ta	179.9475
^{181}Ta	180.9480
W	183.85
^{180}W	179.9467
^{182}W	181.9482
^{183}W	182.9502
^{184}W	183.9509
^{186}W	185.9544
Re	186.207
^{185}Re	184.9530
^{187}Re	186.9557
Os	190.2

TABLE 1. Continued.

Nuclide or Isotope	Atomic Weight
Ir	192.22
Pt	195.08
Au	196.9665
Hg	200.59
Tl	204.3833
Pb	207.2
Bi	208.9804
^{232}Th	232.0381
U	238.0289
^{232}U	232.0371
^{233}U	233.0396
^{234}U	234.0409
^{235}U	235.0439
^{236}U	236.0456
^{238}U	238.0508
^{237}Np	237.0482
^{238}Pu	238.0496
^{239}Pu	239.0522
^{240}Pu	240.0538
^{241}Pu	241.0568[a]
^{242}Pu	242.0587
^{241}Am	241.0568
^{243}Am	243.0614
^{242}Cm	242.0588
^{243}Cm	243.0614
^{244}Cm	244.0627
^{245}Cm	245.0655
^{246}Cm	246.0672
^{247}Cm	247.0704
^{248}Cm	248.0723
^{252}Cf	252.0816

[a] "Chart of the Nuclides," Thirteenth Edition, General Electric Company, 1984.

COMMONLY USED SYMBOLS AND TERMS

A	mass number
A_f	atom fraction
A_w	atomic weight or mass (g/mole)
at.%	atom percent
B^2	buckling (cm^{-2})
C	Dancoff correction factor
D or Ø	diameter (OD outer diameter; ID inner diameter)
Δ	change in quantity [e.g., neutron multiplication factor, Δk; buckling, ΔB^2; tank height, ΔH; radius, ΔR; etc.]
H	height
Ih	inhour – The reactivity that will make the stable reactor period equal to 1 hour (3600 seconds).
k	neutron multiplication factor - The subscripts "eff" and "∞" are used to denote the effective multiplication factor, k_{eff}, and the multiplication factor for an infinite system, k_∞.
m	mass
M	molarity (moles/ℓ)
M	neutron multiplication $M \cong \frac{1}{1 - k_{eff}}$
M_w	molecular weight or mass (g/mole)
mil	$\frac{1}{1000}$ inch
mNile (mN)	1 pcm = 0.00001 Δk/k

N_A	Avogadro's number [6.0221 x 10^{23} (atoms, molecules, etc.) per mole; 0.60221 (atoms, molecules, etc.)/(barn-cm-mole)]
N_i	atomic density (atoms/barn-cm) - The subscript "i" is a general descriptor used to denote either the standard elemental symbol (e.g., N_H, N_O, N_{Pu}) or the isotopic mass number (e.g., N_{235}, N_{238}). For multi-elemental systems where isotopes of one element could be confused with those of another element, both the elemental symbol and the mass number are used (e.g., N_{Pu238}, N_{U238}).
N^a	excess acid (moles/ℓ)
R or r	radius (OR outer radius; IR inner radius)
ρ	reactivity: $\rho \equiv \frac{k_{eff}-1}{k_{eff}}$, sometimes denoted in units of \$ $\equiv \frac{\rho}{\beta_{eff}}$, where β_{eff} is the effective fraction of fission neutrons that are delayed.
ρ_i	density (g/cm^3 or g/ℓ) - The subscript "i" is a general descriptor used to denote the nuclide or compound for which the density is given (e.g., ρ_{U02N03}, ρ_{H20}, ρ_{Pu}, ρ_{HN03}).
pcm	0.00001 $\Delta k/k$
σ	uncertainty representing one standard deviation
σ_{MC}	statistical uncertainty associated with Monte Carlo calculations
σ_p	Hansen-Roach 16-energy-group cross section resonance correction; background potential-scatter cross section per absorber atom
σ_s	scattering cross section
Σ	macroscopic cross section or summation [e.g., Σ_a, Σ_f, Σ_s, Σ_t are macroscopic absorption, fission, scattering, and total cross sections; $\sum_{i=1}^{m}$ is a summation over the range: i = 1 to i = m].
V	volume
V_f	volume fraction

W_f weight fraction

wt.% weight percent

χ (E) fission spectrum

Note: When an index "i" is used in conjunction with another subscript, the two are separated by a comma
(e.g., $W_{f,i}$).